SOIL MACHINE DYNAMICS LIMITED

MONTEREY BAY AQUARIUM RESEARCH INSTITUTE

TIBURON II, QUANTUM ROV SYSTEM DOCUMENTATION

ROV MAINTAINANCE MANUAL

VOL.1 PART 3

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CONFIDENTIALITY

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1 MAINTENANCE

1.1 Post Dive Maintenance

The following procedures must be carried out when the ROV has been returned to the deck:

1. Connect the deck earth lead.

2. If possible, wash the entire ROV with fresh water. If fresh water is not available, use seawater. The ROV must then be washed down with fresh water immediately a supply becomes available.

3. Perform the pre dive checks to check for faults on the ROV.

4. Fit protective lens covers to cameras. If the ROV is to remain on deck for more than a few days, remove the lamps, cameras, echo sounder and sonar head. Thoroughly clean them and store them in a dry place. Remove responder and place on charge. Ensure connectors are greased and capped.

5. Perform the pre dive checks to check for faults on the ROV.

6. Examine all pins for damage and excessive wear, ensuring that lock plates are secure.

7. Check the tightness of structural fasteners.

8. Drain a very small quantity of oil from the oil reservoir and check for water contamination.

9. Visually check valve packs and thrusters for signs of water contamination.

10. Inspect the fabrications for structural damage. Particularly, look for cracks in welds. Repair as necessary. Contact SMD for welding procedures for aluminium and stainless steel as appropriate.

11. Check for any faults suspected during operations and repair as necessary.

1.2 Maintenance after Extended Period of Work

An extended period of work is defined as at least 500 hours submerged operation, or 6 months which ever is sooner.

Note: There is a dial in the control cabinet which records operating hours of the sub-sea motor.

If the ROV has completed a long period of operation, carry out the maintenance tasks shown below, in addition to the post dive maintenance tasks.

1. Wash the ROV thoroughly with fresh water, paying particular attention to any internal sections.

2. Touch up the paintwork as required to prevent corrosion. Do not paint over anodes.

3. Use a torque wrench to check the tightness of all bolts on the ROV and its attachments. See Table 3.

4. Inspect, refurbish and repair equipment on the ROV as required. The recommended minimum service intervals are given in Table1.

Item	Operating Hours	Months
Main Motor	5000	24
Main Pump	2000	12
Thruster Motor	2000	12
Harness	2000	12
Filters	1000	6-12
Hydraulic Oil (HPE 32)*	2000	12
Isolation Oil (Main Motor)	2000	12
Compensator Oil (Valve pack)	5000	24
Anode	As required	6
Hydraulic Hoses	As required	12
Thruster Bearings	4000	12
Thruster Seals	1000	12

Table 1 - Minimum Service Intervals

* Shelf life of new HPE32 = 60 months from date of manufacture

1.3 Storage

If the vehicle is not going to be used for more than five days, carry out the following in addition to the post dive and extended period maintenance.

1. Remove the cameras, lamps, gyro, sonar and transponder. Thoroughly clean them and store in a dry place. Ensure that the connectors are lubricated in accordance with manufacturer's guidelines.

2. Touch up the paintwork as required to prevent corrosion.

3. Inspect all electrical connectors for damage or corrosion. Clean and lubricate in accordance with the manufacturer's guidelines (see Proprietary Information). Reconnect or blank.

4. Grease all pins using 'AquaLube'.

5. Operate the hydraulic system periodically during storage. Each cylinder should be moved through its full stroke. If possible this should be done using the full hydraulic system from the control cabin in order that the motor and pump unit are used. Alternatively the deck power pack may be used to provide hydraulic power to the ROV.

1.4 Buoyancy and Lift Point

The ROV buoyancy incorporates the main lift system for the ROV; hence its inspection and maintenance are vital to the safe operation and recovery of the vehicle.

The following procedure should be carried out after each deployment:

1. Inspect the buoyancy, check for cracks, delamination and scuffs. If damage is severe, contact SMD for advice on repair.

CAUTION

Repair any minor damage to the buoyancy using syntactic foam and polyurethane repair kits in accordance with the manufacturer's instructions.

2. Refer to the general arrangement drawing for the lifting arrangement and this document for torque settings for bolts.

CAUTION

Ensure nuts securing lift pins are secure.

1.5 Manipulators

Before and after each deployment:

1. Check security of all manipulator securing bolts.
2. Lubricate pins with "AquaLube" grease.
3. Check manipulators, tools and hydraulic hoses for leaks (If fitted).

1.6 Hydraulics System Maintenance

1.6.1 General

WARNING

BEFORE COMMENCING WORK ON THE HYDRAULICS SYSTEM, THE VEHICLE MUST BE ISOLATED USING THE KEY SWITCH IN THE CONTROL CABIN AND THE KEY REMOVED.

WARNING

PRIOR TO UNDERTAKING ANY WORK ON ANY EQUIPMENT SUPPLIED BY HYDRAULIC POWER, ENSURE THAT THE PRESSURE TO THE SYSTEM HAS BEEN RELEASED.

WARNING

WHENEVER DISCONNECTING ANY HYDRAULIC HOSES OR PIPES EYE PROTECTION MUST BE WORN.

For reference purposes, the hydraulic symbols used on hydraulic circuits are shown in Figure 1.

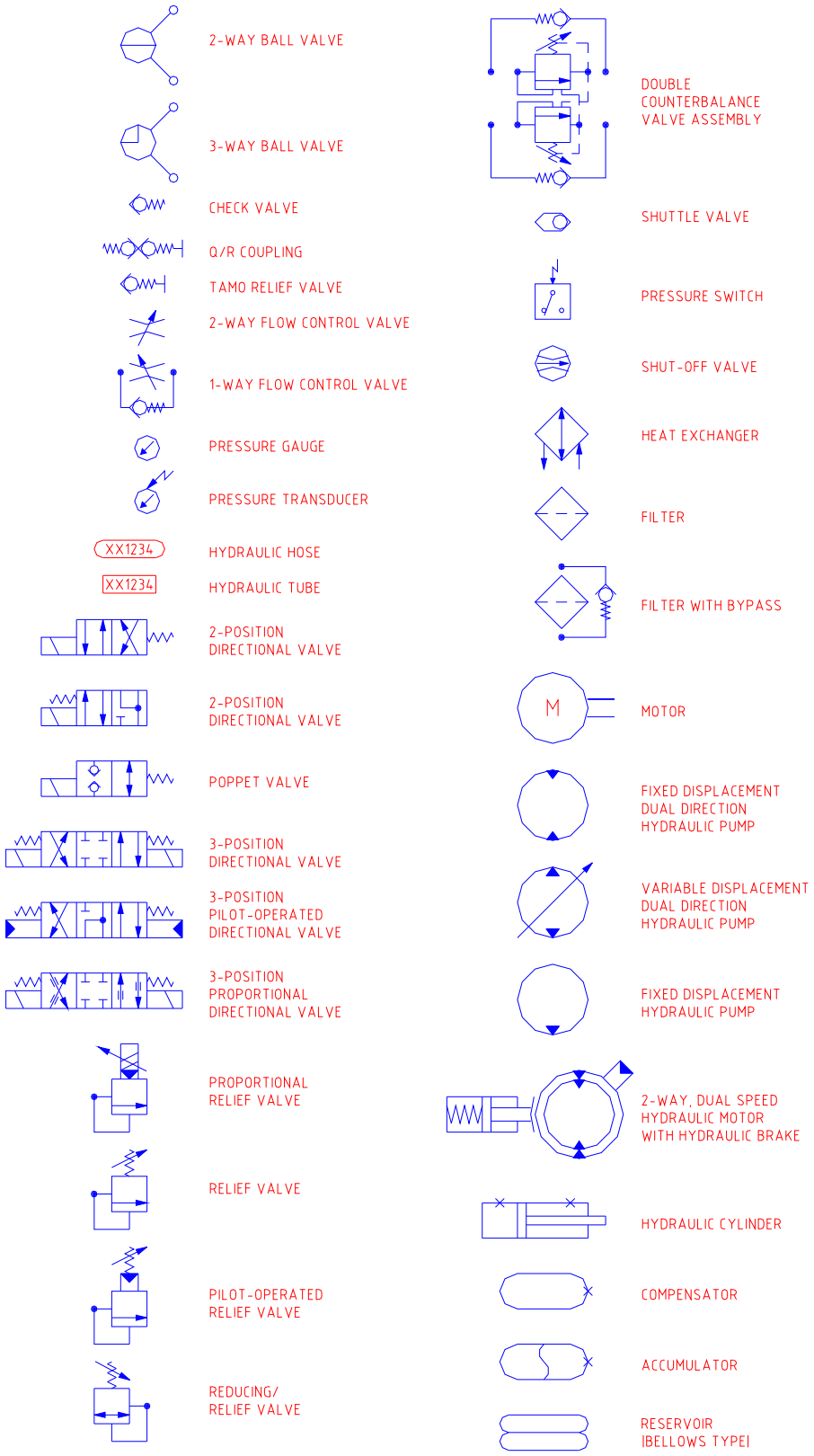

Figure 1 - Hydraulic Symbols Used on Hydraulic Circuits

The hydraulic system is designed to be reliable and easy to maintain. All hydraulic fittings are made of stainless steel. All manifolds are made of hard anodised aluminium.

The reliability of the hydraulic system relies on the cleanliness of the oil - it must be uncontaminated by dirt or water. The following points should be observed:

1. Blank all disconnected hoses and ports immediately after disconnection.

2. Replacement hoses or pipes must be flushed to NAS standard 6 or lower prior to installation.

3. When an SAE flange fitting is disconnected the O-ring should be inspected before reconnection. If there is any sign of damage, the O-ring must be replaced.

If there is any suspicion of dirt or water entering the system the filters must be inspected. If the presence of water is confirmed the oil should be drained out and the system flushed with clean oil. The filters must be replaced and the reservoir refilled with clean oil.

1.6.2 Draining the Oil Reservoir

To drain the oil reservoir:

CAUTION

Do not run the main motor when the reservoir is empty.

1. Connect a drain hose onto the ¾" Quick Release casing labelled "Return" located on top of the reservoir ensuring that the free end is placed into a suitable container. The reservoir will commence draining as soon as the connection is made.

2. When the reservoir is completely flat lift the relief valve on top of the reservoir body, to allow air to enter the reservoir.

3. Continue draining and bleeding air into the reservoir until the required level is reached or the reservoir is empty.

4. Remove the drain connection and allow the relief valve to close.

Note: Oil will remain in all the vehicle hoses and pipes even after the reservoir has been drained.

1.6.3 Filling the Oil Reservoir

CAUTION

Do not fill the reservoir to 100%, as oil will be discharged when the oil temperature rises

Note: Use only clean hydraulic oil to fill the ROV hydraulic system.

1. Connect the discharge hose of the deck power pack to the auxiliary quick release coupling at the base of the reservoir.

2. Operate the auxiliary power pack at 50 psi to pump oil into the reservoir.

3. Lift the relief valve on the reservoir body, to bleed air from the reservoir. Release the relief valve when oil emerges from the valve.

4. Observe the rise in the reservoir level and monitor the deck power pack oil level. Fill as required. Do not allow the deck power pack to run dry.

5. Fill the reservoir to 80% full, approximately 10 litres. Further filling will cause oil to be released through the relief valve on the reservoir.

6. When the desired level is reached, switch off the deck power pack and remove the quick release coupling connection to the deck power pack.

1.6.4 Draining Compensated Valve Packs/Junction Boxes

The ROV has numerous valve packs and junction boxes, all of which are pressure compensated. They will need to be drained before accessing them for maintenance. One compensator may be connected to several valve packs/junction boxes and therefore it will be necessary to isolate the appropriate tank before draining.

To drain the compensated valve packs/junction boxes:

1. Turn off the tap on the compensator hose adjacent to the valve pack to be drained.

2. Slacken the drain plug located at the bottom of the valve pack.

3. Remove the drain plug and drain the oil into a suitable container.

4. Lift the relief valve on top of the valve pack to let air bleed in and thereby allow oil to drain faster.

5. Clean the drain plug, check the seals and refit the plug.

1.6.5 Filling Compensated Valve Packs/Junction Boxes

To fill the compensated valve packs/junction boxes:

1. Confirm that the quick release connector between the compensator hose and valve pack/junction box is connected.

2. Clean the quick release coupling on the compensator fill-point (see Figure 2).

3. Connect the hand pump discharge line to the quick release coupling for the relevant Junction Box or Valve Pack

4. Lift the relief valve to bleed air from the valve pack/junction box as it is filled with oil.

5. Operate the hand pump, pumping oil into the compensator. Visually check the oil level in the valve pack through the transparent perspex cover. For junction boxes, lift the relief valve on top of the box to check if the box is full of oil.

6. Monitor the oil level in the hand pump. Re-fill as required.

7. The compensator is full when the piston is visible through the hole at the base of the compensator. Bleed air from the top of the compensator as required.

8. Inspect the compensated valve pack/junction box and compensation system for leaks. Rectify as required.

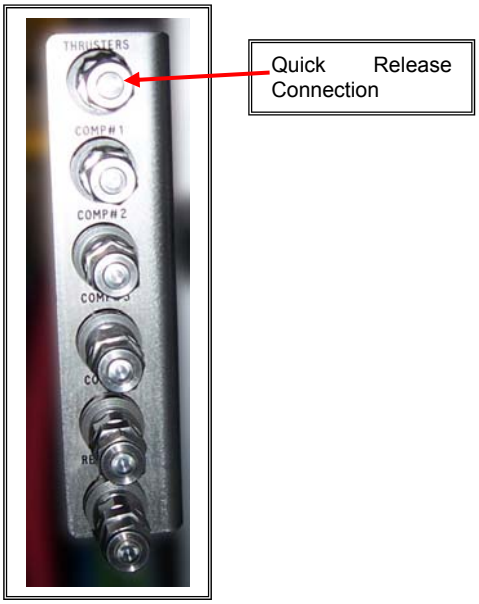

Figure 2 - Compensator Fill Quick Release Connection

1.6.6 Adjusting System Pressure (Pumps)

Operating pressure is adjusted in the analysis screen (analogue output channel, TCU or HCU Flow Control). A percentage value is input to set the appropriate system pressures for each pump in turn (i.e. thruster circuit and tooling circuit).

The value in the software should be adjusted by small amounts to the maximum value shown on the hydraulic circuit drawing (AB3934)

CAUTION

Ensure that the correct pressure is set for the equipment fitted and that the circuit is not modified in such as way as to bypass system relief valves. Typing 100% will theoretically generate 350bar, but the relief valves in the hydraulic manifolds should limit the maximum pressure to 210bar or 250bar depending on the circuit.

To adjust, fit high-pressure gauge to a test point measuring the tooling or thruster circuit pressure as required. The value in the software should only be adjusted when the pumps are *un-loaded*.

Switch motor on and press 'Pump Load' and note down the pressure. Un-load the pump and repeat this process of adjustment until system pressure is at the required value.

1.6.7 Hydraulic Valve Replacement (12 Function Valve Packs)

Each function is fitted with a pilot operated check valve with integral thermal relief valves and a directional valve on top.

The following procedure applies to the replacement of a faulty directional hydraulic valve in any of the HCU valve packs:

1. Isolate the vehicle and hydraulics.

2. Drain the appropriate reservoir to reduce tank line pressure and to minimise oil loss.

3. Isolate appropriate compensator line and drain the oil from the appropriate valve pack.

4. Loosen all M6 socket head cap screws from the valve pack cover flange. The housing can then removed in one piece as shown in Figure 3 (the M6 cap screws are retained in the housing by captive washers).

Note the identification and location of the electrical connections on the valve driver PCB. Disconnect the electrical connectors on the PCB.

5. Remove the four screws securing the PCB and remove it.

6. Remove the retaining fasteners as appropriate and withdraw the valve.

7. Check that the seals are in place on the replacement valve and fit the valve quickly to minimise oil loss.

8. Refit the valve retaining fasteners, taking care not to over-tighten.

9. Re-fit the PCB.

10. Reconnect the electrical connectors.

11. Verify the valve pressure settings.

12. Using the control system and deck pack, verify valve operation by moving the appropriate function.

13. Clean out the valve pack cover taking particular care to clean the flange and seal groove thoroughly.

14. Inspect the valve pack cover seal for damage. Replace if necessary.

15. Refit the valve pack cover and tighten up socket head cap screws.

16. Fill the valve pack.

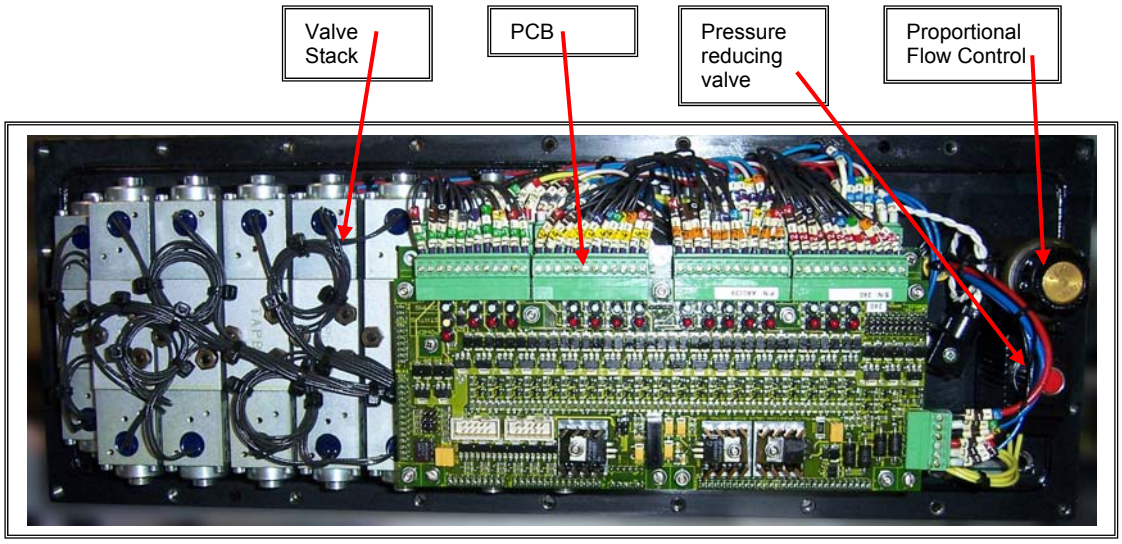

Figure 3 - Valve Pack with Cover Removed

1.6.8 Setting the Function Relief Valves

Thermal relief valves protect all the directional functions fitted with PO check valves on the ROV Figure 4.

CAUTION

Relief valves are low flow, and are only fitted to protect the functions from over pressurisation due to change in ambient pressure (water depth) or thermal expansion due to temperature change.

The hydraulic circuit diagram shows the location of these valves. The method of setting the relief valve on a typical hydraulic function is as per the following procedure.

1. Isolate vehicle and hydraulics.

2. Drain the relevant valve pack and remove the cover.

3. Remove the relevant function hose from the manifold. Blank the free end of the hose to prevent dirt and moisture ingress.

4. Attach a low flow hand pump pressure source, e.g.: Enerpac to the function port, via an adaptor.

5. Operate the pump slowly to increase the pressure - the valve will relieve at the set pressure (factory set at 210 bar).

CAUTION

Turning the setting down too far will result in the complete valve and components being forced out of the end of the valve body.

6. To adjust the setting, slacken the lock screw on the relief valve adjusting screw.

7. Turn the adjusting knob with an Allen key to set the correct pressure, pumping as necessary:

Note: Turning the adjusting knob clockwise will increase the pressure; turning the adjusting knob anticlockwise will decrease the pressure.

8. Release the pressure and tighten the lock screw on the relief valve adjusting screw.

9. Refit the removed hose.

10. Refit the valve tank cover and re-fill with oil.

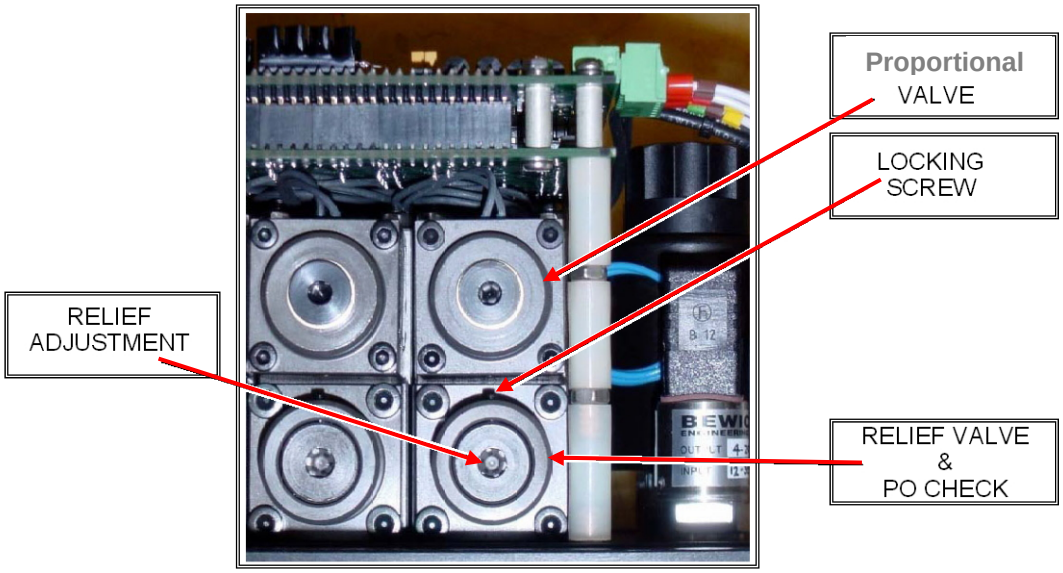

Figure 4 - Typical HCU Valve Stack

1.6.9 Cartridge Pressure Reducing Valve

A reducing valve is installed Inside the 12 Function HCU valve pack to set the pressure for the valve pack. The method of setting a cartridge pressure reducing valve is as follows:

1. Drain the relevant valve pack and remove the cover.

2. Measure the pressure via the transducer in the pack, or via a gauge attached to TP1 on the outside of the pack.

3. Slacken the locknut on the adjuster screw on the pressure reducing valve.

4. With the power pack on, turn the adjuster screw to change the pressure.

Note: Turning the adjusting knob clockwise will increase the pressure; turning the adjusting knob anticlockwise will decrease the pressure.

5. Tighten the locknut on the adjuster screw.

6. Refit the valve tank cover and re-fill with oil.

1.6.10 Hydraulic Hose Replacement

The ROV system spares include a set of spare hoses and fittings for the ROV to enable any hose on the vehicle to be replaced in the event of hose damage.

The hose replacement procedure is as follows:

1. Disconnect and remove the relevant hose. Blank open ports immediately.

2. Fit the new hose, replacing the O-ring seals as required.

1.7 Filter Analysis and Replacement

Hydraulic oil filters should be replaced after 1000 hours. However, it may be necessary to replace filters more regularly dependent on operating conditions.

As the filter gradually blocks up with particulate contaminants, the pressure drop through it increases. By measuring the pressure drop across a filter, it is possible to determine whether the filter element is blocked and needs to be replaced.

A 1/2" bore test hose and a differential pressure gauge will be required for filter testing.

1.7.1 Thruster Circuit Filters

To check the condition of the thruster circuit filters proceed as follows.

1. Attach a differential pressure gauge to the two test points on the relevant filter.

2. Start up the main motor and, whilst observing the readings on the differential pressure gauge, momentarily operate the 8th station servo valve at full demand.

3. The condition of the element can be gauged as follows:

   - 0 - 2 bar – satisfactory.
   - 2 - 2.5 bar - transition.
   - >2.5 bar - change element.

1.8 Thrusters

Refer to the Curvetech manual in the proprietary information for comprehensive maintenance instructions.

1.9 Compensators and Reservoirs

Refer to the Curvetech manual in the proprietary information for comprehensive maintenance instructions.

1.10 Hydraulics Troubleshooting

Logical approaches to troubleshooting common problems are listed in this section.

It is important to ensure that during hydraulic tests:

1. All Safety Procedures are followed.

2. Operators are competent in the use of the ROV control system.

3. The area around the vehicle is clear for testing.

The main hydraulic power will be required during testing of the vehicle. Operators must be familiar with the hydraulic systems. The oil reservoirs must be correctly filled.

1.10.1 Thruster Fails to Move when Operated

1. If only one thruster fails to operate the problem is local. If all thrusters fail to operate, the fault is general, therefore check:

   a. The thrusters are enabled.

   b. The electrical system.

2. If the fault has been narrowed to a local one:

   a. Isolate vehicle and hydraulics.

   b. Check that the thruster can be rotated freely by hand.

3. If the thruster is free, exchange hose connections with a correctly functioning thruster, and check operation again.

4. If thruster now operates the fault is either electrical or a malfunctioning valve:

   a. Verify that the servo valve is receiving a signal.

   c. If the electrical tests are satisfactory, replace the servo valve and retest.

5. If the thruster fails to operate, replace the thruster motor.

1.10.2 Hydraulic Function Fails to Move when Operated

1. Try another function, if this is satisfactory; confirm the flow control settings (Control System) for the appropriate function compared to a function which operates correctly. If it is not satisfactory, the fault is a local or function specific fault. If another function does not operate, the fault is a general one, therefore check the electrical system.

WARNING

Check that there is no pressure in the hoses to be disconnected prior to removing them and that associated mechanical components are appropriately supported.

2. If the function fault has been narrowed down to a local one, remove the service hose from the cylinder or actuator and fit a pressure gauge to the end.

3. If a pressure reading fails to show a flow, the fault may be associated with the directional control valve, therefore check that the LED on the PCB controller illuminates. This indicates that the electrical signal is reaching the valve.

4. If an electrical signal is present, check that the directional valve spool is not jammed. It may be possible to free the valve by operating the function several times in both directions. If not, the valve pack will have to be opened and the valve replaced.

5. If a pressure reading appears on the gauge from the disconnected hoses, refit the pressure gauge via a tee fitting and reconnect the hoses to the cylinder. Check to see if the pressure is up to that specified on the vehicle hydraulic circuit diagram.

6. If the pressure is within specification there may be a mechanical fault with the function being operated.

7. If the pressure is below specification check for:

   a. The correct functioning of the function relief valve.

   b. The correct functioning of a pressure reducing valve.

   c. Damaged cylinder seals.

1.10.3 Hydraulic Function with Gravity Load Creeps Excessively

If the gravity load creep of a hydraulic function is excessive, check the following:

1. The service hoses (including seals) for leaks.

2. The function of the relief valves

3. The cylinder seals

4. The pilot operated check valves

1.10.4 Low Hydraulic System Pressure

The hydraulic supply to the thrusters is limited to a maximum of 280 bar by the main system relief valve in the TCU valve pack.

The system pump load is a proportional pressure valve which is set at 240Bar. In practice, pressure at the thrusters will be approximately 230 bar after allowing for system losses.

A proportional pressure reducing valve in the HCU valve pack limits the maximum pressure to 55 bar for other hydraulic functions. This valve is activated by pressing Tooling pump load.

If there is low system pressure the following procedure should be followed to ascertain the cause:

1. Check if all the thrusters are being operated at 100%. If so, reduce demanded output to some or all of the functions so that power available is distributed more efficiently and system pressure is restored.

2. If low pressure is a problem, recover vehicle onto deck and check the setting of the pilot operated relief valve in the TCU/proportional valve pack.

3. With the vehicle on the deck and isolated, connect the deck power pack to the quick releases for the appropriate circuit.

4. Ensure that the thruster demands are set to zero and that no other functions are active.

5. Confirm the power pack relief is set to maximum and operate the power pack observing the ROV system pressure.

    a. Attempt to adjust the system pressure by altering the pump load valve analogue value in the analysis screen.

    b. Attempt to adjust the relief valve inside the valve pack and confirm that the pressure can be controlled.

    c. If the pressure cannot be controlled the oil is either leaking past the relief valve or the control valves. Replace the relief valve cartridge and repeat the test.

    d. If the pressure can be controlled the oil is leaking past the pump loads valve. Replace and repeat the test.

    e. If, on replacing the relief valve, there is still no control, blank or replace individual valve packs or valves one by one until the faulty unit is confirmed.

1.11 Servo Valve Setup

All thruster control valves are servo valves. When the electrical supply to the valves is disconnected the thrusters should not rotate. If the thrusters rotate with no electrical supply they can be mechanically 'nulled' as follows:

1. Drain the valve pack.

2. Disconnect the electrical connectors from the valves.

3. Release the PCB from its mount and secure to one side.

4. Switch on the ROV control system.

5. Slacken the valve adjuster locking screws (adjustment screw on top of valve).

6. Operate the vehicle hydraulics at system pressure (either deck pack or main motor).

7. Adjust null of each valve in turn by:

    a. Turning the adjustment clockwise until the thruster rotates slowly (note its position).

    b. Turning the adjustment counter clockwise until the thruster rotates slowly in the opposite direction (note its position).

    c. Set the screw mid-way between the two points detailed in a. and b.

    d. Tighten the locking screw.

8. Replace PCB and refit valve connectors.

The valves require a current to drive them to the appropriate position. The TCU valve pack is fitted with a dedicated controller circuit board with integral current drivers. Each servo valve is operated by a current signal between 0 and 32.5mA.

Adjust the valve zero settings as follows:

9. Connect an ammeter (0 -100mA) in series with the servo valve.

10. With the motor switched off, confirm that the current varies from -32.5 to 0mA to +32.5mA.

11. If the current is not zero with thrusters off, adjust the output by editing the number stored as a system variable (SV) in the analysis screen (see Figure 5).

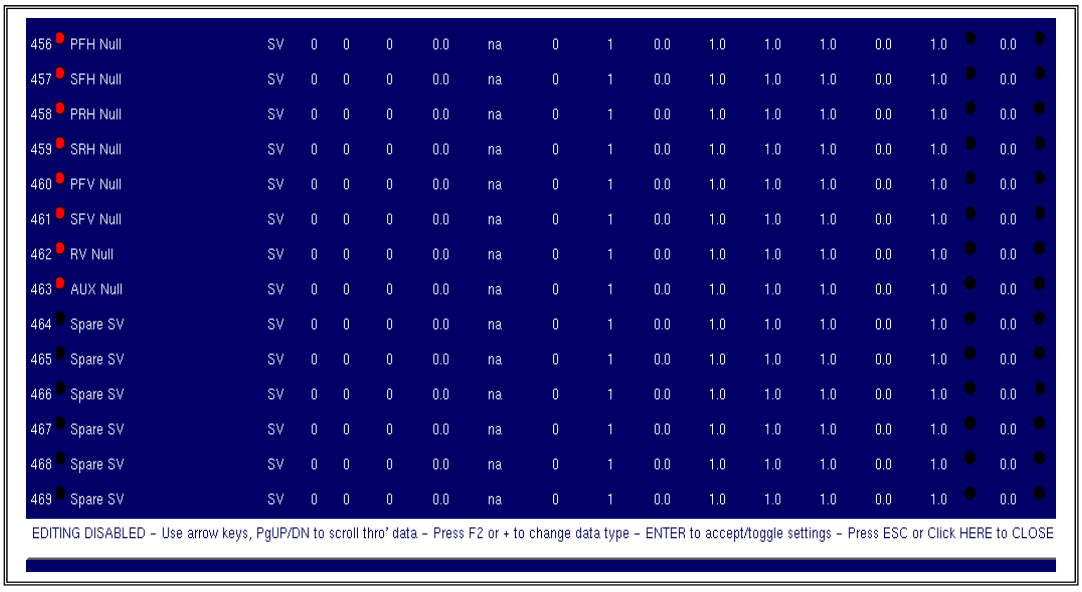

Figure 5 - Adjustment of Servo Valves (Control System)

1.12 Proportional Valve Setup

Proportional valves are used for tooling outputs. The valves require a current to drive them to the appropriate position. The proportional valve pack is fitted with a dedicated controller circuit board with integral current drivers. Two coils operate each valve, each coil requiring a current signal between 200 and 810mA.

Adjust the valve minimum and maximum current settings as follows: -

1 Connect an ammeter (0 -1A) in series with the valve coil.

2. With the motor switched off, confirm that the current varies with the demand set from the touch screen (see Figure 6).

3. To adjust the minimum current, change the value of the R_{min} for the appropriate valve. Set the value to be less than the minimum current required to cause oil flow when 2-3% is demanded on the touch-screen (thus providing a dead band).

4. To adjust the maximum current, change the value of the R_{max} for the appropriate valve. Set the value to be the maximum current of the valve (810mA).

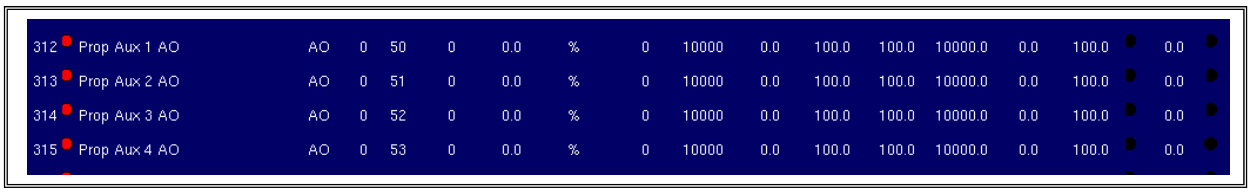

Figure 6 - Adjustment of Proportional Valves (Control System)

1.13 Sub-sea Power Pack

1.13.1 General

The hydraulic power is generated from a motor and pump assembly mounted centrally across the vehicle.

A 55kW electric motor provides the power for the pumps mounted at either end of the unit.

A detailed technical specification and maintenance manual for the pumps can be found in the proprietary information.

The electric motor requires little maintenance. The compensator oil should be renewed as per intervals given in Table 1.

1.13.2 Removal from Vehicle

The motor and pump assembly is mounted on a frame to enable it to be moved sideways out of the vehicle, thereby avoiding the need to remove other components.

To remove the motor from the vehicle proceed as follows:

CAUTION

Take precautions to contain oil lost due to disassembly of hydraulics.

1. Isolate the vehicle and discharge the umbilical.
2. Disconnect and blank all hoses to the main pumps.
3. Disconnect and blank the suction and pressure pipes.
4. Make sure that the umbilical has been discharged.
5. Disconnect the power harness from the sub-sea termination.
6. Disconnect the temperature harness from the motor.
7. Remove the bolts between the channels and the motor feet.
8. Isolate and disconnect the motor compensator.
9. Slide the motor and pump assembly to the side of the vehicle.

CAUTION

The motor and pump assembly weights approximately 300kg when full of compensator oil.

10. Carefully slide and lift the motor pump assembly out of the vehicle. Use soft lifting strops around the motor (not the pumps) or lifting eyes on the motor to lift the assembly.

1.13.3 Disassembly

Refer to the "Curvetech" power pack manual in the proprietary information.

1.13.4 Oil change

To change the oil:

1. Isolate the motor compensator.
2. Drain the oil via the lowest plugs into a suitable container.
3. Remove both caps on top of the motor and allow air to bleed in.
4. Re-fit drain plugs to the motor.
5. Open the compensator valve and fill the motor compensator, bleeding air out of the ports on top of the motor.
6. Operate the motor for 1 to 2 minutes, bleed out any air and top-up the oil level as required.

1.13.5 Insulation Testing

The insulation of the electric motor must be checked in the following circumstances:

1. Following repair and rebuild of the motor.
2. Following an oil change.
3. Following system mobilisation.
4. Whenever power connectors are removed and reconnected.

If possible, the insulation should be measured through the umbilical from the control cabin. In this way, the insulation integrity of the motor, sub-sea connectors, termination's, umbilical and winch sliprings are checked.

Before testing, the deck cable motor cores must be disconnected in the control cabin power room otherwise the insulation check will detect a fault because it will be measuring resistance through the line insulation monitor.

WARNING

Before disconnecting umbilical power cores ensure that the conductors have been checked they are discharged with a high voltage test probe.

5. Ensure that the motor is connected at the ROV.

6. Ensure that the deck lead is connected.

7. Warn all personnel that the high voltage test is about to take place and ensure that they stand clear of the umbilical and the motor.

8. Set the charge voltage to 3000V on the insulation tester (Megger).

9. Measure the insulation between each motor conductor in the deck cable and the control cabin earth. The reading takes approximately 30 seconds as the umbilical becomes charged.

10. Discharge the umbilical after each reading by connecting to earth.

A typical reading on newly built oil filled motor should be 400MΩ. This will reduce as motor running time accumulates. A reading of less than 50MΩ indicates inadequate insulation resistance and must be investigated and rectified.

1.14 Umbilical

1.14.1 Connection/Disconnection Mechanical Termination

Disconnection of the lift point can be carried out as soon as the umbilical is disconnected from the electrical termination.

Disconnect the lift point as follows: -

1. Ensure the umbilical cable is slack (zero tension).

2. Attach a safety line to the umbilical to hold it onto the ROV.

3. Remove the two bolts and lock pin (AB6992) in the end of the main port/stbd pivot pins (item 32) on both sides, shown in drawing AB5465

4. Push one of the pins in to the centre and remove.

5. Push the second pin in to the centre and remove.

6. The mechanical termination is now disconnected from the ROV and may be pulled clear, taking care not to damage the electrical tail (disconnected from the electrical termination).

Re-fitting is a reversal of the above procedure. Ensure that all high strength bolts are tightened to the correct torque.

The following procedure applies to either renewal of the termination assembly and internal components, or re-termination using existing mechanical components. Before re-terminating, ensure that the umbilical is free of both mechanical and electrical defects.

1. Slide the bend stiffener and interface plate onto the umbilical.

2. Slide the termination body onto the umbilical. The termination body internal surfaces must be pre-cleaned with a solvent to remove grease and dirt

3. Fasten a 15 to 20mm jubilee clip approximately 5m from the end of the umbilical. Tightly bind 2mm of galvanised wire immediately adjacent to the jubilee clip and furthest from the end of the umbilical. Two layers of this wire should be wound over approximately 75mm of the length of umbilical.

4. Cut the outer armour layer strands approximately 200mm from the galvanised wire. An angle grinder with cutting disc or suitable file may be used to cut the umbilical armouring

5. Bend the armouring wires out from the umbilical centre.

6. Remove the jubilee clip and slide the termination insert as near as possible to the galvanised wire.

7. Slide the termination body towards end of the umbilical, onto the sleeve.

8. Before using potting compound, clean the wire bundle with suitable solvent. It is advisable to proceed with the electrical termination before potting the mechanical termination. This way, any problems with the electrical termination that warrant a reduction in the length of umbilical do not require the removal of a fully potted mechanical termination.

9. The dimension between the mechanical and electrical termination **must** be adhered to.

10. Ensure an M6 x 20 socket head grub screw is screwed into the tapped hole on the side of the termination body.

11. It may be necessary to seal off the point of umbilical entry to the mechanical termination to prevent leakage of potting compound. This can be done using electrical putty or similar. The termination should be mounted vertically during the potting procedure. This can be done at the same time as the umbilical water blocking. Ensure that the umbilical is centred in mechanical termination.

12. The termination requires approx. 0.5 litre of Wirelock - each 0.5 litre pack comes as two parts - 250ml of solid material and 250ml of resin. Mix the two thoroughly and gradually pour into the body, ensuring that any air bubbles are removed as the Wirelock is poured in. A hole through the wall of the termination body marks the fill limit. See the Proprietary Information for details of Wirelock.

13. Allow the compound to cure in accordance with the manufacturers recommendations.

1.14.2 Electrical Re-Termination

Reference Drawings AB6976

1. Lubricate the rubber gland with silicone grease, e.g. Molykote 33. Feed the compression endcap, rubber gland and O-ring onto the umbilical, up to the end of the armouring.

2. Strip back the outer sheath of the umbilical to the dimension given on the drawing (typically between 600 – 1500mm). Be extremely careful not to damage the power core insulation. Ensure that there is sufficient length between the mechanical and electrical termination.

3. Clean the umbilical water blocking gel from power cores with a suitable electrical cleaner.

4. Twist the drain wires together and cover with a length of heat shrink sleeving.

5. Slide the compression endcap and compression gland close to end of outer sheath.

6. Carefully feed the umbilical tails into the electrical termination box.

7. Push the compression rubber washer well into the socket on the electrical termination box. Pull the umbilical back through the gland until the end of the polyurethane jacket is approximately level with the inside face of the box. Fasten the compression end cap using the stainless steel bolts.

8. Tighten the compression endcap bolts, making sure that the end of the sheath remains in position.

9. Support the gland vertically with the cable entry at the bottom. The umbilical can be potted at the same time as the mechanical termination.

10. Thoroughly clean the inside of the barrel and the cables with an electrical cleaner.

11. Bolt the assembled barrel gland nut onto the base of the electrical termination box, including ensuring that the O-ring is correctly seated.

12. Route all conductors to the appropriate positions on the terminal plate studs.

13. Terminate all cores with the appropriate terminals or connectors. Excess length should be trimmed from all wires to ensure a neat termination whilst leaving sufficient length for future re-terminations.

14. The power cores are joined using crimped eyelets connected to HV stud terminals.

15. The remaining cores are connected through feed-through terminals mounted on a DIN rail strip in the centre of the spacer plate. These cables should be terminated using bootlace ferrules.

16. Fit connectors to fibres (see fibre tool information in Proprietary Information) and connect.

17. Check all connections for continuity, insulation and correct routing (pin allocation). The cabin transformers should be disconnected when checking continuity, as the three phases of each motor are shorted in the transformer.

18. Once system verification is complete, fill the sub-sea electrical termination with appropriate oil via the compensator fill-point.

1.15 Paintwork Repairs

Areas where the paintwork has been damaged should be repaired as soon possible to prevent further corrosion. The area should be prepared by wire brushing to remove any loose paint and rust and degreased thoroughly.

Apply paint to SMD System 2 by brush or spray. An outline of the paint requirements is given in Table 2. The paint manufacturer's data sheets are contained in Proprietary Information.

Layer	DFT (Microns)
1. EPIGRIP L425 (Zinc Phosphate Epoxy Primer) 1 full coat	100
2. EPIGRIP L653 (Epoxy HB Intermediate) 1 full coat	150
3. RESISTEX C750 (Isocyanate free Gloss) 1 full coat	50

Table 2 - Paint Requirements

1.16 Bolt Tightening

Stainless steel bolts throughout the ROV system should be lubricated with 'AquaLube' grease and tightened to the torque values given in Table 3.

For coated steel bolts fitted to the lift point system, refer to the lift point and chassis assembly drawings for bolt sizes and Table 4 below for the tightening torque.

Size	Torque Nm
M6	7
M8	17
M10	33
M12	57
M16	140
M20	273

Table 3 - Bolt Tightening Torque Values