



RP 42-1

PIPING SYSTEMS

December 1996

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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 Recommended Practice

This RP serves to document good engineering practice for in-house engineers and external engineering contractors. It represents a valuable source of information for technical guidance and experience gained by BP throughout many years and across various businesses.

Application

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

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.

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.

Principal Changes from Previous Edition

This document is a major revision of BP Engineering Code of Practice CP 12 (April 1989), also incorporating BP Chemicals requirements where appropriate.



1. INTRODUCTION

1.1 Scope

1.1.1 This Recommended Practice specifies BP general engineering design requirements for metallic piping systems additional to those of [ASME B31.3](#). It has the same scope as [ANSI/ASME B31.3](#), hereafter referred to as ASME B31.3 - 1996 edition, except as modified by this Recommended Practice, and is applicable to:-

- (a) Refineries
- (b) Chemical Plant
- (c) Terminals
- (d) Crude oil and gas gathering centres, to the extent specified by BP
- (e) Marketing terminals, to the extent specified by BP.
- (f) Packaged equipment, in accordance with [ASME B31.3 300.1.2](#), when specified by BP.

BP practice has been to follow the requirements, in general, of [ASME B31.3](#). This RP makes certain modifications to [ASME B31.3](#) to allow for the use of BP and British Standard Specifications and to cover situations where BP practice does not follow that of the USA. It also gives detailed requirements of BP practice for piping in carbon, carbon-manganese and some low alloy steels for application at temperatures below 0°C.

The UK practice is covered in [EEMUA Supplement to ASME B31.3 - Publication No 153/95](#).

This Supplement (BP Group RP 42-1) shall be read in conjunction with [ASME B31.3 - 1996 Edition](#) which governs except as modified by this Supplement. It covers those modifications necessary to adapt [ASME B31.3-1996](#) to meet the minimum requirements of BP.

Wherever 'B31.3' or 'the Code' is used in this Supplement it shall mean [ASME B31.3 - 1996 Edition](#).

To assist in using this Supplement in conjunction with [B31.3](#), the modifications are identified by the reference number of the clause of B31.3 affected.

1.1.2 These requirements are not intended to be applicable to the following:-

- (a) Sea transport.
- (b) Transmission pipelines in land, or sub-sea locations (covered in BP Group Recommended Practice [RP 43-1](#)).



- (c) Pipelines of significant length and diameter, e.g. transfer lines between processing units, storages and jetties, which may be specified by BP to be engineered as main pipelines.
- (d) Production piping systems, as designated by BP (covered by the [IP Model Code of Safe Practice](#), Part 6 and [ASME B31.4](#)).
- (e) Underground drainage systems (covered in BP Group [RP 4-1](#)).
- (f) Steam piping systems within the plot limits of power stations and steam generating stations outside process areas (covered in the UK by [BS 806](#)).
- (g) Heating, ventilating and domestic water systems within buildings, including offshore accommodation modules.
- (h) Non-metallic piping systems. Requirements will be specified by or agreed with BP.

Glass Reinforced Epoxy (GRE) resin, composites can be a cost effective alternative material option for low pressure water piping, a service for which GRE is most often used. The user should carry out the full engineering evaluation of all aspects of achieving a successful GRE piping systems before making the final selection of this material of construction. The UKOOA 'Specification and Recommended Practice for the use of GRP piping offshore' and [BS 7159](#) form a sound basis for the application of composites in piping applications.

Composites have requirements which are very different to more conventional materials options and it is extremely important that the application of these materials be properly engineered. In particular, it is recommended that co-ordination meetings between experienced designers, materials suppliers, installation contractors, and Project personnel should be held at an early stage of any Project to discuss all aspects of design and installation.

Most problems with GRE piping systems have been associated with adhesive joints during installation and hydrotest. It is recommended that all installation work should be fully supervised, by experienced and competent personnel. It is recommended that all installation work should be fully supervised, by experienced and competent personnel. Additionally, the use of adhesive joints should be minimised. The use of simple 'bell and spigot' adhesive joints should be restricted to small diameter (<10"NB), factory assembled spools, and in all other instances fully laminated/overwrapped joints or alternatives mechanical jointing systems should be considered.

- (i) Hydraulic systems covered by BP Group [GS 134-1](#).

1.1.3 This scope is further shown in the Scope Diagram (Fig. 300.1.1 of [ASME B31.3](#), amended by 1.1.1 and 1.1.2).

1.1.4 This Recommended Practice includes BP requirements for piping design, layout, clearances, equipment isolation for maintenance and emergency, valves and fittings, steam tracing and jacketing, instrument piping, flexible hoses and special services. Specific requirements for fabrication, assembly, erection, examination, inspection and testing of piping systems are specified in BP Group [GS 118-5](#) to [GS 118-7](#), based on Chapters V and VI of [ASME B31.3](#).

BP general requirements for particular services were specified in BP Piping Standard Std 170 - Piping Specifications (recently re-designated BP Group [GS 142-6](#)). This standard is no longer maintained by BP Group Research and Engineering. Any future piping line specifications should reflect specific business and/or asset as well as local procurement and regulatory requirements. BP may use equivalent specifications at any operating site, or may approve the use of a contractor's equivalent standard specifications. For further guidance see Chapter IV - Component Requirements.

1.2 Quality Assurance

Verification of the vendor's quality system is normally part of the pre-qualification procedure, and is therefore not specified in the core text of this Recommended Practice. If this is not the case, clauses should be inserted to require the vendor to operate and be prepared to demonstrate the quality system to the purchaser. The quality system should ensure that the technical and QA requirements specified in the enquiry and purchase documents are applied to all materials, equipment and services provided by sub-contractors and to any free issue materials.

Further suggestions may be found in the BP Group RPSEs Introductory Volume.

CHAPTER I SCOPE AND DEFINITIONS

300 GENERAL STATEMENTS

300.1 Scope

300.1.1 Content and Coverage

- (c) Piping and fittings supplied integrally with vessels, compressors, pumps and other equipment shall be in accordance with the requirements of this Recommended Practice concerning limitations on type of piping joint (refer 310, 314 and 335).

(Additional to [B31.3 300.1.1](#))



- (g) Fire protection systems piping shall be in accordance with this Code.

(Substitution for B31.3 300.1.3(g))

300.2 Definitions

Add to 'fluid service'.

- (c) Hazardous fluid service - a fluid service which includes the following services and any other specified by BP:-

- (i) Liquids above their auto-ignition temperature (AIT), or 210°C if the AIT is not known.

The AIT is generally taken for the purposes of this Recommended Practice as 210°C (410°F), though exceptions to this criteria should be specified by BP for certain duties, e.g. unfluxed bitumens and some lubricating oils where the AIT may be higher, or for certain chemicals, e.g., ethyl ether where the AIT may be lower.

- (ii) Flammable liquids flashing on leakage to form a substantial vapor cloud. This shall include LPG, LNG and NGL condensate and others when specified by BP.

- (iii) Fluids liable to cause a hazard by blockage due to hydrate formation, solids deposition or coking.

- (iv) Fluids in which the potential for personnel exposure is judged to be significant and in which a single exposure to a very small quantity of a toxic fluid, caused by leakage, can produce serious irreversible harm to persons on breathing or bodily contact, even when prompt restorative measures are taken.

Fluids in this category include substances classified in terms of occupational health risks as Very Toxic, Toxic, Catcinogeneus, Mutageneus and Corrosive. Components of process streams which are known to cause serious irreversible harm include for example hydrogen sulphide (asphyxiant), hydrofluoric acid (corrosive) and sodium hydroxide (corrosive).

Classification of fluids into this category should take into account both the health hazard of the individual component of the fluid and the concentration of these components within the process stream in question.

- (v) Hydrogen service defined as service in contact with hydrogen or gaseous mixtures containing hydrogen in which the partial pressure of hydrogen is 5 bar (abs), (58 psig) or more.

- (vi) Flammable fluids at class 900 flange rating and above.

(Additional to [B31.3 300.2](#))

CHAPTER II DESIGN

301 DESIGN CONDITIONS

301.2 Design Pressure

Where the pressure is limited by a relieving device, the design pressure shall not be less than the pressure which will exist in the piping systems when the pressure relieving device starts to relieve or the set pressure of the pressure relieving device, whichever is the greater.

The maximum differences in pressure between the inside and outside of any piping component or between chambers of a combination unit, e.g. a jacketed pipe, shall be considered, including the loss of external or internal pressure.

The value of the design pressure to be used shall include the static head, where applicable, unless this is taken into account separately.

Piping subject to vacuum shall be designed for a negative pressure of 1 bar unless a vacuum break or similar device is provided, in which case a higher design pressure may be approved by BP.

(Additional to [B31.3 301.2](#))

301.3 Design Temperature

Design temperatures shall include an adequate margin to cover for the uncertainty in temperature prediction. The Design Maximum Temperature shall be the actual metal temperature expected in service co-incident with the loading case under consideration and shall be used to determine the appropriate design stress *S* for the selected material.

(Substitution for first para. of [B31.3 301.3](#))

301.3.1 Design Minimum Temperature

The Design Minimum Temperature which is used to determine the suitability of the material to resist brittle fracture shall be the lowest metal temperature expected in service. See Appendix X for BP requirements for low temperature systems. In the case of components thermally insulated externally, the lowest metal temperature shall be taken to be the minimum temperature of the contents of the pipe at the appropriate loading condition.

In the case of components not thermally insulated, the minimum temperature of the components under operating conditions and the method used for assessing the lowest metal temperature should be subject to agreement with BP.



In cases where the calculated membrane stress can vary with the minimum design temperature e.g. auto-refrigeration during depressurisation, the various combinations of stress and temperature shall be evaluated and agreed with BP to determine the one which is most onerous for the purpose of a materials selection.

(Substitution for [B31.3 301.3.1](#))

The calculated tensile membrane stresses should normally take into account the effects of all loadings such as internal and external pressures, static levels, self weight, thermal displacement stresses and external loads, but should not include stress intensification factors as used in flexibility analysis. Under certain circumstances only the pressure stresses need to be considered.

301.3.2 Uninsulated Metallic Components

- (a) For fluid temperatures below 38°C (100°F) the effect of ambient temperatures upon the metal temperature under normal and transient operating conditions shall be assessed and the Design Minimum Temperature agreed with BP.

(Substitution for [B31.3 301.3.2\(a\)](#))

301.4 Ambient Effects

301.4.2 Fluid Expansion Effects

On uninsulated lines, account shall be taken of the effects of solar radiation.

(Additional to [B31.3 301.4.2](#))

301.5 Dynamic Effects

General

Engineering guidelines to consider for frequency and stress control of piping subjected to dynamic loads are:-

- (a) *The piping layout should contain adequate guides and line stops where practicable.*
- (b) *Long sections vulnerable to large transient deflections should be avoided.*
- (c) *As many bends as possible should be eliminated and supports added as close to the bend as possible.*
- (d) *The stiffness of clamps and supports should be adequate to restrain the shaking force in piping to acceptable limits.*
- (e) *Pipe supports should be added at all heavy masses such as valves, etc. and at piping discontinuities. The span between supports should be carefully assessed.*

- (f) *Unreinforced branch connections and fittings should not be used where subjected to dynamic effects.*
- (g) *Threaded connections should not be used.*
- (h) *Where static methods are used for design, a minimum factor of 2 should be applied to dynamic loads at fixed supports.*
- (i) *Spring hangers should be avoided or their number minimised.*
- (j) *Dynamic vibration snubbers may require significant inspection, test and maintenance to ensure their serviceability. Additional fixed facilities may be necessary to carry out these activities. It is recommended that alternative means of support are fully investigated before choosing dynamic snubbers e.g. struts'.*

(Additional to [B 31.3.5.1](#))

301.5.3 Earthquake

The design shall not incorporate provision for earthquake induced forces unless specified by BP.

When designing for earthquake, experience shows, that in all probability the adequacy of supports is likely to be the most critical issue.

(Substitution for [B31.3 301.5.3](#))

301.5.5 Discharge Reactions

Lines subject to blowdown and impulse loadings shall be identified by the process engineer and the layout and its support shall be designed to avoid high loadings and vibration.

(Additional to [B31.3 301.5.5](#))

301.5.6 Dynamic Time-Force Analysis

Where dynamic time-force analysis is required, the method of analysis and any computer programs used shall be approved by BP.

Quasi-static design methods have generally been found to be adequate for design to accommodate dynamic effects. However, for critical lines subject to significant dynamic effects or where design using quasi-static analysis is not effective or does not lead to economical design solutions, consideration should be given to the use of dynamic time-force analysis. Criticality of lines may be assessed using the methodology given in Appendix Q

It is recommended that the need for use of dynamic analysis be assessed at the outset of a project in order that due time and resources are provided to carry out the work, and the work fits within overall schedule requirements.

(Additional to [B31.3 301.5](#))

301.5.7 Blast Effects



Consideration should be given to the effects of blast where there is a significant risk of unconfined gas/vapour explosion. Effective support of lines subject to blast loading can be provided by consideration at the design stage.

(Additional to [B31.3 301.5](#))

301.8 Effects of Support, Anchor and Terminal Movements

Where differential settlement may occur between items of equipment, sufficient flexibility shall be provided in the connecting piping.

(Additional to [B31.3 301.8](#))

301.12 Layout (Additional to B31.3 301)

301.12.1 General

- (a) Layout of piping shall consider economy, accessibility for operation, maintenance, construction and safety. Reference shall be made to BP Group [RP 44-7](#) for aspects of general plant layout. Specific attention shall be given to commissioning where piping is required to be steam blown, etc. Adequate allowance should be made for siting steam headers and trapping stations at the plant layout stage.
- (b) Piping and platforms around columns shall, where necessary, leave clear space for lowering equipment to the ground. Pipetracks should not encircle equipment.
- (c) Space shall be left around equipment and instruments to facilitate maintenance (tube bundle withdrawal, cleaning, level instrument bridles, etc.).
- (d) Piping layout should ensure that valves are readily accessible, easily operated and provide proper access to allow maintenance of valves in situ. The design shall enable valves to be removed without 'hot work' where this is not normally permitted. Valves for emergency isolation of equipment and process area limit valves shall be accessible from ground level, or from permanent accessway.

They should be approachable from two sides with easy, readily available escape routes. A single ladder up to an emergency shut off valve is not acceptable.

Valves shall not be installed with their stems below horizontal except for flare and relief line battery limit valves.

Valves in ground level pipetracks, shall be suitably grouped.

Drain valves for level gauges on vessels should be located so that the liquid level can be seen easily from the drain valve position.

Sufficient clearance shall be provided for satisfactory operation of lever valves. Allowance for insulation boxes shall be made.

Where valves are secured in position by clamping between pipework flanges, the effect of removing the adjoining pipework shall be taken into account.

Extended spindle or chain operated valves should be avoided. Where they are used they shall not cause obstruction.

If a wafer type butterfly valve is fitted in a process line, attention should be given to the possibility of the valve jamming in the open position (such an incident has occurred at a BP installation). If this type of valve is considered technically superior then spool pieces may have to be fitted to enable the valve to be removed if it does jam.

- (e) Piping layout shall allow for protection of piping systems, where necessary, to prevent freezing or to prevent difficulties resulting from high viscosities or wax formation. (See also BP Group [RP 44-2](#)).

Methods of protection include:-

- (i) *Heating by external or internal tracing, jacketing or grouping with adjacent hot lines,*
- (ii) *Insulation,*
- (iii) *Grading or sloping to permit complete draining,*
- (iv) *Burying below frost level.*

- (f) Generally, lines shall be run horizontally. Underground lines shall be provided with a means for emptying. Where lines need to be drained completely, the piping shall be sloped and be provided with drainage points.

Examples of lines requiring complete drainage are:-

- (i) *In multi-purpose lines,*
- (ii) *Where hazardous or valuable liquids can be spilt during dismantling of pipework,*
- (iii) *Where there may be polymerisation or settling of solids from liquids in the piping,*
- (iv) *Where there may be contamination of pure products due to liquids standing in lines subject to intermittent use,*
- (v) *Where condensation of gas or vapour streams may occur.*

- (vi) Where two phase flow lines could give rise to residual quantities of liquid.

Lines to be sloped shall be indicated on the engineering line diagram. Drain lines shall slope minimum 1:100. Service (i.e. non-process) lines shall have a slope of between 1:240 and 1:200. Unless specified otherwise, process lines generally shall slope 1:120 except on pipe-tracks where the slope shall be 1:240.

- (g) Branch connections from horizontal steam and air mains shall be taken from the top of the main.
- (h) Spading positions or other means of positive isolation requiring access during routine operation shall be accessible without the use of scaffolding.
- (i) Pipework on overhead structures, in tracks or in permanent trenches, should permit removal of any pipe, fitting, or valve without disturbing adjacent pipework. Pipes entering or leaving piperacks should do so at common intermediate elevations, either above or below the main rack levels. Pipe guides should not require hot work for removal or re-installation.
- (j) For plants containing stainless steel pipework operating at temperatures above 400°C (750°F) the risk of zinc embrittlement due to the proximity of any galvanised structural steelwork should be considered (see 323(a)v).
- (k) Sufficient space shall be allowed between adjacent lines at changes of direction to prevent damage of one line by another due to expansion or contraction.
- (l) Flake lines and other essential utilities should not be run directly above special Fire Risk Areas (see BP Group Document [RP 44-7](#)).

301.12.2 Clearances

- (a) Piping shall be laid out to provide access by mobile equipment (see BP Group [RP 44-7](#)). Access ways shall be planned accordingly and minimum headroom clearances for this purpose shall be:-
- (i) 4.5 m (14 ft 6 in) over railways (top of rail) and clearways for mobile equipment.
- (ii) 5.5 m (18 ft) over the crown of access roads and where specified over clearways for heavy equipment.
- (iii) 2.1 m (6 ft 10 in) over walkways and platforms.



Any greater clearances will be specified by BP.

- (b) Minimum clearance for walkways around pumps, motors, compressors etc., shall be 1 m (3ft 3in), measured from the furthest projection on the equipment, including associated pipework with flanges and insulation boxes, filters, valves in their open position, drains, cabling, instruments etc., between grade and 2.0m (6ft 6in) above grade.
- (c) Minimum clearance between the nearest edge of a pipetrack and the toe of a bund should be 1m (3ft 3in).
- (d) Flanges in parallel pipelines, shall be staggered with a minimum of 150mm (6in) longitudinal clearance between the flanges or insulation boxes.
- (e) Overground lines running side by side shall have a minimum clearance of 25mm (1in) between a pipe and an adjacent flange, after allowing for insulation and deflections. Attention shall be given to pipe movement caused by thermal changes.
- (f) Lines crossing each other shall have a minimum clearance of 25 mm (1in) pipe-to-pipe, after allowing for insulation and deflection.

301.12.3 Specific Requirements Inside Process Areas

- (a) Pipework shall be overhead wherever practicable, and accessways provided where necessary to allow operation of cranes and other mobile equipment.

Overhead racks may contain more than one level of piping, subject to BP approval. In multi-level racks, cable trays should be on the highest level with utilities piping below and corrosive fluid piping on the lowest level.

- (b) Fire water lines should not normally be laid inside process area limits.
- (c) Where main trunk lines for steam, water and other common systems run through a number of process units, offtakes to the users in any one unit shall not be taken directly from the main trunk lines. Offtakes shall be from a header or headers supplying each unit and should be provided with a valve at their junction with the main trunk lines. Where the main trunk lines run in offsite pipetracks, offtakes into each unit shall be fitted with a valve at the plot limit of each unit.
- (d) Pipe trenches close to process equipment should be avoided. Where it is not practicable to run pipe overhead and trenches



below paving level are unavoidable, the trenches shall be in accordance with BP Group [RP 4-3](#). Such trenches should be divided into sections about 10 m (30 ft) in length by firebreak walls in accordance with BP Standard Drawing S-1244.

- (e) Individual lines not exceeding NPS 1 (DN 25), e.g. drains, may be run in chases in paving if no suitable alternative is available.

301.12.4 Specific Requirements Outside Process Areas

- (a) Pipework should preferably run at ground level. Only in exceptional circumstances should trenches be used, or should lines be buried. Spacing of any fire-break walls will be specified by BP.

Pipework should be sufficiently above ground to prevent corrosion of underside by contact with soil and wind blown materials.

- (b) Lines at ground level should be grouped together to form pipetracks and run on supports to give the same bottom of pipe elevation.
- (c) Buried water lines are referred to in 301.12.6.
- (d) Aboveground lines shall not be laid directly over the underground lines where running parallel.
- (e) Piping passing under roads and railways shall be protected against mechanical damage and corrosion. Haunching or sleeves extending at least 1 m (3 ft 3 in) on either side of the road shoulders should be used as protection against damage.
- (f) Pipes in sleeves shall be sealed to the sleeve where:-
 - (i) It is necessary to provide a firebreak.
 - (ii) It is necessary to exclude moisture and avoid corrosion of the internal surface of the sleeve.
 - (iii) The sleeve might become a channel for underground drainage.
 - (iv) It is advisable to prevent ingress of solids which might block the sleeve against any future addition of another pipe.
 - (v) It is desirable to exclude rodents, particularly where the end of the sleeve is above ground, e.g. a thrust bore has been made.

Sealing may be by sheet metal covers with packing or proprietary synthetic rubber cappings.

Pipe sleeves should be galvanised or otherwise protected against corrosion.

- (g) Hot lines in pipetracks should be grouped together and expansion loops nested. The number of expansion loops should be minimised, consistent with the requirements of 313.
- (h) Take-offs from pipetrack to process areas should rise from track level, run low, and rise at the battery limit to the elevation of the piping within the process area. Battery limit valves, spades and drains should be located in the vertical risers, except those referred to in 322.9.2(c).

301.12.5 Specific Requirements for Tankage Areas

- (a) Forces imposed on connections on tanks should be minimised by providing flexibility in the connecting lines.
- (b) Where piping design and layout cannot accommodate differential settlement between tank and piping, flexible joints shall be provided subject to the approval of BP. Such joints shall incorporate fire-safe seals.
- (c) Lines passing through bunds shall be protected to minimise corrosion.
- (d) The annular space between any sleeves and piping shall be large enough to avoid clogging and shall be properly sealed.
- (e) At storage tanks, a by-pass between the water drain branch and the suction piping shall be installed only when it will be necessary to use the suction piping to empty the tank completely. Such by-pass connections should be the same size as the water drain.

301.12.6 Specific Requirements for Underground Pipework

- (a) Pipework should normally be run at ground level or overhead. BP shall approve the running of any piping underground.
- (b) Buried lines subject to corrosion shall be located in accordance with BP Group Document [GS106-3](#). Cathodic protection may also be required, but may not be permitted within certain specified process areas.

Surface markers should be provided to identify buried piping.



- (c) Pipes of cast iron, concrete or other materials liable to fracture shall be buried, and means shall be taken to avoid undue stresses on cast iron flanges.
- (d) Potable water, fire service reticulations and other water services on intermittent duties, shall be buried if protection against frost or sun is required.
- (e) Cooling water reticulations may run below ground to suit local conditions, subject to BP approval.
- (f) Buried lines shall be fitted with low point drain or pump-out connections.

301.13 Line Cleaning (Additional to B31.3 301)

Requirements for line cleaning shall be considered in the design and necessary provisions made. Line cleaning shall be carried out prior to pressure testing of erected piping systems (refer to BP Group [RP 32-2](#)).

Lines to be chemically cleaned should incorporate large flanged drain pockets and sampling points.

301.14 Insulation (Additional to B31.3 301)

Where insulation is required, BP general requirements are given in BP Group [RP 52-1](#) and BP Group [GS152-1](#).

302 DESIGN CRITERIA

302.2 Pressure Temperature Design Criteria

302.2.4 Allowances for Pressure and Temperature Variations, Metallic Piping.

- (h) Temperature variations below the design minimum temperature are not permitted.

(Substitution for [B31.3 302.2.4\(h\)](#))

302.3 Allowable Stresses and Other Stress Limits for Metallic Piping

302.3.5 Limits of Calculated Stresses due to Sustained Loads and Displacement Strains

- (d) The allowable displacement stress range SA (refer 319.2.3) for the computed displacement stress range SE (refer 319.4.4) shall be:-
 - (i) 50% of that calculated using equation (1a) for components in piping systems which:-



- (a) contain welds in or on highly stressed parts (e.g. fabricated branches or mitred bends, other than those welds connecting the component to the adjacent pipe,
- and (b) have a Design Minimum Temperature within 20°C (36°F) of those permitted by either Table 323.2.2 or Table X-1.
- (ii) 100% of that calculated using equation (1a) for all other piping systems.

(Substitution for [B31.3 302.3.5\(d\)](#))



304 PRESSURE DESIGN OF METALLIC COMPONENTS

304.2 Curved and Mitered Segments of Metallic Pipe

304.2.3 Mitre Bends

Proposals for the use of mitre bends shall be subject to approval by BP.

Mitre bends should not be used where the pressure exceeds 5 barg (72.5 psig) or where the stress-range reduction factor f , in the case of thermal or pressure cycling, would be less than 1.0 (see table 302.3.5).

(Additional to 1st para. [B31.3 304.2.3](#))

306 METALLIC FITTINGS, BENDS, MITRES, LAPS AND BRANCH CONNECTIONS

- (a) Fittings, bends and branch connections shall also be limited as defined in BP Group [GS 142-6](#).

(Additional to [B31.3 306\(a\)](#))

306.1 Limitations on Fittings

306.1.1 Listed Fittings

Fittings shall conform to the requirements of [ANSI B16.9](#) and B16.11 as defined in BP Group [GS 142-6](#) and BP Group [GS 142-2](#). Fittings larger than NPS 1 1/2 (DN 40) shall not be manufactured from bar stock.

Fittings to [BS 1640](#) and [BS 3799](#) may be acceptable alternatives, subject to the carbon content not exceeding 0.25%.

Fittings in certain materials (e.g. cupro-nickel) are not normally covered by international standards. These should only be used where there is evidence of proof testing acceptable to BP.

EEMUA Publications No. 144, 145 and 146 provide guidance for Cu - Ni piping components for offshore applications.

(Additional to [B31.3 306.1.1](#))

306.1.2 Unlisted Fittings

Consideration should be given to the use of integral forged fittings e.g. weldolet/branch/flange fittings.

These fittings are superior to set on fabricated type branches.

(Additional to [B31.3 306.1.2](#))



306.2 Limitations on Pipe Bends

306.2.3 Pulled Bends

Pulled bends with a centre-line bend radius not less than 5 x nominal pipe size (NPS) may be made in pipe sizes up to and including NPS 1 1/2 (DN 40), without heat treatment after bending. The use of pulled bends on larger pipe sizes shall be subject to approval by BP.

To compensate for the effects of wall thinning from bending, the following suggested allowances may be considered for carbon steel pipe:-

Bends Radius	Minimum Thickness prior to bending
6D	1.06 tm
5D	1.08 tm
4D	1.14 tm
3D	1.25 tm

where tm is the minimum pipe wall thickness and D is the nominal pipe diameter.

(Additional to [B31.3 306.2](#))

306.5 Limitations on Fabricated Branch Connections

Fabricated branch connections shall be permitted as defined in BP Group GS 142-6.

(Additional to [B31.3 306.5](#))

307 VALVES AND SPECIALITY COMPONENTS

Valves shall be selected in accordance with the guidance given in BP Group [RP 62-1](#) and BP Group [GS 146-6](#) and shall comply with the requirements of the relevant BP, [RP 62-2](#) or national or international standard..

(Additional to [B31.3 307](#))

308 FLANGES, BLANKS, FLANGE FACINGS AND GASKETS

308.1 General Limitations

308.1.1 Listed Components

- (a) Flanges, blanks and flange facings shall, unless otherwise approved by BP, be in accordance with [ANSI B16.5](#) (inch dimensions), supplemented by the requirements of this Code and BP Group [GS 142-12](#).

There are a number of non-standard compact flanges which may offer particular advantages e.g. quick-release facilities or cost and weight saving



on certain duties. Further information on the types and makes of compact flanges is given in Engineering and Technical Centre report [ETC.85.ER.219](#). Composite flanges to be used on cupro-nickel systems are acceptable where called for by BP Group [GS 142-6](#).

- (b) The design pressure and temperature ratings given in [ANSI B16.5](#) shall apply except where modified by BP Group [GS 142-6](#). Hazardous or searching fluids, as defined by BP, may require the use of higher duty flanges even though the operating temperatures and pressures are within the standard rating.

Class 300 flanges minimum should be used on LPG and LNG services.

Flanges should normally be slip-on or welding neck type except that for class 600 and above, welding neck flanges only shall be used. Slip-on flanges shall not be welded directly on to elbows or other fittings and shall be double welded for all services. Weld neck flanges shall not be manufactured from bar stock. Class 400 flanges shall not be used.

- (c) On lines over NPS 24 (DN 600), MSS SP44 or [API Std 605](#) may be used. Flanges to [BS 3293](#) should be avoided in favour of those to [MSS SP44](#) because of their strength limitations. Where [BS 3293](#) flanges are required, because of adjacent equipment, a check calculation on the suitability of the flange design for hydrostatic test conditions shall be made.

When using [BS 3293](#) flanges, it is known that it may be difficult to obtain a leak tight joint at or near the hydrostatic test pressure specified in [ANSI/ASME B31.3](#).

Pending the development of revised standards, it is recommended that a conservative approach be made when selecting the flange rating for a particular duty.

In the case of [API Std 605](#) flanges, care should be exercised when specifying these for valves or fittings on lines which may require to be pigged, since when used as an integral flange (e.g., on a valve) the smaller diameter of the bolt circle as compared with the other two flange standards may result in a reduced bore valve.

It should be noted that the bolt circle diameters are different for [API Std. 605](#) versus [MSS SP 44](#) Flanges, particularly NPS 24 and above hence they are not dimensionally compatible.

- (d) Flanges to [BS 4504](#) may be used on water pipe above NPS 24 (DN 600).
- (e) BP practice concerning orifice flanges is covered in BP Group [RP 30-1](#) to [RP 30-5](#).
- (f) Flanges on powder or pellet conveying lines operating at ambient temperature with pressures up to 1 bar (g) (15 psig),

where the pipe material is aluminum, may be fabricated from 12 mm (1/2 in) thick aluminum plate to [BS 1470 N3](#), flat face and drilled to [ANSI B16.5](#) class 150 (inch dimensions) for sizes up to NPS 12 (DN 300).

- (g) On hot or cold duties and where mating flanges are of different materials, or the bolts are of different material from the flanges, specific measures shall be taken in the design to avoid problems with differential expansion or contraction (see 309.1.3).

(Substitution for [B31.3 308.1.1](#))

308.1.2 Unlisted Components

Proprietary connectors and flanges, may be used subject to approval by BP. Their use may have benefits in space, cost and weight saving.

(Additional to [B31.3 308.1.2](#))

308.2 Limitations on Specific Metallic Flanges

308.2.1 Slip-On Flanges

- (a) Slip-on flanges shall be double welded as in Figure 328.5.2B, and shall be used as defined in 308.1.1(b).

A minimum of 3 runs of weld should be deposited where it is practically possible.

(Substitution for [B31.3 308.2.1\(a\)](#))

308.2.2 Expanded-Joint Flanges

Flanges having expanded-joint inserts shall not be used without BP Approval.

(Substitution for [B31.3 308.2.2](#))

308.2.3 Socket Welding and Threaded Flanges

Threaded flanges shall be used only with the approval of BP.

(Additional to [B31.3 308.2.3](#))

Socket welded flanges on small bore piping provide larger gasket face and lower risk of damage due to arc strikes than raised face flanges.

308.2.5 Flanges for Flared Metallic Laps

- (a) Lapped (tafted) type flanges with loose carbon steel backing rings conforming to [ANSI B16.5](#) may be considered for use with alloy piping, within the pressure/temperature limitation of the carbon steel backing ring, (see 306.4.2). Such flanges may only be used where external conditions are suitable for carbon steel and their use shall be subject to approval by BP.

Backing rings shall have a bevel or corner radius at the bore of approximately 3 mm (1/8 inch).

- (b) For non-ferrous pipework, lap type flanges in accordance with BP Standard Drawings S-1089M and S-1090M should be used unless otherwise specified by BP.

(Substitution for [B31.3 308.2.5](#)).

308.3 Limitation on Flange Facings

- (a) The Facings of class 150, 300, 600 and 900 flanges shall be raised face except where ring type joints are specified by BP.
- (b) The facings of flanges in classes 1500 and 2500 shall be of ring joint type. Class 900 flanges when used on hydrogen service shall also be of ring joint type. Differential hardness between joint ring and flange shall be considered.

The joint ring should have a 30-40 Vickers hardness less than that of the mating face of the flange. Account should be taken of the work relatively high hardening of austenitic stainless steel.

- (c) A steel flange shall be plain (flat) face at a joint with a cast iron or non-ferrous flange having a plain (flat) face.
- (d) Flange jointing faces shall be in accordance with BP Group [GS 142-12](#).

(Substitution for [B31.3 308.3](#))

In order to maintain a leak-tight joint, it is important to ensure that the gasket surface on the flange faces is correct for the type of gasket used. The requirements of BP Group [GS 142-12](#) represent an acceptable standard of



flange face finish for use with spiral-wound gaskets for which the preferred finish is smoother than that ideally required for sheet gaskets, however this finish is an acceptable compromise and may be used with sheet gaskets.

For critical duties, flanges may have to be selected so that they are not at the extremes of the allowable surface finish range. For these duties, it is important to specify a surface finish requirement for the other flanged components (e.g., valves) in the piping system.

308.4 Limitations on Gaskets

- (a) In steam and process services for Class 150 and 300, tanged sheet graphite non stick gasket should be used.

Pre-cut gaskets with burr-free edges should be used where possible. The site cutting of these gaskets should be discouraged, but where unavoidable, extreme care must be exercised in the gasket handling to avoid injury to hands. The use of hand gloves is mandatory.

Graphite should not be used on processes with sulphuric acid, nitric acid, hypochlorites, permanganate and oxygen above 500°C. The use of plain graphite gaskets is not recommended in oxygenated seawater handling systems.

BP Chemicals has undertaken testing of graphite gaskets and have concluded specific agreements with suppliers. All BP Chemical assets should follow these agreements as it is considered that not adhering to them may reduce plant safety and significantly increase plant maintenance. The details of the technology and agreements may be obtained from BP Chemicals Engineering Technology Manager, Vessels and Piping.

In utilities services Class 150 and 300, where the temperature is below 100°C and in equipment blinding applications, high performance nitrile rubber based reinforced sheet, containing non-respirable glass fibres should be used.

Above this temperature and for raised flanges in Class 600 and 900, spiral wound gaskets with flexible graphite filler to BP Group [GS 142-7](#) should be used. On hydrogen or toxic service, spiral wound gaskets should be used on all raised faced joints up to class 600.

Where asbestos is used as jointing or filler material, any restrictions imposed by health or environmental regulations in the country of use should be established. However, any perception of increased health risk in handling the material should be balanced against proven plant operational safety in those applications identified in this standard.

Asbestos in whatever form must be handled, stored and disposed of under specific site procedures which may be based on BP Group Occupational Health guidance.

Disposal costs should be assessed as part of the whole life cost in selecting appropriate materials.

- (b) Metallic octagonal ring type joints shall be used for class 1500 and 2500 flanges. For hydrogen service, class 900 flanges should also have ring type joints unless otherwise specified by BP

Soft iron or steel ring joints should be cadmium or zinc plated.

- (c) For full faced flanges the jointing shall cover the full face.
- (d) To avoid galvanic corrosion, tanged graphite or graphited CAF jointing should not be used with:-
 - (i) Austenitic stainless steel piping systems on corrosive aqueous duties.
 - (ii) Oxidising duty where temperatures may rise above 500°C (932°F).
- (e) Jointing in the form of cut rings shall be in accordance with BP Standard Drawing S-0668M.

Instances have been reported of incorrect size flat ring gaskets being installed in small bore joints. On critical applications/services, consideration should be given to the use of full face flat gaskets on small bore joints (up to 1 1/2 NPS) It should be noted that installation of full face flat gaskets required that all bolts are removable.

- (f) Spiral wound gaskets for use with raised face flanges shall, unless otherwise specified by BP, be provided with both inner and outer guide rings. The inner ring shall be suitable for the specific service fluid.

Special note should be made of the restriction imposed by [BS 3381](#) (Table 1) relating to the use of spiral wound gaskets in conjunction with certain sizes and ratings of slip-on flanges NPS 1 1/2 (DN 40) and below.

Spiral wound gaskets shall not be used with [BS 3293](#) flanges.

Carbon steel outer centering rings of spiral wound gaskets should be epoxy coated, suitable for a temperature range minus 16°C to plus 400°C.

- (g) The use of insulation gasket sets at flanged joints for electrical isolation or protection against galvanic corrosion, shall be subject to BP approval. Insulation sets shall have acceptable operational performance history. (See BP Std drawing S0841).

Mechanical failures of insulation joints have been reported. It is recommended that full engineering assessment should be given to their potential use on critical applications and that consideration be given to alternatives.

Insulation Joints often employ phenolic components, with or without neoprene facings under the heads of nuts and bolts and for the gasket. When compressive loads are high, the neoprene can crack leading to catastrophic failure of the gasket. Careful design appraisal, and control of bolt load is required in the field when using these joints.

Additional guidance on their use is given in the BPX Piping Joints Handbook.

- (h) The use of gaskets incorporating asbestos substitutes other than graphite shall be subject to approval by BP.

(Additional to [B31.3 308.4](#))

Substitutes for asbestos fibre gaskets have been developed in recent years and various types are offered commercially, most of these cannot be used over the full pressure/temperature range of asbestos joints and have not been in use long enough to evaluate all their weaknesses.

309 BOLTING

Bolting for flanged joints shall be in accordance with BP Group [GS 142-9](#) except where specified otherwise in BP Group [GS 142-6](#). The use of cadmium plated bolts and nuts is restricted to sub-zero and ambient temperature conditions.

(Additional to [B31.3 309](#))

Whilst the use of cadmium plated bolts and nuts is accepted for sub-zero and ambient conditions, it should be noted, that cadmium plated components can give off toxic fumes when heated. Thus, the use of heat to release tight nuts should not be used and it is recommended that gloves are worn to handle cadmium plated components to prevent skin abrasions.

309.1 General Limitations

309.1.3 Bolting for Components

Particular attention shall be given in bolting design and material selection to prevent relaxation or overstressing of the bolting when:

- (a) Different materials for bolting and flanges are used at elevated or low temperatures.
- (b) The flange assembly is subject to cyclic temperature conditions.
- (c) The flange assembly or through bolting is used at temperatures above 400°C (750°F) and below -50°C (-60°F).

Where no specification in BP Group [GS 142-6](#) covers the operating conditions, design calculations shall be made, and these and the proposed bolting specification shall be subject to BP approval.



Alloy steel B7 bolts should be specified as the minimum grade for use on chemical, refinery and offshore services.

Threading should be UNC up to and including 1 in diameter, and 8TPI (8 UN series) for sizes 1 1/8 in and above in accordance with BS 1580 Parts 1 and 2.

Bolting in sour service shall not be denied atmospheric exposure (e.g. flanges insulated or buried). If insulation or burial of flanges is required, alternative bolting, resistant to sour service, shall be used and lower strengths, if applicable, shall be taken into consideration in the flange joint design.

309.4

Hydraulic Bolt Tensioners (Additional to B31.3 309)

Flange connections with bolting of nominal diameter 25 mm (1 in) and over shall have sufficient clearance and access to allow the use of hydraulic tensioning equipment. The equipment supplier, tensioning procedure, and supporting calculations shall be subject to approval by BP.

Hydraulic bolt tensioning shall be used for the following:-

Nominal Bolt Diameter	Condition
50 mm and over	All joints
38 mm and over	(a) Class 600 and over (b) Hydrogen service (c) Toxic service
25 mm and over	(a) Joints subject to high temperature or cyclic duties (b) Joints with leakage history (c) Joints where high accuracy is required (d) Other duties specified by BP

Stud bolts shall be longer by one diameter to suit the bolt tensioner. Excess thread shall be protected by a threaded cap. On bolts at ambient temperature duty the cap should have a grease nipple.

An applied bolt stress of 30,000 to 40,000 lb/in², and typically 35,000 lb/in² is adequate for most duties. It should not generally exceed 50% of the bolt material yield stress. The applied bolt stresses should be individually calculated for particularly critical or problematic joints. Such calculations should be carried out for hydrotest and operating cases, and should take into account the following where applicable:-

- *external moments and forces*
- *different bolt/flange material properties*
- *different bolt/flange service temperatures*
- *change in bolt load due to internal pressure*
- *relaxation due to pressure or temperature cycling - temperature transitions.*

Following calculation of a bolt load, the flange design should be checked to ensure that the flanges are not overstressed or subject to excessive distortion (i.e rotation).

The bolt tensioning operation should be carried out to the manufacturers detailed procedure. The tensioning load should be applied a minimum of three times. Tensioning should ideally be applied evenly to all studs in one operation. Where this is not possible, tensioning should be applied to alternate studs in two phases. Particular care is needed in this case to ensure that the first set of bolts tensioned are not relaxed by the subsequent tensioning operations. After applying the tensioning load three times, the residual bolt load should be checked by breaking-out one bolt and measuring the necessary load to achieve break-out, followed by re-tightening the bolt.

310 LIMITATIONS ON PIPING JOINTS - GENERAL

Where joints are not required for regular dismantling, connections should be made by fusion welding or as required in the appropriate line specification.

- (a) The use of socket weld joints and compression fittings shall be as permitted in BP Group [GS 142-6](#) and this Recommended Practice.

Unions should not be used except for water drains.

- (b) Socket-welded and threaded fittings in accordance with [ANSI B16.11](#) may be used up to and including NPS 1 1/2 (DN 40) and up to NPS 3 (DN 80) for water service only, subject to the limitations of 311.2.4 and this Recommended Practice.
- (c) Socket-welding rather than threaded fittings shall be used for searching fluid service where specified by BP, e.g. for glycol service.

(Additional to [B31.3 310](#))

311 WELDED JOINTS IN METALLIC PIPING

311.2 Specific Limitations

311.2.4 Socket Welds

- (e) Where permitted, socket welding joints are preferred to threaded joints, except for non hazardous service as defined in 314.1(a) of this Recommended Practice.

(Additional to [B31.3 311.2.4](#))

312 FLANGED JOINTS

312.3 Minimisation of Flanged Joints (Additional to [B31.3 312](#))

The use of flanged joints should be kept to a minimum, particularly on hazardous service (as defined in 300.2(c)). However, sufficient break



flanges shall be provided to allow removal and replacement of piping or valves without 'hot work' where:

- (a) Valve seats cannot easily be maintained without removing the valve from the line, or valves cannot accommodate 'hot work' for other reasons.
- (b) Process duties may be fouling,
- (c) Deterioration of piping or valves is anticipated in service due to corrosion, erosion, etc.

The gasket or joint ring is but one component of a bolted flanged joint. The suitability of a particular gasket or joint ring must be established from consideration of the type and material of the flanges, flange facing and finish, quantity and type of bolting, service conditions, any specific requirements regarding leak tightness for Health, Safety or Environmental reasons, and any limitations on gasket materials.

Due consideration should be given to control of fugitive emissions from the completed joint by appropriate gasket selection.

For many applications joint selection will be specified in the piping or vessel specification.

Proper bolting up procedures, using appropriate equipment, are essential to ensure the correct and satisfactory joint assembly.

312.4 On Line Bolting (Additional to [B31.3 312](#))

BP Group [RP 42-2](#) provides guidance on the assessment, preparation and execution of Hot Bolting and Odd Bolting.

Hot Bolting is the sequential removal and replacement of fasteners on live piping and equipment flanges. Replacement is carried out one bolt at a time in a predetermined pattern and fully tensioned. The risks are increased bolting stresses and joint failure, also flange leakage due to relaxation of gasket compression.

Odd Bolting is the removal of alternative bolts (so flange is left with half the number of fasteners) during plant depressurisation, usually when the system is close to atmospheric pressure. The risks in this case are reduced gasket compression and flange leakage and the danger that system may be inadvertently re-pressurised.

Both of these techniques are potentially hazardous and therefore the utmost caution must be exercised when planning and carrying these operations.

313 EXPANDED JOINTS IN METALLIC PIPING

Expanded joints shall not be used unless agreed by BP.

(Substitution for [B31.2 313](#))



314.1 General Limitations

- (a) Threaded joints and fittings may be used only where suitable and when:-
- (i) The fluid handled is non-flammable and non toxic, non-hazardous, non-erosive and the duty is non-cyclic.
 - (ii) The design pressure does not exceed 10 bar(ga) (150 psig).
 - (iii) The design temperature is between -29°C (-20°F) and 186°C (366°F), except that steam is not included in this category.

(Substitution for [B31.3 314.1\(a\)](#))

- (b) Where seal welding of threaded joints is used:-
- (i) The materials shall be weldable.
 - (ii) The joints shall be made up clean and without the use of any tape or compound.
 - (iii) The weld shall cover all exposed threads.

Any exposed threads should be removed by grinding prior to seal welding. Welding on top of exposed threads can create stress concentration points and subsequent weld failures. There have been instances of this occurring at various sites.
 - (iv) The welding procedure shall not cause damage to the threaded fitting, e.g. valve soft seats.
 - (v) Welding shall be carried out by qualified welders, to a qualified procedure.
 - (vi) No other satisfactory means of jointing are available.

(Substitution for [B31.3 314.1\(b\)](#))

- (e) Unless otherwise specified by BP, threaded joints and fittings shall not be used for:-
- (i) Hydrocarbon service
 - (ii) General chemical service.
 - (iii) Corrosive fluid.

(iv) Steam service.

(Additional to [B31.3 314.1](#))

- (f) To reduce the incidence of leakage, the use of threaded joints and unions where permitted should be minimised consistent with needs of pipework fabrication. Sufficient threaded joints or unions, where permitted, shall be provided to facilitate dismantling of pipework for all operational, maintenance and inspection purposes, including requirements for shutdown and gas freeing.

(Additional to [B31.3 314.1](#))

- (g) With the exception of connections to instruments and instrument valve manifolds, threaded joints shall not be used in stainless steel, alloy steel or aluminium piping systems unless approved by BP.

(Additional to [B31.3 314.1](#))

Threaded joints or fittings are normally accepted on low pressure steam tracing. Seal welding should be used where possible.

- (h) No threaded joints or fittings shall be used between a pressure vessel or main pipe line NPS 2 (DN 50) or above, and the first block valve isolating a piping system. This valve shall be flanged or may be socket-welded with a flanged joint immediately downstream, subject to BP Approval.

(Additional to [B31.3 314.1](#))

- (i) Where vibration is expected in service, e.g. on rotating machinery, specific means shall be provided for adequate pipe guidance and support where threaded fittings are approved by BP.

- (j) Parallel threads only should be used for plugs. Use of PTFE tape is not allowed in the case of plugs.

(Additional to [B31.3 314.1](#))

314.2 Specific Limitations

314.2.1 Taper Threaded Joints

Threaded pipe joints may also be line-pipe thread to [API Std 5B](#).

(Additional to [B31.3 314.2.1](#))



NPT and API thread forms are similar and are interchangeable. It should be noted that API threads have tighter tolerances.

314.3 Assembly

314.3.1 The guidance on thread compounds and lubricants is given in Para 335.3 of this Recommended Practice

318 PROPRIETARY AND SPECIAL JOINTS

318.3 Compression Fittings

Compression fittings shall be in accordance with BP Group [GS 142-13](#) except where specified otherwise in BP Approved Project on Site Piping Material Specification.

Steel compression fittings shall be subject to the same general limitations as threaded fittings (314.1), except that they may be used for steam service, subject to BP approval. Note the requirements of 322.3.2 also apply for instrument impulse lines.

Compression fittings supplier should confirm in his bid the maximum hardness applicable to the matching tube.

Steel compression fittings shall not be used in the following cases:-

- (a) Where design temperature exceeds 210°C (410°F).
- (b) For joints requiring frequent dismantling or in systems subject to cyclic temperature conditions.
- (c) For sizes exceeding NPS 1 (DN 25).
- (d) Where dismantling is required to be carried out for more than half the dismantling times tested by the supplier.
- (e) Where there is mechanical vibration/cyclic loading.

(Additional to [B31.3 318](#))

318.4 Unions

Socket-welding unions to [ANSI B16.11](#) may be given the same field of application as other socket welding fittings.

(Additional to [B31.3 318](#))



319.1 General

Startup, shut-down, steam-out where applicable and upset conditions - including short-term excursions to higher temperatures or pressures - as well as normal operating conditions, shall be considered in flexibility analyses. This particularly applies to loads applied to connecting equipment. The effect of vibration from machinery on connecting piping shall also be assessed.

The increase in allowable design stress permitted for occasional variations above design conditions shall not be used for flexibility analysis.

Expansion of piping or associated equipment should be accommodated wherever possible by the inherent flexibility of the pipework. If necessary the route of the piping should be modified, or expansion loops should be incorporated, to obtain sufficient flexibility. Only where it is impractical to increase flexibility sufficiently to reduce the stress range or anchor loads to acceptable levels should bellows expansion joints be considered. Where bellows expansion joints are proposed, the approval of BP shall be obtained before proceeding (refer to 319.8).

Specific flexibility requirements at pumps, compressors and drivers are covered in 322.12.

Sufficient flexibility shall be provided in the piping to enable pressure relief valves, spades, line blinds or bursting discs to be changed.

(Additional to [B31.3 319.1](#))

The design conditions to be used for 'stressing' the line are not easily defined, as the problem which is being designed against is one of differential expansion between the pipe and its fixing points. Normally the temperature that has to be considered is the highest (and/or lowest) temperature that the line can reach under any stage of operation, start-up, shut-down, steam out etc. This temperature may be more extreme than the governing 'design temperature' determined in main document 301.3 if the coincident pressure is low. While it is common practice to fit pressure relieving safety devices, it is very much less common to fit temperature controlling safety devices, and it is not always easy to determine what this maximum temperature should be. A further complication is that on certain lines the maximum differential expansion can occur when the pipe is cold relative to its fixing points (e.g. column overheads line during start up).

It should be noted that the exclusion clauses in [ASME B31.3](#) are not relevant to this problem and cannot be used to downrate the design temperature.

319.2 Concepts, Metallic Piping**319.2.1 Displacement Strains**

- (b) Vessels or tanks at which piping terminates should be considered as rigid for the initial piping analysis. Where vessel

or pipe stresses thus obtained are unacceptably high, re-analysis may consider restraint flexibility.

(Additional to [B31.3 319.2.1\(b\)](#))

319.4

Analysis, Metallic Piping

Comprehensive stress analysis should normally be performed for critical lines as identified in accordance with the calculation of piping criticality shown in Appendix Q.

Lines should be categorised giving consideration to strength, reaction hazards (e.g. Nozzle Loads) and service hazards. As a general guide the following lines will be considered critical and require detailed analysis (all lines categorised as 1 and 2 in the Evaluation of Piping Criticality Procedures, and all lines in any one or more of the following categories):-

(a)	Size	Operating Temperature	
		Less Than or Greater Than	
	Less than 4"	-70°C	150°C
	4" up to 18"	-60°C	95°C
	Greater than 18"	-30°C	70°C

- (b) *Connecting to any strain-sensitive equipment (pumps etc.).*
- (c) *Likely to require proprietary expansion devices (Bellow, etc.).*
- (d) *R.T.J. Class lines (normally 900 rating and higher).*
- (e) *Pipe with wall thickness equal to or greater than $D/6$ or P/SE greater than 0.385.*

*Where D = Outside diameter of pipe (ins)
 P = Internal design gauge pressure (psi) SE = Allowable stress (from Appendix A [B31.3](#)) (psi)*
- (f) *Relief lines from relief valves or bursting discs.*
- (g) *All class 'M' Piping (toxic service).*
- (h) *Flowlines.*
- (i) *Flare Lines.*
- (j) *Lines manufactured from 'exotic materials' e.g. Duplex Stainless, Incoloy or Titanium.*
- (k) *Cupro-Nickel lines, greater or equal to 6" N.B.*
- (l) *Bridge lines subject to differential movements between structures.*
- (m) *Lines which may be subject to deck deflections (both dynamic and static) due to structural design or vendor design, which cause overspanning of the line, and or overloading of equipment nozzles.*
- (n) *Hazardous service lines as per para. 300.2 of this Recommended Practice.*
- (o) *Lines subject to slug flow/shock loading.*

- (p) *Lines subject to cyclic conditions.*
- (q) *Lines subject to wind induced or fluid induced vibration.*
- (r) *Lines subject to steam out conditions.*

The analysis should be conducted during the design stage of new piping systems. It should also be conducted for operational plant under the following circumstances:-

- (aa) *Mechanical modifications (e.g. re-routing/extension to an existing piping system, change in weight because of extra valves, flanges, etc., or change in temperature resulting from modified insulation).*
- (bb) *Process modifications (i.e. changes from original static design conditions, including pressure, temperatures and flow rate, or any transient conditions which may not have been considered in the original design).*
- (cc) *Excessive vibration.*
- (dd) *Excessive 'sag', any visible permanent deformation of the piping, or any interference of adjacent piping.*
- (ee) *Equipment problems (e.g. distorted vessels or tank connections, pump or compressor alignment or bearing problems, etc.).*
- (ff) *Installation alignment problems (i.e. difficulty in obtaining leak free joints without excessive cold-pull, particularly at rotating machinery pressure vessels and safety relief valves).*

Information needed for Pipe Stress Analysis

- (a) *Outside diameter of piping, wall thickness (or nominal diameter, schedule number).*
- (b) *Temperatures (minimum, operating, maximum), internal pressure.*
- (c) *Material of piping. (Expansion coefficient, Young's modulus, and material density will be selected for this material).*
- (d) *Insulation thickness and insulation material.*
- (e) *Specific gravity of contents.*
- (f) *Any wind load to be considered? If yes, the direction of application is important.*
- (g) *Any anchor initial translation, x in inches, y in inches, z in inches. (For towers, exchangers etc., nozzle initial translation is important).*
- (h) *Corrosion allowance for piping, inches.*
- (i) *Flange rating, psi ([ANSI B16.5](#)).*
- (j) *Standard valve weight and flange weight will be used. (For special valves mark the weight on pipe stress isometric).*
- (k) *Long radius elbows will be used. (If short radius or any other bend radius mark on the isometric). For short radius elbow radius = diameter.*

- (l) Any allowable loading from manufacturers on pumps, turbines, compressors? (From the vendor drawing for equipment).
- (m) Any preference to use expansion loops, expansions joints, and so on, if needed?
- (n) Mark type of intersection (reinforced fabricated tee, etc.).
- (o) Mark support locations (available steel crossings, and so on) on the stress isometric.
- (p) Is hydraulic testing load condition to be considered to get structural support loads?
- (q) Pipe stress isometrics (x-, y-, z-axis) piping plans, and sections are necessary.

319.8 Bellows Expansion Joints

(Additional to [B31.3 319](#))

Guidance on the selection and application of metallic bellows expansion joints is contained in [BS 6129](#) and in the Standards of the Expansion Joint Manufacturers Association (EJMA). BP general requirements for expansion joints for fluid catalytic cracking units (FCCU) are specified in BP Group [GS 120-2](#).

319.8.1 Materials

Bellows which have convolution wall thickness equal to or less than half the wall thickness of the matching pipe shall be made from an alloy which is resistant to both the internal process fluid and to the external environment.

Additionally, for elevated temperatures the material shall have adequate creep or stress rupture properties, and for low temperatures the material shall not be susceptible to brittle fracture.

The selection of material shall be based on the following:-

- (a) Austenitic stainless steels may be acceptable subject to there being no danger of pitting or chloride/polythionic stress corrosion cracking. This aspect must be assessed for each application.
- (b) Monel is acceptable, providing there is no possibility of sulphide corrosion at high temperature.
- (c) Incoloy 825 has improved resistance to stress corrosion cracking in chlorides and may be used up to 450°C (840°F). At higher temperatures embrittlement can occur.
- (d) Where there is internal or external contact with chlorides, Inconel 625 shall be used. This is acceptable up to 590°C,



above which, embrittlement occurs. At temperatures above 590°C, incoloy 800H shall be used.

- (e) In low temperature service, Monel, Incoloy 825, Inconel 625 and austenitic stainless steel (see (a) above) may be used.

319.8.2 Bellows Components

Bellows components such as flanges, gaskets, bolts, etc., shall be to the appropriate line specification in BP Group [GS 146-2](#).

319.8.3 (a) Vibration

Attention should be given to any expected vibration, e.g., from associated machinery, when specifying the design requirements of the bellows.

(b) Alignment

Attention should be given to maximum allowable axial misalignment.

Some bellows expansion joints are very vulnerable to axial misalignment.

319.8.4 External Shrouds

When specified by BP, external shrouds shall be provided for mechanical protection; the shrouds shall be designed to minimise the ingress, and prevent the retention of water within the convolutions.

319.8.5 Internal Sleeves

Internal sleeves are required when:-

- (a) Flow induced vibration may occur.
- (b) It is possible for solid debris to collect in the convolutions. This debris may be due to insufficient flushing of lines or equipment after initial construction or due to internals coming loose because of corrosion, vibration or erosion.
- (c) The duty is fouling, corrosive or contains solids. In this case purging behind the sleeve will be required if specified by BP.

When an internal sleeve is provided, the bellows should be installed in the vertical position with the sleeve pointing downwards and the convolutions shall be self-draining.

319.8.6 Spool Pieces



When bellows are to be welded directly into a line, they shall be purchased with spool pieces of the same material as that of the line, welded to the ends of the bellows. This weld may be specified by BP to be heat treated.

319.8.7 Insulation

To reduce the possibility of condensation within the bellows, thermal insulation or screening may be used but the bellows material shall not be subjected to a continuous high temperature which would lead to an unacceptable fatigue life. Insulation shall not be applied directly to the bellows convolutions.

319.8.8 Lubricants

The use of molybdenum disulphide lubricants shall be avoided on external tie bars, etc., if the bellows operate at a high temperature.

319.8.9 Support

The supporting and guiding of piping systems containing bellows expansion joints shall be fully assessed at the design stage, preferably by the bellows expansion joint manufacturer, to ensure that the bellows expansion joint deflects in the manner for which it was designed, and that the system retains structural stability.

321 DESIGN OF PIPE SUPPORTING ELEMENTS

321.1 General

Piping should not be supported off other pipes, particularly if either or both pipes are subject to thermal expansion or vibration, without the approval of BP. Nor shall it be supported from vessels or other equipment, except where brackets have been specifically provided. Piping shall not be placed in direct contact with concrete, nor be supported from removable flooring, flexible flooring, deck plating or hand rails.

Non-ferrous and stainless steel piping shall be protected at pipe supports against galvanic and crevice corrosion.

The line shall be designed to be self supporting when pressure relief valves, spades, line blinds or bursting discs are removed.

The maximum span between adjacent supports for horizontally run pipes shall limit maximum deflection due to total self weight to 7 mm (0.275 in) for pipes of NPS 1 to 3 (DN 25 to 80) and either this limit or a stress limit of 40 N/mm² (5800 lbf/in²) for pipes of NPS 4 (DN 100) and above, whichever allows the lesser span. Total self weight shall include any test water, contents and insulation.

All lines should be designed for hydrotest, unless otherwise approved by BP.



For copper, copper alloy or aluminium material a stress limit of 10 N/mm² (1450 lbf/in²) or maximum deflection due to self weight of 7mm (0.275 in) is recommended.

Pipes in a piperack or pipetrack should be grouped according to size to permit longer support centres for the larger pipes.

Where line self draining is essential (see 301.12.1(f)) the deflection of the pipe due to self weight at the point of maximum deflection shall not exceed the vertical fall over the span due to the set slope, (i.e. for set slope of 1:200 a maximum deflection to span ratio of 1:400 is allowable).

The location and identification of all pipe supports shall be shown on the piping drawings. Field supporting of small bore lines shall be carried out in accordance with the principles (spans, flexibility stress levels etc.) laid down in this Recommended Practice.

Pipe support schedules and pipe support design details shall be subject to BP approval.

(Additional to [B31.3 321.1](#))

It is common practice to site run small bore piping during construction, certainly NPS1 but also on occasions NPS 1½ and NPS 2. Special attention by designer must be given to these lines to ensure their proper fitness for purpose.

Small bore deluge pipework for active fire protection may be supported off other pipes, vessels or other equipment.

Stress analysis of local loads (to [BS 5500](#) or [WRC 107](#)) may be required for large diameter/thin walled pipes, to avoid excessive stress and deformation at supports.

The choice of material for supports should take into account the effects of corrosion caused by the environment.

A common method to protect non-ferrous and stainless steel piping against galvanic and crevice corrosion at supports is to use CAF jointing, where suitable for the process conditions.

When calculating the span between supports, no allowance is made for the pipe full of water for a hydrostatic test. If necessary, temporary supports should be provided for a hydrostatic test.

The stress and deflection limits on copper do not apply to cupro-nickel.

321.1.5 Threads

Where supports have vertical adjustment, any bolt projection below the foot plate shall not exceed two bolt diameters. The use of metric threads on pipe supporting elements is permitted.

(Additional to [B31.3 321.1.5](#))

321.2 Fixtures

321.2.2 Inextensible Supports other than Anchors and Guides

See para. X2.2.4 for test requirements for pipe supports welded to impact tested pipe.

- (b) Pipe support clips for carbon steel lines shall be made from round bar (i.e. U bolts) rather than flat strip to reduce corrosion.

(Addition to [B31.3 321.2.2\(b\)](#))

- (c) Shoes shall be provided at supports, on insulated lines where the normal operating fluid temperature exceeds 100°C (212°F). Shoes shall be sufficiently large to prevent disengagement from the supporting structure under abnormal temperature cycle or hydraulic shock conditions.

(Additional to [B31.3 321.2.2](#))

A common fault is to install shoes too short for a possible abnormal temperature; on steam lines, a desuperheater failure can lead to a serious non-correcting incident where the shoes slide off the supports, the shoes jam on the supports and at the very least cranes are required to reposition the line. Overheating of trace heating due to thermostat failure is another common abnormal temperature condition.

Special supports and shoes are required for low temperature applications e.g. propane, LNG etc. Insulation specification should be referred to for details.

321.4 Structural Connections

Where a pipe support acts as a line stop in any direction, the structure or foundations shall be checked for the resisting load or moment.

(Additional to [B31.3 321.4](#))

322 DESIGN REQUIREMENTS PERTAINING TO SPECIFIC PIPING SYSTEMS

322.3 Instrument Piping

322.3.2 Requirements (Additional to [B31.3 322.3.2](#))

- (e) Line specification (See BP Group [GS 142-6](#)) shall apply up to and including the first block valve(s) from the process line or vessel. Any line specification requirements for double valving, etc., shall also apply to this isolation.

The isolation requirements are defined in BP Group [RP 44-10](#) or in local site requirements.

The use of integral manifold blocks to replace individual block and bleed valves at tapping points in piping systems has greatly increased and is an



acceptable practice, the reduced size and weight being advantageous in many applications. Because of the compact nature of integral block and bleed manifolds and their close proximity to the pipe, all valves must be assumed to experience line design conditions. Selection of valve types should take this into account.

The outlet connection from an integral manifold block bleed assembly may be by flanged or threaded connections as specified in (f) and with exceptions (g).

A screwed connection at the integral manifold block or at an instrument vent or drain is allowable provided that:-

- *when the screwed vent or drain is being opened to atmosphere, two closed block valves shall be in place between the process and the open end.*
- *when the vent or drain valve is in use, a closed block valve shall be in place between the process and the vent or drain valve.*
- *when in-service, there shall be at least one closed block valve between the process and the screwed connection. The screwed connection shall be capped or plugged.*

The intention of this philosophy is to allow screwed connections on integral manifold blocks or standard instrument manifolds to be used to vent or drain the instrument body, without having to fabricate vents and drains from individual components and with flanged connections to atmosphere. This does not change the requirements for closed vents and drains on toxic systems.

Further guidance on application of integral manifold blocks is available in [EEMUA doc No.182](#).

Where an instrument is removed for maintenance, the pipework system should be closed by an appropriate method, depending on the construction of the impulse lines, e.g. blind flange, cap or plug. The cap or plug may be screwed on and be of compression fitting design.

Individual sites may develop an isolation policy covering isolations for short term (single shift) work or longer periods. Removal of an instrument and temporary closure of the system should not alter the vent or drain facilities and it shall be possible to safely remove any temporary blind flange, cap or plug by normal working practices.

- (f) Except as defined in (g), instrument impulse lines downstream of the line or vessel isolation valve(s) may be of tube and compression fittings, or threaded connections.

'Impulse lines' means the whole of the instrument piping downstream of the process line isolating valve, but not the instrument piping through which continuous process flow occurs, such as for on-stream analysers. This is treated as process piping.

BP will specify acceptable manufacturers of high integrity compression fittings. Component parts of compression fittings of different manufacture shall not be interchanged, and

standardisation on one manufacturer is recommended for any new project.

High quality, high integrity compression fittings will generally be of the double ferrule design. Physical differences exist between manufacturers products, as do the methods of hardening, treating and finishing the ferrules and bodies. Interchangeability of parts is not allowed.

The key factor in the use of tube and compression fittings is to ensure a well engineered transition from the piping specification components to the tube and compression fittings. Factors to be considered are stresses which may be transmitted between systems e.g. loads, vibration etc. and also protection due to the lower mechanical robustness of tube and compression fittings.

BP Group [RP 30-10](#) shall apply.

This BP Group Recommended Practice addresses issues such as:-

- *selection of fittings,*
- *the required hardness of tube compared to the fitting,*
- *correct assembly procedures, workmanship,*
- *checking and quality control,*
- *inspection and testing.*

- (g) For the following applications, instrument impulse lines beyond the first block valve shall conform to the nominal process duty line specification. Any deviation from the line specification for these applications shall be approved by BP.

An example of a departure from line specification requirements would be the use of 1/4 inch OD tube screwed or compression fittings on a compact instrument assembly (e.g. analyser), on a flammable fluid or hydrogen service at class 800 rating and above. This departure would be justified by the project engineer or piping specialist showing that this installation was of equal integrity to a line specification.

- (i) Liquids piping above their auto-ignition temperature (AIT), or 210°C (410°F) if the AIT is not known.
- (ii) For joints requiring frequent dismantling.

This is vendor specific, but it would be expected that a high quality compression fitting could be dismantled and re-made 80 times, as a minimum. Section 318.1 of this Practice limits dismantling to half the number tested by the supplier. Thus, compression fittings may be acceptable to cases where dismantling up to 40 times is expected, or higher if this can be substantiated by the vendor.

- (iii) Toxic substances as defined by BP.
- (iv) Impulse line sizes exceeding NPS 1/2 (DN 15).
- (v) Hydrogen service above class 900



For hydrogen service up to class 900, tube and compression fittings are acceptable. Screwed connections should be minimised. Flange to tube adaptors, without screwed connections, should be used where this type of connection is required.

- (vi) Flammable fluids above class 900 rating.

This allows tube and compression fittings to be used up to and including class 900. If it is desired to make an exception and use compression fittings at Class 1500 or Class 2500, or in sizes greater than ½", it is recommended that type testing is carried out using the actual fittings and tube material to be employed in the construction.

- (vii) Steam service at 45 bar,(g) (650 psig) and above.

- (viii) Steam service below 45 bar,(g) (650 psig) up to the connection of the condensate leg. The condensate leg connection and impulse line thereafter should comply with (f).

- (ix) For process line temperatures outside the range -200°C to 430°C (-320°F to 800°F), or manufacturers recommended design temperature for compression fittings, whichever is the more onerous.

- (x) For corrosive fluids, where the process conditions can give crevice corrosion or stress corrosion cracking.

- (h) The final connection of the impulse line to the instrument or integral instrument manifold may be by flange or threaded fitting. Where a threaded fitting is used, the impulse line shall be well supported at the instrument and the instrument shall be restrained to prevent accidental unscrewing.

The threaded connection should not be used where connected piping is likely to apply cyclic mechanical loads.

- (i) If compression fittings are used on the following duties the corresponding restrictions shall apply:

- (i) For flammable liquids forming substantial vapour clouds on leakage (see 322.9.3(a)), a restriction orifice of 1.4 mm (0.056 in) diameter shall be installed between flanges immediately downstream of the line or vessel isolating valve(s).

The restriction orifice needs to be clearly identified as such, and a system or procedure set up to ensure that the orifice is always fitted.

- (ii) For systems subject to cyclic temperature conditions, compression fittings may be used only if there is a cooling length, typically 1 m (3 ft 3 in), between the line or vessel isolating valve(s) and the first threaded or compression fitting.
- (j) Vessel or line isolation valves should be located in an accessible position. If this is not practicable impulse lines shall conform to the normal process duty line specification up to the first accessible isolation valve. This valve shall be in addition to the line or vessel isolation valve and, where applicable, the instrument isolation valve.
- (k) Instrument piping containing fluids that are normally static and subject to freezing, or which become viscous at ambient temperature, shall be protected by heat tracing or other heating methods, and shall be insulated.

322.3.3 Instrument Connections (Additional to [B31.3 322.3](#))

- (a) Instrument connections shall be located to be accessible from grade or a permanent platform. Access from grade should be within 2 m (6 ft 6 in) of grade. However, location of connections at a height not exceeding 6 m (20 ft) permitting access by temporary means may be accepted, subject to BP approval. Where access from normal operational platforms is not practicable, additional access facilities shall be provided.
- (b) The instrument connection shall be located to provide sufficient headroom and access to permit removal of inline equipment, or, where specified by BP, for the rodding of tapping points.

322.3.3.1 Temperature Measurement

- (a) Flanged thermowells shall be used for hydrocarbon, steam, corrosive, hydrogen and searching duties. They shall also be used in systems where temperature fluctuations in excess of 100°C (180°F) can occur in normal operation or where specified by BP. Thermowells shall be in accordance with BP Standard Drawings:-
 - S-2006 Flanged thermowell, welded construction (up to class 300)
 - S-2007 Flanged thermowell with retaining flange (up to class 2500)
- (b) Branches for flanged thermowells shall be NPS 1 1/2 (DN 40) minimum and shall conform to the process duty line specification. The minimum flange rating shall be class 150.



- (c) Welded-in thermowells shall be used for steam service above 45 bar (ga), (650 psig) and may also be used on special applications subject to BP approval. The design and installation procedure shall be subject to approval by BP.
- (d) Threaded thermowells to BP Standard Drawing S-0984M may be used on other services where line specifications allow, but they shall not be seal welded. The maximum rating is Class 150 unless otherwise approved by BP.
- (e) The installation arrangement for flanged thermowells shall conform with BP Standard Drawing S-2004.

In the past, there have been isolated or multiple failures of thermowells in liquid and gas transfer systems. The failures have generally been associated with vibration induced fatigue failures, sometimes aggravated by manufacturing faults.

The welded construction flanged thermowell should be 100% DPI examined and the tip should be radiographically examined to ensure there are neither weld defects nor off centre boring. For critical duties, a solid forging thermowell should be used.

When new thermowells are ordered, or there is a proposal to change operating conditions, the design analysis review is recommended to determine operating conditions likely to cause a problem, so that steps can be taken at the design stage to avoid the possible failure in service.

A simple procedures has been developed and is described in [BP Report No 82. ER. 0125](#). More detailed analysis of thermowell installation is covered in [BP Report No. 82.20.0148](#).

322.3.3.2 Pressure Measurement

- (a) Connections for pressure instruments shall be in accordance with BP Standard Drawing S-2005.
- (b) Isolation valves shall be full bore, when specified by BP, to permit rodding.
- (c) Instrument connections shall be orientated horizontally in vertical lines or the top or side of horizontal lines. Tappings at 45 degrees from horizontal will be permitted only where necessary to prevent fouling from adjacent pipework, structure or equipment. The selected orientation shall permit remote mounted instruments to be self venting or self draining. Connections for instruments on immiscible fluids shall be horizontal.

322.3.3.3 Flow Measurement



- (a) Connections from orifice fittings shall be in accordance with BP Standard Drawings:-

S-0387M Orifice Flanges

S-1357M Connections to Orifice Flanges

S-1967 Integral Orifice Assembly

- (b) Installation of flow measurement devices shall follow the manufacturer's installation requirements.
- (c) Piping and primary valving at the orifice fitting or other flow measurement device shall conform with the line specification including any requirement for double block valves.

Line tap connections shall conform with the requirements for pressure tapplings, see 322.3.3.2(c).

Primary isolation valves shall be full bore, when specified by BP, to permit rodding.

- (d) Connections to proprietary devices shall meet the relevant piping specifications.

322.3.3.4 Level and Contents Measurement

- (a) Connections for external float and displacer chambers shall be in accordance with BP Standard Drawings S-1965 and S-1966. Branch connections should be NPS 2 (DN 50).
- (b) Connections for internal level instruments and flange mounted differential pressure instruments shall be sized to permit float removal.
- (c) Drainage from gauge glasses, external float and displacer chambers shall be led via a tundish to a suitable drain at grade.

A closed disposal system shall be provided for drainage of vaporising liquids which evolve H₂S, other toxic gas or large volumes of flammable vapour.

322.3.3.5 Analysers

- (a) Process line connections for analyser sampling systems shall be either:
- (i) A flanged connection to the line specification, to accommodate a probe as detailed in BP Standard Drawing S-1958.



- (ii) A line connection as detailed for pressure instruments on BP Standard Drawing S-2005.

Line specification shall apply up to and including the first block valve(s) from the process line or vessel.

The isolation requirements of BP Group RP 44-10 apply to analyser connections.

- (b) Fast loops up to and including the main sample filter or pressure reducing valve shall be to line specification. Any deviation from the line specification for these applications shall be approved by BP.

It is recognised that it is not always possible to obtain analyser components to line specification.

An example of a departure from line specification requirements, after the isolation valve(s), would be the use of 1/2 OD tube, screwed or compression fittings on a compact instrument assembly (e.g. analyser), on a flammable fluid or hydrogen service up to and including class 1500 rating. This departure would be justified by the project engineer, instrument or piping specialist showing that the installation was of equal integrity to the line specification one.

- (c) Sample lines from the process connection or offtake from the fast loop shall be as specified in BP Group [GS 142-6](#) under instrument impulse lines, and the limitations of usage in 322.3.2(g) above shall apply unless specified otherwise by BP.

322.3.3.6 Control Valve Block and Bypass Valves

- (a) Block and bypass valves shall be provided for control valve installations. Exceptions are:-
 - (i) Where valves are duplicated.
 - (ii) Where regular maintenance is not required.
 - (iii) On hydrogen service.
 - (iv) For three-way valve installations.
 - (v) On non-critical duties (e.g. self-acting steam pressure reducing valves to individual users).
 - (vi) For valves in Category 1 trip systems.

Refer to BP Group RP 30-6. Category 1 trip valves shall not be used for any other function unless confirmed by reliability analysis. There shall be no manual bypass of such valves and no handwheel shall be fitted.



- (b) Where block and bypass valves are not fitted, BP may specify that space be left for possible future installation.
- (c) Block and bypass valves shall not be smaller than sizes in Section 6 of [API RP 550](#) Part 1, Table 6.1.
- (d) Block and bypass assemblies shall have means of depressurising and draining the associated valve and pipework. When specified by BP, the drain and vent valves shall be full bore to permit rodding.

322.6 Pressure Relieving Systems

322.6.1 Stop Valves in Pressure Relief Piping.

Installation of block valves or spades in any location where they would isolate a vessel or system from its pressure or vacuum relief device shall be only as permitted by BP Group [RP 44-1](#).

(Substitution for [B31.3 322.6.1](#))

322.6.2 Pressure Relief Discharge Piping

The discharge piping from relief valves and blowdown lines is covered in BP Group [RP 44-1](#).

(Additional to [B31.3 322.6.2](#))

322.6.3 Pressure Relieving Devices

Overpressure protection systems shall meet the requirements of BP Group [RP 44-1](#).

(Substitution for [B31.3 322.6.3](#))

322.7 Sampling Systems (Additional to [B31.3 322](#))

- (a) Sample connections (NPS 3/4 (DN 20) minimum) in accordance with BP Standard Drawing S-0773M shall be provided for non-hazardous duties on feed and product lines, and elsewhere where specified. Sample coolers shall be provided where specified by BP and in any case where the fluid is above 70°C (160°F).
- (b) For manual sampling systems:-
 - (i) The system shall be designed to minimise the possibility of loss of containment, taking particular account of the process conditions and hazardous nature of the material to be sampled.



- (ii) A representative sample shall be obtained by siting the sample connection at a suitable point on the process line.
- (iii) The effect on area classification shall be considered in positioning sample points.
- (c) All operational parts of sampling systems shall be easily accessible, including the primary isolation valve. Sample points should either be approximately 1 m (3 ft 3 in) above ground level or 1 m (3 ft 3 in) above a level which should have stairway access.

Because of the many and varied analyses carried out on fluids, no single design of sample point or sample vessel would be suitable for all process conditions or type of sample.

A tundish connected to an oily water sewer and fitted with a water seal should be provided for sample containers that will be open to the environment during the sampling procedure. For highly flammable liquids or liquids with toxic or corrosive constituents, this tundish should be partially enclosed and the sample flow control valve suitably remote. A typical arrangement is given in BP Standard Drawing S-2016.

322.8 Vents and Drains (Additional to [B31.3 322](#))

Vents and drains points on piping systems can be the source of loss of containment as a result of internal corrosion, vibration, failure through impact and by virtue of introducing flanged joints. The process engineer and piping design reviews should ensure that this type of connection is kept to a minimum.

- (a) Vents and drains on piping (excluding connections from orifice flanges, carriers and other instrumentation) shall be NPS 3/4 (DN 20) minimum for non-hazardous service.
- (b) Small connections from hazardous service lines, e.g. nipples for vents, drains, pressure tappings, sample points, (excluding connections from orifice flanges, carriers and other instrumentation) shall be NPS 1 (DN 25) minimum for strength.
- (c) If vent and drain connections are not provided on equipment, blanked branches shall be provided on the attached piping and shall be of the following minimum size:-

Equipment Capacity	Vent size		Drain size	
	NPS	(DN)	NPS	(DN)
m ³				
≤ 1.5	1	(25)	1	(25)
≤ 6	1	(25)	1½	(40)

> 6 to 17	1	(25)	2	(50)
> 17 to 71	1 $\frac{1}{2}$	(40)	3	(80)
> 71	2	(50)	3	(80)

- (d) Operational vents, sample points and drains which may discharge flammable fluids shall be minimised and shall be not less than 15 m (50 ft) minimum from possible sources of ignition, e.g. furnaces, hot lines, and rotating machinery. Reference should also be made to BP Group [RP 22-1](#). For vents from rotating machinery see also 322.12.
- (e) Drainage lines for hazardous or valuable process chemicals shall be accessible for inspection and maintenance. Unless otherwise specified by BP, drainage from such equipment shall be permanently piped to a sump tank provided with means for emptying.
- (f) For other services, unless otherwise specified by BP, the drainage from sample points, gauge glasses and level controllers should be led via turndishes into an adjacent drain. Sample points and, where necessary, drains shall be protected against static induced ignition of flammable materials.
- (g) Where a significant release of H₂S, other toxic gas or large volumes of flammable vapour could occur, vents and drains shall be piped to a closed disposal system.
- (h) Separate arrangements should be made for the drainage and, if specified by BP, the tracing of, lines containing materials likely to solidify. Provision should be made for rodding and high pressure water cleaning if specified.
- (i) Vents and drains for pressure test purposes shall be sizes as follows:-

	Pipe size		Vent size		Drain size	
	NPS	(DN)	NPS	(DN)	NPS	(DN)
up to	6	(150)	3/4	(20)	3/4	(20)
	8-14	(200-350)	3/4	(20)	1	(25)
above	14	(350)	3/4	(20)	1 1/2	(40)

- (j) Vents and drains for fiscal metering systems shall include double isolation with one lockable valve, and drip-type sight glass for leakage detection.

322.9 Isolation of Equipment (Additional to [B31.3 322](#))

For this Recommended Practice, isolation is sub-divided into two categories:-

- (a) Positive isolation. Where no leakage can be tolerated, e.g. for safety or contamination reasons.
- (b) General isolation. Where the requirements are less critical than (a) above.

In certain circumstances, it may be necessary for operational reasons or additional security to provide a combination of (a) and (b) above.

Comprehensive guidance on the physical methods of isolation of mechanical and control equipment is given in BP Group [RP 44-10](#).

322.9.1 Positive Isolation

- (a) Positive isolation shall be by one of the following:-
 - (i) The removal of a flanged spool piece or valve and the fitting of blank flanges to the open ended pipes.
 - (ii) Line blind.
 - (iii) A spade in accordance with BP Standard Drawing S-0755M, or S-0756M. The arrangements of spading points, together with venting, draining and purging facilities, shall enable a section of line containing a spade to be checked as free from pressure before spade insertion or removal.
- (b) Positive isolation methods shall be provided:-
 - (i) To permit isolation of major items of equipment or group of items for testing, gas freeing, making safe etc. A group of items containing no block valves in the interconnecting pipework may be considered as one item of equipment.
 - (ii) To isolate utility services e.g. fuel gas, fuel oil, atomising, snuffing, or purge steam to individual fired heaters (see BP Group [RP 22-1](#))
 - (iii) To prevent contamination of utility supplies e.g. steam, water, air and nitrogen where permanently connected to a process unit. (See also 322.15 for vessel steam out

connections). See Figure 1 for isolation of steam connections.

- (iv) Steam and air connections for regeneration and steam/air decoking should be positively isolated from the steam and air systems, preferably by spool pieces or swing bends.

322.9.2 General Isolation

- (a) General isolation shall be by one of the following:-
 - (i) A bi-directional block valve when
 - (a) thermal relief of the valve cavity is not required, or
 - (b) external relief of the valve cavity can be accepted, or
 - (c) the valve has internal cavity relief
 - (ii) A uni-directional block valve, when approved by BP, where isolation in only one direction is required for all conditions and where internal relief of the valve cavity is required.
 - (iii) Two block valves with a bleed valve mounted on the pipework between them. Each valve shall be as (i) or (ii) above. A 'double block and bleed' valve can be used with BP approval.
 - (iv) Two block valves without a bleed valve mounted on the pipework between them when required by (e) below.

Block valves are described in detail in BP Group document [RP 62-1](#).

- (b) Block valves shall be provided:-
 - (i) In all lines at recognised separation of process units or limits of operating areas defined by BP.
 - (ii) At vessel branches, excluding:-
 - (a) Connections for overhead vapour lines, transfer lines, reboiler lines and side stream vapour return lines.

- (b) Pump suction and reflux line connections on vessels which have a block valve located within 10 m (30 ft) in a horizontal direction from the vessel branch. This exception shall not apply where there is a particular process requirement to isolate a vessel inventory.
 - (c) Vents on tanks and vessels open to atmosphere.
 - (d) Relief device connections, other than as permitted by BP Group [RP 44-1](#), or connection to other vessels or piping systems fitted with relief devices that protect the vessel in question (see 322.6.1).
 - (e) Overflow connections.
- (iii) At suction and discharge of pumps and compressors, but not at suctions of air compressors taking suction from atmosphere.
 - (iv) For isolating equipment, e.g., individual or groups of heat exchangers specified by BP as requiring servicing during plant operation.
 - (v) For isolation of instruments where on-stream servicing is specified by BP. (See also BP Group [RP 30-1](#) to [RP 30-5](#)).
- Sufficient vents and drains are required inside the isolation to prove that all pressure/contents have been released before any further maintenance work, including blinding/spading is carried out.*
- (vi) Where required to prevent flow at vents and at drains, sample points, steam out points and for diverting flow through alternative routes and by-passes.
 - (vii) At inlets, outlets and drains of storage tanks.
 - (viii) To isolate utility services i.e. fuel oil, fuel gas, atomising, snuffing and purge steam to individual fired heaters. (See BP Group [RP 22-1](#)).
 - (ix) On supply lines to road and rail car filling stations handling toxic or flammable materials; the block valve shall be located remote from the filling point for emergency shut off.
 - (x) In all utility services at



- (a) Each branch on the refinery or process plant main.
 - (b) The inlet at each individual user.
 - (c) The outlet of each cooling water user.
- (xi) In steam and condensate systems at each branch on the header in each plant or unit if the length of pipe between header and user is 5m (16 ft) or greater.
- (xii) At vents placed in piping for operational purposes. These vents shall be spaded or blanked in accordance with the line specification. Vents for testing purpose only shall not be valved.
- (xiii) At drain connections in the low point of piping systems, where the arrangements shall be as in (xii) above.
- (xiv) At suitable points in ring main or distribution systems to allow sectionalising.
- (xv) At the outlet from each non-condensing steam user, where the user discharges to a pressurised system.
- (c) Process area limit block valves for relief and blow-down pipelines shall be provided with a purpose-built locking device, approved by BP, for locking valves open. Parallel slide or gate valves fitted on this duty and not operated by screw threads, should be installed in the inverted position so that the valves tend to fail in the open position.
- (d) Two block valves with intermediate valve to vent the space between the block valves shall be provided:-
 - (i) Where frequent isolation is required and temporary, not positive, isolation is acceptable for operational safety e.g. in segregating products, to clean filters or for insertion/removal of pigs.
 - (ii) For temporary isolation between permanently connected utility supplies and process units where the utility requirement is in frequent use and there is a need to make the utility readily available for injection into the process, e.g. stripping steam where the system has to be made condensate free right up to the point of injection. (Non-return valves will also be required in all utility services connected directly with process equipment).

- (iii) On a service specified by BP, where equipment may be taken out of service whilst the unit remains in operation e.g. compressors or where there is a requirement to isolate equipment yet hold it readily available for use with the operating unit e.g. hydrogen storage vessels.

Vents must terminate in a safe place.

- (e) Two block valves without bleed shall be provided for sample connections, drains and vents:-
 - (i) in hazardous fluid service.
 - (ii) in class 900 piping or higher.
 - (iii) on unmanned installations where vibration is anticipated, as specified by BP.
 - (iv) where freezing due to cooling on expansion may occur.

The block valves shall be far enough apart to allow safe access to the upstream valve with material discharging from the point of emission.

For materials such as LPG, the block valves shall be separated by at least 1 m (3 ft 3 in) to reduce the risk of simultaneous obstruction of both valves by ice or hydrate formation.

322.9.3 Pump Emergency Isolation

- (a) Except for glandless type pumps, an emergency isolation valve shall be provided in the suction line between a vessel and a pump when any of the following apply:-
 - (i) The suction inventory at normal operating level is 10 m³ (350 ft³) or greater and either: -
 - (a) The pumping temperature is greater than the auto-ignition temperature as defined in (b) below.
 - or (b) the liquid is Category A as defined in BP Group [RP 44-6](#).
 - (ii) The liquid is toxic, as specified by BP.
- (b) For (a)(i)(a) above the auto-ignition temperature shall be taken as 210°C (410°F) unless a more accurate figure is specified by BP.



- (c) Where a pump is paired or spared, the common line shall be fitted with the valve, unless otherwise specified by BP.
- (d) The valve shall be located as close to the vessel as possible outside the vessel supports and not less than 3 m (10 ft) from the pump.
- (e) The valve should be remotely operable when it is less than 15 m (50 ft) horizontally from the pump, unless a fire wall is installed between the valve and the pump.
- (f) For remotely operated valves, the valve control station shall be located not less than 15 m (50 ft) from the pump and, if practicable, within sight of the valve. The control station shall not be located in a special fire risk area (see BP Group [RP 24-1](#) & [RP 24-2](#)), and shall be accessible through a low fire risk area.

A flammable liquid is one which is likely to vaporise rapidly and substantially on release to atmosphere. This category includes Class 0 (LPG) and lighter materials, whether under pressure or refrigerated and other flammable liquids processed or stored at a temperature sufficient to produce more than about 40% wt flash vapourisation on release to atmosphere with no additional heat input.

322.10

Provision of Strainers and Filters (Addition to [B31.3 322](#))

- (a) Permanent strainers or filters shall be fitted in the following instances if they are not already an integral part of the equipment:-
 - (i) In a fuel oil supply to burners and for each set of gas pilots.
 - (ii) Upstream of positive displacement, variable orifice meters and turbine meters.
 - (iii) Hydraulic systems for remote control of valves.
 - (iv) At the inlet of steam turbines, jet ejectors and trapping systems.
 - (v) Loading installations, when necessary to maintain product quality.
 - (vi) In the suction lines of pumps, where the liquid may contain solids liable to damage pumps.
 - (vii) In compressor suction lines, where specified by BP.
 - (viii) In any lubricating system i.e. sealing oil, gland oil and gear coupling lubricators.

(ix) Any flushing oil system.

- (b) Permanent strainers in compressor suction lines shall be provided with isolation to permit easy removal. Maximum design pressure drops and flow direction shall be indicated by a nameplate permanently attached to the strainer.

There is usually a requirement that critical compressors be permanently protected from the risk of debris being drawn into the machine. On certain compressor installations it may be necessary in addition to provide a permanent strainer on the bypass line upstream of the compressor recycle line.

- (c) Permanent strainers should normally have a steel body incorporating a basket which can be removed without dismantling pipework and preferably with a cover closure not requiring the use of a spanner. The mesh size should suit the type of equipment installed. They shall be in an accessible position close to the equipment they protect and valved to facilitate cleaning. Duplex strainers should be of the type which cannot have a cover removed whilst that side is in service. For permanent strainers or filters, selection of the screening materials shall be based on the specific application and manufacturer's recommendations.

- (d) Temporary strainers should be fitted in other cases between the suction valve and the equipment and should ensure that the debris is completely removed from the system when the strainer is cleaned, and be cleaned easily without disturbing the main pipework. Pipework shall be designed to incorporate the strainer, and no pipe springing shall be allowed for retroactive installation. A suitable spacer shall be provided when specified by BP, for use on removal of the strainer.

Permanent strainers should be installed in the suction of all pumps where the liquid pumped will contain solids liable to damage pumps, particularly as follows:-

- (i) Pumps handling liquids received from outside battery limits.
(ii) Pumps handling crude and vacuum distillation unit bottoms.

Temporary strainers should be clearly identified, otherwise they could be left in the system and forgotten.

- (e) Strainers (temporary, if permanent ones are fitted) should normally be located between the pump or compressor and its associated suction-side block valves. On certain duties as specified by BP, e.g. main crude oil charge pumps, twin strainers arranged in parallel and each having its own block valve should be installed upstream of the suction header.

- (f) Twin parallel filters should be provided on vital process pumps which do not have a standby and the shutdown of which for strainer cleaning could lead to a shutdown of the refinery or works, or of an important unit.
- (g) Pressure tapplings shall be provided for measuring pressure-drop at all permanent and temporary strainers.

322.11 Cooling Water Pipework to and from Heat Exchangers

(Additional to [B31.3 322](#))

- (a) Where sea water or aggressive water is used as the cooling medium, the water velocity in the exchanger tubes should be controlled within the design limits given in BP Group [RP 26-1](#) to prevent scaling, erosion, corrosion or the formation of deposits. A diaphragm or butterfly valve shall be used in the outlet piping to achieve this.
- (b) Where further means of limiting maximum water velocity in the tubes is necessary, an orifice plate of type 316 stainless steel, Monel or Incoloy 825 shall be installed in the pipework in a manner preventing the formation of vapours or the build up of silt at the orifice plate. In horizontal lines the orifice plate should be a segmental type. Provision should be made for pressure tapplings around the orifice plate to monitor water flow. Where the pipe is not cement-lined a protective loose-liner 'top hat' spool piece in the piping material should be fitted downstream of the orifice plate for a straight length of at least five times the pipe diameter.

The 'top-hat' spool piece is an open liner with a rim held between flanges.

- (c) Where the water pipework is associated with elevated condensers or coolers, irrespective of the type of water used, the control shall be positioned on the outlet side of the equipment, to ensure that the equipment and pipework always runs full of water. This will avoid vacuum conditions leading to boiling, impingement and scale formation.

322.12 Pipework at Pumps, Compressors and Drivers

(Additional to [B31.3 322](#))

- (a) Specific attention should be given in the design and flexibility analysis of piping connecting to machinery to ensure that piping loads transmitted to the machine are acceptable under all operating conditions. Self weight of large bore piping, valves and fittings and the friction forces imposed at sliding supports

can have a serious effect on machine nozzle loads. Hanger supports shall be used on these lines wherever practicable. Where impractical, low-friction pads (e.g. PTFE) may be used.

- (b) A flexibility analysis for large bore pipework i.e NPS 20 (DN 500) and above, connecting to machinery should include mismatch to the allowed tolerance between pipework and the machine to ensure that the calculated loads represent the worst loads which might be generated. A number of calculations may be necessary to determine the conditions of mismatch which will generate the maximum loads. Specific attention shall be given to mismatch in flexibility analysis of smaller lines where such lines are unusually rigid.
- (c) Pipe layout and supports shall be designed such that the equipment can be removed without temporary supports and without disturbing isolating valves or springing pipes, so that only minimal piping loads are transmitted to the machine in the ambient condition. To verify this, matching flanges shall be disconnected to check that the alignment is within the acceptable tolerances after the pipe is fully fabricated and insulated (if required) and all supports are fitted with spring hangers set to their operating load.
- (d) Subject to the requirement for sufficient flexibility, suction lines to pumps shall be as short and direct as possible.

Horizontal bends should be avoided within two diameters of the pipe suction line.

- (e) A minimum number of vents and drains shall be provided to drain machinery and associated pipework between block valves. These shall be to the line specification except that where the machine casing is drilled to NPS 3/4 (DN 20) as standard, the connection may also be NPS 3/4.

Vents handling flammable or toxic gases from lube oil systems, seal oil systems and degassing drums shall be completely separate from each other. Lube systems shall be vented to atmosphere. Seal systems shall normally be vented to atmosphere. Degassing drums shall normally be vented to flare.

- (f) Warming-through connections shall be supplied for pumps working above 260°C (500°F).
- (g) Where the suction side of a centrifugal pump may be overpressurised through the pump by the closure of its suction valve, the piping including fittings and supports shall be designed for full discharge pressure.

- (h) For multi-stage pump fitted with pressure relief device for pump casing protection, the suction side design pressure need not be greater (but shall not be less) than the relief set pressure. (See BP Group [RP 34-1](#)).

322.13 Fuel Oils and Fuel Gas (Additional to [B31.3 322](#))

- (a) For low flashpoint fuel, a separate all-welded supply system shall be provided with steam connections for purging.
- (b) Fuel gas pipework shall be provided with a condensate knockout drum with means of disposal of the condensate to a closed system, unless otherwise specified by BP.
- (c) Fuel gas lines shall be steam traced and insulated downstream of the condensate knock-out drum, unless otherwise specified by BP (see BP Group [RP 22-1](#))

Only if the fuel gas is completely dry (e.g. natural gas) can the knock-out drums or tracing be omitted.

- (d) Burner piping below fired heaters shall not restrict access or exit from the area, for reasons of safety and for the removal and cleaning of gas and oil burners.
- (e) Fuel oil piping loops to burners should be fully steam traced, the steam supply being kept separate from the atomising steam. It is not permissible to insulate the fuel oil and atomising steam lines in a common jacket in lieu of providing steam tracing. Pressure tapings to fuel oil pressure controllers shall also be adequately traced.

322.14 Hydrogen Service (Additional to [B31.3 322](#))

- (a) Hydrogen service is defined in 300.2(v).
- (b) Leakage shall be minimised by the use of welded joints and the exclusion of threaded connections except as permitted by 322.3. Vents and drains shall be kept to a minimum and their valves blanked.
- (c) Purging connections permanently piped to a supply of nitrogen shall be provided on all units on hydrogen service and on separate pieces of equipment which may have to be isolated during operation of the unit. Such connections shall incorporate double block valves with a valved bleed between.
- (d) All flanges on hydrogen duty must be left exposed unless otherwise agreed.

This requirement applies to insulated lines in order to prevent a hydrogen fire.

322.15 Steam Systems (Additional to B31.3 322)

- (a) Branch connections for steam systems at 45 bar (ga) (650 psig) and above should be NPS 1 (DN 25) minimum and, shall be taken off the top of the main steam distribution system. A stop valve between branch and steam mains should be provided.
- (b) Process steam connections to fired heaters should be provided with a check valve and block valve in series; the check valve shall be located between the block valve and the fired heater.
- (c) Process steam connections to fractionating columns and similar process equipment shall be provided with a check valve and a block valve in series, the block valve being located at the column.
- (d) Piping installed for steaming out fractionating columns and similar process equipment shall be provided with two stop valves, one of which may be that required by (a) above, and with a drain valve fitted between them.

The steaming out connection, shall be independent of the drain from the vessel and shall be provided with a spade for positive isolation.

Steam out connection sizes shall be as follows:-

Vessel Capacity		Connection	
m ³	(ft ³)	NPS	(DN)
Up to 28	(Up to 1000)	1	(25)
Over 28 to 57	(Over 1000 to 2000)	1 1/2	(40)
Over 57 to 1400	(Over 2000 to 50,000)	2	(50)
Over 1400	(Over 50,000)	3	(80)

Special consideration should be given to stripping column steam systems to fractionating columns to ensure that systems can be warmed up and condensate removed prior to commissioning. This is especially important on hot and vacuum duties.

- (e) Process steam and steam-out connections shall be provided with drainage arrangements.
- (f) Steam required for smothering, snuffing, tracing and other services, should be taken off a header connected upstream of the battery limit block valve on the refinery or works steam

main and the take-off valves should be clearly identified (see also BP Group [RP 44-2](#)).

- (g) Exhaust lines from steam machinery discharging to atmosphere should be fitted with an exhaust head suitably drained.
- (h) Block valves shall be of parallel slide type on the main steam distribution system serving the refinery or works together with those at the battery limit of any other area, e.g. a tank farm, administration area. Within any process unit where any section can be taken out of service for maintenance with normal operation continuing on the remaining sections, the section isolating valves shall also be of the parallel slide type.
- (i) When specified by BP, a steam separator shall be supplied on the steam supply line to special purpose turbines. See BP Group [RP 34-1](#).
- (j) If it is necessary to discharge large quantities of steam, noise suppressors shall be provided.

322.16 Steam Tracing, Jacketing and Trapping (Additional to [B31.3 322](#))

322.16.1 Steam Tracing

- (a) Steam tracing of piping should be installed generally in accordance with BP Standard Drawing S-1999.
- (b) Materials for steam tracers shall comply with the appropriate line specification in (BP Group [GS 142-6](#)).

Flattening or crimping of the tracer line shall be avoided. Fittings between steam supply pipes or condensate drain pipes and the copper tracer should be as BP Standard Drawing S-2000.

Alternatively these may be flange to compression fitting adaptors or carbon steel adaptors socket welded to the carbon steel pipe and brazed to the copper tube using Sifbronze No. 2 brazing rods to [BS 1453 C5](#) and [BS 1845 CZ8](#).

The fittings shall be separately insulated from the traced line.

- (c) Use of compression fittings shall be minimised, bends being pulled wherever possible. Fittings shall be used only where necessary to join or tee the longest possible length of tracer and not only for ease of installation. Essential joints shall be located at the pipe flanges. Loops shall be provided adjacent to pipe flanges to allow for future use of compression fittings.



- (d) Piping NPS 1 1/2 (DN 40) and smaller may be grouped together with a single tracer. Piping NPS 2 (DN 50) and larger should be individually traced.

Piping on corrosive services and piping liable to blockage due to deposition of solids or to the formation of solid polymers shall have individual steam tracing, irrespective of the pipe size, and not be grouped together with other pipes.

- (e) External tracing should consist of a single steam line, run at the bottom of the line to be traced, and the pipe and tracer insulated with the standard insulation for the next larger size pipe. Where heat requirements dictate, however, multiple tracers should be provided. Tracers for vertical lines may be coiled around the lines.
- (f) Expansion loops shall be installed where necessary in tracers, and should coincide with flanged joints in traced lines. Loops coinciding with flanges shall be such as to allow flanges to be sprung apart, and at spaded flanges shall allow the spades to be swung.
- (g) Expansion loops should be installed in the horizontal plane and pockets shall be avoided.
- (h) Each steam distribution or supply point should be located above the highest point of the piping system being traced. Each condensate collection header should be located at an elevation low enough to permit gravity flow of condensate from all connected lines.
- (i) Each individual tracing line shall be provided with a block valve located at the steam header or sub header. Valves should be steel socket welding type with break flanges to allow valves, or the sub header including valves, to be removed for maintenance without hot work.

Valves shall be readily accessible from ground or platform level and positioned on the header for ease of maintenance.

Each tracer or leg of parallel tracers shall be provided with its own trap except that groups of tracers which are self draining may drain to a level controlled condensate pot or a collection header.

Tracing on control valves and by-passes should allow control valve removal without interfering with the tracing of the by-pass.

- (j) Tracers shall be attached to lines by strapping or binding wires. Heat transfer cement may be used to improve the transmission of heat from tracer to traced line.
- (k) Where degradation of a product or metallurgical deterioration of the pipe may occur due to local hot spots or where an internal lining may be damaged, direct contact with an external tracing line shall be prevented by a suitable insulating strip between the pipe and the tracing line.
- (l) For pipework on which moisture may form due to low temperature operating conditions or intermittent service which would allow the pipework to cool down during idle periods, corrosion due to a galvanic couple between the pipe and/or support clamps and the tracing line should be avoided by use of an insulating strip e.g. compressed asbestos fibre jointing.
- (m) Steam heated pumps and other equipment shall have their own individual steam supply independent of the line tracing. On pumps, valves or other equipment requiring removal for maintenance, steam tracing and condensate connections should be flanged.
- (n) Each tracing circuit should be labelled clearly and permanently immediately upstream of the supply isolating valve and immediately upstream of the flange on or before the steam trap.

The label should be in stainless steel and should bear the following information:-

- (i) Steam supply point identification code.
- (ii) Line designation.
- (iii) Steam trap station designation.
- (o) A steam or condensate line shall not be attached to, or supported from, any line other than the one it is tracing.

322.16.2 Jacketed Piping

Jacketed piping is classified as 'Partly Jacketed' and 'Fully Jacketed'. Typical details of jacketing are shown on BP Standard Drawing S-2015.

- (a) General Points Common to all Jacketed Piping
 - (i) The design of the piping and flanges shall consider differential expansion between the inner pipe and jacket during startup, shutdown, normal operation or any



abnormal conditions. The design shall ensure no buckling of the inner pipe due to external pressure or differential expansion. Jacket, connections and inner pipe should all be of the same material of construction to avoid problems due to thermal stresses or welding of dissimilar metals.

- (ii) Line/jacket sizes should be as follows:-

Line Size		Jacket Size		Line Size		Jacket Size	
NPS	(DN)	NPS	(DN)	NPS	(DN)	NPS	(DN)
3/4	(20)	1 1/2	(40)	4	(100)	6	(150)
1	(25)	2	(50)	6	(150)	8	(200)
1 1/2	(40)	3	(80)	8	(200)	10	(250)
2	(50)	3	(80)	10	(250)	12	(300)
3	(80)	4	(100)				

- (iii) Spacers shall be used to ensure that the inner pipe is concentric with the jacket.
- (iv) The radius of pulled bends shall be proposed by the fabricator for approval by BP but should not normally be less than five times the jacket nominal i.d.
- (v) Forged elbows may also be used for the fabrication of bends in certain instances where the radii of the bends coincide and where the tangent lengths allow assembly.
- (vi) Valves and jacketed fittings only available with threaded jacket connections shall be seal welded. No other threaded connections are allowed.
- (vii) Where the main process line is sectionalised by block valves, the supply and trapping arrangement shall be similarly arranged, to facilitate maintenance on isolated sections.
- (viii) Transfer of fluid from one jacket to another shall be arranged as follows:-

A single jump-over connected into the jackets by radial branches shall be used on vertical jacketed pipe. These shall be positioned as low as possible on the upper jacket and as high as possible in the lower one. Where the jacketed pipe run is not vertical, one of the following alternatives may be used:

- (a) Single jump-over connections branched tangentially into the lowest part of the jackets

and running in a plane parallel with the jacketed line.

or (b) Double jump-over connections one for heating fluid and one for condensate, branched radially into the jackets in the vertical plane.

- (b) Main flanges, swage ends and jump-over connections should be avoided in vertical sections of line to avoid pockets of condensate in the upper jacket.
- (c) Jump-over connections at main line flanges shall include two pairs of flanges. Jump-overs at other locations shall be all welded.
- (d) Main line flange bolt holes positioned on centre to allow bolt access may be necessary at tangentially branched jump-over.
- (e) Jump-over branches shall be welded into the jacket before assembly on to the inner line.
- (f) Heat transfer cement may be used on any unjacketed parts of the piping to eliminate cold spots.
- (g) Inner pipe welds to be covered by the jacket shall be 100% radiographed.
- (h) Where specified by BP, a live steam test shall be carried out on the jackets after hydrotest and before installation to check that no leak path exists between steam and process spaces.
- (i) Steam jacket supply valves and traps shall be identified by labels as required for steam tracing circuits.

322.16.3 Partly Jacketed Piping

- (a) Partial jacketing is suitable for lines carrying materials where there is no risk of blockage at cold spots and may be specified where contamination of the process fluid with water cannot be tolerated and all butt welds on the jacketed line are required to remain uncovered by the jacket.
- (b) Jackets should be swaged on to the inner pipe adjacent to flanges and at inner line butt welds where these are required to remain uncovered. Alternatively, butt welded caps bored to suit the outside diameter of the inner line may be used. Where branch welds on the inner line remain uncovered, the main jacket shall be locally swaged to the inner line and the branch separately jacketed.

- (c) Main line flanges shall be standard raised face slip on flanges to [ANSI B16.5](#) (inch dimensions) sized to suit the inner line.

322.16.4 Fully Jacketed Piping

- (a) Full jacketing shall be used for duties where it is essential that cold spots are eliminated and butt welds on the inner line may be covered by the jacket.
- (b) The jacket shall be welded to the back of the main line flange. Main line flanges shall be raised face slip on weld flanges to [ANSI B16.5](#) (inch dimensions) sized to suit the jacket but with a bore to suit the inner line.
- (c) Reducing orifice-type flanges complete with a tell-tale hole drilled radially through the rim may be used where leak detection at flange welds is necessary.
- (d) The use of blinds or blanks bored out for this duty is not acceptable.
- (e) Split forged tees shall be used for the jackets of branch connections.

322.16.5 Steam Trapping

- (a) Steam trapping arrangements should conform to BP Standard Drawing S-1240. All trap pipework shall be designed to provide flexibility to allow for thermal movement between the main, trap and condensate return main.
- (b) Trap size shall be based on the maximum quantity to be discharged at the minimum pressure difference between inlet and outlet.
- (c) Traps shall be fitted with a strainer on the inlet, unless it is an integral part of the trap and shall be of cast or forged steel, according to the duty.
- (d) Socket weld trap assemblies shall be provided with flanges to allow for maintenance. The flanges shall be so arranged that the upstream atmospheric blowdown will be effective whilst the trap assembly is removed for maintenance.

Double valves (master and slave) should be fitted at atmospheric blowdown points to avoid maintenance problems with 'wiredrawing' of the seats of a single valve. Bellows sealed

stem glands should be used on valves on small bore steam/condensate lines.

- (e) No steam trap should be connected to more than one steam line nor to more than one section of the same steam line.
- (f) Where condensate may collect downstream of a closed valve, accessible drain valves should be fitted, in addition to any trap which may be fitted.
- (g) Open tail pipes should terminate 75 mm (3 in) above ground level and shall not discharge on to stanchions, pipe supports, or directly into salt glazed drains, etc., which might be adversely affected by the discharge. They shall be directed in such a way as not to present any hazard and in paved areas should be directed so that the condensate does not run across the paving.
- (h) Traps discharging to atmosphere should be mounted to be self draining to avoid frost damage.
- (i) Traps operating on different steam pressures may discharge into the same header, providing the condensate line is adequately sized to accommodate the flash steam.
- (j) Traps should be located adjacent to the equipment they serve, and shall be accessible for maintenance and firmly supported.
- (k) Multiple traps shall be grouped together and installed in enclosures so that the operation of each trap can be checked and prevent frost damage to traps not in use. Tail pipe discharges shall be arranged to allow maintenance on any one trap whilst all others are operating.
- (l) Trapping systems not detailed on the pipework drawings shall be site run, ensuring that steam and condensate lines do not interfere with normal operation and maintenance, and in particular with access to valves and other equipment.

Poor tracing systems often originate from insufficient space in the proper place to position tracing equipment.

- (m) Drainage from large steam consumers such as heaters, condenser, reboilers, should use of level controlled collection pots.
- (n) Condensate pots shall be sized as follows:-

Main Size	Pot Size
4 NPS and below	Main Size
6 NPS	4 NPS



8 NPS and above	6 NPS
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- (o) Valves on condensate pots shall be 1 in nominal bore minimum, they may be of gate, parallel slide or globe type. For high pressure, superheated steam, large or important steam mains, globe or parallel slide types should be used. Globe valves should be used where it may be necessary to control flow.
- (p) All globe valves shall be capable of passing the full rated flow of condensate.

322.17 Service Air (Additional to B31.3 322)

- (a) Service air may be supplied by means of portable compressors. Where a permanent system is specified by BP, materials shall comply with the requirements of BP Group [GS 142-6](#).

322.18 Instrument Air (Additional to B31.3 322)

- (a) Main instrument air supply shall be an independent self-contained system in accordance with BP Group [RP 30-1](#) to [RP 30-5](#). The materials for this main reticulation should be in accordance with BP Group [GS 142-6](#).

Instrument air piping should normally be in carbon steel, since the air is dry and corrosion should not be a problem. Galvanised piping has sometimes been used on certain BP installations.

- (b) Headers or manifolds shall be fitted with isolation valves and removable caps, plugs or flanges to allow for blowdown.
- (c) Main header isolating valves shall be socket weld or flanged gate type. Isolating valves local to each individual instrument offtake may be threaded and of brass construction.
- (d) All low points on main and subheaders shall be provided with an accessible drain valve (NPS 1 (DN 25) or header size whichever is less. Individual supply lines will not normally require drain valves.
- (e) Distribution offtakes shall be taken from the top of horizontal headers.
- (f) Prefabricated distribution manifolds may be used in congested areas, subject to BP approval.
- (g) The specification of tubing for use downstream of the air header isolation valve and for control lines is detailed in BP Group [RP 30-1](#) to [RP 30-5](#).



322.19 Process Air (Additional to [B31.3 322](#))

- (a) Process air shall be supplied by permanently installed compressors which may also supply service air, subject to BP approval.

322.20 Pipework for Service Connections (Additional to [B31.3 322](#))

- (a) Valved hose connections shall be installed throughout the process area to provide steam, water and, where specified by BP, air and inert gas at locations so that working areas at grade and in structures can be reached with a 15m (50 ft) length of flexible hose.

These connections shall conform to plant practice in any established plant on the same site. Connections shall point downwards.

Hot water for process cleaning purposes should be provided via a fixed or mobile steam and water mixing device. This mixing device shall not be used for heating towns water. Towns (potable) water may be used for process cleaning purposes, provided a dedicated break tank complete with pumps, etc. separates the towns water system from the process system. Service water systems shall also be fitted with a break tank. These break tanks must comply with local regulations.

- (b) In any unit involving gas in toxic concentrations, (e.g. H₂S), connections for breathing air masks shall be installed where specified by BP. Certain plants may require breathing air continuously (e.g. acrylonitrile plants); BP practice for Breathing Air Line Installations is given in BP Group [RP 60-2](#) (refer also to 322.23).
- (c) For processes using dangerous chemicals or process fluids, emergency showers and eye wash fountains shall be provided; the type and location will be specified by BP.

322.21 Hydraulic Oil Systems (Additional to [B31.3 322](#))

- (a) Piping for hydraulic oil systems shall meet the requirements of BP Group [GS 134-1](#), except that distribution systems should also meet applicable requirements of this Recommended Practice.

322.22 Piping Connections to Existing Plant (Additional to [B31.3 322](#))

- (a) A cut-in is defined as the provision of a connection into an existing process or utility service.



A tie-in is defined as the connection of a new associated system.

- (b) Cut-ins and tie-ins shall be designed so that:-
 - (i) Fabrication and field work is minimised consistent with plant operating and shut-down limitation requirements.
 - (ii) 'Hot work' (field welds etc.) should be minimised in restricted areas.
- (c) The method and the location of cut-ins and tie-ins shall be approved by the operating management at the design stage.
- (d) The following shall be approved by BP:-
 - (i) A cut-in and tie-in schedule complying with the format of BP Standard Drawing S-2018.
 - (ii) An isometric drawing and material list for each connection.
 - (iii) Drawings and calculations for new supports and for replacement supports.
 - (iv) Cut-in number tagging in the field on existing piping.
 - (v) All materials and documentation.
- (e) The fabrication, installation and testing responsibilities will be defined by BP at the design stage.

The plant availability and the operating management's resources to carry out the work should be taken into consideration when defining the responsibilities.
- (f) On plant which cannot be shut down, a 'hot tap' may be used for a new connection, if approved by BP.

322.23 Breathing Air Systems (Additional to [B31.3 322](#))

- (a) Breathing air systems are applicable to compressed air for breathing masks and to air pressurised by fans for pressurised buildings such as control rooms.
- (b) The consequences of any failure of the system must be fully considered when choosing materials of construction and the design of the system.



- (c) Pipework for pressurised air for use with breathing masks shall be of the highest integrity, perfectly clean and fabricated in stainless steel. Jointing materials for this service may be butyl rubber, neoprene or PTFE. CAF or some synthetic fibres which may be carcinogenic shall not be used. Flanged joints shall be minimised.

323 MATERIALS - GENERAL REQUIREMENTS (ADDITIONAL TO B 31.3. 323)

323.1 General Materials Requirements

323.1.1 Pipe Materials

(i) Steel

The pipe material listed in Table 323 may be used within the design temperature limits given. Other materials and any proposed service outside these limits shall be subject to approval by BP. The additional requirements of Appendix X apply to materials which have a Design Minimum Temperature below that specified in Table 323.3.3.

(ii) Copper and Copper Alloys

Copper pipe shall be solid drawn to [BS 1871](#) with maximum bismuth content of 0.003%, normally in the hard condition.

Copper nickel alloy pipe shall be seamless solid drawn to [BS 2871](#), Part 2 table 3 '0' (annealed) condition up to NPS 16 (DN 400) and seam welded to [BS 2570](#) for larger sizes.

(iii) Aluminium

Aluminium pipe, valves or fittings shall not be used for flammable or toxic fluids, unless approved by BP.

(iv) Other Materials

Proposals to use other materials for corrosion or mechanical reasons e.g. nickel steels, nonferrous materials, higher nickel alloys, or plastic lined pipe shall be subject to approval by BP.

323.1.2 Carbon and Carbon-Manganese Steels

The chemical composition, by check analysis, of steels to be welded shall be restricted as follows:-

Carbon	0.23% max. (pipe)
	0.25% ma. (forgings and castings)

Carbon equivalent (C.E.) 0.45% max.

where

$$\text{C.E.} = \text{C} + \frac{\text{Mn}}{6} + \frac{\text{Cr.} + \text{Mo} + \text{V}}{5} + \frac{\text{Cu} + \text{Ni}}{15}$$

Note: If necessary, to achieve minimum specified strengths, the maximum manganese contents may be a maximum of 1.60% provided the maximum permitted C.E. is not exceeded.

Forged components shall be normalised or normalised and tempered.

323.1.3 Chromium-Molybdenum Steels

Carbon content:

Steels with less than 2% Cr. (nominal): carbon content 0.17% max.

Steels with more than 2% Cr. (nominal): carbon content 0.15% max.

Residual elements:

Copper	0.30% max.
Nickel	0.40% max.
Tungsten	0.10% max.
Tin	0.015% max.
Phosphorous	0.015% max.

Forged components shall be normalised or normalised and tempered.

323.1.4 Maximum Strength

The actual ultimate tensile strength of any steel component shall not exceed the minimum required by the relevant specification by more than 150 N/mm² (22,000 psi).

323.1.5 Compliance with BP Group [GS 142-8](#)

Carbon steel, alloy steel and stainless steel pipes to [API 5L](#), [ASTM](#) and [BS 3601 to 3605](#) standards shall meet the general requirements of BP Group [GS 142-8](#).

323.1.6 Seamless v Welded Pipe

For process lines, seamless pipe is preferred but, if for dimensional or economic reasons, seam welded pipe (i.e. EFW) is proposed, the conditions under which it may be used are specified in Table 323.

Pipe incorporating longitudinal or spiral welded seams shall be subject to appropriate non-destructive testing of the welded seams to an extent depending upon the material, thickness and service as specified by BP Group [GS 118-5](#). This testing should be carried out at the pipe mill.

Note: Seam welded pipe shall only be used for severe cyclic duty when a weld factor of 1 (0.9 for non toxic duty) can be applied to the longitudinal weld, i.e. 100% NDE of the weld is carried out (see 305.2.9).

323.1.7 Material Protection, Painting & Corrosion Under Insulation (CUI)

External environmental considerations should be taken account of at all stages. Requirements for painting are given in BP Group [GS 106-2](#). Special attention is drawn to the need to protect against corrosion under insulation.

BP may specify protection of austenitic stainless steel piping against chloride attack in accordance with BP Group [GS 106-2](#).

323.1.8 Exclusions

Because of the possibility of failure in the event of fire or shock loading, low melting point materials including brasses, aluminium, and brittle materials including cast, nodular or malleable iron are not acceptable for hydrocarbon, other flammable or toxic duty or for fire mains unless specified otherwise by BP. Brittle materials shall not be used on steam or other gaseous duty.

323.1.9 Alternatives

Appendix K of this Recommended Practice lists a number of acceptable alternative standards which are considered to provide material comparable to that covered by the standard referenced in [ANSI/ASME B31.3](#). In cases where the specified minimum strength of the alternative standard is lower than that specified in the referenced standard then the allowable stress as listed in Appendix A of [ANSI/ASME B31.3](#) shall be reduced for the alternative material as follows:-

$$S_{\text{alternative}} = S(A/B)$$

where:

$S_{\text{alternative}}$ = allowable stress for alternative material
 S = allowable stress for comparable material listed in [ANSI/ASME B31.3](#)
 A = specified minimum strength of the alternative material
 B = specified minimum strength for the comparable [ANSI/ASME B31.3](#) referenced material.

323.1.10 Low - temperature requirements for pipe, flanges, valves and fittings shall be in accordance with Appendix X.

323.2 *Materials Requirements for Specific Service Conditions*

323.2.1 *Materials Selected in BP Group [GS 142.6](#)*

Materials selection for specific service condition are given in BP Group [GS 142-6](#)

For moderate temperatures and non-corrosive service, carbon steel should generally be used.

For more severe condition of temperature and corrosivity of fluid handled, a variety of other materials are required as detailed in BP Group [GS 142-6](#). For duties not covered in BP Group [GS 142-6](#) requirements will be specified or proposals subject to approval by BP.

323.2.2 *Materials for Low Temperature Service*

For low temperature service, carbon or carbon manganese steels shall also meet the requirements of 323.2. Where the temperature is such that carbon or carbon manganese steels are unacceptable then 3 1/2% Ni, 9% Ni or austenitic stainless steel materials shall be selected, in accordance with Appendix X.

323.2.3 *Materials for Aqueous Environments*

(i) *Wet H₂S Environments*

Process streams containing water and hydrogen sulphide at concentrations and partial pressures likely to cause sulphide stress cracking to carbon steels, ferritic and austenitic stainless steels should be handled in materials recommended in BP Group [GS 136-1](#). Hardness restrictions apply to parent materials and weldmetal. This also includes measures to prevent hydrogen induced cracking, which are relevant to largest size welded pipe made from plate.

Process streams containing water and hydrogen sulphide in concentrations likely to cause general corrosion should only be handled in materials calculated to give a minimum 10 year life based upon the latest available corrosion data.

(ii) *Caustic Soda Service*

For caustic soda solutions, or for caustic soda solution mixed with hydrocarbon welded pipework should be stress relieved where required by BP Group [GS 136-1](#). Threaded connections should be avoided on this service.

(iii) *C02/H2S Removal-Carbonates/*

Stress corrosion cracking of carbon steel welds in C02 removal plants employing potassium carbonate solutions, generally in the concentration range 20% to 30% can be experienced. For this reason, stress relieving of all carbon steel welds is required.

To avoid stress corrosion cracking of carbon steel welds exposed to hot amine solutions (e.g. concentrations generally between 20 to 30%) stress relieving is required if the temperatures are above the following values:-



MEA (MonoEthanolamine))
DIPS (Di-ISO propanolamine)All design temperatures
DEA (DiEthylamine) DIPA above 60°C.

(iv) *Steam and Condensate*

Carbon steel should be used for steam and condensate service up to 400°C (750°F) although copper or stainless steel may be used for steam tracing in accordance with 3.2.8 below; alloy steels should be used for high temperatures.

(v) *Steam Tracing*

For steam up to 200°C (390°F) or 7 bar (ga) (102 psig) whichever is limiting, tracing lines should be in solid drawn copper tubing to [BS 2871](#) Part 2, C.106 in the 'O' annealed condition and with brass fittings to [BS 2051](#), Part 1.

Above these limits, [API Spec 5L](#) pipe with welded permanent joints and socket welded fittings should be used. This piping may also be used instead of copper below the limits noted above.

Type 304 stainless steel seamless tubing with compatible stainless steel compression fittings may be used as an alternative to either of the above materials subject to an overall economic advantage being shown.

(vi) *Cooling Water and Fire Water*

Carbon steel is preferred for non-aggressive cooling and fire water service and pipework for this service should be according to BP Group [GS 142-6](#).

For aggressive water, pipe in 3" NPS and above should normally be of cement mortar lined carbon steel to BP Group [GS 106-1](#) or be of 90/10 cupronickel. Ductile iron to [BS 4772](#) which has been internally coated corrosion resistance may be used on certain duties subject to approval by BP. For pipe sizes below 3" NPS, hot dipped galvanised carbon steel, type 316 L stainless steel or 90-10 Cu-Ni may be used. Type 316 L stainless steel however may be subject to pitting in aggressive conditions and 6 Mo stainless steel, high alloy duplex (25 Cr.) or Ti have better resistance to aggressive water. Glass reinforced epoxy (GRE) material can also be considered for these services. Use of this material presents its own specific problems, requiring a close attention of all involved parties. See para 1.11.2(h) of this Recommended Practice for further guidance. The material specified will depend on water quality, the particular duty and site location. Materials for valves and fittings should be selected to avoid galvanic couples which could lead to accelerated corrosion. Where the connection of incompatible materials is unavoidable, they should be separated by a rubber lined carbon steel spool piece whose length is at least 3 times the internal diameter.

Water is termed aggressive by BP when it causes unacceptable corrosion and is generally confined to sea, brackish or soft water.

(vii) *Demineralised Water*

To avoid contamination, piping for demineralised water service should be of stainless steel, lined carbon steel or elastics, dependent on the temperature and application. It should be noted that demineralised water is very aggressive before deaeration, when stainless steel is necessary.

(viii) *Effluent Lines*

Effluent lines up to the treatment point should be considered as process lines (see BP Group [RP 4-1](#)) for further details). After this point any pipework within the scope of this Recommended Practice should be designed on the basis that the treatment may be periodically ineffective.

(ix) *HF*

HF acid is normally handled by carbon steel for concentrated condition, and by monel for more aggressive conditions when water is present.

323.2.4

Materials for High Temperature Service

(i) *General Requirements*

For high temperature service, the possibility of creep, corrosion and metallurgical degradation need to be taken account of.

(ii) *High Temperature H₂S*

Process streams at high temperatures containing hydrogen sulphide, other sulphur compounds and hydrocarbons but free from hydrogen, should be handled in materials calculated to give a minimum 20 year life based upon the data in '[High Temperature Sulphide Corrosion in Hydrogen-free Environments](#)', F Henry McConomy, API Division of Refining, 28th Mid-Year meeting, 12th may 1963. This usually involves 5 Cr. 1/2 Mo as a minimum.

(iii) *High Temperature Napthenic Acid*

Some crude oils are napthenic (TAN > 0.5 mg KOH/gm) and require the use of 316 stainless steel (minimum 2.5% Mo) above 220°C.

(iv) *High Temperature Hydrogen Service*

For service temperatures below 230°C (450°F) carbon steel is adequate. For higher temperatures, materials for hydrogen service should be chosen on the basis of Nelso curves ([API Publn. 941](#)) which defines safe operating limits for various steels in terms of temperature and hydrogen partial pressure.

This requires the use of ` Cr. 1/2 Mo/1 1/4 Cr. 1/2 Mo or 2 1/4 Cr. 1 Mo depending on the service condition.

Cr. 1/2% Mo is no longer a recommended material of construction. Cr. 1/2% Mo steel has however been used in the past for high temperature strength and resistance to high temperature hydrogen attack. However, long term operating experience has shown it to be suspect in both applications. The problems have been poor creep ductility and inferior hydrogen resistance.

Where Cr 1/2 Mo material is still in service in old equipment, two safeguards are necessary:-

- *For general high temperature service it is restricted to a maximum operating temperature of 400°C (750°F). This is the temperature*

above which design is based on creep properties and below which it is based on tensile properties.

- It is necessary to check for the presence of any high temperature hydrogen damage. Details are given in BP Oil Report [ESR.93.ER.003](#).

(v) High Temperature $H_2 + H_2S$ Service

Process streams containing hydrogen sulphide (H_2S), hydrogen (H_2) and hydrocarbons should conform to the following:-

- Streams containing more than 0.02 mol % H_2S at temperatures above 260°C (500°F) should be handled in stabilised austenitic steels types 321 or 347.

Where austenitic stainless steels are used, special care should be taken to prevent cracking by:-

using low chloride water for pressure testing,
taking precautions against polythionic acid attack when shutdown.

- Streams containing less than 0.02 mol% H_2S at temperatures above 260°C (500°F) should be handled in steel calculated to give a minimum 20 year life based upon the corrosion data in paper 67, 'New Computer Correlations to Estimate Corrosion of Steels by Refinery Streams Containing Hydrogen Sulphide', A.S. Cowper and J.W Gorman, National Association of Corrosion Engineers, 26th Annual Conference, 2nd-6th March 1970.
- Streams containing any level of H_2S at temperatures below 260°C (500°F) may be handled in carbon steel provided other requirements in this Recommended Practice are not infringed.

323.3 Miscellaneous Special Problems

323.3.1 Nitrate Stress Corrosion Cracking

Nitrates may cause stress corrosion cracking of carbon steels under certain circumstances. Cracking may be initiated by some other mechanism such as fatigue and then propagate by nitrate stress corrosion cracking. Factors which promote cracking are:-

- A high level of stress, either applied or residual.
- High concentration of nitrates in aqueous solution.
- Low pH.
- Temperatures above about 80°C (175°F).

Where an environment suggests a risk of cracking, applied stress should be minimised and residual stresses reduced by thermal stress relief.

323.3.2 Liquid Metal Embrittlement

This failure mechanism depends on a stressed material being in intimate contact with a specific liquid metal within a particular temperature range. The result is cracking (usually intergranular) and brittle fracture of a normally ductile material.



The two couples giving rise to most concerns in process plant are the aluminium/mercury and the stainless steel/zinc couples.

Mercury must not be allowed to contact aluminium and its alloys as extremely small quantities cause rapid and extensive cracking.

Zinc embrittlement of stainless steels commonly occurs at temperatures around 750° C (1380°F). Such temperatures are easily reached in a fire. However, the surface oxide film may have an influence on whether zinc penetrates the steel or not. Therefore after a fire, the possibility of contact between molten zinc and stainless steel needs to be checked. If contact may have occurred then careful and detailed inspection of the stainless steel is necessary. This should be carried out by a metallurgist or inspector familiar with this phenomenon.

It is not normally considered necessary to avoid the use of galvanised steelwork and components in the vicinity of stainless steel equipment.

323.3.3

Acetylene Service (including gas containing 5% or more free acetylene)

Pipework must comply with the appropriate statutory regulation in the country in which the pipework is installed. In the United Kingdom, Home Office approval of the installation is necessary except where acetylene is in a mixture with other gasses (with certain exceptions) and the acetylene does not exceed 5% by volume of the gasses.

Under no circumstances should materials containing more than 60% copper be used in construction of any parts in contact with acetylene. This requirement also applies to the external parts of valves, fittings and all other pipework exposed to acetylene in areas classified as Division 1 for acetylene.

The following requirements should be incorporated in preliminary design for discussion with contractors and for Home Office approval:-

- (a) Piping containing acetylene concentrations less than 20% by volume may be designed according to [ASME B31.3](#).

In addition, piping, fittings and valves carrying acetylene in concentrations of 20% and greater by volume should be designed such that the bursting pressure, in absolute units, at the operating temperature is not less than 50 times the normal maximum working pressure in absolute units.

- (b) There should be the minimum number of changes of direction of the pipework. The minimum radii of curvature of bends should be 3 times the normal bore of the pipe.
- (c) Consideration should be given to the inclusion of bursting discs at points where the effects of explosion in the piping would be most pronounced.
- (d) Adequate flame arrestors should be fitted on all vents to atmosphere.
- (e) When specified, flame arrestor towers should be incorporated in pipelines.

323.3.4

Ammonia Service

Attention is drawn to the susceptibility of carbon steels to suffer stress corrosion cracking in anhydrous ammonia service at ambient temperatures.



Where carbon steel piping is specified for ammonia service in all conditions, except as part of an approved package refrigeration unit, low strength steels (yield strength less than 350 N/mm² (50,000 psi) only should be used and all the welds should be stress relieved.

When specifying valves for ammonia service, ensure that the manufacture/supplier understands the service duty and supplies only all steel valves, that is with bushes and gland followers, not in bronze or brass.

323.6 Identification (Additional to B31.3 323)

323.6.1 General Requirements

Piping shall have continuous longitudinal marking of material grade and cast number when specified by BP. If not specified, marking shall be carried out in accordance with the manufacturing standard (e.g. [ANSI B16.5](#) etc.).

Piping components e.g. elbows, spool pieces, flanges and reducers shall have the following additional information marked upon them using the appropriate coding system and method of marking:

- (i) Manufacturer's name or trade mark.
- (ii) Nominal size.
- (iii) Nominal wall thickness in millimetres or schedule number.

For cast fittings the melt reference should also be indicated where possible.

Normally only stainless steel pipe is continuously stencilled for the full length. Carbon steel pipe greater than NPS 2 (DN 50) is normally only stencilled or stamped at one end and pipe under this size has only bundle labelling with no marking on individual pipes.

323.6.2 Methods of Marking

Pipe and piping components shall be legibly marked for identification using an indelible, heat resistant ink, electrical engraving or titanium oxide pigmented paint.

For austenitic and nickel base steels, the mark shall be such that it shall have a life of at least a year in unheated storage under cover. The dried film shall not contain more than 250 ppm of lead, zinc, tin or copper and paints shall be as free as practicable from sulphur and halogens. Any limits on these elements will be specified by BP. Adhesive tapes shall not be used.

323.7 Certification (Additional to B31.3 323)

All materials shall be supplied with the certification called for in the relevant codes and standards. and in the purchase specifications. Certificates shall refer to the specific items purchased.

CHAPTER IV COMPONENT REQUIREMENTS

The former BP Piping Standard, Std 170 - Piping Specifications (recently re-designated BP Group [GS 142-6](#)) is no longer maintained by Group Research and Engineering. Any piping line specifications should reflect specific business and/or asset as well as local HSE, environmental and procurement requirements. They can be based on existing specifications which are used by the particular asset or business, or BP may approve the use of a Contractor's standard specifications.

A piping line specification is a document which contains information on material standards, component standards and pipe installation practices to be followed. In preparing these specifications all piping, following analysis of the flow conditions and fluids specified by process, should be separated into groups which have common conditions of:

- Piping material
- Maximum pressure
- Maximum temperature
- Piping fabrication procedure (eg. whether socket welded, butt welded, screwed, etc.)
- Gasket type and material
- Maximum and minimum sizes of pipe.

The aim of the pipe line specification is to provide a formalised design procedure which:

- Has proved by many years of background business or asset experience to be adequate and economic and which is accepted by the operator and contracting and regulatory companies.*
- Is easily understood by an engineer at any time in the plant design or operation. The basic design assumptions are to be set out clearly and ambiguities in design methods eliminated.*
- Provides piping components that are compatible for strength, dimensions and assembly in ranges of materials suitable for fabrication and installation.*
- Specifies materials and components that are readily available as stock or standard items from suppliers.*

The pipe line specification should be presented on standard forms so that the information can be found easily, quickly and reliably. Responsibility for development and maintenance of these specifications must be clearly vested in one particular individual or in one section of the project team, asset or business.

Further guidance or assistance with preparation and approval of pipeline specifications may be obtained from the Piping Custodian.

326 DIMENSIONS AND RATINGS OF COMPONENTS

326.1 Dimensional Requirements

326.1.1 Listed Piping Components

- Minimum piping line sizes shall conform to the following requirements:-

Duty

Min Line Size



Non-hazardous fluid service - NPS 3/4 (DN 20)

Hazardous fluid service (refer 300.2)
and steam service 45 barg (650 psig)
and above - NPS 1 (DN 25)

Note that instrument impulse lines can be NPS 1/2 (DN 15) or less.

(b) The following sizes of steel pipe shall be avoided:-

NPS 1 1/4 (DN 32)	NPS 5 (DN 125)
NPS 2 1/2 (DN 65)	NPS 7 (DN 175)
NPS 3 1/2 (DN 90)	NPS 9 (DN 225)

Note that NPS 2 1/2 (DN 65) may be used for alloy pipe.

(Additional to [B31.3 326.1.1](#))

326.3 Hoses (Addition to B31.3 326)

BP requirements for certain types of hoses are covered in:-

- (a) BP Group [GS 128-2](#) - Oil Hoses for Offshore Tanker Loading and Discharging Services.
- (b) BP Group [GS 128-1](#) - Oil Hoses of Dock Loading and Discharging Services.

CHAPTER V FABRICATION, ASSEMBLY AND ERECTION

327 GENERAL

The requirements of Chapter V shall apply as modified and amended by BP Group [GS 118-5](#) to [GS 118-7](#) and this Recommended Practice.

335 ASSEMBLY AND ERECTION

335.2 Flanged Joints

335.2.1 Preparation for Assembly

A bolted joint relies on the skill and application of the fitter who puts it together. Correct use of materials, application of procedures, use of tools combined with the fitter's skill are all essential to ensure joint leak free performance.

It is necessary to train the assemblers to enable them to identify the correct materials, procedures and tools for assembly of bolted joints.

The Piping/Pressure Vessel Specifications are the key to the correct selection of materials for the job. They provide the appropriate selection and specification of pipe, piping components and material grade for a given service. In addition to



knowing what the correct materials are it is also essential that the fitter is able to identify them.

Once the correct components have been identified and procured for use, the integrity of the joint then relies on the selection of the correct preload, application of procedures, use of tools and the fitter's skill in operating the tools. The selection of bolting tools, procedures and control methods for the joint assembly must be compatible with the allowable preload scatter permitted for the joint and the criticality of the joint.

335.2.2

Bolting Torque

The main objective should always be the correct clamping force on the joint in service. The specification of preload and recommended preload control should be done at the design stage.

The range of preload actually achieved at assembly will depend on the number of variables, but mainly on the type of tools and procedures employed. Various means of control are available, namely torque, turn, stretch or a combination of these.

These variables which have a major impact on the torque - preload relationship include the following:

Lubricant	Thread engagement
Plating	Torque
Corrosion	Axiality of assembly
Repeated tightening	Installation method

335.3

Threaded Joints

335.3.1

Thread Compound or Lubricant

- (a) A thread compound or lubricant shall be used for all assemblies except where seal welded, in particular to prevent galling with stainless steel bolting. It shall be suitable for the service conditions and not react unfavourably with the service fluid, the bolts, gaskets or piping material. It must not be used on hydraulic systems as referred to BP Group [GS 138-3](#) (Marine Loading Arms). Details of proposed lubricants shall be submitted to BP for approval.

The effect of liquid metal embrittlement shall be given specific attention when proposing use of a metallic base lubricant. This phenomenon can be critical even at relatively low positive temperatures, and lubricants using a low melting point metallic base shall be avoided.

(Substitution for [B31.3 335.3.1](#))

The reasons for using thread compounds are:-

- (a) To prevent galling of stainless steel fasteners.
- (b) To prevent seizing of high temperature fasteners.
- (c) To facilitate tightening of fasteners to a particular torque setting.
- (d) To make fasteners of all types easier to undo.



Some manufacturers seem confused as to whether their product is a lubricant, sealant or for anti-seize purposes. Their products can be divided into four categories:-

- (a) PTFE tapes - they must be manufactured to [BS 4375](#) or equal, and should be thicker than normal tape with better dispensing methods and notes on how to apply. These are limited by temperature and not recommended for use where operating temperatures exceed 100°C.

The correct amount of PTFE tape used on a threaded joint is very important. Too little, and a seal is unlikely to be made. Too much could be lethal. PTFE tape must never be used to build up a thread - when under pressure the joint could blow apart.

PTFE tape is supplied in several thicknesses range from Standard (0.075mm thick) to Heavy Duty (0.2mm thick). Which to use depends on the pipe (or tubing) size and the maximum pressure. Heavy Duty tape is used on "mechanical" pipe joints. Standard tape is commonly used on low pressure (up to 10 barg) small bore (3 to 25mm diameter) instrument tubing.

- (b) Anaerobic sealing fluids - the locking threads are sealed by the fluid solidifying in the absence of air. The remaining fluid stays liquid in threads to ease dismantling. usually this product contains PTFE.
- (c) Anti-seize sprays - aerosol applied in thin films, similar to the familiar 'copper-greases'.
- (d) Anti-seize pastes - the familiar 'copper greases' although there are several modern varieties on the market, some have the harmful lead removed.

All these products have their uses; but the purpose they are used for has to be clearly defined and understood; i.e. sealing or lubricating and the method of application must be strictly adhered to, especially with PTFE tape. Product developed for a specific use must not be used in a general manner.

In addition to hydrocarbon oils and greases, many thread lubricants contain metallic constituents graphite or carbon, molybdenum disulphide and sometimes chlorides. All these constituents under certain conditions can be considered harmful and adequate consideration to these four potential areas must be given:-

- (a) Liquid metal penetration and embrittlement.
- (b) Galvanic attack due to graphite/carbon.
- (c) Chloride stress corrosion cracking and pitting.
- (d) Thermite reaction between aluminium and iron oxides.
- (e) Toxic effects.

335.3.2 Joints for Seal Welding or Bonding

Having regard to the limitations on the use of threaded joints and fittings in this Recommended Practice, seal welding of threaded joints to provide leak tightness, shall not be a design or construction requirement, except for orifice flange connections or such special cases which shall be subject to BP approval (see 314.1(b)).

Thread compounds on lubricants should not be used on seal welded joints as toxic vapours may be given off at welding temperatures.

(Substitution for [B31.3 335.3.2](#))

335.3.4 Taper Thread Pipe Joints

- (a) Taper pipe threads shall be concentric with the pipe, clean cut with no burrs and made up wrench tight with a sealant in accordance with 335.3.1.
- (b) Thread gauging (length and form) is covered by [ANSI/ASME B1.20.1](#) and [API Std 5B](#). The contractor shall ensure by visual examination that effective thread length is fully engaged and only run out or vanish threads are visible.

(Additional to [B31.3 335.3](#))

335.3.5 Electrical Bonding

Specific measures shall be taken to maintain any requirements for electrical bonding.

(Additional to 335.3)

336 PIPE CONTENTS

Erected piping shall be colour coded to identify the pipework contents in service. The colour coding shall be in accordance with [BS 1710](#) or the site colour coding system as specified by BP.

(Additional to [B31.3](#) Chapter V)

CHAPTER VI INSPECTION, EXAMINATION AND TESTING

340 INSPECTION

340.1 General

The requirements of Chapter VI shall apply as modified by BP Group [GS 118-5](#) to [GS 118-7](#), BP Group [RP32-2](#) and this Recommended Practice.

(Additional to [B31.3 340.1](#))



340.2 Responsibility for Inspection

The inspection of pipework must be given adequate consideration through all stages from initial design through shop manufacture, site fabrication or erection, commissioning and subsequent operation until permanent de-commissioning and disposal.

It is the responsibility of owner at each stage to:-

- (a) Ensure that pipework is suitable for its proposed service and that it is in a safe condition to commission and operate and that documentation to this effect is available.
- (b) Ensure compliance with national statutory regulations applicable to design, operation, inspection, test and certification of equipment.
- (c) Ensure that the inspection requirements as defined by this Recommended practice are implemented, so that pipework is maintained suitable for operation consistent with the prime requirement of safety, compliance with national statutory regulations and economical operation, in that order of priority.

(Additional to [B31.3 340.2](#))

340.4 Qualifications of the Owners Inspector

- (b) The Owners inspector shall have qualifications and/or experience appropriate for the proposed duties.

(Substitution for [B31.3 340.4\(b\)](#))

341 EXAMINATION

341.1 General

Where piping is categorised (refer 1.4 and Appendix Q), examination plans should be developed for each category.

Where piping is not categorised, the minimum examination/radiography requirements shall be specified for each individual duty.

(Additional to [B31.3 341.1](#))

345 TESTING

345.1 Required Leak Test



Consideration should be given to the potential cost and time penalties associated with the requirements of not carrying out painting and coating of all site and spool-piece closing welds until after the final hydrostatic test.

Where these costs are likely to exceed the benefits gained by complying with the requirements, consideration may be given to waiving the requirement. Any such review should be carried out by experienced piping and inspection engineers and consideration be given to factors such as:-

- *line content and associated hazards*
- *line pressure and temperature*
- *materials of construction*
- *welding processes used*
- *weld geometry*
- *number of runs required to complete weld*
- *accessibility of the weld*
- *amount and type of inspection carried out*
- *painting/coating to be applied to complete weld*

345.9 Alternative Leak Test

- (a) Where it is practicable to carry out a hydrostatic leak test in accordance with [B 31.3,345.4](#) before erection, e.g. on pre-assembled units (PAUs) and pre-assembled pipe racks (PARs), and where agreed between the manufacturer and the owner, the test requirements shall be as follows:-
 - (i) A minimum of one in ten circumferential butt welds shall be fully radio-graphed prior to hydrostatic leak testing.
 - (ii) A hydrostatic leak test shall be applied in accordance with [B 31.3, 3345.4](#).
 - (iii) All site closure welds shall be fully radiographed and/or ultrasonically examined. When heat treatment is required, the examination shall be performed after heat treatment.
 - (iv) The piping system after erection shall be subjected to a sensitive leak test at a minimum pressure of 4 bar or 15% of the design pressure, whichever is less. Alternatively see [B31.3, 345.8](#).
 - (v) When bringing the system into operation, a preliminary check shall be made at not more than the sensitive leak test pressure applied in (4). The pressure shall be increased gradually, in steps, up to the operating pressure, to allow sufficient time for piping strains to be equalized and for the checking for leaks.
- (b) Where it is not practicable to carry out a hydrostatic leak test in accordance with [B31.3, 345.4](#) before erection, the test requirements shall be as follows:-

- (i) Welds, including those used in the manufacture of welded pipe and fittings, which have not been subjected to hydrostatic leak tests in accordance with [B31.3, 345.4 or 345.5](#) shall be non-destructively examined as follows:-

- (i) Circumferential, longitudinal and spiral butt welds shall be fully radiographed.
- (ii) All welds, including structural attachment welds, not covered in (i) above shall be liquid penetrant examined. If the material is magnetic, magnetic particle examination may be used in lieu of liquid penetrant examination.

When heat treatment is required, the above examinations shall be performed after heat treatment.

- (ii) A flexibility analysis of the piping system shall be made in accordance with [B31.3, 319.4.2](#) (c) and (d).
- (iii) The Piping system after erection shall be subjected to a sensitive leak test at a minimum pressure of 4 bar or 15% of the design pressure, whichever is less. Alternatively see [B 31.3, 345.8](#).
- (iv) When bringing the system into operation, a preliminary check shall be made at not more than the sensitive leak test pressure applied in (3). The pressure shall be increased gradually, in steps, up to the operating pressure, to allow sufficient time for piping strains to be equalized and for the checking for leaks.

(substitution for [B31.3 345.9.1, 345.9.2 and 345.9.3](#))

CHAPTER IX HIGH PRESSURE PIPING

K300 GENERAL STATEMENTS

- (a) Scope and Applicability. When use of Chapter IX is agreed by BP, additional requirements may be specified by BP.

(Additional to [B31.3 K300\(a\)](#))



Material Type	Note	Design Maximum Temperature as stated, Design Minimum Temperature above that specified in Table 323.2.2	Low Temperature Service Design Minimum Temperature below that specified in Table 323.2.2
API 5L Grade A (OH, EF or basic oxygen)	1,2	Seamless, 400°C (750°F)	Seamless
API 5L Grade B (OH, EF or basic oxygen)	1,2,3	Seamless or EFW) 400°C (750_F)	Seamless or EFW
BS 3601 S360, S410		Seamless, 400°C (750°F)	Seamless
BS 3601 SAW 410	1	EFW, 400°C (750°F)	
ASTM A106 Grade A or B (silicon killed)	1	Seamless, 475°C (890°F)	
BS 3602 Grade 360, 410		Seamless, 475°C (890°F)	
ASTM A672 Grade B.55 class 32	1	EFW, 475°C (890°F)	
ASTM A672 Grade B.60 class 32	1	EFW, 475°C (890°F)	
BS 3602 SAW 410		EFW, 475°C (890°F)	
ASTM A333 Grade 1, Grade 6	1		Seamless
BS 3603 Grade 410 LT 50			Seamless
ASTM A333 Grade 3	4		Seamless
ASTM A333 Grade 8	5		Seamless
BS 3603 503 LT 100			Seamless
BS 3603 503 LT 196			Seamless
ASTM A335	6	Seamless	)
BS 3604	6	Seamless	) temperature range as specified in the design code
ASTM A672	7	EFW	)
ASTM A691	7	EFW	)
ASTM A312	8	Seamless	
BS 3605	8	Seamless	) temperature range as specified
BP Group GS 142-8		EFW	)

TABLE 323 (page 1 of 2)

TEMPERATURE LIMITATIONS FOR SELECTED PIPE MATERIALS



Notes:

1. Carbon content shall not exceed 0.23%.
2. Attention is drawn to the difference in maximum allowable design stress values between Grade A and B.
3. Only seamless pipe shall be used below 0°C.
4. Heat treatment as specified.
5. Quenched and tempered or double normalised and tempered.
6. Grade and heat treatment as specified.
7. Grade and heat treatment as specified, radiographed and hydraulically tested.
8. Grade as specified.

TABLE 323 (page 2 of 2)

TEMPERATURE LIMITATIONS FOR SELECTED PIPE MATERIALS



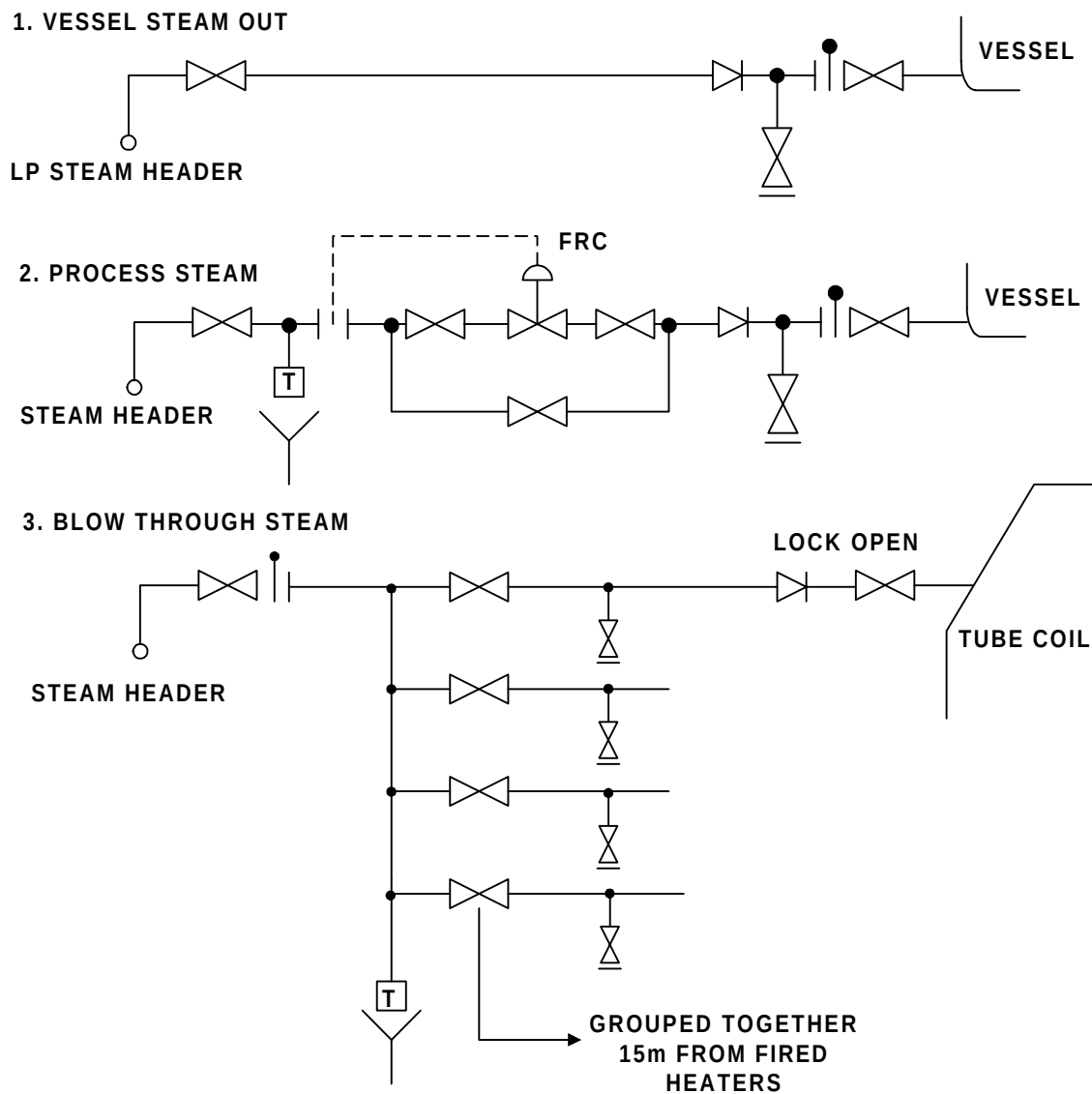


FIGURE 1
ISOLATION OF STEAM CONNECTIONS

DEFINITIONS AND ABBREVIATIONS

Definitions

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

Abbreviations

AIT	Auto-ignition temperature
ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BS	British Standards
CAF	Compressed Asbestos Fibre
DN	Nominal Diameter
EJMA	Expansion Joint Manufacturers Association
EEMUA	Engineering Equipment and Materials Users Association
EFW	Electric Fusion Welded
IP	Institute of Petroleum
LPG	Liquefied Petroleum Gas
MSS	Manufacturers Standardisation Society of the Valve and Fittings Industry
NACE	National Association of Corrosion Engineers
NPS	Nominal Pipe Size
PTFE	Polytetrafluoroethylene
PWHT	Post Weld Heat Treatment
WPQ	Weld Procedure Qualification Test

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 purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

British Standards

BS 1470	Wrought Aluminium and Aluminium Alloys for General Engineering Purposes Plate, Sheet and Strip
BS 1503	Specification for Steel Forgings (including semi-finished forged products) for Pressure Purposes
BS 1560	Steel Pipe Flanges and Flanged Fittings
BS 1640	Steel Butt-Welding Pipe Fittings for the Petroleum Industry
BS 1710	Identification of Pipelines
BS 1845	Specification for Filler Metals for Brazing
BS 2871	Copper and Copper Alloys. Tubes.
BS 3293	Carbon Steel Pipe Flanges (over 24 in nominal size) for the Petroleum Industry
BS 3601	Steel Pipes and Tubes for Pressure Purposes: Carbon Steel with Specified Room Temperature Properties
BS 3602	Specification for Steel Pipes and Tubes for Pressure Purposes: Carbon and Carbon Manganese Steel with Specified Elevated Temperature Properties
BS 3603	Specification for Steel Pipes and Tubes for Pressure Purposes: Carbon and Alloy Steel with Specified Low Temperature Properties
BS 3604	Specification for Steel Pipes and Tubes for Pressure Purposes: Ferritic Alloy Steel with Specified Elevated Temperature Properties
BS 3605	Seamless and Welded Austenitic Stainless Steel Pipes and Tubes for Pressure Purposes



BS 3799	Steel Pipe Fittings, Screwed and Socket Welding for the Petroleum Industry
BS 4504	Flanges and Bolting for Pipes, Valves and Fittings. Metric Series
BS 5500	<i>Unfired Fusion Welded Pressure Vessels</i>
BS 6129	Code of Practice for the Selection and Application of Bellows Expansion Joints for Use in Pressure Systems

American

ANSI/ASME B1.20.1	Pipe Threads, General Purpose (inch)
ANSI B16.5	Steel Pipe Flanges and Flanged Fittings
ANSI B16.9	Factory made Wrought Steel Buttwelding Fittings
ANSI B16.11	Forged Steel Fittings, Socket Welding and Threaded
ASME B31.3	Chemical Plant and Petroleum Refinery Piping, (1984 Edition)
ANSI B31.4	Liquid Transportation Systems for Hydrocarbons
API Std 5B	Specification for Threading, Gauging and Thread Inspection
API Std 605	Large Diameter Pipe Flanges
API Spec 5L	Specification for Line Pipe
ASTM A105	Specification for Forgings, Carbon Steel, for Piping Components
ASTM A106	Specification for Seamless Carbon Steel Pipe for High Temperature Service
ASTM A181	Specification for Forgings, Carbon Steel, for General Purpose Piping
ASTM A216	Steel Castings, Carbon, Suitable for Fusion Welding for High Temperature Service
ASTM A333	Specification for Seamless and Welded Steel Pipe for Low Temperature Service



ASTM A350	Forgings, Carbon & Low Alloy Steel, requiring Notch Toughness Testing for Piping Components
ASTM A352	Steel Castings, Ferritic and Martensitic, for Pressure Containing Parts, Suitable for Low Temperature Service
ASTM A420	Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Low Temperature Service
MSS SP44	Steel Pipe Line Flanges

BP Group Documents

BP Group RP 4-1	Drainage Systems (replaces BP CP 5)
BP Group RP 4-3	Foundations and General Civil Works (replaces BP CP 4)
BP Group RP 22-1	Fired Heaters (replaces BP CP 7)
BP Group RP 24-1	Fire Protection - Onshore (replaces BP CP 15/16)
BP Group RP 24-2	Fire Protection - Offshore (replaces BP CP 15/16)
BP Group RP 26-1	Heat Exchange Equipment (replaces BP CP 9)
BP Group RP 30-1 to RP 30-5	Instrumentation & Control (replaces BP CP 18)
BP Group RP 30-6	<i>Protective Instrumentation Systems - Shutdown Systems</i> (replaces BP CP 48)
BP Group RP 32-2	Site Inspection, Testing and Precommissioning of New Plant. (replaces BP CP 20)
BP Group RP 34-1	Rotating Machinery (replaces BP CP 10)
BP Group RP 43-1	Transmission Pipelines to BS 8010 (replaces BP CP 43)
BP Group RP 44-1	Overpressure Protection Systems (replaces BP CP 14)



BP Group RP 44-2	Winterisation (replaces BP CP 24)
BP Group RP 44-6	Area Classification to IP 15 (replaces BP CP 39)
BP Group RP 44-7	Plant Layout (replaces BP CP 3)
<i>BP Group RP 44-10</i>	<i>Isolation of Equipment for Maintenance</i>
BP Group RP 50-1	Guide to the Application of Criticality Ratings (replaces BP CP 53)
BP Group RP 52-1	Thermal Insulation (replaces BP CP 13)
BP Group RP 60-2	Breathing Air Line Installations
BP Group RP 62-1	Valve Selection (replaces BP CP
<i>BP Group GS 106-1</i>	<i>Cement-Mortar (Factory Applied) Lined Steel Pipe & Fittings (replaces BP Std 106)</i>
BP Group GS 106-2	Painting of Metal Surfaces (replaces BP Std 141)
BP Group GS 106-3	External Coatings for Steel Transmission Pipelines (replaces BP Std 144)
BP Group GS 118-5	The Fabrication, Assembly, Erection and Inspection of Carbon, Carbon Manganese and Low Alloy Ferritic Steel Pipework to ANSI/ASME B31.3 (replaces BP Std 167 Parts 1 & 2)
BP Group GS 118-7	Fabrication of Pipework to ANSI B31.3. Part 3: Austenitic and Duplex Steel Pipework, Cupro-Nickel and Nickel Base Alloy Pipework (replaces BP Std 167 Part 3)
BP Group GS 120-2	FCCU Expansion Joints (replaces BP Std 250)
BP Group GS 128-1	Oil Hoses for Dock Loading and Discharging Services (replaces BP Std 179)
BP Group GS 128-2	Oil Hoses for Offshore Tanker Loading and Discharging Services (replaces BP Std 176)



BP Group GS 134-1	Hydraulic Power Supplies (replaces BP Std 115)
BP Group GS 136-1	<i>Materials for Sour Service to NACE Std MR0175-90</i> (replaces BP Std 153)
BP Group GS 142-6	Piping Specifications (replaces BP Std 170)
BP Group GS 142-7	Gaskets and Jointing (replaces BP Std 173)
BP Group GS 142-8	EFW Austenitic Stainless Steel Pipe (replaces BP Std 174)
BP Group GS 142-9	Bolting for Flanged Joints (Unified Inch Series) (replaces BP Std 175)
BP Group GS 142-12	Pipe Flanges and Fittings (replaces BP Std 260)
BP Group GS 142-13	Selection Supply & Installation of Compression Fittings (replaces BP Std 261)
BP Group GS 146-2	Unfired Pressure Vessels: Vessels to BS 5500 (replaces BP Std 194 Part 1)
BP Group GS 152-1	Materials for Thermal Insulation of Pipework & Equipment (replaces BP Std 172)
BP Report No 82.20.0148	The Mechanics of Thermowell Design
BP Report No 82.ER0125	A Checking Procedure for BP Standard Thermowell Installations for Minimise the Risk of Mechanical Failure as a Result of Vortex Shedding Induced Vibration
BP Report No ETC 85.ER-219	Compact Flanges
EEMUA & Other Documents	
EEMUA No. 144	90/10 Copper Nickel Alloy Piping for Offshore Applications: Tubes - Seamless and Welded
EEMUA No. 145	90/10 Copper Nickel Alloy Piping for Offshore Applications: Flanges - Composite and Solid



BP Standard Drawings

S-0387M	Standard Orifice Flanges
S-0668M	Dimensions of Joint Rings to Suit BS 1560 and BS 3293 Flanges
S-0755M	Spades for Raised Face Flanges to Suit BS 1560 and BS 3293 Flanges
S-0756M	Spades for Class 900 Raised Face Flanges to Suit BS 1560
S-0773M	Sampling Point
S-0984M	Screwed Thermowell
S-1089M	Aluminium Pipes with Carbon Steel Backing Flanges Class 150
S-1090M	Copper Pipe with Carbon Steel Backing Flanges class 150
S-1240	Steam Trapping Arrangements
S-1244M	Pipe-Track Fire Traps
S-1357M	Connections to Orifice Flanges
S-1958	Instrumentation Sampling Probe
S-1965	Level instruments on Standpipes
S-1966	Level Instruments Direct to Vessel
S-1967	Integral Orifice Assembly
S-1999	Steam Tracing Details
S-2000	Adaptor for 15 mm CS to 10 mm OD Copper

S-2004	Thermowell Installation
S-2005	Pressure Instrument Connections to Line
S-2006	Flanged Thermowell Welded Construction
S-2007	Flanged Thermowell with Retaining Flange
S-2015	General Arrangement of Jacketed Piping
S-2016	<i>Typical Sampling Point for Hazardous and Toxic Materials</i> Cut-in and Tie-In Schedule



GUIDANCE ON PIPING CRITICALITY CATEGORISATION

Q1. INTRODUCTION

- (a) Piping criticality categorisation provides a basis for development of appropriate fitness for purpose criteria for design, manufacture, fabrication, installation, inspection and testing.

Use of piping criticality categorisation is recommended for major projects, where significant benefits in efficiency and economy of quality control may accrue.

- (b) For smaller and simpler projects, and works associated with existing plant the categorisation of piping may be waived, subject to agreement with BP. This Recommended Practice, together with BP Group [GS 142-6](#) and BP Group [GS 118-7](#) specifies requirements to give assurance of quality. However, the logic of this Appendix may be applied to refine or develop specific quality controls.

- (c) This Appendix gives a piping criticality categorisation procedure which has been used successfully on major projects and may be used as a basis for new projects. Piping criticality categorisation can be performed efficiently without disruption to the project.

- (d) Categorisation should be carried out by a group comprising the Piping Engineer, Piping Stress Engineer, and Metallurgist/Welding Engineer with assistance as necessary from the Piping Layout Designer and Process Engineer.

- (e) Categorisation requires certain design information as input data. Where full or final design information is not available provisional categories may be assigned. Provisional categorisation should be reviewed as final information is available, particularly for piping not falling in the most critical categories.

- (f) Piping criticality categorisation should also be applied to package units with significant piping.

Q2. PIPING CRITICALITY CATEGORISATION PROCEDURE

Q2.1 Design Information Required

The following information is required

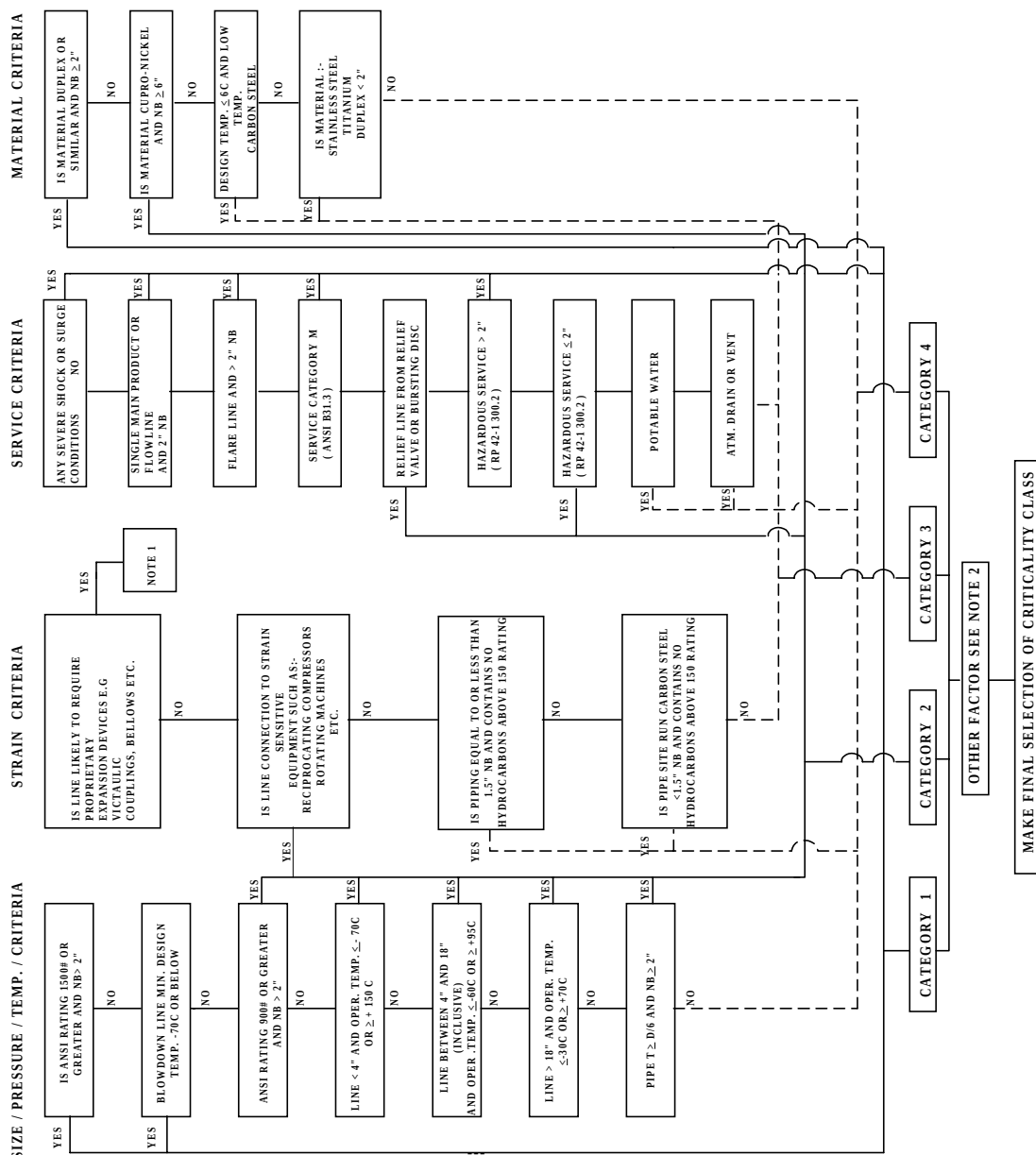
Piping line list Piping material specifications, P&I diagrams and Piping layout drawings (or model)

Q2.2 Criticality Category Decision Diagram

- (a) Piping criticality categorisation involves assessment against various criteria which can be grouped under:

Material Service Strain Size/temperature/pressure

- (b) Sets of generally applicable criteria under these headings have been developed as a decision diagram (Fig. Q1). This diagram has been maintained, simplified in content, and may be modified for specific projects.
- (c) Use of the diagram requires consideration to be given to any factors not listed which may be relevant, and any overall project criticality criteria.
- (d) For each piping line, determine the criticality category given by each set of criteria. Generally it will be appropriate to then select the most critical category identified. However, consideration of other factors may justify selection of a lower category e.g. for open drain lines. It is recommended that justifications be recorded.
- (e) The piping criticality category should be recorded on the piping line list.



NOTES.

- For bellows etc, class 1 requirements shall apply through design to testing stages. For adjacent piping class 1 requirements shall apply at least for design and erection stages.
- E.g special materials, high temp service, experience of vendor/fabricator with material, deck movement etc.

FIGURE Q1
DECISION DIAGRAM

PIPING CRITICALITY RATINGS

Suggested Piping Quality Programmes for Specific Ratings

DESIGN STAGE	I	II	III	IV
Layout Review	Yes	Yes	Yes	Yes
BP Standard Compliance	Yes	Yes	Yes	Yes
Stress Analysis by Contractor - Rigorous,	Yes			
Comprehensive				
- Comprehensive		Yes		
- Simplified			Yes	Yes
Stress Check by BP	Yes	20%		
Support Review by BP	Yes	20%	20%	
Isometrics Review by BP	Yes	50%		
Piping Specification Sheet Review by BP	Yes	Yes	Yes	Yes
COMPONENTS PROCUREMENT AND MANUFACTURE				
Vendor Quality Programme	Yes	Yes	Yes	
Vendor Quality Plan	Yes	Yes	Yes	
Preproduction Meeting				
- Contractor with Vendor	Yes	Yes		
Preproduction Meeting - As Above Plus BP	Yes			
Contractor Witnessing Vendor's QC Hold Points	100%	5%	2%	
BP Witnessing Vendor's QC Hold Points	50%			
FABRICATION AND ERECTION				
Vendor Quality Programme	Yes	Yes	Yes	Yes
Vendor Quality Plan - Contractor with Vendor	Yes	Yes	Yes	Yes
Preproduction Meeting - As Above Plus BP	Yes	Yes		
Review by Contractor	Yes	Yes	Yes	Yes
- Fabricator's Selection				
- Fabrication Methods				
- Welding Procedures				
- NDT Methods and Results				
Material Certification Check	Yes	Yes	Yes	Yes
Review by Contractor's Designer	Yes	Yes		
Review by BP Specialist Engineer	Yes	25%		
Review by BP Resident Engineer	Yes	Yes	Yes	Yes
Records	Yes	Yes	Yes	Yes
TESTING				
Witnessed by Contractor and BP Resident Engineer	Yes	Yes	Yes	Yes
Witnessed by Specialist Engineer/Inspector	Yes	25%		
Records and Final Data Folders	Yes	Yes	Yes	Yes
Final Check for Completeness by RE	Yes	Yes	Yes	Yes

PIPING CHARACTERISTICS BY CRITICALITY CATEGORIES

FABRICATION STAGE				
<i>Criticality Category</i>	<i>I</i>	<i>II</i>	<i>III</i>	<i>IV</i>
<i>Fit-up tolerance on root gap qualified in WPQ (Note 1)</i>	-0.5 mm +1.0 mm	.+ or - 1.5 mm	.+ or - 2.00 mm	.+ or - 2.0 mm
<i>Welding Procedure/Welder Qualification</i>	No pre-existing qualifications acceptable	<i>B31.3</i> Chap 5 + NSC-520- 24006 clauses 9.2 & 9.3 ----->		<i>ANSI B31.3</i> Chapter 5
<i>Heat Treatment</i>	<i>ANSI B31.3</i> Piping Code Procedures to be approved by Purchaser	<i>ANSI B31.3</i> Piping Code	----->	
<i>Misalignment Tolerances at Bore</i>	Over 100 mm Bore -1.0 mm Bore -1.6 mm (Note 2)	Up to 100 mm Bore -1.0 mm Over 100 mm Bore -1.6 mm	Up to 100m Bore -2.5 mm Over 100 mm Bore -3.0 mm	-----> ----->

Note 1 = WPQ - Weld Procedure Qualification Test

Note 2 = Tolerances to be analysed as acceptable by Vendor Stress Engineer for Criticality Category 1.

VENDOR EXAMINATION AND TESTING				
Criticality	I	II	III	IV
<i>Visual Components</i>				
<i>-Dimensional</i>	100%	100%	100%	100%
<i>-For Damage and Cleanliness</i>	100%	100%	100%	100%
<i>Visual Weld Fit-up</i>	100%	100%	100%	100%
<i>Visual Completed Work -Welding</i>	100%	100%	100%	100%
<i>-For Completeness</i>	100%	100%	100%	100%
<i>Magnetic Particle or Dye Pen (1)</i>	100%	100% of Branch Welds	10% of Branch Welds	Spot if Suspect
<i>X-Ray or Ultrasonic (1)</i>	100%	100% on 1 in 10	Spot on 1 in 10	Spot on 1 in 20
<i>Acceptance Standards for Welds per ANSI B31.3 Table 327.4.1.A (2)</i>	100%	Random Radiography	Visual or Random	Visual or Random
<i>Hydrotest (or as specified)</i>	Shop Fab Spool	Yes	Yes	Optional Not Req'd
<i>Post Erection</i>	Yes	Yes	Yes	Yes
<i>Records</i>	Yes	Yes	Yes	Yes

- Notes:
- (1) In the case of random, 10% or spot this shall include the first weld from each welder and then a percentage from each
 - (2) Any acceptance of undercut or concave root features shall be subject to the judgement and discretion of the Purchasers Inspector.



REQUIREMENTS FOR LOW TEMPERATURE PIPING SYSTEMS

Where a piping system may be subject to impact loading during service, or to other severe loadings, the notch ductility requirements of the steels used in its construction may need to be more onerous than those specified in this Appendix. In such cases, BP will specify appropriate requirements.

*X1 GENERAL REQUIREMENTS

The following additional requirements shall apply to the design, materials, testing and inspection of all piping systems which have a Design Minimum Temperature below those specified in Table X.1. These requirements shall apply to all pressure parts and welded attachments which have a reference thickness not exceeding 28 mm (1 1/8 in). When this limit is exceeded, BP will specify appropriate requirements.

Austenitic steels and certain non ferrous materials are not susceptible to brittle fracture and no special requirements are necessary for their use at temperatures down to -200°C (-328°F).

Note that on first cooling below ambient temperature and down to -200°C, some austenitic steels increase slightly in size due to a permanent metallurgical change. This may result, for example, in bolts relaxing their pre-load the first time they are cooled. The designer should take account of this in selecting the steels used.

Welded austenitic to ferritic steel joints for sub-zero service are not covered by this Recommended Practice and shall only be used when approved by BP.

X2 DESIGN PARAMETERS

X2.1 Design Minimum Temperature

The design minimum temperature shall be as determined by 301.3.1 of this Recommended Practice.

X2.1.1 Design Reference Temperature

The design reference temperature T_r is the temperature to be used with the reference thickness Table X (1) to determine the suitability of materials for resisting brittle fracture. T_r shall not be greater than $T_d + T_s$.

Where

T_d is the minimum design temperature as defined in 301.3.1

Ts is an adjustment depending on the calculated membrane stress, as follows:

Ts is 0°C when the calculated membrane stress is equal to or exceeds $2S/3$;

Ts is +10°C when the calculated membrane stress is equal to or exceeds 50 N/mm² but does not exceed $2S/3$;

Ts is +50°C when the calculated membrane stress does not exceed 50 N/mm².

In all cases the membrane stress should take account of internal and external pressure, static head, self weight, thermal stresses and external loads.

S is nominal design stress.

Requirements for carbon and carbon-manganese steel piping systems for application at temperatures below 0°C are based upon the 1994 issue of BS 5500, Appendix D, to which reference may be made for information regarding the background and basis of such requirements. The Table X (1) is based on Fig. D.3.2 (1) and D.3.2 (2) of BS 5500.

However, the BS 5500 requirement for the temperature adjustment, depending on the construction category, is not followed in this Recommended Practice. Inspection practices for piping should be assessed on an individual basis to ensure the required level of integrity of piping is achieved, therefore the BS 5500 pressure vessel categories' requirements are not appropriate.

X2.1.2 Design Reference Temperature for Ambient Temperatures

For UK and countries, where the minimum temperature is due to lower seasonal ambient conditions, the design reference temperature Tr can be assumed to be 0°C for material reference thickness 19 mm and smaller.

All design codes require the engineer to select the lowest metal temperature in order to determine when impact testing is necessary.

It has become a common practice in the UK to relate the minimum design metal temperatures to data published by the Meteorological Office. LODMAT (low one day mean ambient temperature) has become the preferred reference point.

When piping is subjected to operating loads at these low ambient temperatures, experience shows that the applied stresses tend to be well below the maximum design stresses. Therefore, the benefits of clause X2.1.1 can be utilised, which resulted in the 0°C material design reference temperature for material reference thickness equal or less than 19 mm. This is further supported by the successful experience within the oil and gas industry, where there is an enormous population of piping systems constructed in non-impact, non-stress relieved materials with wall thicknesses up to 19 mm, with little or no known incidence of brittle fracture.

It must be understood that the rule in X2.1.1 does not remove special concern for protection of piping systems during the hydrostatic testing, where the full consideration of brittle fracture is still required.

X2.2 Reference Thickness

In this Appendix, thickness refers to the nominal thickness including corrosion allowance of the item as specified. Applications where the actual thickness used exceeds this value by more than the normal manufacturing tolerance shall be referred to BP. See Figure X(1).

X2.2.1 Butt Welded Components

The reference thickness of each component should be taken as the thickness of the component at the edge of the weld preparation.

X2.2.2 Flanges Weld Neck, Plate and Slip on (or Hubbed) Flanges

The reference thickness shall be the greater of the thickness of the pipe (or fitting), or one quarter the thickness of the flange, except that the flange thickness can be ignored in the case of welded welding neck flanges where the weld is more than four times the weld thickness from the back of the flange.

X2.2.3 Branches

The reference thickness shall be that of the main, branch or compensating plate (if any), each item being considered individually.

X2.2.4 Attachments

Non-pressure attachments welded directly to a pressure component shall be regarded as part of the pressure component, and the reference thickness shall be taken to be equal to the thickness of the attachment at the point of attachment.

X2.2.5 Unwelded Items

Unwelded items shall be considered as equivalent to stress relieved items and the reference thickness shall be taken as one quarter of the thickness of the item.

X3 ALLOWABLE STRESS RANGE FOR COLD DUTIES

Where components contain welds at highly stressed locations, (e.g. fabricated branches or mitred bends) other than the butt welds connecting the component to the adjacent pipe, the allowable stress range SA for those components shall be reduced to 50% of that defined in 302.3.5. Alternatively the full value of SA may be used if the Design Minimum Temperature is 20°C or more above that permitted by Table X(1).

The allowable stress range SA is reduced to take account of the fact that the highest value of stress occurs for the first time on cooling down to service temperature.

X4 NOTCH DUCTILITY REQUIREMENTS

X4.1 Pipe, Fittings and Flanges

Materials shall conform to the appropriate category indicated in Table X(1) for the reference thickness and Design Reference Temperature of the part under consideration.

X4.2 Attachments

The minimum specified impact energy of non-pressure attachments welded directly to a pressure component shall not be less than that required for the pressure component to which it is attached.

The impact test requirements shall not be less than those of the pressure part to which the attachment is made.

X4.3 Castings

X4.3.1 Castings may be used provided:

- (i) They meet the same analytical restrictions as plate and forgings (see 323).
- (ii) They are in the normalised or normalised and tempered condition and are reheat treated if any welds or weld repairs are made other than butt welds incorporating them into the piping system. These latter welds shall be left as welded or be stress relief heat treated, depending on the Design Reference Temperature and the reference thickness.
- (iii) In the case of flanged castings, the reference thickness shall be taken as one quarter the flange thickness. For butt

welded castings, the reference thickness shall be taken as the thickness at the weld.

X4.3.2 Materials for castings shall be chosen from the following material specifications. Note that in some cases the impact test requirements are lower than those for comparable wrought steels and the Design Reference Temperature specified in Table X(1) shall be increased where indicated:

- | | |
|----------------------|---|
| Category A material: | ASTM A216 WCA
ASTM A216 WCB
ASTM A216 WCC
BS 1504-161 Grade 430
(all as welded). |
| Category B material: | Category A materials in the postweld heat treated or nonwelded condition. |
| Category C material: | ASTM A352 LCA (+2°C)
ASTM A325 LCB (+10°C)
ASTM A352 LCC (+20°C)
BS 1504-161 Grade 430
LT 40 (+5°C)
(all as welded). |
| Category D material: | (i) Category C materials in the postweld heat treated or nonwelded condition (Design Reference Temperature increased as Category C materials).

(ii) ASTM A352 LC3 BS 1504-503 LT 60. |

X4.4 **Bolting**

Bolting materials shall be in accordance with BP Group [GS 142-9](#).

X4.5 Welding

Unless otherwise agreed by BP, only seamless pipe shall be used for Category B, C and D materials when the Design Reference Temperature is less than 0°C.

Seamless pipe, flanges and fittings, when repaired by welding shall be post-weld heat treated if they are to operate at temperatures below 0°C unless a welding procedure which avoids PWHT has been approved by BP. Notch ductility requirements for welds used in fabricating pipework shall be in accordance with BP Group [GS 118-5](#) to [GS 118-7](#).

X5 DESIGN, MANUFACTURE AND WORKMANSHIP

X5.1 Design

X5.1.1 Specific attention shall be given to avoid details that will produce local areas of high stress, e.g. lugs, gussets producing discontinuous stiffening and abrupt structural changes.

Supports attached by tack or intermittent welding shall not be used.

X5.1.2 Threaded connections shall not be used except as permitted by 314.1(a).

X5.2 Manufacture

All materials used shall have appropriate certification. Pieces of pipe, plate, etc., of uncertain origin shall not be used even for apparently unimportant items.

Hard stamping and pop marking shall not be used where these marks will remain on the finished items unless such items are subsequently postweld heat treated.

X5.3 Heat Treatment of Components

All cold pulled bends where the calculated outer fibre elongation exceeds 20%, or 10% for impact-tested grades, shall be given a normalising heat treatment after forming.

Ferritic steel parts that have been hot formed shall be normalised unless it can be demonstrated that the temperature control during hot forming results in the item having the same mechanical properties as if it were normalised.

TABLE X1



DESIGN REFERENCE TEMPERATURE AND REFERENCE THICKNESS RELATIONSHIP FOR VARIOUS MATERIAL CATEGORIES

Reference Thickness mm	Design Reference Temperature °C for Material Category			
	A	B	C	D
5	-32	-48	-72	-90
10	-15	-30	-72	-90
20	+2	-20	-33	-80
28	+12	-12	-13	-72

Permissible design minimum temperature and reference thickness relationship for various material categories; an extended range of temperature limits for reference thicknesses up to 40 mm would be:-

Reference Thickness mm	Design Minimum Temperature °C for Material Category			
	A	B	C	D
5	-32	-48	-72	-90
10	-15	-30	-72	-90
20	+2	-20	-33	-80
28	+12	-12	-13	-70
30	-	-10	-11	-70
40	-	0	-2	-40

Requirements for materials thicker than those listed will be specified by BP.

Intermediate values may be obtained by linear interpolation. The Design Reference Temperature specified above shall be increased where indicated:-

Material Category A:	Non-impact testing carbon steels, as welded; API 5L ASTM A105 ASTM A106 ASTM A181 BS 1503 221, 223, 224 BS 3601
Material Category B:	Category A materials in the postweld heat treated condition.
Material Category C:	Impact tested carbon steels, as welded; ASTM A333 Grade 1 or Grade 6 ASTM A350 LF1 (+20°C) ASTM A350 LF2 (+10°C) ASTM A420 WPL6

BS 1503 - 223, - 224, Grades 410 LT 50
and 430 LT 50
BS 3603 Grade 410 LT 50

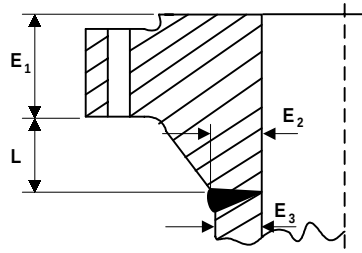
Note for Category C it is assumed that material impact requirements at -40°C will be met.

- Material Category D:
- (i) Category C materials in postweld heat treated condition.
 - (ii) 3 1/2% Ni as welded, to the following:
 - ASTM A333 Grade 3
 - ASTM A350 LF3
 - ASTM A420 WPL3
 - BS 1503 Grade 503 LT 80
 - BS 3603 Grade 503 LT 100

Unless otherwise agreed by BP, 3 1/2% Ni steel shall not be used in the postweld heat treated condition.

9% Ni steel pipe to ASTM A333 Gr. 8 or BS 3603 Gr. 509 LT 196 and fittings and forgings to ASTM A420 WPL8 or BS 1503 Grade 509 LT 196 can be used at temperatures down to -196°C in thickness up to 20 mm. For thicknesses exceeding 20 mm additional requirements will be specified by BP.

Limitations in the use of austenitic stainless steels shall be as defined in ASME B31.3; requirements for the fabrication, inspection and testing of these welds are in BP Group GS 118-5 to GS 118-7.



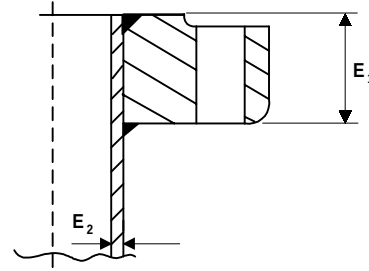
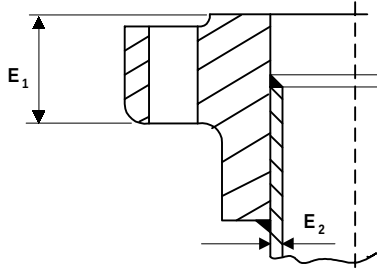
(A) WELD NECK FLANGE

REFERENCE THICKNESS FOR THE FLANGE IS :-

- 1) FOR $L < E_2$:
THE GREATER OF $E_1/4$ OR E_2
- 2) FOR $L \geq E_2$:

E_2 .

REFERENCE THICKNESS FOR THE PIPE IS E_3

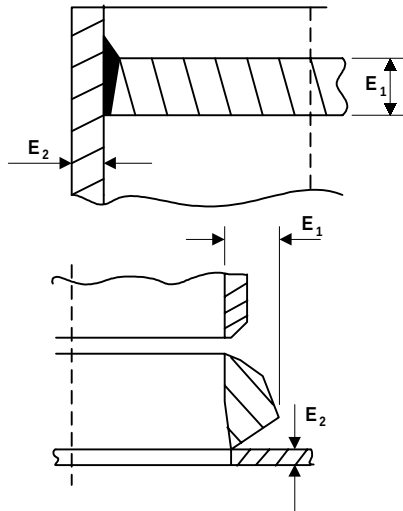


(B) SLIP ON AND PLATE FLANGE

REFERENCE THICKNESS FOR THE FLANGE IS :-

THE GREATER OF $E_1/4$ OR E_2

REFERENCE THICKNESS FOR THE PIPE IS E_2 .



(C) FLAT END

REFERENCE THICKNESS FOR THE FLAT
END IS :

THE GREATER OF $E_1/4$ OR E_2

REFERENCE THICKNESS FOR THE PIPE IS E_2

(D) REINFORCED BRANCH CONNECTORS

REFERENCE THICKNESS FOR THE BRANCH
CONNECTOR IS :-

THE GREATER OF $E_1/4$ OR E_2

REFERENCE THICKNESS FOR THE PIPE IS E_2

FIGURE X(1)

REFERENCE THICKNESS: FLANGES AND FLAT ENDS