TECHNICAL SPECIFICATION

HYDRAULIC SYSTEMS FOR REMOTE OPERATION OF SHUT-OFF VALVES

DEP 31.36.10.30-Gen.

July 1996

DESIGN AND ENGINEERING PRACTICE

PREFACE

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The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design and testing 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 number, dated November 1992.

This DEP shall be used in conjunction with DEP 31.38.01.11-Gen., which includes the selection requirements for standard shut-off valves, and the Requisition sheet DEP 31.36.10.93-Gen.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS.

Unless otherwise authorised by SIOP 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 which 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 which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which 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 Specific definitions and abbreviations

DE	De-Energised
Emergency panel	The main panel to shut off all the mechanical valves. The panel is located at a safe distance from the valves to be operated.
ESD	Emergency Shut Down
Fire-safe valve	A valve design which by nature of its features/properties is capable of passing a fire test.
Fire-tested valve	A design subjected successfully to prototype fire testing. Fire testing shall be done in accordance with BS 6755 part 2 or API

	spec. 6FA.
IPF	Instrumented Protective Functions
IPS	Instrumented Protective Systems
Local panel	The operating panel located close to the mechanical valve to be operated.
MCC	Motor Control Centre
PEFS	Process Engineering Flow Scheme
Power pack	The compact installation for the generation of the power source to serve the valve actuators.
Power source	Medium which drives the actuators.
QA	Quality Assurance
QC	Quality Control
ROV	Remote Operated Valve
SIA	Secured Instrument Air

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 (13).

2. GENERAL

The hydraulic system shall be suitable for the remote operation of valves (ROVs), with the purpose of effecting a quick shut-off in emergencies.

These ROVs are usually installed at critical locations, e.g. in the suction piping of pumps which draw from a large inventory of liquid hydrocarbons (DEP 80.47.10.30-Gen.). They are also commonly installed in the suction and discharge piping of compressors, at the outlet nozzles of storage tanks, in transmission pipelines, in product lines to ship loading hoses or loading arms, and in loading arms between ship and shore (DEP 30.06.10.20-Gen.).

The shut-off valves in these piping systems shall be remote-operated due to their emergency shut down (ESD) function. Sometimes it is desirable to create an independent power source and instrumented protective system to meet reliability requirements during emergency conditions, e.g. fire. Hydraulic systems can meet these requirements relatively simply and are compact in comparison to pneumatic or electrically driven valves.

The minimum number of ROVs should be selected to provide protection for the unit under consideration.

The drive systems of the ROVs may be supplied from an individual source or from a common source; in the latter case, the common source shall be suitable for the simultaneous remote operation of the required number of valves and shall effect a controlled action of all valves.

The operational reliability of the complete drive system shall be such that the risk of it failing is equivalent to that of pneumatically driven valves (DEP 32.80.10.10-Gen.). Minor equipment faults should not disturb normal plant operations, e.g. a small leakage of hydraulic fluid, nitrogen or instrument air supply. 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 system shall be designed such that trouble-shooting and maintenance can be carried out with minimum disruption to the operability of the system.

The valve Manufacturer shall be responsible for the performance of the valves and shall specify actuator sizing to overcome possible valve fouling as specified in the related data/requisition sheet.

The Supplier of the system shall be responsible for sound engineering, delivery and functioning of the entire system, including all items delivered.

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

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

3. DESIGN CRITERIA

The hydraulic system for the remote operation of shut-off valves shall be designed to cover the minimum requirements mentioned below:

3.1 FIRE RATING

The shut-off valves shall be selected in accordance with the appropriate piping class DEP 31.38.01.12-Gen. or DEP 31.38.01.15-Gen.

ESD valves shall be of an inherently fire safe design, with metal-to-metal seats, or metal back-up seats in the case of soft seated valves. Soft seated ESD valves shall be of a fire tested design.

For 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 such that each individual ROV shall remain operable for a period of at least 15 minutes when engulfed in a fire having a temperature profile as described in UL-1709.

NOTE: This can be a reason to select a hydraulic system instead of a pneumatic or electrical system.

To achieve this, additional protection to safeguard the operability of ESD valves may be necessary (DEP 30.06.10.20-Gen.).

3.2 SYSTEM

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

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 seconds, unless otherwise specified by the purchaser.

NOTE: ESD valves in LPG/LNG marine loading arms shall be able to close within 5 seconds (DEP 30.06.10.20-Gen.).

This can 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.

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 opening of an ESD valve shall be possible only from the local operating panel or on the actuator itself (5.3).

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

The remote emergency operation shall always overrule local operation.

The remote closing from the control room and/or emergency shut-off panel shall overrule local actuation of the ESD valve(s).

The operation of an ROV shall always be the result of an operator action and shall never be the result of any system or power supply failure.

The ROVs shall be closed by means of a lever switch on the emergency panel (5.2) or, if specified, also from the main panel in the control room.

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

A piston actuator shall only be pressurised on one side. Systems shall not cause both sides of the actuator to be pressurised simultaneously.

The system shall be designed for the hazardous area classification in which it is installed.

The Principal shall specify the relevant hazardous area classification zone.

The 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.

Valve actuators installed in tropical areas shall be protected against direct sunlight.

The selection of the system components and the system design shall be such that a lifetime of at least twenty (20) years will be achieved (or other required lifetime as specified by the Principal).

3.3 POWER SUPPLY

The power packs shall be pressurised using either pneumatically or electrically driven pumps, whichever is considered the most 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 Motor Control Centre (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 switch board).

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

a) Instrumentation to be specified by the Principal (DEP 32.31.09.31-Gen.).
b) Principal's Motor Control Centre (normal MCC).

For the control of pneumatically driven pumps, secured instrument air (SIA) shall be used.

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.

3.4 INSTRUMENTED PROTECTIVE FUNCTIONS

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 ESD panel.

The operational reliability of the source system, the unrevealed and revealed failure rate, in combination with e.g. the hydraulic controls and alarms and the manual test interval, result in a Probability of Failure on Demand and revealed failure rate of the valves driven by the hydraulic system which shall be equivalent to the corresponding figures for pneumatically driven valves, including the solenoid valves (DEP 32.80.10.10-Gen.).

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

For the purpose of testing an ESD valve at operating conditions, a limit switch shall be included in the system to ensure that during testing the valve can only be moved from its fully open position towards the closed position over a distance of maximum 20% of the valve stroke, without the risk of accidentally fully closing the valve.

4. HYDRAULIC SYSTEMS

4.1 CONTENT

Each hydraulic system shall consist of the following main components:

- A hydraulic 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)

4.2 LAYOUT

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

The hydraulic power pack and the emergency shut-off panel shall be located well away from the related ROVs and equipment. 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 control panel 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 valves have to be operated. If ROVs are installed far apart, multiple systems shall be used if needed to achive a safe location for the emergency shut-off panel.

The installation of a self-contained hydraulic unit per ROV should be considered when 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.)

A combination of the arrangements shown in Figures 1 and 3 or Figures 2 and 3 can be made if necessary. For each project, the safest combination shall be selected in consultation with the Principal.

4.3 CONFIGURATION

The power pack, accumulator rack 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 panel is acceptable if the safety aspects of (5.3) are met.

These modules shall be provided with suitable protection against prevailing environmental/weather conditions.

If the modules have to be fire-resistant, which shall be indicated by the Principal, 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 classification Zone 1 and the system shall then

be designed accordingly.

5. MAIN COMPONENTS OF HYDRAULIC SYSTEMS

A simplified flow scheme of the hydraulic system is shown in Appendix 1.

5.1 HYDRAULIC POWER UNIT

The hydraulic power unit shall maintain full and continuous system pressure in the supply lines to the operating panels. The unit shall include a hydraulic power pack, accumulator rack(s) and piping, as specified below.

5.1.1 Hydraulic power pack

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

- **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 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 minutes. In any case, the oil reservoir reserve capacity shall be such that at maximum operating liquid level it shall have enough remaining capacity to drain the entire 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. (Appendix 1).

- **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.

- **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.

- **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.

- **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. Each pump shall have sufficient capacity to charge the accumulator from the empty condition to the full condition within 120 seconds.

  Normal operating pressure of the hydraulic system shall range between 150 and 200 bar (ga). Pumps shall be driven by air motors or electric motors. Electric motors shall comply with DEP 33.66.05.31-Gen.

  Where 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.

- **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.

- **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.

5.1.2 Accumulator racks

The accumulators and related nitrogen cylinders shall have sufficient capacity for emergency operation of all ESD valves (three full strokes, i.e. one closing stroke, one opening stroke and one 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 materials 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 sealing arrangement of the piston shall be such 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).

A secondary metallic seal configuration shall be such that the piston cannot be damaged. The maximum leakage rate is specified in (8).

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 BS 5045 part 1.

5.1.3 Packaged unit piping

The complete assembly of pipes, control valves, fittings, filters, etc. which is incorporated in the hydraulic power unit 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.

The material of construction for piping (DN>20), tubing (DN≤20), fittings, couplings and valves shall normally be stainless steel AISI 316L. If stress corrosion cracking is to be expected then either of the following materials should be selected:

- UNS S31254 ("254 SMO");
- UNS N08028 ("Sanicro 28");

- UNS N0825 ("Incolloy 825").

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

The piping shall be in accordance with ASME B31.3.

All tubing and piping shall be adequately supported and anchored.

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

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 ANSI B16.5.

Installation of the compression fittings shall be done in accordance with the Manufacturer's instructions.

The use of any threaded connections (other than the compression tube fittings) is subject to the approval of the Principal; NPT threads should be used for such connections.

5.2 EMERGENCY SHUT-OFF PANEL

For hydraulic systems serving ESD valves, the emergency shut-off panel and accumulator rack should be integral with the hydraulic power unit.

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

NOTE: The non-latching push buttons in the control room to initiate a general emergency shut off action of a process unit fall within the scope of the plant IPS.

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 control panel. Piston-type directional valves shall not be used.

A simplified process flow scheme of the controlled valves shall be attached to the panel. Details for the flow scheme shall be provided by the Principal.

5.3 LOCAL OPERATING CONTROL

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 control stand shall consist of the following equipment:

- Directional valves. These valves shall be a three-position spring-centred shear seal type valve, 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.

- Speed control/non-return valves in the supply lines. Alternatively, fixed orifice plates may be installed. The orifice shall be calculated based on the maximum viscosity of the hydraulic fluid.

5.4 HYDRAULIC ACTUATORS

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 shall be provided to prevent slamming of the valve at the end of the stroke.

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 sealing arrangement of the piston and piston rod shall be such 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, e.g.:

- 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 (8). If the actuator system cannot meet the fire rating requirements (3.1) an adequate fireproof cabinet may be provided if approved 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 fire box, 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.

Actuators shall be equipped with a mechanical locking device to block valves in their safe position in case equipment maintenance, repair or testing is required. 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.

The delivered actuator torque at minimum 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) then the delivered actuator torque shall be 1.5 times the required valve torque. In both cases (fouling and non-fouling), the valve Manufacturer may specify a higher required valve torque.

The hydraulic system Manufacturer shall inform the valve Manufacturer about the maximum torque load on the valve stem. Finally, the torque which 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.

5.5 SHUT-OFF VALVES

Valve types shall be specified by the Principal.

Valves shall comply with the specified MESC buying descriptions and specifications.

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

The self-aligning coupling, if required, between the valve and the actuator shall be supplied by the Manufacturer of the hydraulic equipment.

Valves shall be tested and certified by the valve Manufacturer in accordance with the requirements of the relevant MESC specifications and BS 6755 part 1. For the complete assembly test, see (8.3.1).

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

- the relevant opening and closing forces;
- the torque required to operate the valves, based on the specified maximum process differential pressure across the valve in the closed position, to be specified by the Principal;
- the travel length of the stem (for rising stem).

5.6 HYDRAULIC PIPING

This shall include all piping, tubing, fittings, separation, isolating and check valves, couplings and quick-release couplings for the mobile pump unit. The 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 hydraulic piping and tubing shall comply with (5.1.3) and the following:

Flanged joints shall be installed with spiral wound stainless steel, graphite-filled gaskets with an inner and outer guide ring, using ASTM A 193 GR B7 bolts and A 194 GR 2H nuts.

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 stands and between the lines from the local operating 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. regardless of 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 hydraulic power pack and shut-off valves actuators shall be locked open during operation of the hydraulic system.

5.7 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 executed 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 metres having quick connection couplings at the free ends. The 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. Proper support to provide for steady operation shall be ensured.

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.

5.8 HYDRAULIC FLUID

Sufficient hydraulic fluid for the initial inventory of the 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.

The hydraulic fluid Supplier shall indicate the life expectancy of the fluid.

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 system (10.1).
- 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.

5.9 AUXILIARY EQUIPMENT

All necessary instruments such as pressure gauges and transmitters for level and pressure controls for automatic start/stop of the hydraulic pumps shall be specified by the Principal (7.2).

The switchgear and the electric cabling to supply the electric motors shall be provided by the Principal. Also, signal cabling to the junction boxes shall be provided by the Principal.

The selection and installation of electric control switches shall be in accordance with DEP 33.64.10.10-Gen. The necessary safety devices and level gauges shall be provided by the Supplier of the hydraulic installation and are subject to approval by the Principal.

6. SELF-CONTAINED HYDRAULIC UNITS

Self-contained units shall be such that the shut-off valve actuator, power pack, accumulator, nitrogen bottle, instrumentation and local controls are integrated into one unit of modular construction.

If the system has to be fire-resistant, which shall be indicated by the Principal, a fire-resistant box or enclosure shall form an integrated part of the module. The box shall also provide suitable protection against prevailing environmental/weather conditions. The enclosure may cause it to be classified as hazardous area classification Zone 1 and the system shall then need to be designed accordingly.

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 (5.2) or, if specified, from the main panel in the control room.

NOTE: Remote emergency operation, such as from the control room and/or the emergency shut-off panel, shall overrule local operation of the ROV.

For self-contained hydraulic units this DEP shall likewise apply, 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.
- Accumulators need not be mounted in a vertical position.

7. INSTRUMENTATION OF HYDRAULIC SYSTEMS

7.1 GENERAL REQUIREMENTS

The hydraulic system shall be supplied with the instruments and components in accordance with DEP 32.31.09.31-Gen. Instrument selection shall be specified by the Principal.

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 supports.

The pneumatic driven pump systems should be actuated by a pneumatically operated solenoid valve.

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 331, i.e. it shall withstand temperatures of up to 750 °C for a period of 3 hours, e.g. signal cable installed in fire-resistant sealed instrument cable ducting.

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

The routing of the signal cable and the type of fire-proofing and construction shall be approved by the Principal.

7.2 STANDARDISATION

To achieve standardisation with other instrumentation in the plant, the use of particular makes and type of instruments shall be specified by the Principal.

7.3 ACTUATOR LIMIT SWITCHES

Each hydraulic actuator shall be equipped with an adjustable proximity type limit switch and mechanical sensor to detect the ROV's 80% open position. In addition, fully open, 80% open and fully closed limit switches shall be provided for remote status display of the ROVs.

Limit switches shall be of the proximity type and shall be in accordance with IEC 947. The mounting instructions supplied by the Manufacturer of the limit switches shall be followed by the hydraulic system Manufacturer. The hydraulic system Manufacturer shall submit a detailed drawing of the limit switch arrangement for approval by the Principal.

Proximity switches shall be provided with a screened signal cable, which shall terminate in a junction box on the superstructure of the ROV. The cables shall be mechanically protected by a flexible conduit between the sensor and the junction box. Signal 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. The method of mounting the limit switches shall be subject to the approval of the Principal.

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

7.4 HYDRAULIC POWER PACK/ACCUMULATOR

The power pack shall include all the necessary instruments, such as level gauge, level switches, pressure gauges, temperature gauge/alarm, pressure/gauges/transmitters, pressure switches.

The accumulator shall be provided with a maximum volume switch (by measuring the highest possible position of the piston in the accumulator) to assure a completely charged back-up system regardless of the ambient temperature. The switch shall be of the proximity type, situated in a manifold on top of the accumulator.

7.5 INSTRUMENTED PROTECTIVE FUNCTIONS

7.5.1 Control description

All functions of the hydraulic system shall be controlled by skid mounted control equipment to maintain the required hydraulic energy to shut off the ROVs in an emergency.

The alarm and system control shall be of the fail-safe principle. Under normal conditions, contacts shall be closed, and under abnormal condition contacts shall be open.

The solenoid valve for remote actuation of the ROVs shall be normally energised (NE).

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;
- "common failure alarm" of the hydraulic unit, if the system is no longer able to perform its emergency function.

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

7.5.2 Summary of minimum IPF requirements

Description	Function	Trouble	Failure	Action/Remark
Main/stand-by pump switch	Selection			Respectively A:B or B:A
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 (stuck piston detection)
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

7.6 SELF-CONTAINED HYDRAULIC UNITS

All the requirements specified in 7.1 through 7.4 covering instrumentation are also applicable to self-contained hydraulic units. The control description of 7.5 is applicable to a single pump situation.

Each self-contained hydraulic unit shall be provided with a nitrogen buffer system as shown in Appendix 1.

7.6.1 Summary of minimum IPF requirements

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 full charged accumulators (stuck piston detection)
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

7.6.2 Signal cabling

The signal cables between the self-contained hydraulic units (ROV) and emergency panel shall be of the fire-resistant type, or of other fire-resistant construction in accordance with IEC 331, i.e. it shall withstand temperatures of up to 750 °C for a period of 3 hours, e.g. signal cable installed in fire-resistant sealed instrument cable ducting.

The routing of the instrument air lines, signal cables and type of fireproofing/construction shall be approved by the Principal.

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.

7.7 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 number, functional description and purchase order number. Identification of instrument components which are packed separately shall be applied 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.

8. INSPECTION AND TESTING OF HYDRAULIC SYSTEMS

8.1 GENERAL

The complete hydraulic system shall be inspected and tested at the Manufacturer's works, to demonstrate its compliance with the purchase order. The acceptance test for the shut-off valves shall be carried out at the valve Manufacturer's works. The Principal shall indicate if, and to what extent, he wishes to witness the Manufacturer's inspections and tests.

8.2 BACK-UP SEAL TESTS

Before assembly the leak rate test of the accumulator and 10% of the actuators shall be executed 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.

8.2.1 Leak rate test of accumulator

The accumulator leak rate shall be established with the primary seal removed. The Manufacturer shall propose a test arrangement to simulate a primary seal failure.

In this test the leakage shall be measured at the maximum allowable differential pressure.

The leak rate shall be less than 60% of the capacity of one pump.

8.2.2 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 cm^3 hydraulic fluid per minute at the maximum allowable differential pressure across the piston.

8.3 ASSEMBLY TESTS

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

Each combination of shut-off valve, actuator and control unit shall be tested. The Manufacturer shall submit to the Principal a functional testing procedure which shall, in addition to the Manufacturer's requirements, also include the requirements mentioned below.

8.3.1 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 seconds. 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 seconds. 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. The minimum hydraulic and nitrogen pressure shall be noted and shall be more 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.

- 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 8.3.2).
- Shut-off valve operations from the emergency shut-off panel (test 2, see 8.3.3).
- Leakage testing of the hydraulic power unit, local operating panels, actuators and mobile pump.
- A test to demonstrate the ability for operational testing to be performed (see Section 11).
- Functioning of the alarm and IPS.
- Fluid sampling to demonstrate that specified fluid cleanliness is in accordance with code 15/12 of ISO 4406.

8.3.2 Test 1

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

- fully open;
- 80% open;
- fully closed.

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

8.3.3 Test 2

From the emergency shut-off panel the shut-off valve shall be closed. This position shall be maintained for at least 15 minutes. 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 which could result in leakage.

8.4 INSPECTION REPORT

The Manufacturer shall compile an inspection report which shall include all pertinent data:

- Material and test certificates as specified in the purchase order.
- Certificates of all pressure/leakage tests.
  The report shall be complete with process valve tag numbers, drawing numbers, opening and closing times, valve leakage rates.

- Functional test data: hydraulic pressures, operating force and/or torque requirements for each ROV type and size.
- Dimensional checks
- General arrangement and detailed dimensional drawings.
- Bill of materials.

9. PACKING AND SHIPPING

9.1 GENERAL

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.

Disassembly of the system shall be such 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, hydraulic power unit, control 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.

The driving units shall be preserved in accordance with the Supplier's standards.

Valves and actuators shall be dispatched only as a complete unit, preferably in the position in which they have been tested. A sealed lead wire shall be installed between valve and actuator, stamped by the Manufacturer's authorised quality control representative.

The modules shall be packed in appropriately sized and numbered wooden crates, suitable for fork-lift truck handling. ROV assemblies shall be well supported, and packing shall be such as to achieve an even balance of the crates. If equipment is to will be sea-freighted, a strong "plastic" foil shall be used to ensure seaworthy protection. Suitable packing shall be used for additional protection of assembled instruments. 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 seaworthy packing. They shall then be packed in appropriately sized and numbered wooden crates suitable for fork-lift truck handling.

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

- All items that are susceptible to mechanical damage shall be packed in bubble-plastic bags.
- Threaded connections, e.g. instrument air connections, shall be protected by thread protectors.
- 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/installation instructions.

9.2 OPERATION AND MAINTENANCE MANUALS FOR HYDRAULIC SYSTEMS

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;
- trouble shooting schemes;
- requirements for the maintenance of hydraulic fluid cleanliness;
- operational testing procedure.

10. INSTALLATION AND COMMISSIONING OF HYDRAULIC SYSTEMS

10.1 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 flushing procedures shall be supervised by the Contractor.

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 connecting the modules their cleanliness shall be checked, e.g. of the accumulators.
- After flushing, the interconnecting piping shall be pressure tested at 1.5 times the maximum working pressure and inspected for leakage.

10.2 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 (8.3.2) shall be performed.

Test 2 (8.3.3) 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 hydraulic power unit shall be closed and opened while only one hydraulic pump is in operation. The time required to regain the required working pressure shall be maximum 75 seconds.

By closing all the ROVs from the emergency shut-off panel, opening them from the local control 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 seconds. The maximum hydraulic and nitrogen pressure and the ambient temperature shall also be noted.

11. OPERATIONAL TESTING

Since shut-off valves usually do not operate for extended periods, if they are installed in aggressive or viscous media there is a danger that they could seize. 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.

12. 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.
- Weights and outline dimensions of the modules.
- Dimensions of the power pack with oil reservoir and of the mobile unit.
- Completed noise limitation sheet, DEP 31.10.00.94-Gen.
- 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 proposed deviations (if any) from the requirements of this specification.
- Operating and Maintenance Manual leaflets.

13. 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

DEPs

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.
Requisitioning (binder)	DEP 30.10.01.10-Gen.
Painting and coating of new equipment	DEP 30.48.00.31-Gen.
Pressure vessels (amendments/supplements to BS 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.
Instrument air supply	DEP 31.37.00.11-Gen.
Piping - General requirements	DEP 31.38.01.11-Gen.
MF Piping classes	DEP 31.38.01.12-Gen.
EP Piping classes	DEP 31.38.01.15-Gen.
Pipe supports	DEP 31.38.01.29-Gen.
Instrumentation for equipment packages	DEP 32.31.09.31-Gen.
Control valves: Selection and specification	DEP 32.36.01.17-Gen.
Classification and implementation of instrumented protective functions	DEP 32.80.10.10-Gen.
Electrical engineering guidelines	DEP 33.64.10.10-Gen.
Electric motors - Cage-induction and synchronous type	DEP 33.66.05.31-Gen.
The preservation of old and new equipment and piping standing idle	DEP 70.10.70.11-Gen.
Requirements for fire protection in onshore oil and gas processing and petrochemical installations	DEP 80.47.10.30-Gen.

DATA/REQUISITON SHEETS

Equipment noise limitation	DEP 31.10.00.94-Gen.
Hydraulic operation of valves	DEP 31.36.10.93-Gen.

NOTE: Data/requisition sheets are contained in binder DEP 31.10.01.10-Gen.

STANDARD DRAWINGS

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

AMERICAN STANDARDS

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

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

Specification for alloy steel and stainless steel bolting materials for high-temperature service	ASTM A 193
Specification for carbon and alloy steel nuts for bolts for high pressure and high temperature service	ASTM A 194

Issued by:
American Society for Testing and Materials
1916 Race Street
Philadelphia, PA 19103
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.

BRITISH STANDARDS

Transportable gas containers, Part 1. Specification for seamless steel gas containers above 0.5 litre water capacity	BS 5045, Part 1
Testing of valves:	
Specification for production pressure testing requirements	BS 6755 Part 1
Specification for fire type-testing requirements	BS 6755 Part 2

Issued by:
British Standards Institution
389 Chiswick High Road
London W4 4AL
United Kingdom.

INTERNATIONAL STANDARDS

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 Varembé
P.O. Box 56
CH -1211 Geneva 20
Switzerland.
Copies can also be obtained from national standards organizations.

Fire resisting characteristics of electric cables	IEC 331
Low-voltage switchgear and control-gear	IEC 947

Issued by:
Cental Office of the IEC (Sales Dept)
3, Rue de Varembé
1211 Geneva 20
Switzerland.
Copies may also be obtained from national standards organizations.

14. FIGURES

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

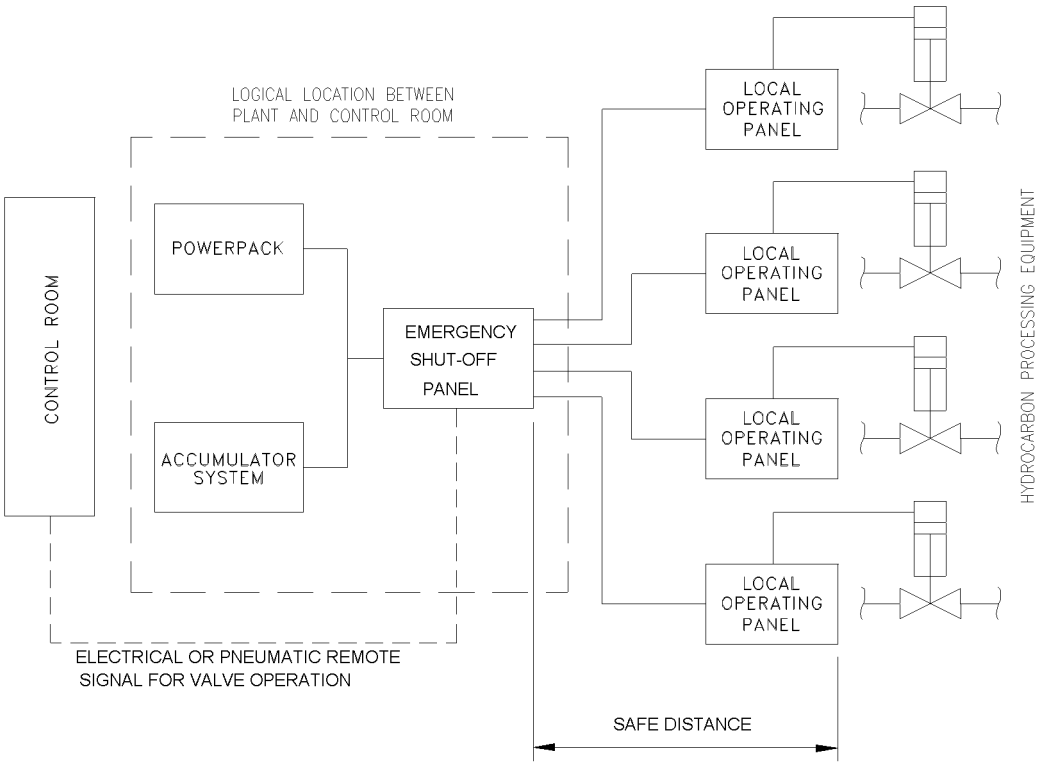


FIGURE 2 LAYOUT OF MULTI-HYDRAULIC SYSTEMS FOR REMOTE OPERATION OF SHUT-OFF VALVES WITH AN ESD FUNCTION

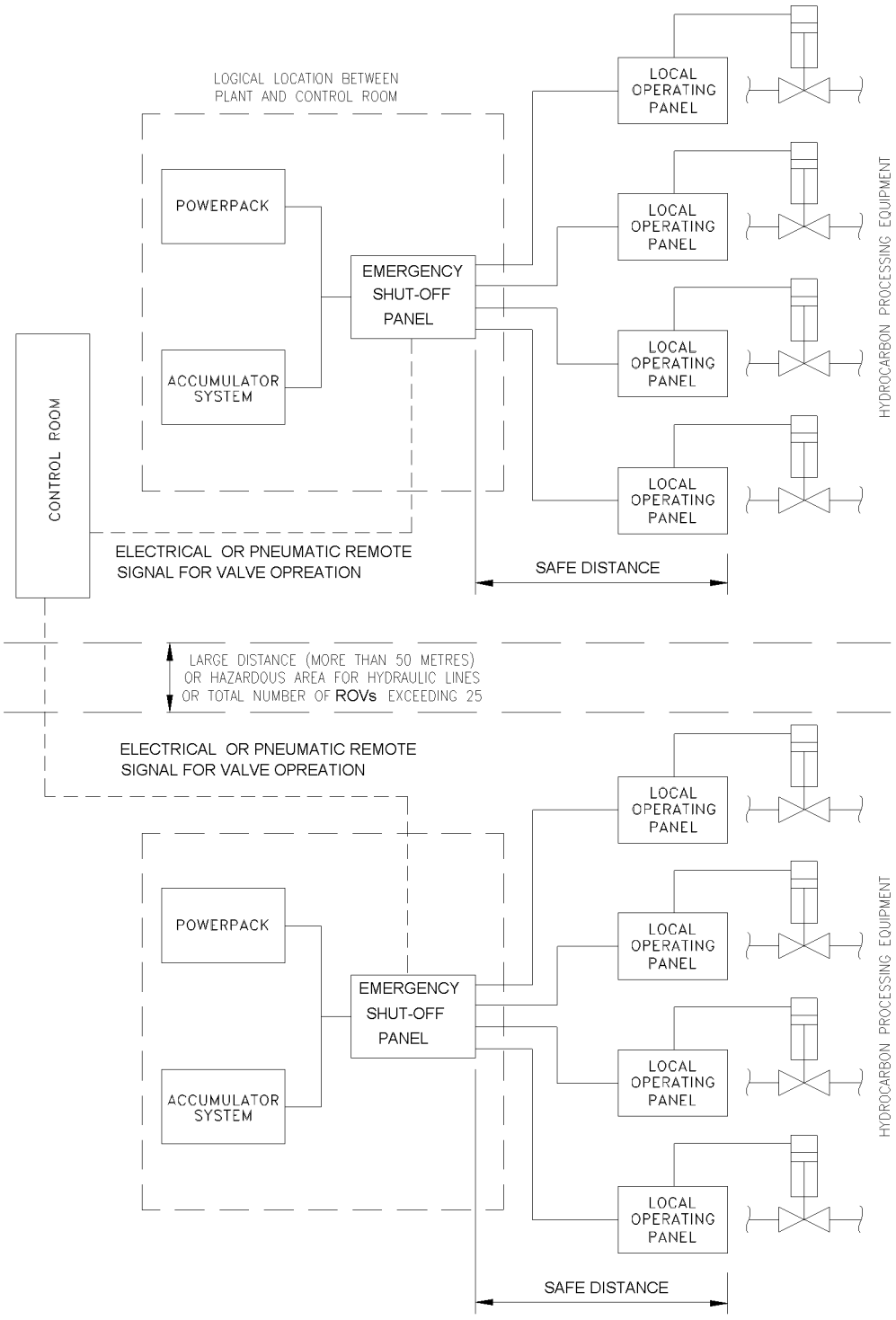
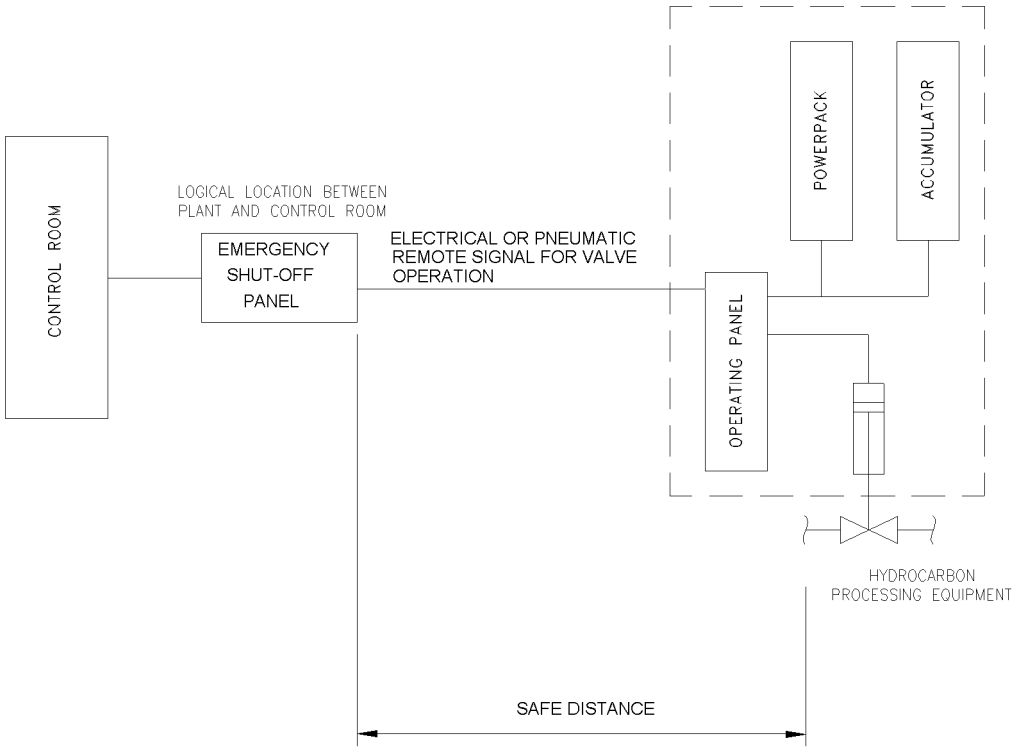


FIGURE 3 LAYOUT OF SELF CONTAINED HYDRAULIC UNIT FOR REMOTE OPERATION OF A SHUT-OFF VALVE WITH AN ESD FUNCTION



APPENDIX 1 SUMPLIFIED FLOW SCHEME FOR HYDRAULIC REMOTE OPERATION OF SHUT-OFF VALVES WITH AN ESD FUNCTION