



RP 30-10

SELECTION, SUPPLY AND INSTALLATION OF COMPRESSION FITTINGS

December 1996

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BP GROUP RECOMMENDED PRACTICES AND SPECIFICATIONS FOR ENGINEERING			
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This Recommended Practice is a revision of BP Standard 261 and its Supplementary 'yellow pages' first issued in 1990 and is based on BP Petroleum Development report ER 2931 dated December 1988. The conversion of Std. 261 from a Standard to a Recommended Practice has occurred to increase the awareness of the importance of instrument impulse pipework, particularly aspects of design, construction, inspection and testing which impact pressure containment capabilities. It specifies all BP general requirements for the application of twin-ferrule fittings and fittings to BS 4368 and BS 2051 that are within its stated scope.			
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FOREWORD

Introduction to BP Group Recommended Practice 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 Recommended Practice gives the basis for the selection, supply, installation, inspection and testing of compression fittings. It has been developed from Standard 261. The initial series of RP30-1 to 9 documents, were those BP Standards which were required to be updated periodically. Other BP Standards, for example on compression fittings were unlikely to change, unless there was some significant breakthrough in technology. These Standards were converted to Guidance for Specification documents. There has been a perception that the information in Std. 261 was dated and contained information which was no longer current or relevant. In the absence of International Standards on high quality, dual ferrule compression fittings, RP30-10 and [RP42-1](#) Piping Systems remain the best available sources of information.

A number of failures of compression fittings in service has resulted in the need to re-emphasise the available information on tube and compression fittings for instrument impulse lines and to specify RP30-10 as a Project or Asset practice.

To date there has been little development in compression fitting technology, with vendors concentrating on the hardening process of ferrules. Vendors have also been implementing compression fittings in a wider range of materials and sizes.

The value of this Standard to its users will be significantly enhanced by their regular participation in its improvement and updating. For this reason, users are urged to inform BP of their experiences in all aspects of its application.

Application

Text in *italics* is Commentary. Commentary provides background information which supports the requirements of the Practice, and may discuss alternative options. It also gives guidance on the implementation of any "Specification" or "Approval" actions; specific actions are indicated by an asterisk (*) preceding a paragraph number.

This document may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies



with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Principal Changes since last Issue

Principal changes in RP30-10 from Std. 261 are:-

- a) The use of compression fittings at Class 900 rating, from Class 600.
- b) The recommendation for type testing if used by exception at Class 1500 or above.
- c) The recommendation for type testing if used in sizes greater than 1/2".
- d) Increase of hydrotest pressure to 150% of line design pressure from 110%.
- e) The requirement for 100% inspection of fittings.
- f) The requirement for training and qualification of installers with subsequent refresher training.
- g) The requirement to purchase tube and fittings either against a specification or to supply process details with the order.

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 Engineering or the Custodian. See Quarterly Status List for contacts.



1. INTRODUCTION

1.1 Scope

This Practice sets down the BP requirements and recommendations for the use of tube and compression fittings for instrument installations. It contains sections on application, selection, installation, inspection and testing of compression fittings.

Compression fitting failures continue to impact the Technical Integrity of facilities across the BP Group in all Businesses and geographical areas. A major factor in the majority of failures is the incorrect make-up of fittings.

This Practice contains advice on training and qualification of installers with supplementary inspection and testing of installations, and is intended to reduce the number of in-service failures of compression fittings.

It covers fittings to [BS 4368](#), twin-ferrule or similar designs for use on instrument impulse lines, hydraulic, lube oil and high pressure diving gas systems for use offshore or on onshore oil and chemical processing applications. It may also be applied to steam fittings supplied to [BS 2051](#). It does not apply to fittings for heavy wall tubing, high vacuum fittings and welded or brazed instrument fittings.

Impulse lines means the whole of the instrument piping system downstream of the process line isolation valve, but not piping through which continuous process flow occurs.

Reference to tube material (paragraph 2.3.2) in this Practice is made only for general information and relates to aspects that effect the application and assembly of compression fittings. All aspects covering the specification, application, installation and support of tubing are not covered.

This Practice excludes special fittings such as quick release couplings and fittings containing non-return devices.

The definition of the term heavy or thin wall used with reference to tube may vary with the fitting design and the tube material (consult fitting manufacturer for the acceptable range of wall thicknesses i.e. minimum and maximum wall thickness). Heavy tube required for high vacuum service may not be suitable for use with most available types of fitting.

1.2 Application of this Practice.

1.2.1 To apply this BP Practice, supplementary specification and approval actions by BP, purchaser, or both, are required to adapt it to each specific project application.



2. APPLICATION, ENGINEERING DESIGN AND SELECTION

2.1 Application and Engineering Design.

This Recommended Practice allows the use of tube and compression fittings on instrument impulse lines hydraulic, lube oil and high pressure diving gas systems for use offshore or on onshore oil and chemical processing applications, over the specified ranges of pressures and temperatures.

A key factor in the use of tubing and compression fittings for instrument impulse pipework, is to ensure a well engineered and installed 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 mechanical protection due to the lower mechanical robustness of tube and compression fittings.

RP42-1 (Piping Systems) Section 318.3 specifies that compression fittings may be used on process pipework (not instrument impulse pipework) with the same range of application as threaded connection process pipework, Section 314.1. Exceptions are that compression fittings may be used on steam duty where threaded fittings are excluded. The application of threaded pipework and compression fittings on process pipework is limited to non-flammable, non-toxic, non-hazardous, non-erosive fluids on non-cyclic duty. The pressure and temperature range is also greatly restricted. See relevant RP42-1 Sections for details of applications, sizes and pressure/temperature ratings.

The design of instrument impulse pipework should be carried out against either a specified vendor catalogue issue, or against an Instrument Piping Specification. Tube and compression fittings should be ordered for specific duties with process fluid details, pressure and temperature ratings supplied to the vendor.

This approach should be strongly considered for all major projects and critical applications. The intention is to ensure that tube and compression fittings are not treated as "Bulk" items, ordered from a general catalogue. Vendor catalogues are uncontrolled documents and can be updated periodically with revised pressure and temperature ratings and other de-rating factors, particularly with new materials, modifications or additions to ranges. Users should ensure, by reference to the supplier, that the catalogues being used are current. For less critical applications, modifications and maintenance this approach may not be appropriate and reliance on site procedures for the correct specification and management of fittings is required.

For modifications to existing Assets, fittings should be compatible with the existing facility.

The minimisation of tubing by close coupling of instruments should be considered in any design.

Close coupling provides an inherently safer installation with reduced exposure to mechanical damage and fewer potential leakage points.



Impulse piping is often specified by a generic design of tube and fitting, with the instrument location and installation carried out as a site activity. This can lead to the situation where the length and the routing of tubing are far greater than the design intent. For critical applications, impulse piping should be designed and specified exactly.

- * 2.1.1 Compression fittings may be used for instrument impulse lines downstream of the line or vessel isolation valve(s). Tube and compression fittings shall not be used for the following applications unless approved by BP.

Guidance is provided to allow individual Assets to consider exceptions which arise, from package vendors or from cost reduction initiatives. Exceptions may be justified, subject to rigorous testing of the actual components to be used, in the materials, sizes, pressures and temperatures to be used, with approval by the Asset or plant Technical Authority.

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

This is vendor specific, but it would be expected that a high quality compression fitting, correctly made up, could be dismantled and remade 80 times as a minimum. [RP42-1](#) limits the acceptable number of times that a fitting can be dismantled, to half the number tested by the vendor. Thus compression fittings may be acceptable for cases where dismantling up to 40 times is expected, or higher if this can be substantiated by the vendor. This is acceptable for the majority of instrument installations. For any joints requiring frequent dismantling, plant procedures and technician training should cover leak testing, examination of fittings for wear and galling etc.

The No-Go gauge supplied by vendors may not be suitable for use on re-assembly of the fitting, due to the tightening slightly past the original position.

- (c) Toxic substances as defined by BP.
- (d) Impulse line sizes exceeding NPS 1/2 (DN 15).

Information contained within this document on sizes larger than 1/2" is provided for guidance only. Any use on sizes larger than 1/2" is by exception and type testing is recommended.

- (e) Hydrogen service above Class 900 flange rating.

Operation at Class 900 flange ratings is allowed. Hydrogen service is defined as hydrogen or gaseous mixtures containing hydrogen in which the partial pressure of hydrogen is 5 bar (abs) (72.5 psig) or more.



Screwed connections should be minimised. Flange to tube adaptors, without NPT screwed connections, should be used where this type of connection is required.

- (f) Flammable fluids above Class 900 flange rating and above.

Operation at Class 900 flange ratings is allowed. In vendor catalogues the maximum allowable design pressures quoted are generally based on the bursting pressure of the tube, with a safety factor of approximately 3 to 4, depending on the vendor. The burst pressures are based on a limited number of tests. Material hardness, surface finish and tolerances on wall thickness can have an impact. Further derating factors are applied for high temperature operation. These temperature factors are generally derived by calculation, without testing for burst pressures. Pressure/temperature ratings are specified in [ANSI B31.3](#).

For equivalent materials, the rating of tube and compression fittings is higher than Class 900 for sizes up to and including 1/2", even in the lower wall thickness tubes. For the common range of wall thicknesses for tubes used in the industry:

<u>Size</u>	<u>Wall thickness</u>
1/4"	0.035"
3/8"	0.049"
1/2"	0.065"

The tube and compression fitting ratings are more than double the Class 900 ratings. This provides a safety factor additional to that applied by the vendors.

A welded or flanged pipework configuration is required above Class 900. If it is desired to make an exception and use compression fittings at Class 1500 or Class 2500 ratings, or in sizes larger than 1/2", it is recommended that type testing is carried out using the actual fittings and tube material to be employed in the construction. The common range of wall thicknesses above, should be adopted as a minimum. In operating at Class 1500, the margin between the tube operating pressure and the tube rupture pressure is being reduced. In the common range of tube wall thicknesses used in the industry, Class 2500 ratings exceed the maximum operating pressures for compression fittings. Any operation at this rating would be relying on the the remaining safety factor used by the vendors. Factors such as material hardness, temperature effects and wall thickness tolerances may substantially lower the burst pressure, reducing the vendor safety factor. Tube of greater wall thickness, but still within the acceptable range quoted by the vendor may be selected for type testing.

- (g) Steam service at 45 barg, (650 psig) and above.
- (h) Steam service below 45 barg, (650 psig) up to the connection of the condensate leg. The condensate leg connection and impulse line thereafter may be of tube and high integrity compression fittings. The use of copper pipe and fittings are limited to a maximum of 7 barg and 205°C.



- (i) For process line temperatures outside the range -200°C to 430°C (-328°F to 806°F), or manufacturer's recommended design temperature for compression fittings, whichever is the more onerous.
- (j) For corrosive fluids, where the process conditions can give crevice corrosion or stress corrosion cracking.

* 2.1.2 If compression fittings are used on the following duties, the corresponding restrictions shall apply:-

- (a)
 - (i) For flammable liquids forming substantial vapour clouds on leakage (e.g. where a pump suction inventory at normal operating level is 30 m³ (1060 ft³) or greater at auto-ignition temperatures of 210°C (410°F).
 - (ii) The liquid is toxic as specified by BP.

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).

- (b) 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 thread or compression fitting.

The practical arrangement of cooling (or warming) lengths if required, should be individually assessed. The impulse line should meet the process line specifications to ensure containment. Cooling lengths are provided to minimise temperature cycle effects.

2.1.3 The final connection of impulse lines to instruments or integral manifolds may be flanged or threaded fittings. When threaded fittings are used, all impulse lines shall be supported at the instrument and the instrument restrained to prevent accidental unscrewing.

Fast sample loops for on-stream process analysers will generally be treated as process flow piping up to the connection of the analysers where a transition to tubing and compression fittings may occur.



2.2 Selection

* 2.2.1 Suppliers

Sites, existing plants or fields may wish to adopt a single supplier policy or limit the sources for various fitting type in order to reduce the possibility of incorrect components being fitted. To this end it would be advisable to adopt the use of twin-ferrule fitting for all general services, in which case BP will advise the contractor the sources of manufacture allowed. For all new projects a single supplier policy shall be adopted. Any use of additional designs or suppliers for special applications may only be made subject to the approval of a BP technical authority.

There are in excess of 30 vendors of dual ferrule compression fittings world wide. Standardisation across a Project or Asset is strongly recommended.

The exceptions to the rule of a single supplier policy and using twin-ferrule fittings may be the use of 'O' Ring type fittings for hydraulic service and flared types for diving gas and diving hot-water systems or on particular explosion protected equipment.

When sour service requirements necessitate fittings to meet NACE requirements, the choice of fittings and spares stocked should ensure that non-NACE parts shall not be fitted in error in NACE applications.

It is not intended that existing installations should change all existing fittings, and it is quite acceptable for the continued use of single-ferrule and flared types. It may be necessary to reduce the fitting types, stock a 'standard' fitting, reduce access of other types and operate a tracking system to find 'rogue' fittings. The supply of 'non-standard' fittings and spares should be controlled.

* 2.2.2 Standards

The design of twin ferrule fittings is not currently covered by any British Standard and the Standards should be used for general information only when referring to this design. Therefore, a particular manufacturers designs shall be subject to approval by BP.

Single-Ferrule type compression fittings shall comply generally with the following standards:-

(a) **BS 2051:** Tube and Pipe Fittings for Engineering Purposes

Part 1 - Copper and copper alloy capillary and compression tube and fittings for engineering purposes.

Part 2 - Specification for olive type copper alloy compression tube fittings.



These are for use with general service or low pressure steam tracing.

(b) BS 4368: Compression Couplings for Tubes

Part 1 - Specification for heavy series couplings (metric).

Part 3 - Specification for light series couplings (metric).

Part 4 - Specification for type test requirements.

These are for use on all services including instrument impulse lines, process service or tracing services.

(Note this standard has been amended and includes requirements for copper alloy, carbon and stainless steel).

2.2.3 Fitting Types

Compression fittings are generally supplied in the following types (see Figure 1):-

- (a) Compression couplings, Type A ([BS 2051](#) and [BS 4368](#)) in which the joint is made and the tube is gripped by the compression of a ring or ferrule, or part of the coupling on the outside surface of the tube, known as 'single-ferrule' fittings.
- (b) Compression couplings, Type B ([BS 2051](#) and [BS 4368](#)) in which the joint is made and the tube is held by the compression of a manipulated portion of the tube at or near its end against the face of the coupling body, or against a loose ring or sleeve within the coupling, known as 'flared' fittings.
- (c) Compression couplings, Type C ([BS 4368](#)) in which the joint is made by means of a sealing ring (and retaining washer if required) which does not hold the tube. A second ring is included to hold the tube, known as 'O-ring' fittings. Fire resistant types are available which have secondary rings which can seal at temperatures up to 700°C (1292°F).
- (d) Twin-ferrule compression couplings similar to Type A, but with two ferrules to separately seal and hold the tube. There are currently no national or international standards covering design and manufacture of this design and users have to judge manufacturer's proprietary designs on their merits.
- (e) Zero insertion clearance fittings of single ferrule, metal to metal design, without gaskets, sealants or 'O' rings.

2.2.4 Fittings for General Service, Impulse and Pneumatic Signal Lines

Twin ferrule fittings shall be used unless BP approve the use of single ferrule fittings for non-critical service. All connection threads should be NPT.

For pneumatic signal lines and local instrument air supplies twin ferrule fittings are recommended, particularly where the instrument may be subject to frequent removal and refitting. Single ferrule fittings may be used on instrument signal lines and air supplies, subject to approval by BP with the awareness of the possible failure modes due to over tightening single ferrule fittings.

Consideration can be given to zero insertion clearance fittings in hydrocarbon applications subject to approval by BP.

2.2.5 Diving Applications

For most diving gas systems, flared brass fittings for use with tungum alloy tube should be used in marine environments at temperatures of 50°C (122°F) and below. For temperatures above 50°C (122°F) the use of Incoloy is recommended. Stainless steel shall not be used for applications where the gas has a high percentage of oxygen present in either normal or abnormal operations.

For diving hot-water systems, twin-ferrule or flared type stainless steel fittings should be used in exposed marine environments of 50°C (112°F) or below. For higher temperatures Incoloy is recommended. For standardisation purposes it is recommended that twin-ferrule fittings are chosen when these are the common type used on the platform or site.

Alternatives to tungum tube are stainless steel, Incoloy or Monel. Brass twin-ferrule compression fittings are not suitable for use with tungum because of inadequate ferrule hardness.

2.2.6 Hydraulic Systems

O-Ring type fittings should be used for hydraulic service and fire resistant types chosen where services are hazardous. The O-ring material shall be compatible with the line fluid and for high pressures shall be resistant to explosive decompression. All fittings shall meet the requirements of Guidance for Specification [GS134-1](#) (e.g. all fittings shall be provided with parallel threads).



* 2.2.7 Sour Service

Materials for sour service shall comply with the requirements of [NACE Standard MR0175-90](#) and BP Guidance for Specification [GS136-1](#). Stainlesssteel (316 or 316L) tube and fittings may be used, subject to the approval of BP. The tube and fittings (excluding ferrules) shall be in the solution annealed condition. Bending of the tube should be avoided. When permitted the minimum bend radius shall not be less than 5D.

Monel tube and fittings are preferred and should be used where other elements such as chlorides are present in the fluid. Other materials such as incoloy or hastelloy may be considered as alternatives. Mixed materials (e.g. stainless steel tube with monel ferrule or stainless steel fitting on monel tube) shall not be used.

Stainless steel is suitable for most sour services except where high temperatures occur together with a high H₂S and chloride content of the fluid. PVC covered 316 stainless steel tube may be considered for special applications (e.g. for tube exposed to a marine environment which can contain sour gas). Care must be taken to paint any exposed stainless steel tube in marine environments. For aggressive fluids, where stainless steel is not acceptable Incoloy 825 or equivalent may be considered.

2.2.8 Extra High Pressure Steam Service

Fittings with flat metal ring gaskets and butt weld ends should be used for this service (see Figure 1) subject to the manufacturers maximum pressure and temperature limits.

2.2.9 Steam Tracing Services

Copper alloy fittings may be used for low pressure steam tracing applications up to a maximum temperature of 204°C (400°F). The user should consult the manufacturer to confirm the maximum allowable temperature for his fittings. They should generally comply with [BS 2051](#) or [BS 4368](#).

Fittings to [BS 2051](#) are intended for low pressure steam tracing used on chemical and refinery applications.

* 2.2.10 Vacuum Service

Metal to metal twin-ferrule fittings may be used for vacuum applications subject to the manufacturers recommendation and approval by BP. For high vacuum duties 'O'-Ring type, flat ring type or specially designed fittings may be required.



2.3 Materials

2.3.1 General

The following table gives a list of general material temperature limitations. Significant de-rating factors will apply at elevated temperatures:-

Material	Min. Temp.	Max. Temp.
Metals:		
Aluminium	-196°C (-321 F)	204°C (400°F)
Brass	-196°C (-321°F)	204°C (400°F)
Copper	-196°C (-321°F)	204°C (400°F)
Copper-Nickel (70/30)	-196°C (-321°F)	371°C (700°F)
Copper-Nickel (90/10)	-196°C (-321°F)	316°C (600°F)
Hastelloy B2	-196°C (-321°F)	427°C (800°F)
Hastelloy C 276	-196°C (-321°F)	537°C (1000°F)
Inconel 600	-196°C (-321°F)	649°C (1200°F)
Incoloy 825	-196°C (-321°F)	427°C (800°F)
Monel	-180°C (-292°F)	427°C (800°F)
Steel	- 20°C (- 4°F)	400°C (750°F)
Steel (Cadmium Plated)	- 20°C (- 4°F)	232°C (450°F)
Stainless Steel (Type 304)	-196°C (-321°F)	538°C (1000°F)
Stainless Steel (Type 316)	-180°C (-292°F)	649°C (1200°F)
Titanium	- 75°C (- 94°F)	300°C (572°F)
Tungum Alloy	-196°C (-321°F)	200°C (392°F)
Plastics and Elastomers:		
Natural Rubber	- 50°C (- 58°F)	70°C (158°F)
Ethylene-Propylene	- 40°C (- 40°F)	135°C (275°F)
Neoprene	- 4°C (- 25°F)	120°C (248°F)
Nylon	- 40°C (- 40°F)	74°C (165°F)
Silicone Rubber	-100°C (-148°F)	250°C (482°F)
PTFE	-196°C (-321°F)	230°C (446°F)
Viton	-15°C (5°F)	200°C (392°F)

These temperatures are a guide only and subject to the material grade, the service conditions and the manufacturers recommendations. See Appendix C for service recommendations.

Inserts may be required when using plastics and elastomer materials.

Care must be taken when choosing elastomer seals as these harden and shrink at low temperatures, some suffer from explosive decompression and have limited temperature ranges when compressed. PVC covered



or other alternative coated tubing and fittings may be considered for corrosive environments. Their application shall be subject to approval by BP.

* 2.3.2 Tube Materials

Tube materials may be purchased to comply with the following standards and shall be round and free of scratches and weld beads (where applicable) on outside diameter. The fitting supplier should confirm the maximum allowable hardness of the tube.

Compression fittings shall only be used on the range of tube wall thicknesses specified by the compression fitting vendor.

This is important for both thin wall effects where the tube may collapse or burst and also for thick wall effects where the tube may not be sufficiently deformed for the front ferrule to seal and the rear ferrule to grip.

Vendor recommendations for minimum wall thickness for gas service to minimise leakage, should be considered. A minimum wall thickness is recommended to allow the ferrule to "coin" out or overcome surface imperfections, creating a good seal.

All tube shall normally be seamless. Welded tube may only be used subject to approval by BP.

Tubing shall be seamless only, welded and drawn tube may be subject to de-rating factors for weld integrity and may only be used subject to the fitting manufacturers recommendations and approval by BP.

Carbon Steel	Soft annealed hydraulic tubing to ASTM A179 .
Stainless Steel	Fully annealed, seamless or welded and drawn to ASTM A269 maximum hardness allowable Rb 90, recommended hardness Rb 80.
Incoloy 825	Full annealed seamless or welded and drawn to ASTM B468 . Maximum allowable hardness Rb 95.
Monel Tubing	Fully annealed seamless to ASTM B165 , monel 400 maximum allowable hardness Rb 75.
Cupro-Nickel	High quality tube to BS 2871 Pt 2 CN102 or 107.
Copper Tubing	High quality soft annealed seamless to ASTM B68 and B75 . ASTM B88 is also acceptable if there is no outside diameter embossing.



Tube to [BS 2871](#) grade C106 together with fittings to [BS 2051](#) may be used for steam tracing duties.

Aluminium Tubing	Seamless drawn annealed tube to ASTM B210 .
Titanium	Annealed seamless to ASTM B338 Grade 2. Maximum allowable hardness Rb 90.
Tungum Alloy	Seamless aluminium-nickel-silicon-brass tubing to BS 2871 Grade C2 127 maximum allowable hardness Rb 76, surface condition and tolerances to BS 2871 , Part 2 (metric).

The tolerances on the outside diameter of small bore stainless steel, monel, inconel, hastelloy, alloy 20 or titanium tubing to ASTM specifications shall not exceed + or - 0.003 in for 1/16 in or 1/8 in O.D. tubing or + or - 0.075 mm for 3 mm O.D. tubing. The tolerances on all tubing shall comply with the requirements of the fitting manufacturer.

Carbon steel and aluminium tube shall not be used for offshore applications. Aluminium tube shall not be used in fire hazardous areas without approval by BP.

All tubing shall be softer than the fitting material and where fittings are of the same material the tube shall be fully annealed. The tube wall thickness, finish and roundness shall be checked against the fitting manufacturer's requirements. The tube hardness, finish and limits shall be specified on the purchase order. Half hard copper tube may only be used when specified or approved by BP.

Copper tube for steam tracing applications shall comply with specification [BS 2871](#): Pt. 2.

Non-metallic tubing may be considered for corrosive non-hazardous environments or laboratory applications, subject to approval by BP. The fittings shall be metal or nylon subject to the manufacturers recommendations (pressure/temperature rating). The following tube materials may be considered:-



MATERIALS	SIZE RANGE mm	O/D in	MAXIMUM WORKING PRESSURE BAR (psig)	MAXIMUM WORKING TEMPERATURE
Nylon	3 to 12	1/8 to 1/2	43 (625)	82°C (180°F)
Polyethylene	6 to 12	3/16 to 1/2	8.6 (125)	60°C (140°F)
Polypropylene	6 to 12	3/16 to 1/2	41.4 (600)	121°C (250°F)
PTFE (NB: Has low coeff. of friction)	6 to 12	3/16 to 1/2	Consult manuf.	204°C (400°F)
PVC	6 to 12	3/16 to 1/2	Consult manuf.	74°C (165°F)

Note: All pressure and temperature ratings are subject to manufacturers recommendations. Compression type fittings may not be suitable for all types of PTFE or PVC tube.

The allowable minimum wall thickness shall be based on the requirements of [ANSI B31.3](#) and [GS 142-6](#) using the maximum pressure and temperature the system will experience.

Gases such as air, hydrogen, helium, nitrogen can find leak paths through small tube surface defects. For these applications medium or heavy tube wall thicknesses should be chosen which will allow satisfactory action of the ferrule eliminating the possibility of wall collapse.

2.3.3 Fitting Materials

Fitting materials shall conform to the following standards unless otherwise specified in the purchase order or approved by BP.

Carbon Steel: All materials shall meet the requirements of [BS 2051](#) or [BS 4368](#).

Brass: [ASTM B124-C46400](#).

316 Type
Stainless
Steel: [ASTM A276 - S31600](#) (bar stock - condition A) or [BS 970](#) Pt.4 S16.

Incoloy 825: [ASTM B425 - UNS No. 08825](#).



3. SUPPLY REQUIREMENTS

3.1 External Standards

The fitting design shall generally comply with [BS 2051](#) or [BS 4368](#) as specified in the line specification or be of high quality double ferrule design.

Consideration can be given to single ferrule designs (metal to metal connection without 'O' rings, gaskets or sealants) with flat, zero insertion clearance.

3.2 Supplier Requirements

It is recommended that only suppliers which can demonstrate that their pressure rating and temperature derating tables can be supported by a comprehensive test programme, carried out on tube and fitting assemblies across all materials to be used, should be considered.

These tests must demonstrate that the claimed factor of safety before burst can be achieved for the range of pressure and temperature combinations and tube wall thicknesses covered by the suppliers claims. The tests must also be carried out for a statistically significant number of cases which will cover fitting manufacturing tolerances and allowable tube I.D. and O.D. tolerances.

The use of high quality double ferrule fittings and the importance of design data based on actual testing is of greater significance where fittings are being used above Class 900 or in new material/ size combinations.

3.3 Packaged Units

- * 3.3.1 *It is preferable that fittings for packages shall meet the requirements of this Practice and be of the same type and manufacture used at that particular plant.*

4. INSTALLATION

4.1 Quality Control

- 4.1.1 The material shall be within allowable maximum tube hardness specified by the purchaser.

Tube should be carefully stored and handled to avoid scratches on tube O.D. and never be dragged across cement, asphalt gravel steel work or other hard surfaces.

Consideration should be given to the adoption of a colour coding system where different materials are stored (e.g. stainless steel and monel ferrules can be confused).

4.2 Competence

- 4.2.1 Only those personnel, whether BP or contractor, who have completed instruction and training and have demonstrated satisfactory



performance in making up fittings and understanding of the principles involved, shall be permitted to fit, maintain or inspect compression fittings. The contractor shall provide proof that training has been given. The training should include but not limited to:-

- (a) Principles of operation, application of fittings (and potential misuse) including materials and duties.
- (b) Installation techniques e.g. tube supporting, cutting and preparation, use of hydraulic swaging tools, assembly of fittings and re-making joints.
- (c) The dangers of mixing components and possible results of failures.
- (d) The importance of the correct specification of tube.
- (e) Inspection and testing.
- (f) Practical experience of making-up fittings, inspection and testing in the range of fitting types and materials to be used at the plant or site. A sample of these shall be hydrotested to 1.5 times the maximum working pressure for the tube/ fitting assembly, as a confidence building measure for each candidate.

The level of training should be such that a qualification can be given which will be valid for a period (typically 2 or 3 years, but no greater than 4 years). Thereafter, refresher or re-training will be required to ensure continued competence in the installation and maintenance of compression fittings. The requirements for competence include service agent personnel for equipment which is repaired both on and off-site.

4.3 Workmanship

- 4.3.1 The fittings shall be installed in accordance with the manufacturers recommendation. Where a manufacturer recommends that a special number of turns from hand tight are required, the nut and body shall be marked in order that the correct pull up can be verified or a gap gauge used when recommended or supplied by the fitting manufacturer. Care shall be taken to ensure the tube is correctly aligned and inserted into the fitting body.

The following errors should be avoided:-

- (a) *Fittings are not under or over-tight.*
- (b) *The use of a mixture of different manufacturers parts or incompatible tube/fitting materials.*



- (c) *The use of out of specification tubing. Prior to fitting, the tube surface condition shall be checked. The outside diameter and wall thickness shall be checked by physical measurement.*
- (d) *The reverse fitting of ferrules in twin-ferrule designs (e.g. fitting ferrules the wrong way round).*
- (e) *Poor tube cutting and deburring. Correct cutting, ensuring a square tube end, with no reduction or swaging of the tube O.D., is essential to ensure that the correct starting point is achieved*
- (f) *The use of incorrect size spanners (pipe wrenches or shall not be used).*
- (g) *Bending of tube inserted in a fitting or the installation of a coupling on a tube bend.*
- (h) *Interfering with the ferrule after it has been made up.*
- (i) *Bleeding a system by loosening a fitting nut or retightening fittings when a system is pressurised. **Depending on the hardness of the ferrule and tube, and the system pressure, loosening a joint under pressure may cause the tube to blow out of the fitting.***
- (j) *Connecting fittings in a straight line. A bend in between should be used to prevent movement of ferrule during pull up.*
- (k) *Where practical, compression fittings should not be fitted within five diameters of a pulled bend to avoid crimping ferrule on a hardened or thinned pipe section. Sufficient straight length shall be provided to allow the tube to bottom in the fitting.*
- (l) *Attention shall be given to tube runs, to protect couplings from the effects of strain and vibration. Tube runs shall be securely clipped (but not directly to couplings), and shall be flexible enough to absorb equipment and pipe movements, thermal expansion and contraction. Couplings shall not be used to pull tubing and equipment together.*
- (m) *When using compression fittings on large tube, care shall be taken to ensure no undue weight is suspended from them (e.g. between instrument isolating valve and level switch).*

4.3.2 Where a compression fitting on an existing system is disassembled it shall be re-made using all the original parts, by following the vendors re-assembly instructions or re-made with a complete new compression fitting. Any elastomeric 'O' rings shall be replaced.

4.3.3 During installation 100% of joints shall be visually inspected by the installer. Details of procedures for various fitting types are given in Appendix D.

A signed record of inspection by the installer should be made using a document such as the instrument impulse pipework hook-up diagram, where each fitting can be identified and the checks recorded.



5. INSPECTION AND TESTING

5.1 Inspection

5.1.1 Inspection of fitting shall be carried out by certified and trained staff.

Personnel carrying out inspection of tube and compression fittings shall have received training in the assembly of fittings as per Section 4.2.1.

5.1.2 It is recommended that an inspection should be made of compression fittings by a person independent of the original installer.

The inspection may be carried out by using vendor supplied gauges providing the gauges check the both the correct tightness of the nut and the correct abutment of the tube in to the fitting. Alternatively dismantling, inspection and retightening of the fitting will be required.

The experience of tube and compression fitting failures within the BP Group is dominated by failures due to incorrect make-up of the fitting. Typical failure causes are insufficient tightening of the nut and improper abutment of the tube in to the fitting.

Individual Assets may determine a percentage inspection level, based on the criticality of the service.

5.2 Testing

5.2.1 Before pressure testing the installation shall be checked for:-

- (a) Installation and inspection, in accordance with drawings and specifications.
- (b) Adequacy of supports.
- (c) Approval of any deviations from specification.

* 5.2.2 The system shall be subject to a hydrostatic pressure test as specified by BP. The hydrostatic test pressure shall be 150% of the line design pressure unless specified otherwise by BP.

The test pressure shall be 150% of the line design pressure for a duration of 10 minutes. This is the test pressure used under ANSI B31.3 for process pipework. This will ensure that all elements of the process pipework and instrument impulse system will be tested to the same test pressure. The gland packing of instrument valves, subjected to 150% of line design pressure, should be checked.

Hydrotesting and subsequent drying out of systems if required, is the preferred method of pressure testing. Only where a hydrotest of instrument impulse tube and compression fittings is incompatible with the process and where failure to remove water would leave a hazard and all other liquid testing alternatives have been considered, a pneumatic test may be applied.



The pressure rating of connected instruments and valves should be checked prior to testing. Any equipment of inadequate pressure rating shall be removed during testing. Any equipment removed and subsequently re-instated after hydrotest shall be subjected to a leak test at 110% of line design pressure.

Pneumatic testing involves the hazard of released energy in compressed gas, due to sudden compression fitting failure. Brittle failure, which is temperature dependant, is also a consideration. The pneumatic test pressure shall be 110% of design for 10 minutes. Testing of fittings with soap and water is recommended. A procedure shall be developed which raises the pressure to 25 psig or one half the test pressure, whichever is lower, where an initial leak check will be carried out. The pressure will then be raised in stages to the test pressure, holding the pressure at each step long enough to equalise tubing / compression fitting strains. The pressure shall then be reduced to the design pressure where all compression fitting joints shall be checked for leakage.

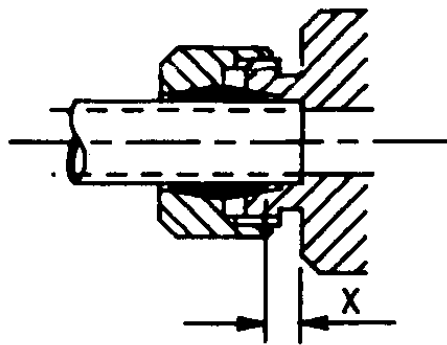
- 5.2.3 All lines shall be tested separately from any process piping and the tests shall have a minimum duration of 10 minutes using a test gauge to detect leakage. In addition a soap and water test may be applied to joints to help identify suspected leaks.
- 5.2.4 Instrument air systems shall be checked using dry air from compressors or storage systems. If portable compressors are used a dry alumina filter should be used to ensure oil free air.
- 5.2.5 After completion of the pressure test all fittings shall be checked for any slackness caused by relaxation during testing with special attention given to 'O' ring type fittings.
- 5.2.6 The final tests shall be witnessed/approved by a BP inspector unless otherwise waived by BP.

6. CERTIFICATION

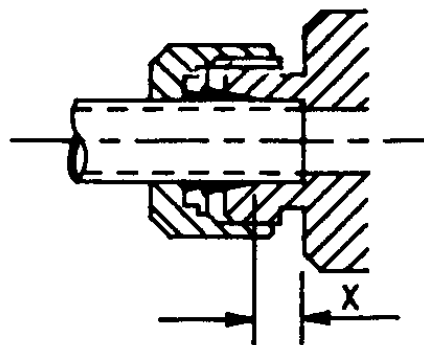
6.1 Certification

- 6.1.1 The following certification shall be provided by the vendor:-
 - (a) Fittings Certificates of conformity.
 - (b) Tubes Material certificates.



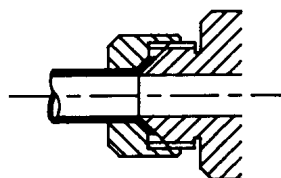
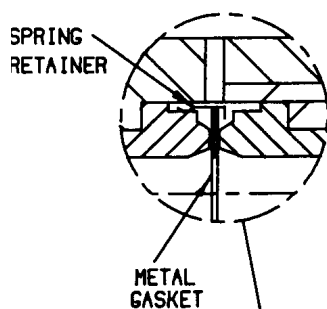


SINGLE - FERRULE TYPE (TYPE A)

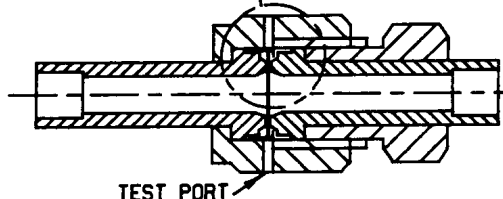


TWIN - FERRULE TYPE

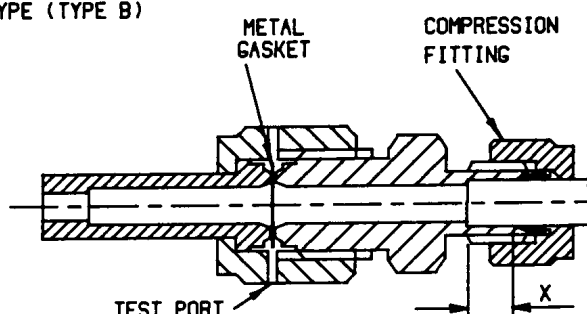
X = FERRULE SECURED
NOT LESS THAN 3 TO 4 mm
END OF TUBE



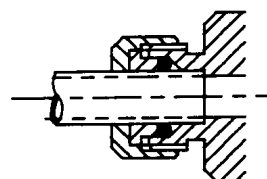
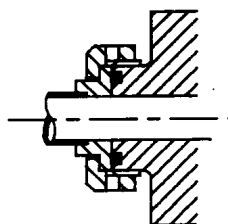
FLARED TYPE (TYPE B)



FITTING WITH METAL GASKET & RETAINER



FITTING WITH METAL GASKET
& COMPRESSION FITTING



TYPICAL 'O' RING TYPES

FIGURE 1

TYPICAL COMPRESSION FITTING DESIGN

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
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BS	British Standards
DN	Nominal Diameter
ISO	International Organisation for Standardisation
NACE	National Association of Corrosion Engineers
NPS	Nominal Pipe Size
NPT	American Standard Taper Pipe Thread
O.D	Outside Diameter
PVC	Poly-Vinyl-Chloride
QA	Quality Assurance
PTFE	Polytetrafluoroethylene
Rb	Rockwell 'B' Hardness

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 970** Specification for wrought steels for mechanical and allied engineering purposes.
- BS 2051** Tube and pipe fittings for engineering purposes.
Part 1: Copper and copper alloy capillary and compression fittings for engineering purposes.
Part 2: Specification for olive type copper alloy compression tube fittings.
- BS 2871** Specification for copper and copper alloy tubes.
- BS 4368** Compression couplings for tubes.
Part 1: Specification for heavy series couplings (metric)
Part 3: Specification for light series couplings (metric)
Part 4: Specification for type test requirements

International Standards Organisation

A draft standard, ISO/CD 8434-1, Metallic Tube Connections for Fluid Power and General Use, Part 1: 24 Compression Fittings, is currently in preparation. This standard covers single ferrule (24°) compression fittings.

American Standards

- ANSI/ASME B31.3** Chemical plant and petroleum refinery piping.

Industrial Standards

- ASTM A179** Specification for seamless cold-drawn low-carbon steel heat-exchanger and condenser tube.
- ASTM A276** Specification for stainless steel and heat-resisting steel bars and shapes.
- ASTM A279** Specification for Seamless and Welded Stainless Steel Tubing



ASTM B68	Specification for seamless copper tube, bright annealed.
ASTM B75	Specification for seamless copper tube.
ASTM B88	Specification for seamless copper water tube.
ASTM B210	Specification for aluminium-alloy drawn seamless tubes.
ASTM B124	Specification for copper and copper alloy forging rod, bar and shapes.
ASTM B165	Specification for nickel-copper alloy (UNS No4400) seamless pipe and tube.
ASTM B338	Specification for seamless and welded titanium alloy tubes for condensers and heat exchangers.
ASTM B425	Nickel-iron-chromium-molybdenum-columbium alloy (UNS N08825 and UNS N088221) rod and bar.
ASTM B468	Specification for welded chromium-nickel-iron molybdenum-copper-columbium stabilized alloy (UNS N08020) tubes.
NACE Std MR0175-90	Material requirements - sulphide stress cracking (1980 Revision) resistant metallic material for oil field equipment.

BP Group RPSEs

BP GS134-1	Hydraulic power supplies.
BP GS136-1	Materials for sour service to NACE Standard MR0175-94.



APPENDIX C

SERVICE RECOMMENDATIONS FOR USE OF COMPRESSION FITTINGS

Service Exposed	Marine Env.	Maximum Pressure Rating	Maximum Temp. °C	Type	Fitting	Tube Material	Material
Hydrocarbons and Sour Service	No	CL 900	430 (1)		Twin Ferrule	316 SS	316 SS
Hydrocarbons and Sour Service	Yes	CL 900	50		Twin Ferrule 825	Monel or Incoloy	Monel or Incoloy 825
Hydrocarbons and Sour Service	Yes	CL 900	430 (1)		Twin Ferrule (or eqv)	Incoloy 825	Incoloy 825 (or eqv)
Hydraulic Systems	No	Dependent on Tube Size (3)	200		'O' Ring or Twin Ferrule	316 SS	Tungum
Hydraulic Systems	Yes	Dependent on Tube Size (3)	50		'O' Ring or Twin Ferrule	316 SS	Tungum
Hydraulic Systems	Yes	Dependent on Tube Size	200		'O' Ring or Twin Ferrule	Incoloy 825 (or eqv)	Tungum
Hydraulic Systems	No	4100 psig (4)	430 (1)		'O' Ring or Twin Ferrule	316 SS	316 SS
Hydraulic Systems	Yes	4100 psig (4)	50	'O'	316 SS Ring or Twin Ferrule	316 SS	



SERVICE RECOMMENDATIONS FOR USE OF COMPRESSION FITTINGS

Service Exposed	Marine Env.	Maximum Pressure Rating	Maximum Temp. °C	Type	Fitting	Tube Material	Material
Hydraulic Systems	Yes	4100 psig	430 (1)		'O' Ring or Twin Ferrule	Incoloy 825 (or eqv)	Incoloy 825 (or eqv)
Diving Gas	No	Dependent on Tube Size (3)	200		Flared	Brass	Tungum
Diving Gas	Yes	Dependent on Tube Size (3)	200		Twin Ferrule	Incoloy 825 (or eqv)	Tungum
Sea Water	-	4100 psig (4) (5)	50		Twin Ferrule	316 SS	316 SS
Sea Water	-	4100 psig (4)	430 (1)		Twin Ferrule	Incoloy 825 (or eqv)	Incoloy 825 (or eqv)
Sea Water	-	Dependent On Tube Size (3)	50		Twin Ferrule	316 SS	Tungum
Sea Water	-	Dependent on Tube Size (3)	200		Twin Ferrule	Incoloy 825 (or eqv)	Tungum
Instrument Air (After Air Header Block Valve)	No	500 psig	100		Twin Ferrule (2)	Brass	PVC Covered Copper
Instrument Air	Yes	500 psig	50		Twin Ferrule	316	316 SS
Instrument Air	Yes	500 psig	430 (1)		Twin Ferrule	Incoloy 825 (or eqv)	Incoloy 825 (or eqv)



SERVICE RECOMMENDATIONS FOR USE OF COMPRESSION FITTINGS

Service Exposed	Marine Env.	Maximum Pressure Rating	Maximum Temp. °C	Type Fitting	Tube Material	Material
Potable Water	No	500 psig	100	Twin Ferrule	Brass	Copper
Potable Water	Yes	500 psig	50	Twin Ferrule	316 SS	316 SS
Potable Water	Yes	500 psig	430 (1)	Twin Ferrule	Incoloy 825 (or eqv)	Incoloy 825 (or eqv)
L.P Steam	No	100 psig	205	Single or Twin Ferrule (2)	Brass	Copper BS 2871 (C106)

Notes:

1. Or manufacturers Design Temperature, whichever is the lower.
2. Many installations and sites use single-ferrule and flared fittings on these services which are quite acceptable. The use of twin-ferrule fitting is recommended for new installations, in order to standardise on training and stock holding.
3. Maximum pressure rating is determined by tubing burst pressure with a 4:1 safety factor.
4. This has been determined by the maximum pressure on a 1 in. threaded connection. Higher pressures may be used for smaller sizes and for special designs as specified by the supplier.
5. 316 SS is not suitable for aerated seawater at 50°C.



INSPECTION PROCEDURES FOR INSTALLED COMPRESSION FITTINGS**D.1 Twin-Ferrule Type**

1. Some manufacturers produce a 'no-go' gauge allowing a check on the gap between the fitting body and nut to be made, to ensure that the fitting has been made up with the correct number of turns. When using fittings for which 'no-go' gauges are available, this check is to be made. Steps 2 to 7 apply whether or not such gauges are available.
2. Disassemble the fitting.
3. Ensure that the end of the tube has been cut square and is free from burrs, scratches and imperfections.
4. Visually ensure that no gross plastic deformation of tube and/or ferrules have occurred.
5. Check all threads for visible galling.
6. Verify that the ferrules are firmly secured to the tube external diameter around its periphery no less than 3 to 4 mm from the open end of the tube (see Fig. 1).
Note: A 'No-Go' gauge will not indicate that this condition has been achieved. A ferrule secured too close to tube end may result in failure and leakage.
7. On completion of the inspection, the fitting is to be re-made in strict accordance with manufacturer's instructions. (This should consist of tightening the nut to its original position, and then tightening slightly past the original position).

D.2 O-Ring Type

1. Check the extent to which the threads are covered by the nut of the fitting and the make-up torque. Details of these shall be provided by the manufacturer/supplier of the fitting.
2. Carry out procedures 2 to 5 in D.1 above.
3. Re-make the fitting, checking that both the extent to which the threads are covered by the nut of the fitting and the make-up torque are within the limits specified by the manufacturer/supplier.

D.3 Single-Ferrule Type

Carry out procedures 2 to 7 in D.1 above.



D.4 Flared Type

1. Disassemble the fitting.
2. Ensure that the end of the tube has been cut square and is free from burrs.
3. Visually ensure that no gross plastic deformation of the tube has occurred, and that no cracks or splits have developed where the tube has been flared.
4. Ensure that the diameter of the flare lies between the outside sleeve diameter and the inside sleeve diameter of the fitting (as specified by the fittings' manufacturer).
5. Check all threads for visible galling, using thread gauges as required.
6. On straight lengths ensure that tubing has been cut to the correct length (with an allowance for the tube flaring) so as not to pull on the fittings(s).
7. On completion of the inspection, the fitting is to be re-made in strict accordance with the manufacturer's instructions.

