



GS 134-1

HYDRAULIC POWER SUPPLIES

November 1993

Copyright © The British Petroleum Company p.l.c.

All rights reserved. The information contained in this document is subject to the terms and conditions of the agreement or contract under which the document was supplied to the recipient's organisation. None of the information contained in this document shall be disclosed outside the recipient's own organisation without the prior written permission of Manager, Standards, BP International Limited, unless the terms of such agreement or contract expressly allow.

BP GROUP RECOMMENDED PRACTICES AND SPECIFICATIONS FOR ENGINEERING											
Doc. No. GS 134-1		Issue Date November 1993	Latest Amendment Date								
Document Title HYDRAULIC POWER SUPPLIES (Replaces BP Engineering Standard 115)											
APPLICABILITY Regional Applicability: International											
SCOPE AND PURPOSE This Specification is for Hydraulic Power Supplies and applies to closed and open loop systems using either mineral oil, fire resistant, or water based fluids as the power transmission medium. Its purpose is for the specification of 'fit for purpose' Hydraulic Power Supplies at minimum cost.											
AMENDMENTS <table border="1"> <thead> <tr> <th>Amd</th> <th>Date</th> <th>Page(s)</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td colspan="4"> </td> </tr> </tbody> </table>				Amd	Date	Page(s)	Description				
Amd	Date	Page(s)	Description								
CUSTODIAN (See Quarterly Status List for Contact) Electrical Engineering											
Issued by:- Engineering Practices Group, BP International Limited, Research & Engineering Centre Chertsey Road, Sunbury-on-Thames, Middlesex, TW16 7LN, UNITED KINGDOM Tel: +44 1932 76 4067 Fax: +44 1932 76 4077 Telex: 296041											

CONTENTS

FOREWORD	ii
1. INTRODUCTION.....	1
1.1 Scope	1
1.2 Quality Assurance.....	1
2. GENERAL REQUIREMENTS.....	1
3. SAFETY	1
3.1 General.....	1
3.2 Noise.....	2
3.3 Isolation	2
3.4 Emergency Stop	2
3.5 Over-Pressure Protection.....	2
3.6 Hazardous Areas	3
3.7 Failure Modes and Effects Analysis (FMEA).....	3
4. DESIGN REQUIREMENTS	3
4.1 General.....	3
4.2 Maintainability and Operability.....	4
4.3 System Pressure.....	5
4.4 Capacity	5
4.5 Hydraulic Circuit	5
4.6 Instrumentation and Test Points.....	5
4.7 High Reliability	7
5. DETAILED DESIGN.....	7
5.1 Hydraulic Fluid and Material Compatibility	7
5.2 Fluid Leakage	8
5.3 Return Lines.....	8
5.4 Flow Rates	8
5.5 Air Bleeding	8
5.6 Hydraulic Tanks	8
5.7 Electric Motor Prime Movers	11
5.8 Diesel Engine Prime Movers	11
5.9 Air Motor Prime Movers	11
5.10 Prime Mover Mountings and Couplings	11
5.11 Hydraulic Pumps and Motors.....	12
5.12 Hydraulic Cylinders	12
5.13 Seals.....	13
5.14 Valves	13
5.15 Manifold Blocks	14



5.16 Accumulators	14
5.17 System Cleanliness and Filtration Equipment.....	15
5.18 Heaters and Coolers.....	17
5.19 Piping and Fittings	18
5.20 Flexible Hoses	21
5.21 Pipe Supports	22
5.22 Controls.....	22
5.23 Lifting Points.....	22
6. EQUIPMENT IDENTIFICATION	22
7. TESTING AND INSPECTION	23
7.1 General.....	23
7.2 Testing	23
7.3 Flushing.....	25
8. DELIVERY AND INSTALLATION.....	25
8.1 Protection.....	25
8.2 Installation.....	25
8.3 Grit-Blasting.....	25
8.4 Certificates	26
9. DOCUMENTATION REQUIREMENTS.....	26
9.1 General.....	26
9.2 Hydraulic Circuit Diagram	27
9.3 Service Manuals	27
APPENDIX A.....	29
DEFINITIONS AND ABBREVIATIONS	29
APPENDIX B.....	31
LIST OF REFERENCED DOCUMENTS.....	31
APPENDIX C.....	33
PREFERRED TYPES OF CONNECTION FOR PIPES IN	33
HYDRAULIC POWER SUPPLY SYSTEMS	33
APPENDIX D.....	34



FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

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

Value of this Guidance for Specification

This Guidance for Specification gives guidance on those requirements considered essential for the component parts that go to make up a Hydraulic Power Supply system.

Application

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

Text in italics is Commentary. Commentary provides background information which supports the requirements of the Specification, 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.

Specification Ready for Application

A Specification (BP Spec 134-1) is available which may be suitable for enquiry or purchasing without modification. It is derived from this BP Group Guidance for Specification by retaining the technical body unaltered but omitting all commentary, omitting the data page and inserting a modified Foreword.

Principal Changes from Previous Edition

This BP Group Guidance for Specification is a general updating and conversion to the new 'Way Forward' style of BP Engineering Standard 115.



Feedback and Further Information

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

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



1. INTRODUCTION

1.1 Scope

1.1.1 This Specification specifies BP general requirements for the design, fabrication, testing and installation of hydraulic power supplies, and the associated piping systems, for applications where the transmission of fluid power is required on demand.

1.1.2 The Specification applies to closed and open loop systems, using either mineral oil, fire resistant, or water based fluids as the power transmission medium. However, it does not apply to 'wet' power packs operating underwater.

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 specification. 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

2. GENERAL REQUIREMENTS

2.1 This Specification defines the minimum requirements for hydraulic power supply units and hydraulically driven equipment.

2.2 The power supply unit shall be sized and its main features specified by use of the accompanying data sheets (Appendix D). These shall be completed jointly by equipment vendor and purchaser and form a basis for the purchase order.

2.3 The Design philosophy for the system should be one based on minimising life cycle costs.

3. SAFETY

3.1 General

The system shall be designed such that all components operate within the manufacturer's specifications. The system, so designed shall not present a hazard to personnel or cause damage to other equipment.



3.2 Noise

Noise limitations may be specified by the purchaser, however the following limit shall be imposed unless otherwise stated:-

85 dB(A) at a distance of 1 m from the equipment.

Noise limits below 85 dB(A) may be required in some countries.

3.3 Isolation

To permit safe maintenance and inspection, means shall be provided to safely isolate all power sources (electrical, hydraulic, pneumatic) connected to the equipment concerned. Positive means to prevent accidental isolation shall be provided.

3.4 Emergency Stop

A manually-initiated emergency stop facility shall be provided local to the power pack and at any remote operator's console.

Normally a button-switch, red, mushroom-headed, stay-put, manual-reset type will suffice. When activated, all prime movers should stop and equipment motions cease, even with motion controls in the fully selected position.

3.5 Over-Pressure Protection

3.5.1 All components in the hydraulic circuit shall be protected against over-pressure.

3.5.2 If over-pressure can result from a single component failure, and if this could lead to major system or component damage, over-pressure protection shall be provided for those components or parts of systems susceptible to this over-pressure.

These requirements include, but are not limited to, the following:-

- (a) *Parts of systems located downstream of a pressure regulator should be protected by a relief valve in case of regulator failure, if they are not able to withstand the higher supply pressure.*
- (b) *Differential area cylinders operated through pilot-operated non-return valves shall either be designed for the intensified supply pressure or fitted with a local relief valve, in case of pilot-operated non-return valve failure.*

Such considerations are also relevant to any FMEA performed (see 3.7)

3.5.3 Over-pressure protection shall permit full fluid flow without the maximum working pressure of the components and piping being exceeded.



3.6 Hazardous Areas

When the equipment may be subjected to a hazardous atmosphere, appropriately protected and certified equipment shall be used.

Electrical equipment should be certified for use in the appropriate hazardous area by BASEEFA or equivalent. Equipment certified by other organisations may be suitable - seek expert advice.

3.7 Failure Modes and Effects Analysis (FMEA)

3.7.1 The vendor shall consider whether the complexity of the system, or the consequences of failure of the system are serious enough to warrant an FMEA being performed.

An FMEA is a useful tool to highlight weaknesses in a complex system design and means to overcome them. FMEAs should always be considered if the consequence of the systems failure to function properly can result in loss of life or major equipment loss.

An FMEA would usually be carried out by an independent consultant, in accordance with an agreed standard, e.g. [US MIL-STD-1629A](#). This will require, in advance of the FMEA, the vendor and purchaser to agree on which of the failure consequences will be subject to corrective action.

Consequences are often categorised as:-

- (I) Loss of life or catastrophic equipment loss*
- (II) Serious injury or major equipment loss*
- (III) Minor injury or minor unacceptable equipment damage*
- (IV) Minor acceptable equipment damage.*

Depending on a judgement or calculation of the likelihood of these consequences, Category I and II failures will usually demand corrective action through revised system design.

The purchaser and vendor should agree in advance of the FMEA, how any additional cost of corrective actions will be treated.

4. DESIGN REQUIREMENTS

4.1 General

The overall design philosophy should be based upon:-

- (a) component reliability rather than redundancy,
- (b) avoidance of components of known low reliability,
- (c) simplicity of design,



- (d) indication of fault states rather than their observation through malfunction,
- (e) minimisation and ease of maintenance,
- (f) fail safe logic, and
- (g) compatibility with local environmental conditions.

4.2 Maintainability and Operability

4.2.1 General

4.2.1.1 Drip trays shall be provided to collect any fluid lost during maintenance (see 5.2).

4.2.1.2 Removal of main components from the system for maintenance shall be possible with a minimum loss of fluid, and with minimal disturbance to surrounding pipework.

It can be assumed that maintenance which requires the dismantling of individual components shall be performed away from the system site, in a clean workshop.

4.2.1.3 For major components (e.g. pumps), or those requiring frequent maintenance, means of isolation prior to component removal shall be provided if this would otherwise result in major loss of fluid or inconvenience (e.g. draining of the reservoir).

4.2.1.4 Facilities for air bleeding shall be provided.

4.2.2 Accessibility

Component layout shall be such that the adjustment or removal of major components or pipework shall be possible without the dismantling of adjacent equipment.

In compact equipment compromises on access may be required. Problems often arise in the following areas:-

- (a) *External pipe fasteners and couplings, the removal of which require adjacent pipework to be dismantled.*
- (b) *Pumps, actuators, accumulators and filters; often these are large items and should be sited with good access for removal.*



4.2.3 Isolation

Valve actuators shall be capable of positive isolation for maintenance purposes. The status of this isolation shall be clearly visible and lockable if required for safety reasons.

4.2.4 Fault Diagnosis

Test points with simple self-sealing couplings shall be provided to enable logical fault diagnosis. Using the test points it shall be possible to locate a fault to preferably one component, or failing that to a maximum of two components, before it is necessary to remove a component from the system. See 4.6 for further details.

Diagnostic points are often omitted by system suppliers, though one of the first modifications to be made by that same suppliers' field service engineers. 'Minimess' type non-return valve tappings are adequate. Their location should be determined by consideration of fault-finding and maintenance routines for the system.

4.3 System Pressure

The design pressure of any part of the system and its associated components shall be not less than the maximum working pressure of any component in that part of the system. The design pressure shall also be adequate to meet testing requirements (see 7).

4.4 Capacity

The system capacity, defined on its volume and flow rate, shall be sufficient to maintain the system pressure within a defined band, when subject to the hydraulic service loads specified, taking account of dwell, thermal storage and differential actuator volume effects.

4.5 Hydraulic Circuit

Hydraulic circuits shall be protected from gas, liquid or solid contaminants during assembly and normal operation. Provisions shall be made to permit air bleeding of the system. Filters shall be installed to protect sensitive components.

4.6 Instrumentation and Test Points

4.6.1 Instrumentation

4.6.1.1 Instrumentation shall be selected from the following lists, and be located as indicated:-

+ local to the power pack
= at the control stand or console



- (a) + Service pump(s) delivery pressure gauge(s).
- (b) + Full depth hydraulic reservoir level sight gauge.
- (c) + Power consumption (wattmeters) of electric prime movers.
- (d) + Boost pressure gauge(s).
- (e) + Power pack delivery pressure gauge (for constant pressure systems).
- (f) + Reservoir temperature gauge.
- (g) + Reservoir high temperature alarm (visual and audible).
- (h) = Oil high temperature alarm (visual and audible). Installed downstream of cooler where fitted.
- (i) = Boost pressure low alarm (visual and audible).
- (j) Filter differential pressure gauge (visual at filter).
- (k) = Filter differential pressure high alarm (audible at console).
- (l) = Reservoir low level alarm (visual and audible). Combined with auto-start of standby pump where fitted.
- (m) = Reservoir extra low level alarm (visual and audible). Combined with trip of all pumps fitted.

Where diesel prime movers are fitted, instruments shall be provided as follows:-

- (n) + Tachometer.
- (o) + Cooling water temperature gauge.
- (p) + Fuel oil pressure gauge.
- (q) + Lubricating oil pressure gauge.
- (r) + Lubricating oil temperature gauge.
- (s) + Flow meter.
- (t) = Lubricating oil pressure low alarm (visual and audible).
- (u) = Cooling water temperature high alarm (visual and audible).
- (v) = Lubricating oil temperature high warning (visual and audible).

The diesel engine shall also be fitted with an automatic overspeed shut-down device, see 5.8.

The above lists are comprehensive and it will be appropriate to fit all the instruments only in the largest of systems. Judgement will be required by the purchaser and vendor and the system data sheets supplied in this specification used to identify exact requirements.

4.6.1.2

Safety Pattern pressure gauges fitted in accordance with the above shall be of the Bourdon type (to [BS 1780](#)) filled with glycerine. Maximum scale reading shall be 50% higher than the maximum relief valve setting, calibrated in bar and selected from the range specified in [BS 1780](#). The pressure gauges shall be fitted with an isolating valve and a



surge damping device. The isolating valve shall be of a type which permits air bleeding through a captive grub screw.

4.6.2 Test Points

4.6.2.1 Pressure test points should be designed to accept a proprietary quick connecting, self-sealing type of coupling, to permit connection and disconnection under full system pressure.

4.6.2.2 The facility to temporarily install a flowmeter shall be considered for the outlet of variable displacement pumps.

4.6.2.3 Hydraulic fluid sampling points shall be provided to allow testing for fluid contamination. Sampling points shall be provided in the base of the reservoir, and at one other point in the system of high fluid turbulence (typically after filtration).

4.7 High Reliability

4.7.1 Where the system is required to operate continuously and/or with high reliability, component redundancy shall be provided.

These circumstances will typically require:-

- (a) *a duplicate (standby) pump to the running pump, with automatic quick change-over, alarm and isolation of the defective pump circuit, or*
- (b) *multiple running pumps.*

And possibly require

- (c) *multiple actuators.*

In either case each pump should have individual prime movers, pressure line filter, pressure control valve, associated loading valve where required, and relief valve with dump line sight glass. The system should be such that interaction between duplicated components, particularly relief valves would not be possible.

5. DETAILED DESIGN

5.1 Hydraulic Fluid and Material Compatibility

5.1.1 The hydraulic fluid and any additives used shall be agreed between vendor and purchaser. Where practical and appropriate for the duty, BP fluids shall be used.

5.1.2 The fluid shall retain its essential properties at all temperatures between maximum and minimum design temperature.



- 5.1.3 A fluid with a high viscosity index is preferred. Due consideration shall be given to the predicted fluid viscosity at both start-up and operating temperatures.

Viscosity index (VI) indicates the change in viscosity to be expected with increased temperature. The higher the VI, the more stable the system behaviour will be under load.

- 5.1.4 Components used in hydraulic systems shall be compatible with the selected hydraulic fluid and with the maximum operating temperature. In particular, care shall be taken when selecting materials for 'O' rings, gaskets and seals.

- 5.1.5 The materials of system components shall also be compatible with or adequately protected from the environment in which the system will operate.

5.2 **Fluid Leakage**

Where maintenance or the removal of system components may result in the unavoidable release of hydraulic fluid, means to collect and drain this fluid to a safe point shall be provided.

5.3 **Return Lines**

Motor drain lines returning to tank shall be independent of each other, and pilot return and spool valve drain lines shall be independent of primary low pressure lines.

If these lines are common, pressure build-up in return lines, due to high flow rates or blocking return line filters, can result in spurious component operation (e.g. piloted valves, pressure regulators) where such components rely on a constant, low drain pressure.

5.4 **Flow Rates**

The pressure drops resulting from the maximum operating fluid flow, the selected line size and the number of bends shall be compatible with safe system operation across the operating temperature range.

5.5 **Air Bleeding**

The system shall be fitted with bleed points to permit the safe release of air at positions where a build-up of air is likely and where this would affect system operation. The bleeding device shall be of a design such that the moving part remains captive at all times.



5.6 Hydraulic Tanks

5.6.1 Construction

5.6.1.1 The tank shall be constructed from stainless steel plate without any internal coating. Only special circumstances may dictate otherwise. The wall thickness of the tank shall be sufficient to support the fittings and penetrations, or local stiffening shall be provided. The tank design shall permit easy cleaning.

5.6.1.2 Fixtures and fittings exposed to the tank interior shall also be constructed from stainless steel or an equivalent corrosion resistant material.

5.6.2 Capacity

5.6.2.1 The criteria for sizing the tank shall be dependent on the system concerned:-

- (a) for continuous power transmission systems, based on the residence time required for adequate air separation and cooling, or
- (b) for essentially static systems (e.g. valve actuation systems powered by charged accumulators), based on the fluid volume change within the system.

5.6.2.2 For continuous power transmission systems, the tank capacity shall be sized for all combinations of fluid flow rates encountered during system operation and shall be adequate for drain down of the total circuit contents. The capacity shall be at least 1.1 times the maximum fluid volume contained, to allow space for thermal expansion and air separation. The maximum fluid volumetric capacity shall be not less than 3 times the maximum operating discharge rate per minute. Allowance shall also be made for changes in volumetric capacity of other system components during operation.

5.6.2.3 For control systems (e.g. for valve actuation) the capacity shall be such that the operating volume between the maximum and minimum levels shall hold the complete control system capacity plus 20%.

5.6.3 Suction and Return Lines

The suction and return connections on the tank shall be adequately separated to promote fluid cooling and air separation. The discharge end of the return line shall be submerged at all times and direct the fluid flow towards the tank wall and away from the pump suction.



5.6.4

The following fixtures and fittings shall be provided:-

- (a) Means of filling the tank either by an air or electrically driven lift pump, or hand pump shall be provided. A coarse strainer shall be incorporated at the fill point.

The method of filling adopted will depend on system size and utilities available. It should be possible to fill the tank in less than 1 hour. A permanently installed filling pump is usually preferred, located adjacent to the reservoir. Any filling device should include an in-line 6 micron absolute filter (without bypass), relief valve back to pump suction (except hand pump), and hose for connection to hydraulic oil drums.

- (b) A tank drain point at least 25 mm diameter and isolation valve shall be provided at the lowest point and through the base plate of the reservoir.
- (c) Baffles, or an equivalent shall be fitted between the suction and return lines to promote cooling and air separation from the working fluid.
- (d) Means to prevent the ingress of airborne liquid or solid contaminants and moisture accumulation through breathing shall be provided.

Bladder compensators are preferred and where used, over-pressure and vacuum relief check valves need to be fitted to protect the bladder. This requirement may be relaxed for systems permanently sited in a controlled indoor environment.

- (e) Access to the inside of the tank for effective cleaning shall be provided.

A bolted and sealed manhole connection will suffice. (Special provision may be necessary on small systems). Take care with selection of fluid-compatible gasket materials.

- (f) A tank connection, identical and adjacent to the main fluid return line connection, shall be provided as a spare entry for possible future use. (Special provision may be necessary on small systems).
- (g) A clearly visible full depth level gauge shall be provided. High and low fluid levels shall be indicated. The gauge shall be either of the armoured type or otherwise suitably protected against accidental damage. The gauge shall be of a type which will not discharge the tank contents in the event of gauge glass failure and which does not require manual intervention to read.

This requirement can easily be met with standard equipment, but could be relaxed for small systems on non-critical duty. Note: N.Sea offshore regulations require special precautions for isolation of combustible inventories.

- (h) Level switches if required as indicated in 4.6.
- (i) For operating capacities greater than 500 litres , the tank shall be provided with at least one additional port and cover plate, below the minimum fluid level, not less than 150 mm diameter suitable for fitting a spare heater or additional instrumentation.
- (j) Means of isolation shall be provided to enable removal of pumps and filters without the need to drain the tank.
- (k) Under certain circumstances the outlet valve from the tank shall be capable of being closed from a remote location. Otherwise these valves shall be capable of being locked open.

See commentary for (g).

5.7 Electric Motor Prime Movers

- * 5.7.1 If an electric prime mover is selected it shall comply with a separate electrical specification to be supplied by BP.
- 5.7.2 Electric prime movers are preferred for systems where the prime mover may be required to cut in and out automatically (e.g. hydraulic control systems powered by charged accumulators).

5.8 Diesel Engine Prime Movers

- * 5.8.1 If a diesel engine prime mover is selected it shall comply with a separate specification to be supplied by BP.
- 5.8.2 The engine shall be fitted with an automatic overspeed shut-down device.

5.9 Air Motor Prime Movers

Air motor prime movers, if selected, shall be compatible with the maximum and normal air supply pressures as specified on the data sheets.

The utility air quality will normally require an air filter and lubricator to be supplied with the motor.



5.10 Prime Mover Mountings and Couplings

Rotating shafts and couplings shall be guarded. The guidelines concerning the guarding of machinery in [BS 5304](#) shall apply.

The type of couplings and the method of fitting should be approved by the manufacturers of both the driving and driven units. Normally, pumps should be seated on resilient mounts and connected to the system with flexible hoses.

5.11 Hydraulic Pumps and Motors

5.11.1 Ready access for precharging components with oil shall be provided where necessary.

5.11.2 If removal of the pump could result in a significant loss of system fluid, means to isolate the pump before its removal shall be included. Such isolation shall be capable of being locked open.

5.12 Hydraulic Cylinders

5.12.1 Hydraulic cylinders and their anchor points shall be designed to withstand all associated loadings, and their sizes selected from the [CETOP guidelines, publication RP 10H](#).

Loads to consider are axial loads, bending moments, internal pressures (including pressure spikes due to sudden accelerations) and side loadings due to asymmetry. The requirements of pressure vessel codes [BS 5500](#) or [ASME VIII](#) can be applied.

Cylinder and rod end mountings which incorporate bolt fixings, should be provided with shear pads or dowels such that the mounting bolts are not subject to shear loading.

5.12.2 Damping of piston travel shall be included at each end of the cylinder.

This avoids limit shock load transmission to associated structures.

5.12.3 Cylinder rods exposed to a marine or corrosive environment (see Data Sheets) shall be manufactured from stainless steel grade 316 and chrome plated.

Exposed rods of carbon steel with chrome plating alone are inadequate for any outdoor duty. Even nickel coating with chrome finish will have a much reduced life compared to stainless steel in a marine environment.

For single-acting cylinders, special protection (e.g. oil-filled header tank) should be considered to protect the ambient pressure side of the cylinder from moisture and contaminant ingress.

5.12.4 Seal arrangements shall be chosen to suit the local environmental conditions.

For most circumstances, a single pressure seal plus one scraper seal are adequate. For dusty environments, higher integrity dry rod seals should be used and cylinders fitted with flexible gaiters to protect the rod seals from damage. Such gaiters should then incorporate drainage holes to prevent the accumulation of moisture.

Cylinder ports should be internally bevelled, if necessary to avoid damage to piston seals during assembly.

5.12.5 All cylinders shall be fitted with air bleed points as specified in 5.5.

5.12.6 The system shall be designed to ensure that in the 'stowed' position the cylinder rods are in the retracted position.

5.13 Seals

5.13.1 All seals shall be compatible with the hydraulic fluid, the external environment, and the pressure differences imposed during operation.

The seal design and associated component clearances should be such as to prevent extrusion of the seal and leakage past the seal when held under design pressure for extended periods.

5.13.2 Seals on pipe joints shall comply with the requirements in 5.19.

5.14 Valves

5.14.1 Valves shall wherever possible be surface mounted on manifold blocks, rather than line mounted.

5.14.2 Valves designed for flow in one direction only, shall be clearly and permanently marked on the surface of the valve.

5.14.3 Valves having adjustable position settings shall be capable of adjustment under pressure and shall maintain their settings under operating conditions and when subject to vibration.

5.14.4 Direction control valves shall:-

- (a) employ the manufacturers standard spool designs,
- (b) be designed to avoid hydraulic lock,
- (c) have pressure balanced spools (i.e. not inadvertently operated if the drain line of the valve becomes pressurised), and
- (d) be capable of manual override (but protected against accidental operation).

- 5.14.5 Solenoid operated valves shall:-
- (a) operate correctly within + 10% or - 15% variation of the electrical supply voltage,
 - (c) be continuously rated,
 - (d) be suitably sealed and glanded to prevent the ingress of dirt and moisture, consistent with the environmental conditions,
 - (e) be capable of manual override (but protected against accidental operation) without the need to remove the solenoid cover.
- 5.14.6 Pressure relief valves shall be provided to safeguard the system against over-pressure due to thermal expansion effects in parts of the system where fluid may be 'locked in' e.g. between non-return valves and manifold isolation valves. Pressure regulators shall not be used for this duty.
- 5.14.7 Where necessary to prevent drain down of the system when not operating, spring loaded non-return valves shall be fitted to tank return and drain lines.
- 5.14.8 Where installed in conjunction with actuators, isolation valves, pilot operated check valves or counterbalance valves shall be mounted directly at the actuator ports.
- 5.15 Manifold Blocks**
- 5.15.1 Manifold blocks shall be used for component mounting where practical.
- 5.15.2 Manifold blocks shall be manufactured from hot rolled or forged steel and shall be individually pressure tested (Sections 7 and 8).
- 5.16 Accumulators**
- 5.16.1 Accumulators shall comply with the requirements of [BS 5045: Part 1](#).
- 5.16.2 The charging medium shall be nitrogen.
- 5.16.3 All accumulators shall be supplied complete with a safety pressure relief valve, a charging valve and a means to measure the nitrogen pressure.
- 5.16.4 Means to safely and positively isolate the accumulator from the rest of the hydraulic system shall be provided.

5.16.5 Means shall be provided to safely relieve the nitrogen and fluid pressures before removal of the accumulator.

5.16.6 Adequate information to enable safe servicing of the accumulator shall be provided in the service manual and on the hydraulic circuit diagram, and a local warning plate to this effect, installed.

5.17 System Cleanliness and Filtration Equipment

5.17.1 The filtration equipment provided shall maintain the cleanliness of the hydraulic fluid within the operating limits specified by the manufacturers of all components forming part of the hydraulic power system.

If these limits are unknown, the cleanliness levels recommended in the 'Guidelines to Contamination Control in Hydraulic Power Systems', a publication of the British Fluid Power Association, may be used. A cleanliness level of class 16/14 (ISO 4406) or class 8 (NAS 1638) should be considered a minimum requirement, however, equipment embodying components with a high sensitivity to contamination will require a higher standard accordingly.

Filter elements should be of the disposable (i.e. non-cleanable) type, designed not to release contaminant to the hydraulic circuit during their replacement. Provision to drain the filter bowl during change-out is useful.

When specifying filters, parameters referred to in the following sections shall be used:-

- (a) Particle removal rating (5.17.5 and 5.17.6)
- (b) Size (flow rating)
- (c) Collapse pressure rating
- (d) Bypass valve opening pressure
- (e) Indicator setting
- (f) Operating pressure rating

5.17.2 Two acceptable contamination levels shall be agreed between vendor and purchaser:-

- (i) Maximum operating contamination level
- (ii) Maximum contamination level to be achieved during flushing.

The latter will typically be one class better than the maximum operating level; e.g. class 15/13 (class 7) for an operating level of 16/14 (Class 8).



- 5.17.5 High pressure filters shall be fitted to each pump discharge line.
- To achieve the fluid cleanliness levels specified, these would typically be rated such that Beta is not less than 75 at 12 microns (ref. [ISO 4572](#)). This is equivalent to a filter rating of 12 microns absolute.*
- 5.17.6 Return line filters shall be fitted to each line connected directly to the reservoir.
- To achieve the cleanliness levels specified, these would typically be rated such that Beta is not less than 75 at 12 microns (ref. [ISO 4572](#)). It should be noted that there are benefits from installing even finer filtration on the return line.*
- The return line filters should be generously sized to reduce the load and extend the life of the pressure line filters.*
- 5.17.7 The filter element shall be sized such that under 'cold start' full flow conditions, with a clean element, no flow shall pass through the bypass valve.
- 5.17.8 The element shall be sized such that under normal operating temperatures and flows, with a clean element, differential pressure does not exceed 0.5 bar or one quarter of the indicator setting whichever is the lesser.
- Good quality filter suppliers should have no difficulty meeting this requirement. If this requirement is not met, the 'filter blocked' indicator can trigger frequently.*
- Special attention shall be given to filtration size in systems using ram actuators, owing to possible high return line flows.*
- 5.17.9 All filters shall normally be fitted with a correctly sized by-pass valve and filter blocked indicators.
- The bypass valve should be sized such that when fully open, the differential pressure across the element is less than one half of the element collapse pressure rating. The bypass valve should not start to open until a pressure at least 30% higher than the indicator operating pressure is reached.*
- Filters should be fitted locally with visual differential pressure indicators to signal filter condition. The indicators shall have a thermal lock-out to prevent operation under 'cold start' conditions. The reset of a visual indicator should be manual, not automatic.*
- 5.17.10 Where agreed between purchaser and vendor, filters shall also be fitted with electrical means to provide remote alarm in the event of a filter blockage.
- A common alarm covering all filters associated with one power unit will often suffice.*

- 5.17.11 To prevent undue loss of system fluid, means of isolation of the filter housing shall be provided for maintenance purposes.

5.18 Heaters and Coolers

- 5.18.1 Thermostatically controlled heaters or coolers shall be used where control of the hydraulic fluid temperature, or its viscosity is required within specified operating limits.

Whether to fit a heater should be based on the minimum ambient temperature, the viscosity index of the system working fluid, and the cold-start requirements of main prime movers. If heaters are required, they should be fitted to the system reservoir.

For some systems it may be desirable to interlock power pack operation with temperature monitoring, to inhibit operation until fluid temperature is within acceptable limits.

- 5.18.2 Heaters shall incorporate a thermal cut-out with manual reset.

The cut-out must be independent of the normal thermostat control. It may be wired into the reservoir temperature gauge, if fitted, provided this system is independent of the heater thermostat.

- 5.18.3 The power dissipated at the heater surface shall not exceed 7 kW/m².

Power per unit area is limited to prevent carburisation of some hydraulic oils.

- 5.18.4 For water coolers, the water supply pressure shall not exceed the normal operating hydraulic fluid pressure in the cooler.

This prevents a cooler failure resulting in gross water contamination of the hydraulic system. A pressure regulator for the water supply should be included with the power pack, if the maximum possible supply pressure is too high.

Coolers should also be compatible with the oil-side pressure drops associated with the maximum flow at the lowest temperatures, and with the maximum inlet temperatures of both the cooling medium and the hydraulic fluid.

- 5.18.5 The cooler shall also be designed to accept the worst case differential pressures, associated with the maximum working pressures of the fluid on each side of the exchanger surface acting in isolation.

- 5.18.6 The cooler shall be fitted with an automatic full flow by-pass arrangement where necessary for cold start conditions.

5.19 Piping and Fittings

- 5.19.1 All components shall be interconnected with hard piping except where flexible hose is used to allow for relative movement between components, (see 5.21).



This general requirement is based on the premise that the long term reliability of hard piping is greater than flexible hose, which can be subject to damage due to abrasion, overpressure, kinking or twisting. Some operators accept the widespread use of flexibles, but impose a, say 7 year, change-out program.

- 5.19.2 Piping, fittings and valve trim materials shall be selected to be compatible with the environment in which they are to operate. Specially resistant materials are essential for long term use in marine or subsea environments.

The following guide should be used for material specification of pipes, fittings and valve trim:-

(a) *For exposed marine environments:-*

either

- (i) *Grade 316 stainless steel, solution heat treated (grade 316L for welded components), providing material temperature does not exceed 50_C. Solution heat treatment is particularly important for subsea components which will suffer preferential corrosion at sites work-hardened during machining.*

or

- (ii) *Al-Ni-Si brass tubing to [BS 1306](#). This material is a traditional alpha-brass in widespread use on tankers and ships, with a particularly good track record. 'Tungum' is perhaps a better known name for the same material.*

(b) *For non-corrosive environments:-*

either

- (i) *Cold drawn carbon steel, annealed, descaled, oiled and plugged.*

or

- (ii) *Hot finished seamless carbon steel, descaled, oiled and plugged.*

Surface coatings should be to an appropriate standard, e.g. BP Group [GS 106-2](#).

- 5.19.3 Piping sizes shall be selected as follows:-

(a) To limit the fluid velocity to the following maximum values:-

- 4 m/s for pressure lines
- 2 m/s for return lines
- 1 m/s for drain lines
- 1 m/s for suction lines

These velocity limits are suggested to minimise noise and cavitation potential.



- (b) To limit the pressure drops in the circuit to the following maximum values:-

10 bar for pressure lines
2 bar for return lines
1 bar for drain lines
0.2 bar for suction lines

These pressure drop limits are suggested to avoid component malfunctions and unnecessary power losses.

5.19.4 The design pressure of piping shall be not less than the following values:-

- (a) 400 bar (g) (or maximum working pressure, whichever is the higher), for pipes up to and including 20 mm outside diameter
(b) 250 bar (g) (or maximum working pressure, whichever is the higher), for pipes between 20 mm and 38 mm outside diameter
(c) Maximum system working pressure, in bar, for pipes in excess of 38 mm outside diameter.

These values will limit the number of types of pipe used in the system (useful for maintenance and specification purposes) and ensure the pipes have a strength sufficient to resist extraordinary external loads.

The minimum wall thickness of carbon steel or stainless steel pipes shall be based on the formula:-

$$t = \frac{2.25 pd}{f + 2p}$$

which allows for a 4:1 safety factor, and a 12 1/2% allowance for manufacturing tolerance and wall thinning at bends.

*t = pipe wall thickness, mm
p = design pressure, N/mm²
d = pipe outside diameter, mm
f = minimum tensile strength, N/mm²*

For copper alloy piping, minimum wall thickness should be determined from [BS 1306 : 1975](#), with allowance for manufacturing tolerances and wall thinnings at bends.

5.19.5 Pipe connections shall be selected in accordance with the following criteria:-



- (a) Whether the connections are regarded as (i) 'sealed for life' or (ii) may require disconnection for inspection or maintenance purposes.
- (b) The pipe diameter.
- (c) The working pressure of the line.

See Appendix C for preferred types of fittings.

5.19.6 Fittings of a given type shall all be obtained from the same manufacturer (e.g. different makes of compression fittings shall not be mixed).

5.19.7 Tapered thread connections are not permitted.

The use of tapered thread fittings requires the use of PTFE tape or a sealing compound such as Loctite. There have been numerous examples of system malfunction due to these sealants entering the circuit and blocking control ports or jamming spool valves. Contamination is especially likely during subsequent system maintenance when the fittings are broken and re-made with new sealant.

While it may be impossible or impractical to obtain some main components with parallel thread ports (e.g. casing drain points on some pumps and motors), this clause should be adhered to wherever reasonably practical.

5.19.8 Threaded connections shall be of the parallel thread type. A sealing method employing captive 'O' rings or bonded washers shall be used. Systems which are required to be fire resistant may require special consideration.

Parallel thread systems are often sealed with bonded polymeric washers. These do not exhibit fire resistance. If this is required (e.g. wellhead control systems), metal-metal sealing systems should be used.

5.19.9 Non-standard thread forms are not permitted. Thread forms shall be to an internationally recognised standard.

5.20 Flexible Hoses

5.20.1 The use of flexible hose shall be minimised and only permitted in special circumstances, as described in 5.19.

5.20.2 Flexible hoses shall conform to an internationally recognised standard such as [ISO 3862 \(BS 4586\)](#), [ISO 1436 \(BS 3832\)](#) or [SAE Standard J517 100R-Series](#), and conform to the maximum allowable working pressures therein.



- 5.20.3 Each hose assembly, complete with its end fittings, shall be pressure tested to 1.5 x design pressure.

It is good practice to stamp the type of hose, and design pressure on one end fitting.

Hoses should have been type tested with certification of witnessed burst and impulse testing. The minimum proof bursting pressure shall be at least 4 times the design pressure of the hose.

Where practical, hoses should be limited to two sizes only in bore and length, to limit the stock-holding of spares.

- 5.20.4 Flexible hoses shall be installed in accordance with the hose suppliers recommendations and limitations.

Hoses should be installed

- (a) *without twist,*
- (b) *without bends of a radius less than the minimum recommended by the manufacturer,*
- (c) *without contact with other hoses or equipment such that external damage to the hoses could occur during operation,*
- (d) *adequately restrained if hose failure would present a hazard, and*
- (e) *away from damaging heat sources.*

- 5.20.5 The hose end fittings shall be of the swaged type, with female running nuts.

Hose end fittings of a screwed compression-grip type are unsuitable.

5.21 Pipe Supports

Pipework shall be adequately supported. The maximum support intervals shall be as follows:-

- (a) 1 m for pipes up to and including 20 mm outside diameter.
- (b) 2 m for pipes between 20 and 38 mm.
- (c) 3 m for pipes above 38 mm outside diameter.

It is good practice to position pipe supports immediately before and after a bend, and immediately before a change from hard pipe to flexible hose. Pipe supports should be of a vibration absorbing non-metallic material.

5.22 Controls

Control station location, panel layout and control device types shall be mutually agreed between purchaser and vendor.

Particular considerations are:-

- *protection from accidental operation,*
- *directional, proportional, spring-centred to neutral controls for mechanical handling equipment,*
- *clear markings to identify the type and direction of operation,*
- *station siting to allow the operator a full view of operations.*

5.23 Lifting Points

5.23.1 Lifting points designed and certified to statutory requirements, shall be fitted to heavy or bulky equipment to assist in handling and removal.

5.23.2 The power pack shall be clearly and permanently marked with both the empty and full self weight.

6. EQUIPMENT IDENTIFICATION

6.1 All components, pipe and hose runs shall be clearly and permanently tagged with references identical to those on the hydraulic circuit diagram.

The tags shall be of stainless steel or brass construction, securely attached to each component.

It may be relevant to use the BP numbering system as per BP Group [GS 144-1](#).

For major components (pumps, motors, valves, cylinders, accumulators) the following should always be identifiable on the tag, nameplate or in the manual:-

- (a) *Manufacturers name and location.*
- (b) *Component type number.*
- (c) *Design pressure.*
- (d) *The appropriate symbol from [ISO 1219 \(BS 2917\)](#).*
- (e) *Voltage and current rating where applicable.*
- (f) *For filters: rating in microns, direction of flow, element reference code, number of elements per housing.*
- (g) *For accumulators: serial number; year of manufacture; total shell volume; design pressure; test pressure; legal stamp; gas type and precharge pressure; a warning sign as described in 5.16.*



It is particularly important to identify component ports, test points, bleed points and manifold block ports, in a manner consistent with that used on the circuit diagram.

- 6.2 The fluid to be used when filling and the total and operating capacity of the system shall be marked on the reservoir.

7. TESTING AND INSPECTION

7.1 General

The vendor and purchaser shall agree the level of testing and inspection required, including any third party inspection, and the split of this between vendor factory acceptance tests and on-site system commissioning.

7.2 Testing

- 7.2.1 Tests shall be carried out to meet the full requirements of statutory authorities and any test programme agreed between vendor and purchaser.
- 7.2.2 Pressure tests shall be performed on all piping, hose assemblies, filters and manifold blocks to 1.5 times the design pressure. This test may be performed on components individually or on groups of the components as part of the integrity test in 7.2.3. The test pressure shall be held, without loss, for a minimum of 30 minutes.
- 7.2.3 An integrity test shall be performed on the whole system, at the maximum working pressure for a duration of 30 minutes. System relief valve settings may if necessary be temporarily increased to permit this test.
- 7.2.4 For certain hydraulic systems (e.g. cranes, man-riding equipment) there may be a statutory requirement to subject the system to a specified mechanical overload, above the maximum working pressure. For such systems, the components shall be approved as suitable for use under the overload condition by the equipment supplier.
- 7.2.5 Fluid contamination level shall be measured, to demonstrate cleanliness is within the specified limits.
- 7.2.6 The power supply shall be function tested in conjunction with the complete system. Acceptance of the power supply may therefore be dependent on total system integration and testing, if so agreed between vendor and purchaser.



Function tests should normally be carried out both in the factory acceptance tests, and post-installation to cover the following:-

- (a) Reservoir level switches and alarms.*
- (b) Maximum pressure and flow delivered by pumps.*
- (c) Proper functioning of each alarm and safety devices.*
- (d) Proper functioning of each control and the powered equipment.*
- (e) No excessive vibration or pressures surges.*
- (f) No mechanical damage results from system operation.*
- (g) All fastenings are secure.*
- (h) No filters are by-passing.*
- (i) Noise levels are acceptable.*
- (j) The steady state operating temperature of the fluid is within design limits.*

Prior to these tests, calibration of all instruments, flow and pressure regulating valves, temperature and pressure switches and gauges should have been carried out.

The above tests should be carried out with the system under load and for a period long enough to allow steady state conditions to be reached.

7.2.7 All testing and inspection shall be logged and the records submitted as part of the operating documentation.

7.3 Flushing

If necessary to achieve the agreed levels of cleanliness, the power supply and/or the assembled total system shall be flushed. The flushing details should be agreed between vendor and purchaser.

Other than for very simple systems, it is advisable to prepare a flushing procedure. Flushing should be carried out after installation and before functional testing, using a separate flushing skid with dedicated filtration. Flushing should be carried out with the same type of fluid to be used in the system. Exceptions to this are:-

- (a) carbon steel systems requiring internal anti-corrosion treatments*
- (b) silver-soldered copper alloy pipework, where hot water flushing is required to remove flux deposits.*

Pulsed and nitrogen-injection-assist systems are a relatively new innovation and can be particularly effective.



8. DELIVERY AND INSTALLATION

8.1 Protection

8.1.1 All components or sub-assemblies shall be drained and adequately protected for shipment and storage prior to final assembly.

8.1.2 All ports and openings shall be suitably plugged or sealed prior to shipment, and shall remain so until final assembly commences.

8.2 Installation

After delivery and installation, the system shall be inspected to confirm it is free from damage.

Actuators should be checked for damage (to cylinder rods or mountings) and correct mounting.

The alignment of prime movers and driven equipment should be rechecked.

8.3 Grit-Blasting

Where grit blasting is required, all hydraulic components shall be protected from contamination.

8.4 Certificates

Test, inspection, and approval certificates shall be provided and include:-

(a) Pressure tests on individual components.

Normally required for all hose assemblies, piping, manifold blocks, accumulators and hydraulic cylinders. Valves, pumps and motors may be covered by a letter of conformity.

(b) Pressure test for the complete system (see 7.2).

(c) Cleanliness level attained during flushing.

(d) Electrical items certified for use in hazardous areas.

(e) Instrument calibrations.



9. DOCUMENTATION REQUIREMENTS

9.1 General

9.1.1 System design documents shall be supplied to a schedule agreed between vendor and purchaser. Documents should include:-

- (a) a hydraulic circuit diagram and component schedule,
- (b) an electrical circuit diagram and component schedule,
- (c) for multi-load systems, a power flow diagram (showing how prime mover input power is distributed amongst all end users, hydraulic or otherwise),
- (d) general arrangement drawings, showing the major system components; cross-section drawings where appropriate,
- (e) copies of the manufacturer's data sheets for all system components.
- (f) a piping layout drawing,
- (g) service manuals,
- (h) certification documents (see 8.4),
- (i) testing logs,
- (j) commissioning instructions, including a detailed flushing procedure,
- (k) recommended spares lists for commissioning and operation.

Depending on contract strategy, (a), (b), (c) and (d) could be supplied in a preliminary form with the tender, and (e) submitted after contract award. (e) are regarded as essential for subsequent system maintenance, and are often required at the design appraisal stage of complex systems.

9.2 Hydraulic Circuit Diagram

The circuit diagram shall use graphical symbols in accordance with [ISO 1219 \(BS 2917\)](#) and include full component and setting details to allow the reader to establish modes of operation.

Typical details which the circuit diagram should include, some of which may require amendment to as-commissioned status, are:-



- *Discrete identification number for each component, identical to that used to physically tag the item*
- *Prime mover : power in kW, starting and full load currents, r.p.m. and type.*
- *Pumps : type, displacement per revolution, maximum working pressure and speed.*
- *Motors : type, displacement per revolution, torque output at a given set of conditions, maximum working pressure and speed.*
- *Gearboxes : ratio, r.p.m, and type.*
- *Hydraulic cylinders : type, stroke length, bore area, and rod area.*
- *Size and specification of each pipe or hose.*
- *Filters : type, size rating (in microns absolute) flow rating (in litres per minute) and by-pass setting.*
- *Accumulators : total volume, maximum and minimum working volumes, and pre-charge pressure.*
- *Reservoir : overall capacity, maximum and minimum working capacities and maximum discharge rate.*
- *Hydraulic fluid : description, specification and viscosity.*
- *Relief valves : pressure settings.*
- *Test points : location and type.*
- *Heat exchangers : flow rates, type of cooling fluid, inlet and outlet temperatures, maximum working pressures on both sides.*
- *Fluid sample points.*
- *Air bleed points.*

9.3 Service Manuals

A service manual shall be supplied containing as a minimum the following information:-

- (a) Description of the operation of system, including valve sequences and interactions.
- (b) Hydraulic circuit diagram.
- (c) Electrical circuit diagram.
- (d) Start up and shutdown procedures.
- (e) Service procedures for each maintainable assembly.
- (f) Details of consumables and replaceable elements.
- (g) A list of the recommended spares holding.
- (h) Routine maintenance procedures and recommended service intervals.
- (i) System flushing procedure and cleanliness levels to be maintained.



- (j) A full parts schedule itemising all components and indicating where common components are used and can be interchanged.
- (k) Copies of manufacturer's data sheets for all hydraulic components.
- (l) A lubrication chart.
- (m) Details of the type and mode of operation of all safety devices.
- (n) Trouble-shooting procedures.



DEFINITIONS AND ABBREVIATIONS**Definitions**

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

actuator:	a device for converting fluid power (pressure and flow) into mechanical power, e.g. a motor or hydraulic cylinder.
closed loop system:	a system in which one (or several) pumps are associated with one (or several) motors, allowing oil to continuously circulate between pump(s) and motor(s). Oil loss from the loop is replenished by a separate make-up pump supplying oil to the low pressure side of the loop.
design pressure:	the pressure at which components within a system are designed to withstand. At least equal to the maximum working pressure.
maximum working pressure:	the maximum pressure at which the circuit or component may operate under extreme conditions, for example at that governed by a relief valve setting. Special interpretation may be required for systems involving cross-line relief valves.
open loop system:	a system in which the hydraulic fluid is drawn from the reservoir by the pump and then delivered to the motor or cylinder drivers via a control system, before dumping back to the reservoir.
test pressure:	the pressure to which the system is tested prior to commissioning. This is the highest pressure the hydraulic system will be subject to under normal circumstances.
working pressure:	the pressure generated in a circuit or component during steady state operation of the system.



Abbreviations

BS	British Standard.
BASEEFA	British Approvals Service for Electrical Equipment in Flammable Atmospheres.
CENELEC	European Committee for Electrotechnical Standardisation.
CETOP	Comite Europeen des Transmissions Olehydrauliques et Pneumatiques.



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.

<i>ISO 1219</i> (identical to BS 2917)	<i>Specification for graphical symbols used on diagrams for fluid power systems and components.</i>
<i>ISO 1436</i> (identical to BS 3832)	Specification for wire reinforced rubber hoses and hose assemblies for hydraulic installations.
<i>ISO 3862</i> (identical to BS 4586)	Specification for spiral wire reinforced rubber covered hydraulic hoses and hose assemblies.
<i>+ISO 4406</i> (technically equivalent to BS 5540 Pt. 4)	<i>Hydraulic fluid power - Fluids - Methods for coding level of contamination by solid particles.</i>
<i>ISO 4572</i> (identical to BS 6275 Pt. 1)	<i>Hydraulic fluid power filter elements. Method of evaluating filtration performance (multi-pass method).</i>
<i>CETOP</i>	Guidelines, Publication RP 10H (available from The British Fluid Power Association).
<i>BS 1306</i>	<i>Copper and copper alloy pressure piping systems.</i>
<i>BS 1780</i>	Specification for bourdon tube pressure and vacuum gauges.
<i>BS 4368</i>	Carbon and stainless steel compression couplings and tubes Part 1 : Specifications for heavy series couplings Part 3 : Compression couplings for tubes Part 4 : Specification for type test requirements.
<i>BS 5045</i>	Transportable gas containers Part 1 : Specification for seamless steel gas containers above 0.5 litre water capacity.

BS 5304	Code of Practice for safeguarding of machinery.
BS 5500	<i>Specification for unfired fusion welded pressure vessels.</i>
ANSI B16.9	Factory made wrought steel butt welding fittings.
ASME BPV-VIII	<i>Boiler and pressure vessel code. Section VIII. Pressure Vessels.</i>
MIL-STD-1629 (USA Department of Defense)	<i>Military Standard. procedures for performing a failure mode, effects and criticality analysis.</i>
NAS 1638	<i>Cleanliness requirements of parts used in hydraulic systems.</i>
SAE STD J517	Hydraulic hose.
BP Group GS 106-2	<i>Painting of Metal Surfaces (replaces BP Std 141)</i>
BP Group GS 144-1	<i>Plant Equipment Identification (replaces BP Std 254)</i>
+ In course of preparation	



**PREFERRED TYPES OF CONNECTION FOR PIPES IN
HYDRAULIC POWER SUPPLY SYSTEMS**

Pressure	Outside Diameter (mm)	Material	Connections for breakable joints	Connections for permanent joints
High	6 to 25	316 S/S Carbon steel	Compression or flared tube fittings of a type agreed with BP	Compression or flared tube fittings of a type agreed with BP
High	12 to 50	316 L S/S Carbon steel	SAE or weld-neck ANSI flanges	Butt-welded fittings schedule 160 or XXS (in accordance with ANSI B16.9)
High or Low	6 to 76.1	Copper based alloy	Fittings (type 'C') to BS 4368 Part 1 compatible with tube material (6 - 50 mm)	Silver soldered fittings of a type agreed with BP (6 - 76.1 mm)
Low	6 to 33	316 S/S Carbon steel	Compression or flared tube fittings of a type agreed with BP	Compression or flared tube fittings of a type agreed with BP
Low	12 to 100	316 L S/S Carbon steel	SAE or weld-neck ANSI flanges	Butt-welded fittings (schedule 40 in accordance with ANSI B 16.9)

- Note: 1) Compression fittings shall not be used on pump suction lines.
- 2) High pressure : greater than 30 bar (ga).
Low pressure : up to 30 bar (ga).
- 3) Materials shall be selected in accordance with Section 5.20 of this Standard.
- 4) Compression or flared tube fittings shall comply with [BS 4368](#) parts 1, 3 and 4.

INDENT/PURCHASE ORDER NUMBER TO BE COMPLETED IN BLOCK CAPITALS		PAGE 1 OF 2		
TO BE COMPLETED BY EQUIPMENT VENDOR AND CHASER AS APPROPRIATE				
PUR				
1	SERVICE DESCRIPTION:			
2	ITEM NO:			
	PRESSURES			
3	MAXIMUM WORKING (RV SETTINGS):		bar (ga)	
4	MAXIMUM NORMAL OPERATING:		bar (ga)	
	FLOWS			
5	MAXIMUM PUMP DELIVERY:		litre/minute	
6	NORMAL OPERATING PUMP DELIVERY:		litre/minute	
	RESERVOIR			
7	TOTAL VOLUME:		litre	
8	MAXIMUM OPERATING FLUID VOLUME:		litre	
9	MINIMUM OPERATING FLUID VOLUME:		litre	
10	MATERIAL OF CONSTRUCTION:			
	PRIME MOVER			
11	TYPE:			
12	MANUFACTURER:			
13	POWER CONSUMPTION (ELECTRIC ONLY):		kW	
14	MIN SUPPLY PRESSURE REQUIRED (AIR ONLY):		bar	
15	FLOW (AIR ONLY):		m ³ /minute at S.T.P.	
16	SPEED:		rpm	
	PUMP (MAIN DELIVERY)			
17	TYPE:			
18	MANUFACTURER:			
19	DISPLACEMENT:		cm ³ /rev	
20	MAX WORKING PRESSURE (DESIGN):		bar (ga)	
21	MAX OPERATING FLOW:		litre/minute	
22	MAX OPERATING SPEED:		rpm	
23	EFFICIENCY:			
	PUMP (BOOST)			
24	TYPE:			
25	MANUFACTURER:			
26	MAX WORKING PRESSURE (DESIGN):		bar (ga)	
27	MAX OPERATING FLOW:		litre/minute	
	PUMP (CASE FLUSHING/HEATING)			
28	TYPE:			
29	MANUFACTURER:			
30	MAX WORKING PRESSURE:		bar (ga)	
31	MAX FLOW:		litre/minute	
	PUMP (SYSTEM FILLING)			
32	POWER SOURCE:			
33	MAX FLOW:		litre/minute	
	ACCUMULATOR			
34	MAX WORKING PRESSURE:		bar (ga)	
35	MIN WORKING PRESSURE:		bar (ga)	
36	OPERATIONAL FLUID VOLUME: litre			
REV	DATE	REMARKS	BY	APP



	INDENT/PURCHASE ORDER NUMBER PAGE 2 OF 2			
	TO BE COMPLETED IN BLOCK CAPITALS			
	TO BE COMPLETED BY EQUIPMENT VENDOR AND PURCHASER AS APPROPRIATE			
	FILTERS			
37	MANUFACTURER:			
38	ELEMENT SIZE (PRESSURE LINE):	micron absolute		
39	ELEMENT SIZE (RETURN LINE):	micron absolute		
40	ELEMENT SIZE (DRAIN LINE):	micron absolute		
41	ELEMENT SIZE (FILLING PUMP LINE):	micron absolute		
	INSTRUMENTATION REQUIREMENTS (DELETE AS APPLICABLE)			
42	LOCAL PUMP DELIVERY PRESSURE GAUGES:	YES/NO		
43	POWER PACK DELIVERY PRESSURE GAUGE:	YES/NO		
44	RESERVOIR LEVEL SIGHT GAUGE:	YES/NO		
45	ELECTRIC PRIME MOVER AMMETERS:	YES/NO		
46	RESERVOIR FLUID TEMPERATURE GAUGE:	LOCAL/REMOTE/BOTH		
47	RESERVOIR FLUID LOW LEVEL SWITCH:	YES/NO		
48	RESERVOIR FLUID LOW LOW LEVEL SWITCH:	YES/NO		
49	RESERVOIR FLUID HIGH LEVEL SWITCH:	YES/NO		
50	FLUID HIGH TEMPERATURE ALARM:	YES/NO		
51	BOOST/CONTROL FLUID LOW PRESSURE ALARM:	YES/NO		
52	MAIN DELIVERY HIGH PRESSURE ALARM:	YES/NO		
53	MAIN DELIVERY LOW PRESSURE ALARM:	YES/NO		
54	FILTER CLOGGING INDICATOR (ALL FILTERS):	VISUAL/ELECTRIC		
	WORKING FLUID			
55	SUPPLIER:			
56	TYPE:			
57	MAXIMUM SYSTEM VOLUME:	litre		
	DESIGN CLEANLINESS LEVELS			
58	TO BE ACHIEVED DURING FLUSHING:	to NAS 1638		
59	PERMITTED FOR OPERATION:	to NAS 1638		
	PIPING			
60	MATERIAL:			
61	PRESSURE LINE SIZE:	mm inside diameter		
62	RETURN LINE SIZE:	mm inside diameter		
63	DRAIN LINE SIZE:	mm inside diameter		
	PIPE FITTINGS			
64	TYPES TO BE USED:			
65	SUPPLIERS:			
66	MATERIALS:			
	ENVIRONMENTAL CONDITIONS			
67	MARINE:	YES/NO		
68	PARTICULARLY DIRTY/DUSTY:	YES/NO		
69	MINIMUM AMBIENT TEMPERATURE:	Celsius		
70	MAXIMUM AMBIENT TEMPERATURE:	Celsius		
	HAZARDOUS AREA CLASSIFICATION			
71	ZONE:			
72	GAS GROUP:			
73	TEMPERATURE CLASS:			

REV	DATE	REMARKS	BY	APP

