

TECHNICAL SPECIFICATION

HYDRAULIC SYSTEMS FOR REMOTE OPERATION OF SHUT-OFF VALVES

DEP 31.36.10.30-Gen.

September 2002
(DEP Circular 19/05 has been incorporated)

DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design, engineering, manufacturing, assembly, supply, testing and commissioning of hydraulic systems for the remote operation of shut-off valves (ROVs) with an emergency shut down (ESD) function.

This DEP is a revision of an earlier DEP of the same title and number, dated July 1996. A summary of changes to the previous edition is described in (1.5).

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS.

Unless otherwise authorised by Shell GSI and SIEP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers nominated by them (i.e. the distribution code is "F", as defined in DEP 00.00.05.05-Gen.).

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

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General Definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Technical Definitions and Abbreviations

DCS	Distributed Control System
DE	De-Energised
ESD	Emergency Shut Down
IPF	Instrumented Protective Function
IPS	Instrumented Protective System
MCC	Motor Control Centre
PLC	Programmable Logic Controller

ROV	Remote Operated Shut-off Valve
SCU	Self-Contained Hydraulic Unit - A compact power pack, integrally built with actuator on top of or next to shut-off valve.
SIL	Safety Integrity Level classification

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the number of the section or sub-section referred to is shown in brackets. All publications referred to in this document are listed in (8).

1.5 SUMMARY OF CHANGES FROM PREVIOUS EDITION

The revision has been a general update to the previous edition. Other than editorial changes for added clarity, the changes include feedback from Suppliers, re-grouping of topics, an update of the instrumentation & control chapter and an updating of the references. There have been no significant technical changes.

2. HYDRAULIC SYSTEMS - GENERAL REQUIREMENTS

2.1 GENERAL

Remote operated shut-off valves (ROVs) are usually installed at critical locations, e.g. in the suction piping of pumps which draw from a large inventory of liquid hydrocarbons. They are also commonly installed in the suction and discharge piping of compressors, at the outlet nozzles of storage tanks, in transmission pipelines and in product lines to ship loading hoses or loading arms.

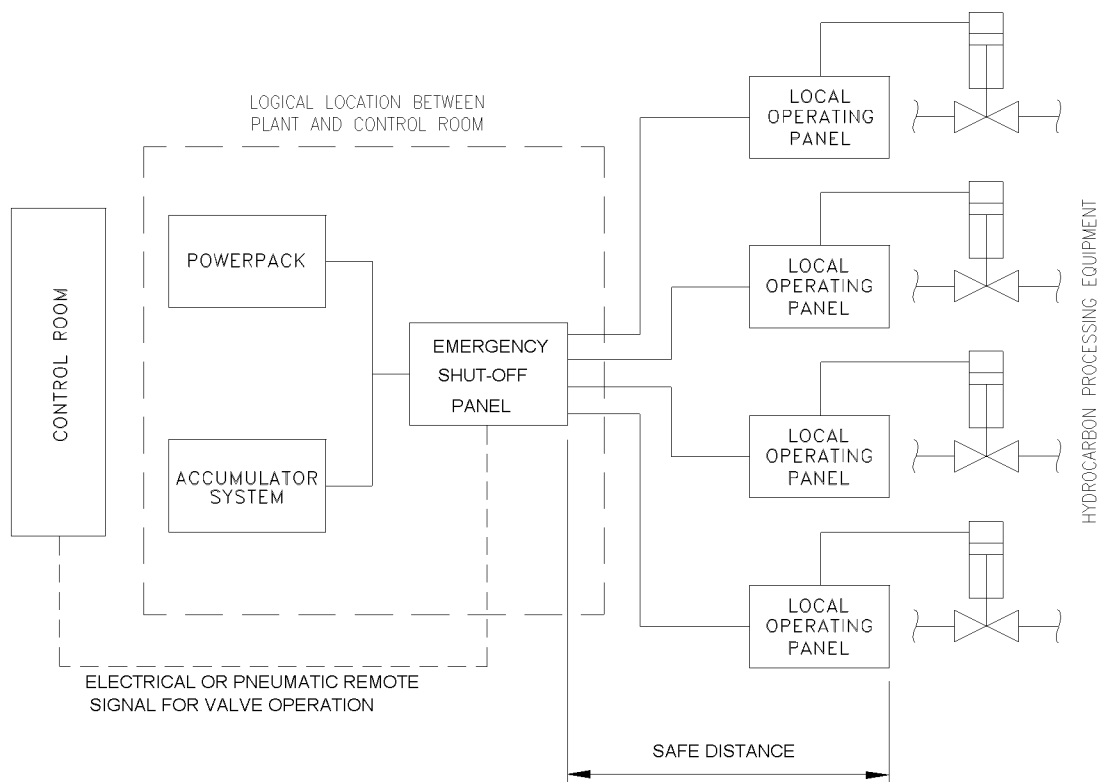
Sometimes it is desirable to create an independent power source and instrumented protective functions (IPF) to meet reliability requirements during emergency conditions, e.g., fire. Hydraulic systems can meet these requirements relatively simply.

The hydraulic system shall be designed so that troubleshooting and maintenance can be carried out with minimum disruption to the operability of the system.

Minor equipment faults, e.g., a small leakage of hydraulic fluid, nitrogen or instrument air supply, should not disturb normal plant operations. Furthermore, unintentional opening or closing of the valve, e.g., due to a supply pipe burst or for any other reason, shall not be possible.

The layout of a hydraulic system is shown schematically in Figure 1.

FIGURE 1 LAYOUT OF A HYDRAULIC SYSTEM FOR REMOTE OPERATION OF SHUT-OFF VALVES WITH AN ESD FUNCTION



2.2 ORDERING

2.2.1 Requisitioning

The Principal shall specify in the requisition the functions, requirements and types of shut-off valves to be installed, as well as the basic requirements for the actuator and hydraulic system packages.

The hydraulic system Supplier shall be responsible for the engineering, delivery and functioning of the entire system, including assembling of ROVs.

The valve Manufacturer shall be responsible for the performance of the valve and assembly, and shall provide data to the hydraulic system Manufacturer to sufficiently size the actuator; see (2.7).

The Principal shall specify in the requisition whether or not installation supervision by the hydraulic system Supplier is required at site.

The hydraulic system shall be suitable for outdoor operation in the prevailing local environmental and weather conditions, as indicated in the requisition. Painting shall be in accordance with DEP 30.48.00.31-Gen.

This DEP shall be used in conjunction with Requisition sheet DEP 31.36.10.93-Gen. and Requisition for Engineering Documents (RED) sheet DEP 40.10.01.93-Gen.

2.2.2 Information to be submitted with the Tender

A hydraulic flow scheme ("Process Engineering Flow Scheme - PEFS") shall be provided showing all equipment, lines, valves and instrumentation and indicating limits of supply. The following information shall be included as a minimum:

- specification of the pump capacity, accumulator capacity, reservoir capacity, heating and/or cooling requirements;
- minimum system pressure to close and open all shut-off valves;
- minimum required hydraulic fluid/nitrogen volume;
- maximum system pressure;
- normal operating pressure;
- return line pressure (not applicable to an SCU);
- weights and outline dimensions of the modules;
- main dimensions of the power pack with oil reservoir and of the mobile unit;
- completed noise limitation sheet, DEP 31.10.00.94-Gen.;
- names of all proposed Sub-suppliers with a full description of the equipment being supplied by them;
- required spare parts for commissioning;
- spare parts required for day-to-day maintenance for a period of three years after commissioning;
- special tools required;
- list of deviations, if any, from the requirements of this DEP.

2.3 CONTENT

Each hydraulic system shall consist of the following main components:

- a power pack for the supply of the hydraulic pressure and flow rate;
- an accumulator back-up system to ensure full hydraulic pressure in case of pump failure;
- emergency shut-off panel(s);
- local operating panel(s) (optional);
- a mobile hydraulic pump unit (optional);
- hydraulic actuator(s) to operate the ROV(s);
- interconnecting piping;
- electric cables/wiring;
- instrumentation;
- tubing;
- heating (optional);
- hydraulic fluid filter unit;
- skids/racks;
- weather/fire shielding (optional).

2.4 LAYOUT

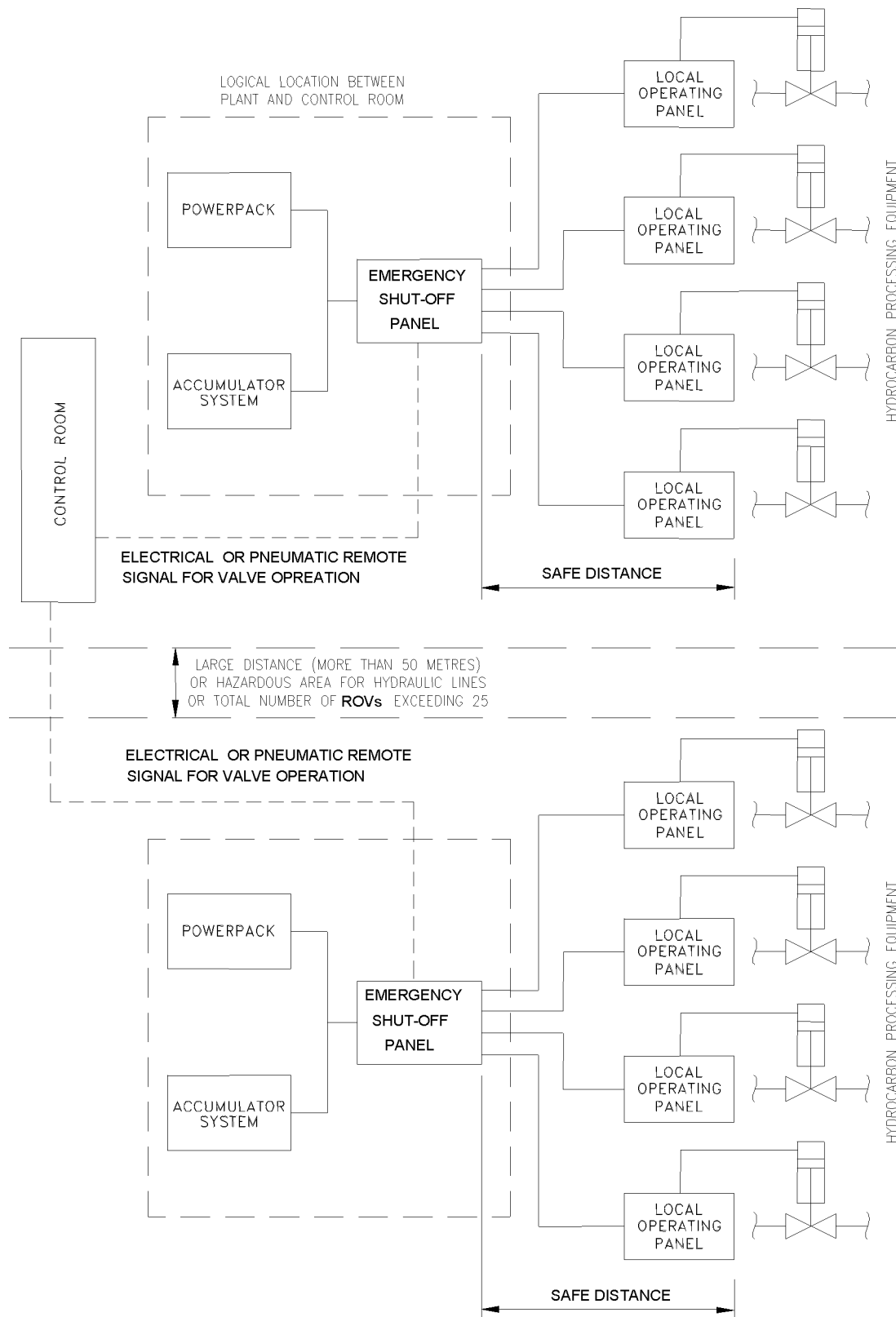
The power pack, the accumulator system and the emergency shut-off panel shall be located well away from the related ROVs. The location shall be freely accessible and unlikely to be affected by a fire, and shall allow a reasonable view of the related equipment area.

The local operating panel, if applied, shall be located adjacent to or near the related ROVs.

The hydraulic system shall be split into multiple systems (as shown in Figure 2) if:

- more than 25 ROVs have to be operated (depending on size this figure may vary);
- the distance between groups of ROVs is greater than 50 m (on average, figure may vary);
- ROVs are installed far apart, to achieve a safe location for the emergency shut-off panel.

FIGURE 2 LAYOUT OF MULTI-HYDRAULIC SYSTEMS FOR REMOTE OPERATION OF SHUT-OFF VALVES WITH AN ESD FUNCTION

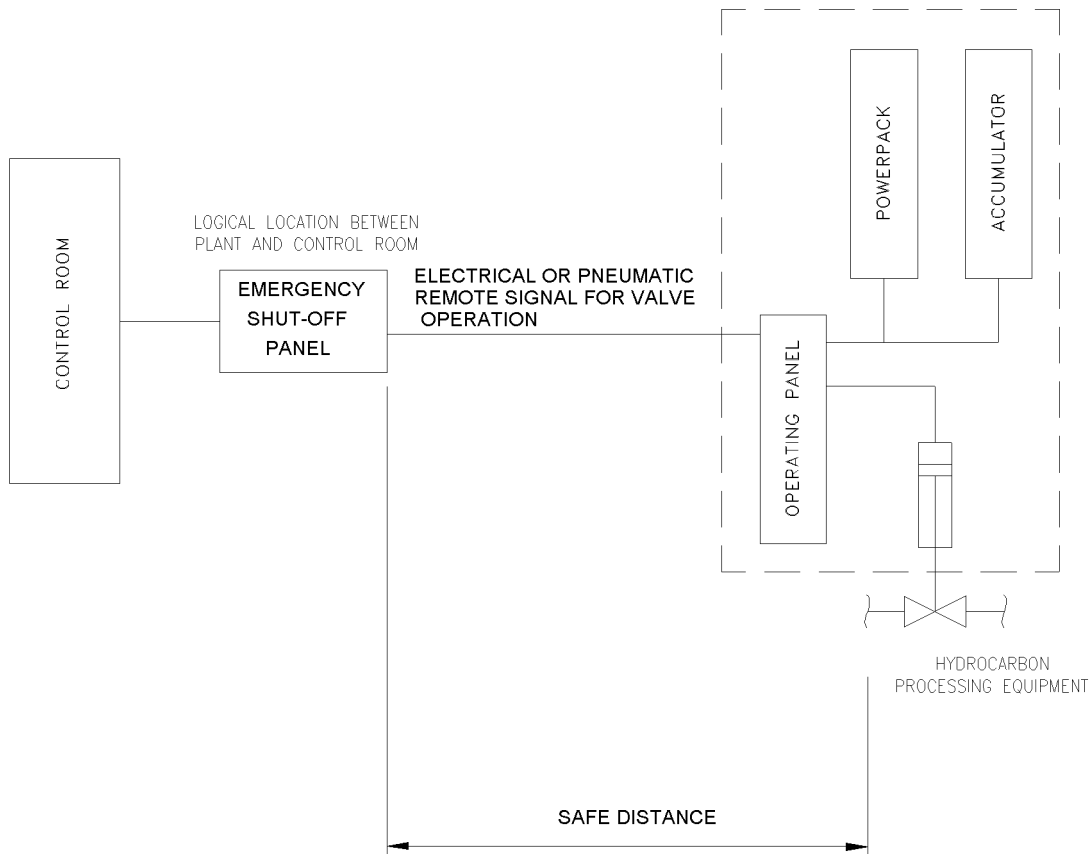


The installation of one SCU per ROV should be considered if:

- the ROV is located a long distance away from the rest of the group or;
- the number of ROVs does not justify a central hydraulic system (see Figure 3).

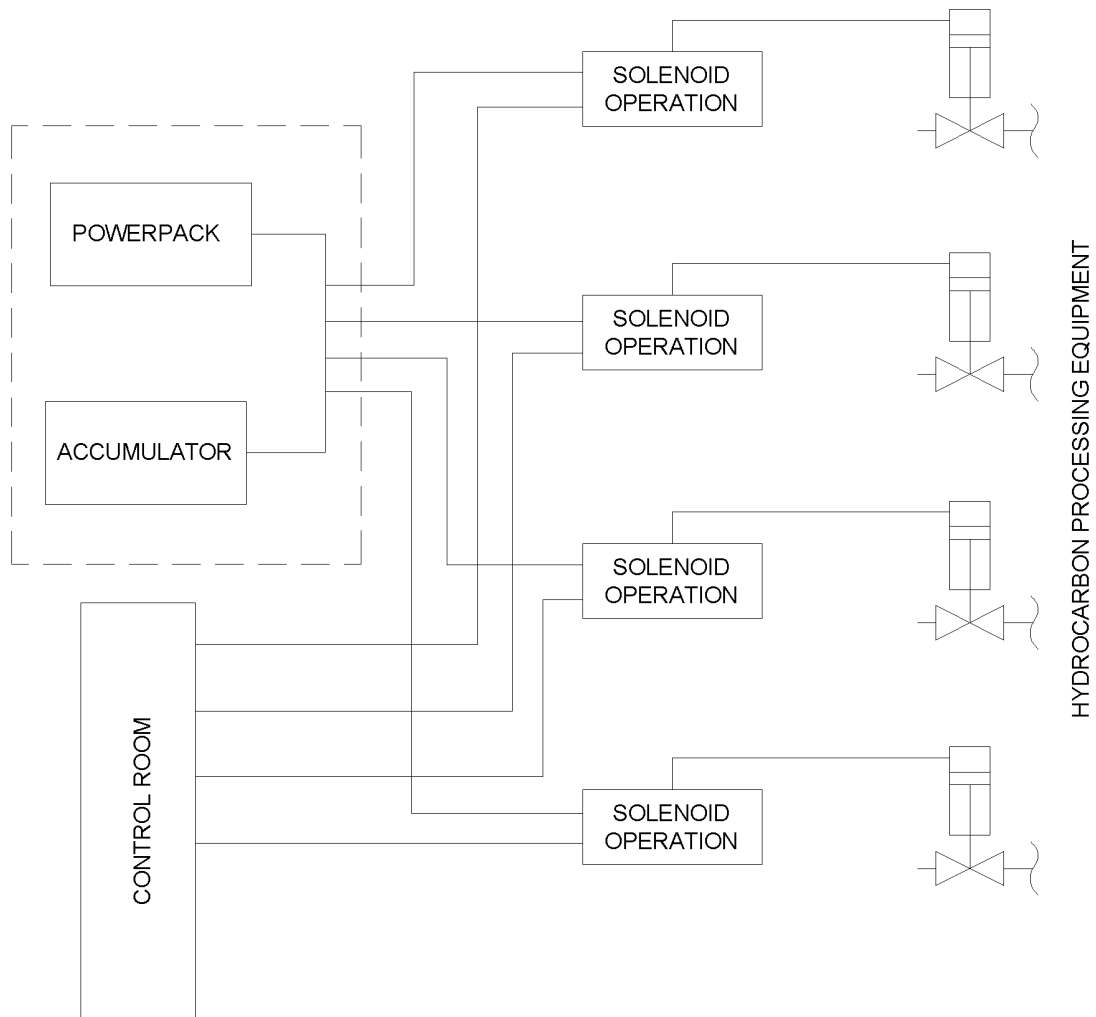
For specific requirements for SCUs, see (2.6) and (4.2.2).

FIGURE 3 LAYOUT OF SELF CONTAINED HYDRAULIC UNIT FOR REMOTE OPERATION OF A SHUT-OFF VALVE WITH AN ESD FUNCTION



For particular applications, e.g., loading arms, the Principal may decide that the shut-off valve will be controlled remotely only. A configuration as shown on Figure 4 can then be used then. No emergency shut-off panel is required.

FIGURE 4 LAYOUT OF A HYDRAULIC SYSTEM FOR REMOTE OPERATION OF SHUT-OFF VALVES WITH OPERATION ONLY FROM CONTROL ROOM



Note: No emergency shutoff required

2.5 CONFIGURATION

The power pack, accumulator rack (including nitrogen bottles) and emergency panel shall be built on a common skid as far as is practically feasible.

The actuator and shut-off valve shall be built as a common unit. Integration of the local operating panel is acceptable if the requirements of (3.7) are met.

If the modules have to be fire-resistant, which the Principal shall indicate, a fire-resistant box or enclosure shall form an integrated part of the module. The enclosure may cause it to be classified as a hazardous area and the hydraulic system shall then be designed accordingly.

2.6 SELF-CONTAINED HYDRAULIC UNITS

Self-contained hydraulic units (SCUs) shall be designed and built so that the shut-off valve actuator, power pack, accumulator, nitrogen bottle, instrumentation and local operation panel are integrated into one unit of modular construction.

This DEP shall likewise apply for SCUs, except that:

- a spare pump is not required;
- the usable volume of the oil reservoir shall be at least 1.5 times that of the volume of the contents of the entire hydraulic system for each unit;
- return filters are not required.

2.7 INTERFACE SHUT-OFF VALVES

In order to facilitate proper installation of the actuator, the required mounting facility on the valves shall be designed and manufactured in consultation with the Supplier of the valve actuator. For part-turn valve actuator attachment, see ISO 5211.

A self-aligning coupling, if required between the valve and the actuator, shall be supplied by the hydraulic system Manufacturer.

Valves shall be tested and certified by the valve Manufacturer. For the complete assembly test, see (5.3).

The valve Manufacturer shall determine and notify the Supplier of the hydraulic equipment of the following data:

- the relevant opening and closing forces;
- the torques required to properly operate the valve, including safety factors, see (3.8.3);
- the travel length of the stem (for rising stem).

2.8 FIRE RATING

For hydraulic systems serving an ESD shut-off valve, the valve actuator and the threatened sections of power lines and control systems shall be designed and manufactured so that each individual ROV shall remain operable for a period of at least 15 min. when engulfed in a fire having a temperature profile as described in UL-1709.

To achieve this, additional protection to safeguard the operability of ESD valves may be necessary.

2.9 NOISE

The Manufacturer shall submit guaranteed sound power levels and sound pressure levels (including octave band spectrum) of the equipment, together with any other relevant information as requested in the data sheet, DEP 31.10.00.94-Gen.

3. SPECIFIC HYDRAULIC SYSTEM COMPONENT DESIGN REQUIREMENTS

3.1 SYSTEM

3.1.1 General

The hydraulic system shall be suitable to simultaneously serve the number of valve actuators specified in the requisition.

The hydraulic system shall maintain full and continuous system pressure in the supply lines to the ROVs.

The emergency shut-off panel and the local operating panel should be installed at ground level. Both panels shall be easily accessible for manual operation, maintenance and inspection.

The power source shall have adequate back-up features to guarantee the operability of the hydraulic system under emergency conditions.

The hydraulic system shall be designed for the hazardous area classification in which it is installed. The Principal shall specify the relevant hazardous area classification zone.

A simplified flow scheme of a hydraulic system is shown in Figure 5A and Figure 5B.

FIGURE 5A SIMPLIFIED FLOW SCHEME FOR HYDRAULIC REMOTE OPERATION OF SHUT-OFF VALVES WITH AN ESD FUNCTION (1/2)

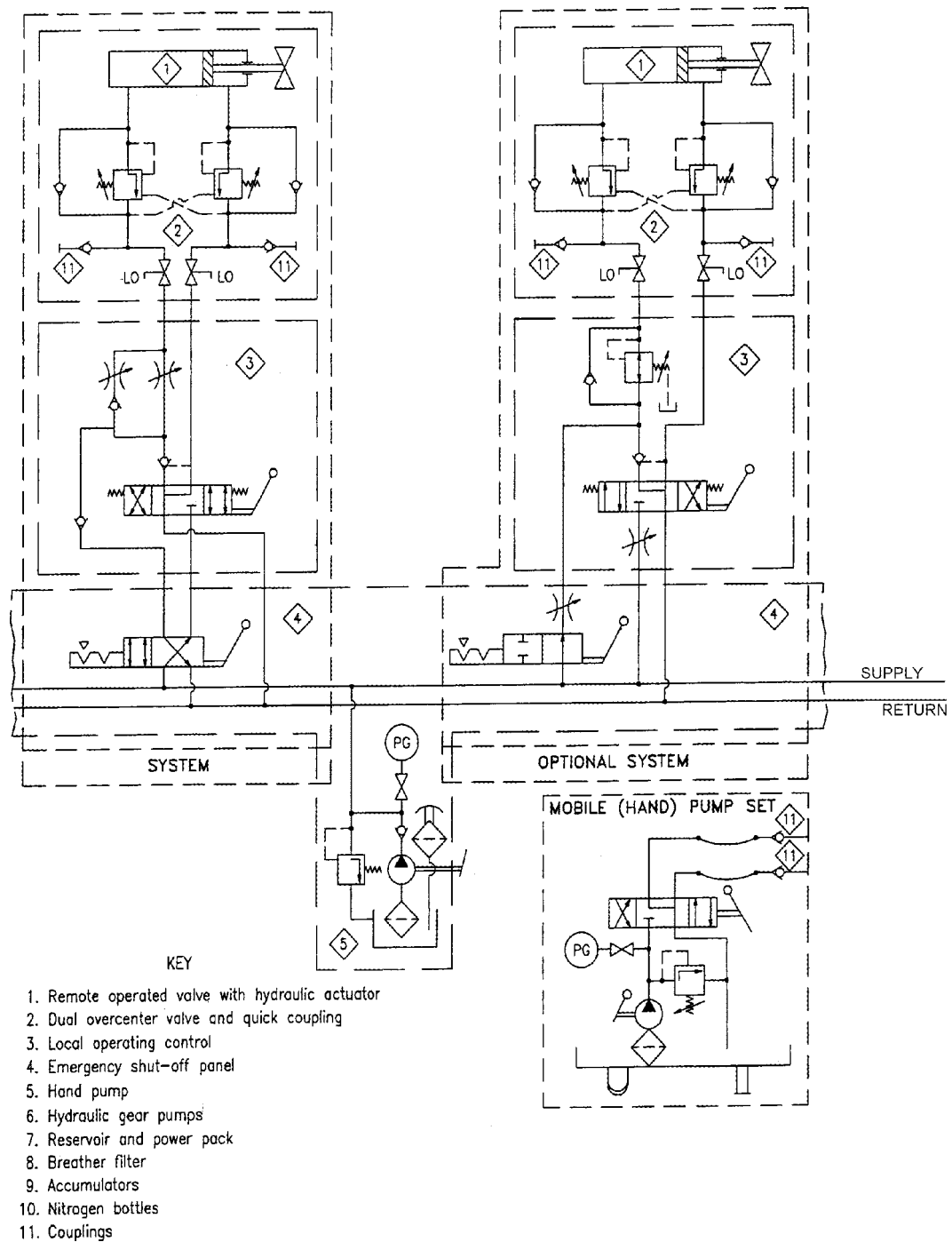
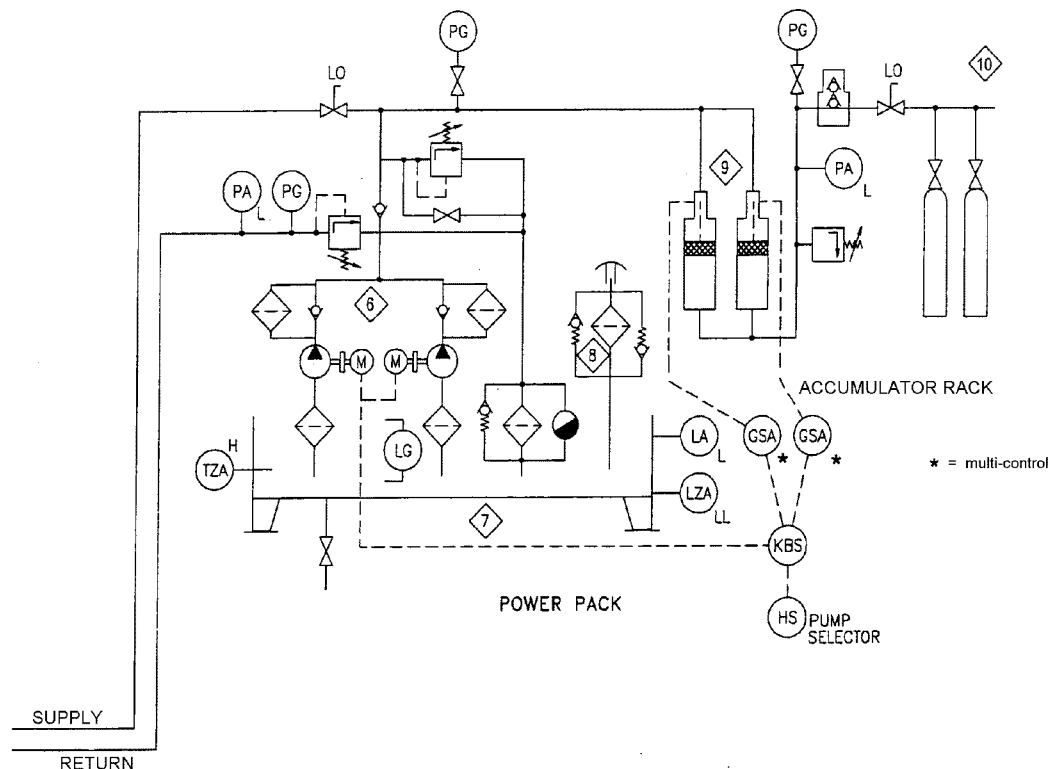
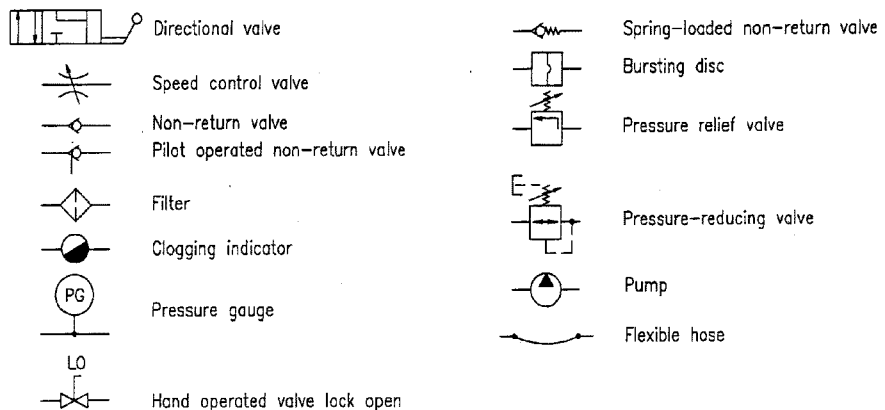


FIGURE 5B SIMPLIFIED FLOW SCHEME FOR HYDRAULIC REMOTE OPERATION OF SHUT-OFF VALVES WITH AN ESD FUNCTION (2/2)



LEGEND



3.1.2 Valve closing

The closing time for valves up to and including nominal size DN 600 shall be no more than one second per 25 mm of nominal diameter. For larger sizes the maximum closing time shall not exceed 30 s, unless otherwise specified by the Principal.

NOTE: ESD valves in LPG/LNG marine loading arms shall be able to close within 5 s; see DEP 30.06.10.20-Gen. This may be a reason to select a hydraulic system instead of a pneumatic or electrical system.

The final valve closing times shall be determined on the basis of surge calculations, and the flow rates may have to be reduced to avoid excessive surge pressures generated by rapid valve closure.

In the event of an emergency, e.g., a severe leakage and/or fire, it should be possible to close the ROV by means of a switch mounted on the emergency shut-off panel (3.6) or, if specified, from the main panel in the control room.

3.1.3 Control

The opening of an ESD valve shall only be possible from the local operating panel (3.7) or on the actuator itself.

The arrangement of the system shall be such that accidental operation of an ROV that causes the valve to move from its safe position is not possible.

The remote emergency operation, either from the control room or emergency shut-off panel, shall always overrule local operation of the ROV or ESD valve.

The operation of an ROV by any hydraulic system or power supply failure shall be as follows:

- in case of hydraulic failure, the valve will stay in its present position;
- in case of failure of electric power to solenoid valve (fail safe principle), the valve will move to its safe position.

3.2 POWER SUPPLY

The power packs shall be pressurised by either pneumatically or electrically driven pumps, whichever is considered the more reliable.

The arrangement of the power supply system shall be such that a failure will not cause loss of source pressure for the ROVs, nor cause an ROV to move to a position different to that specified by the Principal.

The power supply functions serve to activate power packs, and solenoid switches/valves shall be from a vital electrical or secured pneumatic source.

Each electric motor shall be independently connected with an electric power cable running from the Principal's MCC and shall be connected in accordance with Standard drawings S 67.004 and S 67.019. One of the motors shall be fed from the "normal supply" and the other one from the "maintained interruptible supply" (emergency switchboard).

For control of the hydraulic system the following shall be used:

- instrumentation to be specified by the Principal, see DEP 32.31.09.31-Gen.;
- Principal's normal MCC.

All cabling shall be of the fire-resistant type, or of other fireproof construction, e.g., signal cable installed in fire-resistant sealed instrument cable ducting.

3.3 POWER PACK

3.3.1 Introduction

The power pack shall consist of the following items, assembled as a complete skid-mounted unit.

3.3.2 Hydraulic fluid reservoir

The hydraulic fluid reservoir shall be of a welded carbon steel or austenitic stainless steel construction. If carbon steel, it shall be provided with a corrosion protective coating inside and outside in accordance with DEP 30.48.00.31-Gen.

The reservoir shall have sufficient capacity for the hydraulic system. The usable volume, i.e., that between maximum and minimum level, shall be the volume of the rest of the hydraulic system plus the volume displaced by one pump in 5 min. In any case, the oil reservoir reserve capacity shall be such that at maximum operating liquid level it shall have sufficient remaining capacity to drain the entire hydraulic system into it (piping and cylinder volume). The reservoir shall be equipped with two pumps (one standby) with separate suction and discharge filters, one common return filter with fouling indication, one aeration filter, one filling filter, a drain valve (including blind flanges), instrumentation and an inspection hole with cover; see Figure 5B.

3.3.3 Filling filter

Filling of the tank shall only be possible through a filter having an absolute rating of 10 µm, fixed on the tank. The Manufacturer shall propose a loading system for the hydraulic fluid for approval by the Principal.

3.3.4 Aeration filter

The aeration filter shall have a nominal rating of 10 µm and a maximum clean element pressure drop across the filter of 0.1 bar.

3.3.5 Return filter

The return filter shall have an absolute rating of 10 µm. The total area of the perforations shall be at least twice the cross sectional area of the return line. The clean element pressure drop across the filter shall not exceed 3 bar at the specified viscosity, temperature range and throughput of the hydraulic fluid.

3.3.6 Hydraulic fluid pumps

Two hydraulic fluid pumps shall be installed (one standby). These pumps shall be of the submerged gear type and shall be an integral part of the hydraulic fluid reservoir. Both pumps shall have sufficient capacity to charge the accumulator from the empty condition to the full condition within 120 s.

Normal operating pressure of the hydraulic system shall range between 150 bar and 200 bar (ga). Air motors or electric motors shall drive pumps. Electric motors shall comply with DEP 33.66.05.31-Gen.

If a pneumatic pump is chosen for this purpose and instrument air is used to drive the pump, provisions shall be made to prevent hydraulic fluid from entering the instrument air supply piping, e.g., the air piston and hydraulic piston shall be in separate cylinder housings.

3.3.7 Suction filters

Each pump shall be equipped with a suction filter having a nominal rating of 130 µm. The pressure drop across the filter shall not exceed 0.1 bar at the specified viscosity, temperature range and throughput of the hydraulic fluid.

The filter suction pipe shall have a free space of at least 30 mm above either the bottom or the drain facilities of the reservoir.

3.3.8 Discharge filters

Each pump shall be equipped with a discharge filter having an absolute rating of 10 μm . The clean element pressure drop across the filter shall not exceed 5 bar at the specified viscosity, temperature range and throughput of the hydraulic fluid.

3.4 ACCUMULATOR RACKS

The accumulators and related nitrogen cylinders shall have sufficient capacity for emergency operation of all ESD valves, which means three full strokes, i.e., one closing stroke, one opening stroke and another closing stroke. The required capacity shall be determined by the change in volume of fluid contained in the accumulator between the main pump start position (with the pump switched off) and the minimum system pressure to finish the last stroke of all ESD valves properly.

Accumulators shall be provided with a pressure safety valve in order to prevent nitrogen overpressure. Filters in the nitrogen supply lines, if applicable, shall have a nominal rating of 10 µm and a maximum pressure drop across the filter of 0.1 bar.

Accumulators shall be mounted in a vertical position to prevent possible deposition of hard particles on the honed inside surface of the cylinder.

The accumulator racks shall be constructed as a welded steel frame and designed to be free standing. If specified by the Principal, the rack shall be provided with a roof or shields protecting the accumulators and nitrogen bottles against direct sunshine and/or radiation from other heat sources. Mounted in the frame shall be accumulators, nitrogen cylinders, filters, control valves, instrumentation, filling, testing and safety devices.

The material of the accumulator assemblies shall be steel. The accumulator shall be of the piston type. Tie rods shall not be installed around the cylinder.

The piston sealing shall be arranged so that a single seal failure can be tolerated without consequences for the functionality of the complete hydraulic system.

The seal configuration should be:

- a primary elastomeric seal for the hydraulic fluid;
- a primary elastomeric seal for the nitrogen;
- a secondary seal for both (combined duty).

**Amended per
Circular 19/05**

The design of the accumulator vessels shall comply with DEP 31.22.10.32-Gen. or DEP 31.22.20.31-Gen. The nitrogen cylinders shall comply with local regulations or, in the absence of such regulations, EN 1964.

3.5 HYDRAULIC PIPING

3.5.1 Introduction

Hydraulic piping shall include all piping, tubing, fittings, separation, isolating and check valves, couplings and quick-release couplings (for the mobile pump unit). For special requirements for packaged unit piping, see (3.5.2).

The hydraulic system Supplier shall provide procedures and instructions for the installation of hydraulic piping, tubing and supporting fixtures in accordance with the layout drawings, which will be included with the purchase order.

Routing shall be such that the lines are least likely to be exposed to a fire, e.g., routed away from and not above the pumps. Stainless steel piping shall not be located directly below galvanised structures. Where this cannot be avoided, adequate shielding of the piping shall be provided. Shielding details require the Principal's approval.

The lines shall be shop assembled to the maximum practicable extent, thereby minimising the amount of field assembly.

All lines shall be adequately supported and anchored. Special attention shall be paid to stress-free supporting of the lines between the emergency shut off panels and the local operating panel stands and between the lines from the local operating panel stands to the hydraulic actuators. Supporting shall comply with DEP 31.38.01.29-Gen.

Lines running through Zone 1 areas shall be installed in enclosed ducts made of stainless steel sheeting.

Insulation of lines requires the approval of the Principal. Lines shall be painted in accordance with DEP 30.48.00.31-Gen. whether or not they are insulated.

Lines shall be continuously pressurised at low (return line) pressure to prevent air locks and to indicate possible system leakage.

Valves installed in supply and return lines between power pack and shut-off valves actuators shall be locked open during operation of the hydraulic system.

Piping, tubing, fittings, couplings and valves shall normally be constructed from stainless steel AISI 316L, preferably as specified in the requisition. For more severe conditions, a corrosion engineer shall select an appropriate material. Selection of other materials shall be subject to approval by the Principal. Piping components shall be in accordance with piping class X3021, as defined in DEP 31.38.01.12-Gen. For materials other than AISI 316L, the appropriate piping class shall be selected.

The material certification of all hydraulic system components shall be in accordance with ISO 10474 type 3.1.B.

Piping design, manufacturing and inspection shall be in accordance with ASME B31.3.

Pipe connections shall be butt-welded to the maximum practical extent, with sufficient flanged connections, however, to allow cleaning.

3.5.2 Packaged unit piping

The complete assembly of pipes, control valves, fittings, filters, etc., which is incorporated in the power pack and accumulator rack, shall be supplied as part of the packaged unit. Wherever practical, components should be assembled as a modular unit rather than being individually connected by pipe or tubing.

Tubing and piping connections between the nitrogen cylinders and the accumulator shall be butt-welded to the maximum practical extent.

For connections where subsequent removal is necessary, flanges or compression fittings shall be used as follows:

- Tubing: high pressure, parallel threaded, double ferrule compression tube fittings, of a type approved by the Principal;
- Piping: welding neck flanges in accordance with ASME B16.5.

The specialised compression fittings shall be installed in accordance with the Manufacturer's instructions. NPT threads should be used for such connections. The use of other threaded connections (other than the compression tube fittings) is subject to the approval of the Principal.

3.6 EMERGENCY SHUT-OFF PANEL

The emergency shut-off panel, power pack and accumulator rack should be integrally built as one unit.

The emergency shut-off panel shall be equipped with directional valves that allow the ROVs to be closed only.

The directional valves should be of the shear seal type with metal-to-metal contact between the sealing elements. In whichever position the directional valve is switched, opening of the ROV shall be possible only via the local operating panel. Piston-type directional valves shall not be used.

A simplified process flow scheme of the controlled valves shall be attached to the panel. The Principal shall provide details for the flow scheme.

3.7 LOCAL OPERATING PANEL

The normal operation of the ROVs shall be effected by controls mounted on the actuator. If access to the controls on the actuator is restricted, a local operating panel or cabinet mounted on a stand should be installed.

The local operating panel shall consist of the following equipment:

1. Directional valves. These valves shall be a three-position, spring-centred, shear seal type, with metal-to-metal contact between the sealing elements. The valve shall have three positions in which it can be switched, i.e., the "open", the "neutral" (centre), and the "closed" position. Alternatively, two-directional valves may be installed, one to open the ROV and one to close the ROV. These valves shall also have a "neutral" position (spring return). Piston type directional valves shall not be used. Mechanical locking of the directional valve in the "closed" position shall be possible;
2. Speed control/non-return valves in the supply lines. Alternatively, fixed orifice plates may be installed. The orifice shall be calculated according to the maximum viscosity of the hydraulic fluid.

3.8 HYDRAULIC ACTUATORS

3.8.1 General

The hydraulic actuators should be double-acting hydraulic cylinders, linear or rotary (scotch yoke or rack-and-pinion type), mounted on the ROVs.

Hydraulic damping, to prevent slamming of the valve at the end of the stroke, shall only be applied if deemed necessary by the valve Manufacturer.

The materials of the piston rod assembly shall be stainless steel AISI 316. Tie rods shall not be installed external to the hydraulic cylinder if no additional fire protection is applied. Selection of the other materials shall be subject to approval by the Principal.

The hydraulic actuator shall be provided with connections for a mobile pump unit (nitrogen driven) with block valves to isolate the hydraulic cylinder. The firebox, if installed, shall be designed for direct access to these connections. Re-adjustment of the valve stem position in relation to the actuator piston position shall be possible. The design shall also include a mechanical position indicator, proximity switches, a static load thermal relief valve and vent valves.

A dual over-centre valve shall be installed, to hydraulically block-in the actuator in the desired position if the hydraulic pressure is accidentally lost.

3.8.2 Sealing

The piston and piston rod sealing shall be arranged so that a single seal failure can be tolerated without affecting the functionality of the complete hydraulic system. The piston seal configuration shall be of a fire safe design, such as:

- a primary elastomeric seal, and
- a secondary metal seal to prevent excessive leakage across the piston in case the primary seal fails due to a fire.

The metallic seal configuration shall be such that the cylinder cannot be damaged. The maximum allowable leakage rate is specified in (5). If the actuator system cannot meet the fire rating requirements (2.8), an adequate fireproof cabinet may be provided if approved by the Principal.

3.8.3 Torques

The valve Manufacturer shall specify the torques required to operate the valve, based on the specified maximum process differential pressure across the valve in the closed position, as specified in the requisition. These include break-open-, break-close-, and further torques as specified in DEP 31.40.70.30-Gen.

The actuator torque, delivered at the specified minimum hydraulic system pressure and at minimum ambient temperature, shall be at least the required valve torque specified by the valve Manufacturer.

If fouling is expected (to be specified by the Principal), the delivered torque shall be adjusted.

The valve Manufacturer shall specify the safety factors for torque data. The actual safety factors in relation to the minimum safety factor requirements, as specified in DEP 31.40.70.30-Gen., shall be taken into account.

The hydraulic system Manufacturer shall inform the valve Manufacturer of the maximum torque load on the valve stem. Finally, the torque that the actuator shall deliver at maximum system pressure shall be less than the maximum allowable stem load as specified by the valve Manufacturer.

The results of the actuator sizing calculations, together with the selected actuator type/size and the above-stated torque values, shall be submitted to the Principal for approval.

3.8.4 Mechanical locking device

Actuators shall be equipped with a mechanical locking device to block valves in their safe position if equipment maintenance, repair or testing is required. The positions of the valve are 20 % and 100 % of the stroke (closed position). The locking arrangement shall be such that accidental actuation causing movement of a valve from its safe position is not possible. This locking device shall be clearly visible when installed. The locking device shall be designed to withstand the closing force of the actuator with the maximum specified hydraulic pressure applied.

3.9 MOBILE HYDRAULIC FLUID PUMP UNIT

The mobile pump unit for maintenance and emergency back-up purposes shall consist of an integral oil tank and either a hand pump or a nitrogen driven pump unit, to be specified by the Principal. The nitrogen pump unit shall be furnished complete with a small nitrogen bottle. The unit shall be self-contained and shall be complete with directional valve, pressure relief valves, pressure gauges, instrument connections, and flexible hoses with a length of 5 m having quick connection couplings at the free ends. The end couplings on the end of the flexible hoses shall be protected with caps to prevent dirt or water from entering the lines. The pump set shall be mounted in a frame on wheels.

The suction side of the pump shall be provided with a filter having a nominal rating of 130 μm . The discharge side of the pump shall be provided with a filter having an absolute rating of 10 μm .

3.10 HYDRAULIC FLUID

Sufficient hydraulic fluid for the initial inventory of the hydraulic system shall be supplied with the system. Hydraulic fluid shall be Shell Tellus T for systems normally operating below 100 °C, or other equivalent hydraulic fluid approved by the Principal.

In order to delay ageing of hydraulic fluid, the following shall be considered in the layout of the hydraulic system:

- prevent water entering the hydraulic circuit (oil shall be clear and bright, water content < 50 ppm);
- avoid dead ends and closed loops, allowing proper flushing of the hydraulic system (7.1);
- install separate supply and return lines.

A sample point in accordance with ISO 4021 shall be provided, and the hydraulic fluid shall be sampled for analysis at the interval specified by the hydraulic fluid Supplier.

3.11 AUXILIARY EQUIPMENT

The hydraulic system Supplier shall provide the system as a package with all instrumentation, gauges and switches cabled up to one or more junction boxes.

The Principal shall provide the control equipment, e.g., PLC, DCS, the switchgear and the electric cabling to supply the electric motors. The Principal shall also provide signal cabling to the junction boxes. For further specifications on signal cabling, refer to (4.4.2).

The selection and installation of electric control switches shall be in accordance with DEP 33.64.10.10-Gen.

Electric control cabinets with ROV control card, for generation of alarms and motor start/stop signals, shall be provided as specified in the requisition.

4. INSTRUMENTATION, CONTROL AND FUNCTIONALITY

4.1 FUNCTIONAL REQUIREMENTS

The hydraulic system shall be supplied with the instruments and components in accordance with the options selected in accordance with DEP 32.31.09.31-Gen.

All measurement and control instruments shall be installed on the skid. If specified, these instruments shall be wired to one or more junction boxes, located at the edge of the skid. The segregation of the type of signals per junction box is defined in DEP 32.37.20.10-Gen.

Actual control and instrumented protection functions (IPF) shall be executed in the central DCS or IPS, unless indicated otherwise. The Manufacturer shall submit a description of the required control and protection functionality for the purpose of system configuration.

For input and output signals the fail-safe principle will be applied. Under normal conditions, contacts shall be closed. The solenoid valve for remote actuation of the ROVs shall be normally energised.

The signal control functions shall activate the operation of valves to a pre-determined position and shall indicate the open or closed position of the ROVs on the emergency shut-off panel.

The main and stand-by pumps shall be controlled automatically. A pump selection switch shall be provided on the power pack.

- Position 1: pump A running and pump B stand-by.
- Position 2: pump B running and pump A stand-by.

The system shall be controlled on the basis of the accumulator volume. If the accumulator volume drops below 95 %, the selected main pump shall start to re-load the accumulator. If the accumulator volume drops below 90 %, the stand-by pump shall also start. The pump(s) shall stop when the end position of the accumulator piston is reached.

The system shall include the following alarms for remote indication in the control room:

- "common trouble alarm" of the hydraulic unit, if the system is still able to perform its emergency function, see (4.2);
- "common failure alarm" of the hydraulic unit, if the system is no longer able to perform its emergency function, see (4.2).

The primary power source shall be controlled so that the required source for all emergency actions is directly available, independently of the ROV actions.

Power pack:

The power pack shall include all the necessary instruments, such as level gauges, level switches, pressure gauges and switches, temperature gauges and alarms, transmitters, etc.

The accumulator shall be provided with three volume switches for motor control. These switches shall be set as follows:

- The top switch is set at the piston position for fully charged accumulator. This switch will stop both motors.
- The second switch is set at the piston position for 5 % volume loss. This switch will start motor A.
- The third switch is set at the piston position for 10 % volume loss. This switch will start motor B.

For an SCU configuration with a single pump, the third switch is not required.

The switches shall be of the "failsafe" proximity type, situated in a manifold on top of the accumulator. See also (4.4).

The Manufacturer shall inform the Principal if any additional features to those mentioned above are considered necessary.

4.2 SUMMARY OF MINIMUM FUNCTIONAL REQUIREMENTS

4.2.1 Hydraulic unit with remote valves

The following control and protection functionality shall be provided for each hydraulic system:

DESCRIPTION	FUNCTION	TROUBLE	FAILURE	ACTION/REMARK
Main/stand-by pump switch	Selection			A:B or B:A as appropriate
Hydraulic accumulator piston 5 % volume loss				Start main pump (Pump A)
Hydraulic accumulator piston 10 % volume loss		X		Start also stand-by pump (Pump B)
Accumulator piston	End position			Stop main and stand-by pumps
Nitrogen accumulator 5 % pressure loss	Low/low		X	Pumps are not running
Hydraulic return line pressure	Low	X		Indication of hydraulic fluid system leakage
Hydraulic fluid level switch	Low	X		Alarm
Hydraulic fluid level switch	Low/Low		X	Trip main and stand-by pump
Hydraulic fluid temperature	High		X	Trip main and stand-by pump
Running time too long	Expired		X	Accumulator will not be fully charged

4.2.2 Self-contained hydraulic units

All the functional requirements specified in (4.1) are also applicable to self-contained hydraulic units. The following control description is then applicable to a single pump situation:

DESCRIPTION	FUNCTION	TROUBLE	FAILURE	NOTES
Hydraulic accumulator piston 5 % volume loss				Start pump
Accumulator piston	End position			Stop pump
Nitrogen accumulator 5 % pressure loss	Low/low		X	At fully charged accumulators
Hydraulic fluid level switch	Low/low		X	Trip pump
Hydraulic fluid temperature	High		X	Trip pump
Running time too long	Expired		X	Accumulator will not be fully charged

4.3 INSTRUMENTED PROTECTIVE FUNCTIONS

Instrumented Protective Functions, e.g., hydraulic fluid low/low level protection, are subject to a SIL (Safety Integrity Level) classification, which is determined on the basis of the consequences of a failure on demand (PFD) of that particular function. The IPF classification and implementation rules are specified in DEP 32.80.10.10-Gen. The Principal normally determines the IPF classifications in close cooperation with the Supplier.

If an IPF classification results in requirements more stringent than the typical implementation of this DEP, then the instrumentation shall be altered accordingly, based on the classification results. See DEP 32.80.10.10-Gen.

4.4 ACTUATOR LIMIT SWITCHES

4.4.1 Functionality

For testing an ESD valve, and to detect the position of the valve, a minimum of 2 adjustable proximity type limit switches shall be installed on the hydraulic actuator:

- one indicating the position of the actuator when the valve has travelled over a distance of maximum 20 % from its total stroke;
- one indicating the position of the actuator when the valve has travelled over the full stroke (100 % closed or opened).

Limit switches shall be of the proximity type and shall be in accordance with IEC 60947-5-2. The mounting instructions supplied by the Manufacturer of the limit switches shall be followed by the hydraulic system Manufacturer.

Proximity switches shall be provided with a screened signal cable, which shall terminate in a junction box on the superstructure of the ROV. A flexible conduit between the sensor and the junction box shall mechanically protect the cable. Cable entry shall be into the bottom of the junction box.

The proximity switches, sensors and their associated equipment shall be of fire-retarding construction. Alternatively, the limit switch assembly shall be suitably protected against fire

in a sealed fire-resistant box and/or enclosed by stainless steel sheeting, see also (2.8) and (3.8.2).

The limit switches shall be properly adjusted by the hydraulic system Manufacturer.

4.4.2 Signal cable

The signal cable between the actuator limit switch and junction box in the emergency shut-off panel shall be of the fire-resistant type, or of other fireproof construction in accordance with IEC 60331-11, i.e., it shall withstand temperatures of up to 750 °C for a period of 3 h.

NOTE: Mineral insulated metal covered cable types shall not be used.

The Principal shall approve the routing of the signal cable and the type of fireproofing and construction.

Signal cable entry connections shall be from the bottom of the ROV control box.

The ROV control box shall be provided with the following connections/entries for instrumentation purposes:

- cable glands;
- signal cable entries;
- instrument air supply connection.

4.5 TUBING

For pneumatic operation and/or pneumatic emergency switches, the instrument air signal lines shall be seamless tubing of the same material as the hydraulic piping/tubing. The tubing shall have a minimum OD of 6 mm.

Electrically insulating spacer material shall be applied between the stainless steel tubing and the metal supports.

4.6 NAMEPLATES

All instruments forming part of the supply of the hydraulic system shall be provided with a stainless steel nameplate (see DEP 32.31.09.31-Gen.). The nameplate shall bear the Principal's instrument tag number and service. Instrument components that are packed separately shall be identified by a stainless steel tag which properly indicates the type or instrument number.

Marking on valves shall include a nameplate with the relevant ROV number clearly indicated. Visibility of the ROV number shall not be obscured by the installation of the actuator equipment.

5. INSPECTION AND TESTING

5.1 GENERAL

The complete hydraulic system shall be inspected and tested at the hydraulic system Manufacturer's works. The Principal shall indicate whether, and to what extent, he wishes to witness the Manufacturer's inspections and tests.

5.2 LEAK RATE TESTS

5.2.1 General

Before assembly, the leak rate test of the accumulator and 10 % of the actuators shall be carried out to prove the functionality of the back-up seal arrangements.

The Principal may waive these tests if compliance with the maximum leak rates is obvious from the nature of design of the back-up seals.

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5.2.2 Leak rate test of actuators

For actuators with a secondary metallic seal, the leak rate shall be established with the primary seal removed before assembly. For other than secondary metallic seals, the Manufacturer shall propose a test arrangement to simulate a primary seal failure.

The leakage rate of the metallic seals during closing shall be less than 500 cm³ hydraulic fluid per minute at the maximum allowable differential pressure across the piston. For large pistons, the leakage rate shall be less than 1000 cm³ hydraulic fluid per minute.

5.3 ASSEMBLY TEST

5.3.1 General

The shut-off valve and actuator assembly shall be tested as one unit, complete with operating controls and including the mobile pump set. Proper adjustments and settings shall be the responsibility of the hydraulic system Manufacturer.

Each combination of shut-off valve, actuator and control unit shall be tested. The Manufacturer shall submit to the Principal a functional testing procedure that shall, in addition to the Manufacturer's requirements, also include the requirements of (5.3.2), (5.3.3) and (5.3.4).

If it is not possible to test the whole assembly because of the size or capabilities, the Principal may allow the assembly tests to be subdivided as follows:

- hydraulic functional tests (pump capacity, accumulator size, operating times) at the hydraulic system Manufacturer's works, for power pack with actuators but without shut-off valve;
- valve actuator tests (hydrostatic, cryogenic etc.) at the valve Manufacturer's works for actuator with shut-off valve, operated by a hydraulic (handpump) unit, but without power pack;
- to guarantee correct assembly, a check must be done to test that the available minimum pressure by power pack is greater than the minimum hydraulic pressure necessary to unseat the valve at design process pressure.

5.3.2 Functional system test

The functional test shall include the following:

- Pump capacity test:

The time in which each pump can charge the accumulator from the empty condition to the fully charged condition shall be noted and shall be less than 120 s. This test shall be done with a nitrogen prefill pressure equal to the pressure expected at the maximum ambient temperature at site.

The time in which both pumps can charge the accumulator from the empty condition to the fully charged condition shall be noted and shall be less than 60 s. This test shall be done with a nitrogen prefill pressure equal to the pressure expected at the maximum ambient temperature at site. The maximum hydraulic and nitrogen pressure shall also be noted and shall be less than the specified maximum pressure.

- Accumulator minimum pressure test:

The accumulator shall be discharged from the full condition to the empty condition within a time span equal to or less than expected at site (emergency closure, manual open and emergency closure again). This test shall be done with a nitrogen prefill pressure equal to the pressure expected at the minimum ambient temperature at site, or according to a reference temperature table. The minimum hydraulic and nitrogen pressure shall be noted and shall be greater than the pressure used as basis for the sizing of the actuators.

- Accumulator capacity test:

By operating one or more attached shut-off valves, it shall be shown that the accumulator capacity at the pump 1 start position is sufficient for the operation of all shut-off valves for three one-way strokes. The pumps shall be switched off during this test.

- Actuator production tests:

Each complete actuator shall be exercised throughout its stroke to demonstrate correct action of local and, where applicable, remote control. This test shall also be carried out to confirm limit switch and position indicator operation and to ensure that the actuator operates smoothly without sticking at any point during the opening and closing stroke.

For fail-close actuators, the break-open torque shall be measured at the minimum and maximum specified hydraulic pressure.

- Shut-off valve opening and actuator size test:

At maximum differential pressure, the shut-off valve shall be slowly opened with the mobile (handpump) unit and the hydraulic pressure needed to open the shut-off valve shall be noted. This pressure shall be less than the pressure calculated for the actuator size and the required torque according to the valve Manufacturer. After this test the shut-off valve shall be thoroughly dried.

- Shut-off valve operations from the local operating panel (test 1, see 5.3.3).
- Shut-off valve operations from the emergency shut-off panel (test 2, see 5.3.4).
- Leakage testing of the power pack, local operating panels, actuators and mobile pump.
- A test to demonstrate the ability for operational testing to be performed (see 7.3).
- Functioning of the alarm and IPS.

5.3.3 Test 1

From the local operating panel, the shut-off valve shall be put in the following positions:

- fully open;
- 80 % open (= 20 % stroke)
This test only to be performed with a mechanical locking device in place;
- fully closed (= 100 % stroke).

Each position shall be maintained for at least 15 min. with fully charged accumulators without any additional control being required. There shall be no system pressure drop and/or movement of the valve that could result in leakage.

The shut-off valve shall be opened from the local operating panel and closed from the emergency shut-off panel, and the operating time shall be registered. The above test shall be done at the maximum and minimum system pressure.

5.3.4 Test 2

From the emergency shut-off panel the shut-off valve shall be closed. This position shall be maintained for at least 15 min. The test shall be done at the minimum and maximum system pressure. There shall be no system pressure drop and/or movement of the shut-off valve that could result in leakage.

5.4 HYDRAULIC DATA BOOK

The Manufacturer shall compile a hydraulic data book that shall include the following:

- material and test certificates as specified in the requisition;
- certificates of all pressure/leakage tests, complete with process valve tag numbers, drawing numbers, opening and closing times, valve leakage rates;
- Functional Acceptance Test data: hydraulic pressures, operating forces and/or torque requirements for both actuator and each ROV type and size;
- actuator cycle test report (if specified);
- dimensional checks;
- general arrangement and detailed dimensional drawings;
- bill of materials;
- assembly and disassembly procedures;
- electrical certificates (if required);
- certificate of conformance/compliance (design, assembly and testing).

6. DOCUMENTATION, PACKING AND SHIPPING

6.1 REQUIRED DOCUMENTATION

The system Supplier shall submit an Operating and Maintenance manual, including as a minimum, information regarding:

- normal and emergency operation;
- daily and periodic maintenance;
- hydraulic flow scheme "as built";
- data with respect to the pressures (minimum, operating, maximum);
- return line pressure;
- data with respect to the maximum pressure drop across each filter;
- test reports;
- detailed information/drawings of the components;
- special tools;
- troubleshooting schemes;
- requirements for the maintenance of hydraulic fluid cleanliness;
- operational testing procedure.

6.2 PACKING AND SHIPPING

After shop inspection and testing, the system shall be disassembled. All hydraulic fluid and lubrication oil shall be drained. Surface preparation shall consist of cleaning, drying, de-rusting and painting. Machined surfaces and unpainted parts shall be protected with one coat of a suitable corrosion inhibitor.

The system shall be disassembled so that required installation at site shall be limited to interconnecting piping, electrical and instrumentation connections. The system shall be packed and shipped in modules, e.g., valve and actuator, power pack, local operating panels, etc.

NOTE: Galvanising shall not be applied to any item.

Unpainted parts and machined parts shall be adequately preserved for 6 months' storage in accordance with DEP 70.10.70.11-Gen.

Valves and actuators shall be dispatched preferably as a complete unit, in the position in which they have been tested. The modules shall be packed in appropriately sized and numbered wooden crates, suitable for forklift handling. ROV assemblies shall be well supported, and shall be packed so as to achieve an even weight distribution amongst the crates. If equipment will be sea-freighted, seaworthy protection shall be used.

Each instrument forming part of the supply of the system and packed separately shall be adequately protected in plastic foil to prevent ingress of moisture. Valves, fittings and piping shall have open ends protected with close fitting plastic caps or equivalent. Screwed connections shall be plugged.

Pipes and tubing shall be suitably bundled and packed in appropriately sized and numbered wooden crates suitable for forklift handling.

Individual items shall be packed so that contact between other items during movements is prevented.

- All items that are susceptible to mechanical damage shall be packed in bubble-plastic bags.
- Thread protectors shall protect threaded connections, e.g., instrument air connections;

- All openings shall be provided with temporary closures to prevent entry of dirt and other materials.
- Spare parts shall be protected.
- Voids in boxes and crates shall be filled.
- All items shall be labelled.
- A list with description and numbering of the contents shall be issued per box/crate. This list shall specifically identify those items which require special field attention and/or installation instructions.

7. COMMISSIONING

7.1 FLUSHING

Before commissioning, the interconnecting piping shall be flushed. The system shall be flushed and tested in accordance with the specifications, procedures and instructions of the Manufacturer of the hydraulic system. The Contractor shall supervise the flushing procedures.

The flushing/testing procedures shall be subject to approval by the Principal.

The flushing procedure shall address the following requirements:

- flushing oil shall be of the same type as the hydraulic fluid required to operate the system;
- the interconnecting piping shall be disconnected from the modules to ensure that hydraulic components are not flushed;
- a separate flushing unit shall be used to provide an oil flow speed of at least 8 m/s;
- flushing shall take place continuously in one direction until the hydraulic fluid meets the cleanliness requirements of ISO 4406, code 15/12;
- filling and flushing of the hydraulic system should be done in the same direction;
- after flushing, the hydraulic fluid shall be sampled from the end of the flushing loop to check on cleanliness;
- hydraulic fluid used for flushing may be returned to the system, provided the cleanliness requirements of ISO 4406, code 15/12 are met;
- before the modules are connected, the cleanliness of the accumulators shall be checked;
- after flushing, the interconnecting piping shall be pressure tested at 1.5 times the maximum working pressure and inspected for leakage.

7.2 FUNCTIONAL TEST AT SITE

After flushing and pressure testing, the functional tests shall be carried out by the Contractor and witnessed by the Principal.

Each ROV shall be operated by the mobile hydraulic pump connected to the actuator.

Test 1 (5.3.3) shall be performed.

Test 2 (5.3.4) shall be performed.

The ROVs shall be closed by operating the mobile hydraulic pump attached at the emergency shut-off panel.

All ROVs connected to the same power pack shall be closed and opened while only one hydraulic pump is in operation. The time required to regain the required working pressure shall be a maximum 75 s.

By closing all the ROVs from the emergency shut-off panel, opening them from the local operating panel, and closing them again from the emergency shut-off panel, it shall be shown that the accumulator capacity at the pump 1 start position is sufficient for the operation of all ROVs for three strokes. The pumps shall be switched off during this test. The closing time of each actuator/valve combination shall be registered for both the first and second emergency closure. After this test the time in which both pumps can recharge the accumulator to the fully charged condition shall be noted and shall be less than 60 s. The maximum hydraulic and nitrogen pressure and the ambient temperature shall also be noted.

7.3 OPERATIONAL TESTING

Because shut-off valves usually do not operate for extended periods, there is a danger that they could seize if they are installed in aggressive or viscous media. Reliability and proper operability of the valve systems shall therefore be checked at regular intervals. The test requirements and intervals shall be in accordance with DEP 32.80.10.10-Gen. In addition, the nitrogen pressure shall be checked and the related IPF shall be tested once per year, to ensure the hydraulic pressure availability. The test shall also include the partial stroking (80 % open) of the valves at operating conditions.

8. REFERENCES

In this DEP reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
ESD systems for loading and discharging refrigerated and pressurised LNG and LPG carriers	DEP 30.06.10.20-Gen.
Painting and coating of new equipment	DEP 30.48.00.31-Gen.
Equipment noise limitation	DEP 31.10.00.94-Gen.
Pressure vessels (amendments/supplements to PD 5500)	DEP 31.22.10.32-Gen.
Pressure vessels (amendments/supplements to ASME Section VIII, Division 1 and Division 2)	DEP 31.22.20.31-Gen.
Hydraulic operation of valves	DEP 31.36.10.93-Gen.
Piping classes – refining and chemicals	DEP 31.38.01.12-Gen.
Pipe supports	DEP 31.38.01.29-Gen.
Quarter-turn on/off actuators	DEP 31.40.70.30-Gen.
Instrumentation for equipment packages	DEP 32.31.09.31-Gen.
Instrument Signal Lines	DEP 32.37.20.10-Gen.
Classification and implementation of instrumented protective functions	DEP 32.80.10.10-Gen.
Electrical engineering guidelines	DEP 33.64.10.10-Gen.
Electric machines - Cage-induction types (Amendments/supplements to IEC 60034-1)	DEP 33.66.05.31-Gen.
Requisition for Engineering Documents (RED)	DEP 40.10.01.93-Gen.
The preservation of old and new equipment and piping standing idle	DEP 70.10.70.11-Gen.

STANDARD DRAWINGS

Schematic diagrams of control circuits for LV motors	S 67.004
Single line diagrams of LV switchboard panels	S 67.019

AMERICAN STANDARDS

Pipe flanges and fittings	ASME B16.5
Chemical plant and petroleum refinery piping	ASME B31.3

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

Fire test of protection materials for structural steel UL-1709

Issued by:
Underwriters Laboratories Inc.
Publications Stock
33 Pfingsten Road
Northbrook, Illinois 60062
USA

EUROPEAN STANDARDS

Transportable gas cylinders - Specification for the design and construction of refillable transportable seamless steel gas cylinders of water capacities from 0,5 litre up to and including 150 litres EN 1964

Issued by:
CEN
Rue de Stassart 36
B-1050 Brussels
Belgium

Copies can also be obtained from national standards organizations

INTERNATIONAL STANDARDS

Hydraulic fluid power - Particulate contamination analysis - Extraction of fluid samples from lines of an operating system ISO 4021

Hydraulic fluid power-Fluids-Method for coding level of contamination by solid particles ISO 4406

Part-turn valve actuator attachment ISO 5211

Steel and Steel Products, Inspection documents ISO 10474

Issued by:
International Organisation for Standardisation
1, Rue de Varembe
Geneva, Switzerland CH-1211

Copies can also be obtained from national standards organizations.

Tests for electric cables under fire conditions – circuit integrity – Part 11, Apparatus – Fire alone at a flame temperature of at least 750 degrees Celsius IEC 60331-11

Low-voltage switchgear and control-gear – control circuit devices and switching elements – proximity switches IEC 60947-5-2

Issued by:
International Electrotechnical Commission
3, Rue de Varembe
Geneva, Switzerland CH-1211

Copies may also be obtained from national standards organizations.

NOTE: The DEPs and most referenced external standards are available for Shell users on the SWW (Shell Wide Web) at address <http://swww.shell.com/standards>.