SMD CABLE PLOUGH SYSTEM
PLOUGH SPECIFICATION

System Component Weights and Dimensions

The general arrangement of the Plough is illustrated in Figure 2.1

Weights

Plough with all assemblies fitted (eight in total): 18500 kgs (Approx)
Submerged weight of plough: 15500 kgs (Approx)

Lengths

Skids down, share fully down: 9.1 m
Skids up, share fully down: 10.3 m
Skids down, front chassis and share horizontal: 9.4 m

Widths

Across skids: 4.5 m
Across front of chassis: 4.2 m
Across stabilisers: 5.1 m
Across rear of chassis: 1.7 m
Heights

Top of front camera cage, chassis horizontal: 4.7 m
Top of umbilical termination post, depessor down: 4.4 m
Top of tow swivels, Drawbar at 90°. Steering at 0°, chassis horizontal: 6.1 m

General Specification

Burial System: Parallel sided blades provides pull forces and good penetration

Operation: Towed over the seabed by towrope from surface vessel

Control: Full remote control from shipboard control console whilst being towed

Operating depth: 1500 metres maximum

Towing forces:- (Normal Ploughing) 10 to 80 tonnes (up to 3m deep)
- (Max. Permissible pull at plough) 80 tonnes

Burial depth: 3000 mm. Maximum possible cutting depth to underside of cable in favorable conditions

In strong soils, it may not be possible to reach this depth, because the plough will not penetrate, or the maximum tow force of 80 tonnes will be exceeded. Depth verified by independent trailing arm.

Depth control: The cutting depth of the plough is continuously variable between zero and 2.0 m and is controlled by varying the position of the skids and the ploughshare. Depth accuracy is better than 50mm in normal conditions.

Depths of 2.0m to 2.2m are achieved by plough sinkage until rear stabilisers reach the fully up position.

Depth is increased from 2.2m to 3.0m by rotating the share hinge position with rear stabilisers fully up. The rear stabilizers can also be used to assist with depth control on soft ground.

Rear stabilizers: Stabilizers are rear-mounted used to assist with deployment and recovery and to prevent sinkage on soft ground conditions.

Each stabilizer cylinder is fitted with a transducer.
Cable and repeater size: (Cables) Cables from 17mm diameter to 150mm diameter. (Repeaters) Up to 380mm diameter x 3 metre long with semi rigid ends including 1800mm rigid length, 266mm dia Alacatel repeater. (Cable splice boxes) Up to 150mm diameter will pass through share.

Repeater burial: Share flabs temporary widen trench and a full depth patch into the seabed for the repeater.

Cable bend radius: (Normal ploughing conditions) 1.5m minimum along the cable path.

Soil types: All with good rock ripping capability. In soft mud – capacity 5 kPa minimum.

Ploughing Conditions: Hydraulic power steering provides approximately ±15° of steering angle between the towrope and the direction of travel. Actual maximum angle depends on soil conditions.

Tow rope vertical angle: 10° to 15° maximum above plough horizontal. (Nominal range) Range 0° to 30°. Higher tow angles generally apply to operation in shallow water. At low towing tensions in soft soils, higher tow angles are only possible without lifting the front of the plough off the seabed.

Ploughing speed: Up to 2m/s – dependent on seabed conditions

Cable tracking: Visual by means of the forward television camera. Sensing by lateral mounted cable angle detector (cable)

Cable counter: Active cable length measurement speed as the cable passes through the plough.

Travel/speed: Emergency recovery: Attachement for an emergency recovery ropes are provided. (The ropes are not supplied)

Structure: Fabricated from high strength steel
Wear parts: Parts subjected to high wear are made from very hard, wear-resistant steel coated on critical areas with chrome and tungsten carbide deposited by electric arc welding methods

(Wear plates) Easily replaceable wear plates are provided for areas of highest wear

(Ploughshare) The complete ploughshare (or body) is replaceable if required

(Wear strips and wear disks) Additional easily replaceable. Trimay wearstrips and UTP wear disks to extend the life of other areas of the share.

Corrosion protection is achieved in a number of ways depending on the nature of the material being protected

Cathodic protection: Zinc sacrificial anodes are fitted in strategic areas on the plough

Painting: (Surface preparation) Shot blasting to SA 2 following the fabrication
  (Primer) 1 coat 100 micron EPIGRIP DFT
  (Intermediate) 1 coat 150 micron EPIGRIP L653 DFT
  (Finishing) 1 coat 50 micron RESISTEX M475 DFT
(Closed internal sections) Trimite high Flash HP20 grey anti-corrosive paint
(Closed internal sections) Sprayed with Tectyl 506 Corrosion Inhibitor

Hydraulic System

Motor: 7.5kW 3 phase, 2000V 50/60 Hz
Oil filled and pressure compensated

Pump type: Constant displacement gear pump
(Q) 18 litres/min
(P) Up to 250 barg
Hydraulic functions:

Front Valve Tank:
- Pump unload
- Starboard stabilizer up / down
- Starboard skid up / down
- Disc up / down
- Rock up / down
- Drawbar up / down
- Drawbar latch in / out
- 1 spare

Rear Valve Tank:
- Share hinge open / close
- Depressor up / down
- Accumulator charge / discharge
- Steering port / starboard
- Repeater flaps open / close
- Port skid up / down
- Port stabilizer up / down
- 1 spare

Directional control:
- Solenoid operated spool valves

Float function:
- Solenoid operated poppet valves

Control:
- Overcentre valves: Dual over centre valves provides leak proof load holding and working
- Port relief protection

Cylinders:
- Heavy-duty marine with chrome plated stainless steel rods & welded swivel eyes. With in-cylinder transducers and counter balance valves where appropriate

Valve tanks:
- Stainless steel, oil filled and pressure compensated

Reservoir:
- Flexible pressure compensated, 100 litres working capacity

Manifolds:
- Stainless steel (304L) where exposed to seawater

Pipework:
- Mainly multi-spiral flexible hoses. Rigid pipes in stainless steel

Fittings:
- Stainless steel SAE `O’ring flange type where possible

Hydraulic oil:
- Houghton Vaughan Hydrodrive HPE 118

Transducers

Below follows an overview of the transducers on the plough. More detailed specifications are given in section 4.
Pressure

Sensors:
- Water depth
- Depressor pressure
- Hydraulic system pressure

Linear Displacement

Sensors:
- Port skid position
- Starboard skid position
- Steer angle
- Port stabilizer position
- Starboard stabilizer position
- Drawbar position
- Depressor position
- Hydraulic oil volume in reservoir
- Share position
- Flap position (port & starboard)

Force

Sensors:
- Cable tension in Plough (15t SWL)
- Port pull force (80t SWL)
- Starboard pull force (80t SWL)
- Umbilical cable tension at Plugh (15t SWL)

Temperature

Sensors:
- Motor temperature (Platinum resistor)
- Electronics pod temperature (Integrated semiconductor device)

Moisture Ingress

Sensors:
- Hydraulic oil reservoir moisture ingress
- Front valve tank moisture ingress
- Rear valve tank moisture ingress
- Electronics pod moisture ingress
- Motor moisture ingress is continuously monitored via the Line Insulation Monitoring System

Inclination

Sensors:
- Pitch
- Roll
Altitude

Sensors: Plough altitude (Echosounder)

Heading

Sensors: Plough Heading (Flux Gate Compass)

Rotary Encoder

Sensors: Cable Distance

Angular Displacement

Sensors: Vertical tow angle starboard
Rotary Hoizontal cable entry angle
Potentiometers: Depth skid

Proximity

Sensors: Drawbar down
Drawbar vertical
Depressor down
Repeater in bellmouth
Cable in share

Surveillance Equipment

The Surveillance equipment compress television cameras, associated lamps, pan and tilt units, obstacle avoidance sonar and hydrophone.

Cameras

Provision is made for three low light, monochrome, SIT, subsea television, camera and NTSC output. These are mounted on pan and tilt units or fixed brackets to provide optimum viewing the the plough. Cables and brackets on the plough but cameraes missing.

Lamps

Five lamps are provided, suitable positioned to provide optimum illustration for the SIT cameras. Each lamp is individually switched from the control concle.

Pan and Tilt units

Provision is made for two electrically powered subsea pan and tilt units, one located within the front cage and one within the rear cage of the Plough. Each of the units carries one of the subsea cameras.
Sonar

A sonar unit is located at the front of the Plough, where they are used as obstacle collision sonar.

Acoustic Positioning

Provision is made to fit a responder/transponder
GENERAL

The Plough control system operates at high voltages and contains several potentially dangerous mechanisms. Dangers are increased by the ability to operate the system remotely from the control cabin. It is essential that operators are familiar with the system and fully aware of the dangers.

The generation of, and adherence to, well layed out and conceived operational procedures will ensure that all risks inherent with the operation of the plough can be overcome.

Good communication between guidelines on safety and outlines the main potential dangers of the plough system. The procedures described are intended only to provide guidelines rather than rigorous instructions. Improved procedures will be developed through continued use of the system.

Caution! Before attempting any work on vehicle ensure that it is adequately to ships deck.
**Electrical Safety**

The system must be earthed. If the container is welded to the deck of the ship a good earth can normally be guaranteed. However where this is not so an extra conductor of 120 mm² minimum should be attached to the external earthing stud.

The Plough motor runs at a voltage of 2000V and the subsea electronics at 1000V. **These voltages are lethal.** The installation and treatment of the deck cable(s) requires extra care due to its exposure lying across the open deck. This cable must have a robust shields placed over it to protect it from accidental damage.

The power to the vehicle must be switched off whenever the Plough is not in use or is being worked on. To isolate the subsea system in the control, van the “Isolate” key-switch should be pressed in and locked. Added safety can be achieved by locking the key-switch in the depressed position and removing the key. The subsea motor, switched fuses should also be operated whenever the motor is not in use, these be locked off with padlock when necessary.

It must be remembered that these high voltages are present throughout the umbilical system including the winch terminal boxes.

Before undoing any of the subsea connections on the vehicle ensure that all associated power is switched off. This not only protects the operators from accidental shock but also saves the connector from damage by arcing as the pins are withdrawn from the sockets.

**WARNING** All connectors must be scrupulously clean before mating; specially the 2000V motor connector. Carefully lubricate with silicone spray.

Whenever the Plough is to be powered up on deck a 25mm² earth strap must be attached between the deck and the Plough earth point. A standard 25mm² welding lead is suitable and should be clamped securely to a deck lug.

The first operation when the Plough is recovered on deck must be the earth strap attachment. This should be conducted with the power off to the subsea system and with the operator wearing high voltage “Linesman gloves”. Gloves in accordance with British Standards 697 should be used.

After the umbilical has been powered down there may be residual energy stored between the conductors due to the capacitance of the cable. The longer the cable and higher the voltage the more energy is stored.

Before allowing access to any part of the umbilical system, the termination or connectors, it is essential to discharge all power conductors. Ensure that the subsea power is located and then use the earth probe in the umbilical connection enclosure at the rear of the control cabin to momentarily connect each of the umbilical conductors to ground. Inside the umbilical termination enclosure is a Perspex terminal cover through which are several small access holes. (See figure 1)
There are potentially dangerous voltages throughout the system. All electrical equipment should be treated with respect and precautions appropriate to the safe use of electricity on board ship be borne in mind at all times. Although Line Insulation Monitors protect the subsea electrical system, the very high voltages used mean that SMD does not recommend powered operation of the vehicle in the vicinity of divers.

**Control System**

These safety notices are not meant to replace those in the proprietary information package.

The control software for the cabin contains many instructions that are safety critical. Modifications to the control software should be performed with care.

**CONTROL CABIN SPECIFICATION**

**Control System Description**

**General**

Drawing PG5847 details the 4 bay control cabin layout.

The control cabin is housed in a standard size ISO 20 ft container. The design has been developed to provide maximum comfort for the Plough operating team during long term burial operations whilst facilitating system maintainability. The cabin is completely self-contained so that the only service it requires from the support vessel is a three phase electrical supply.

The cabin comprises two main areas that are separated by the control console. On the desk side of the console is the operating area, whilst on the opposite side of the cabin is the main emergency exit. The other door on the maintenance area side is used for normal access.

The control cabin has standard ISO corner pedestals for mounting on the lower four corners for twist lock attachment to the vessel and ISO corner blocks on the upper four corners.

**Operating Area**

During operations, the operators would normally be seated in the operating area in front of the console. In addition to the console, the operating area contains a desk area and cupboards and shelves for general storage. The internal walls of the operating area are lined and insulated to provide thermal and acoustic shielding from the external environment. The steel floor has a wooden insulation layer and a rubberized surface.
**Maintenance Area**

The maintenance area contains all the transformers, switchgear and power distribution and protection equipment for the system and allows easy access to all the major components. The equipment fitted in the control consoles can also be accessed from the maintenance area via the doors fitted to the rear of each console bay.

The cable entries and terminations for all external connections are also located in the maintenance area. These connections include the main three phase supplies to the chain, the deck cable to the umbilical winch and vessel interface connections such as video, telephone, communications systems etc.

The cable entries are designed to prevent ingress of water. Weatherproof power outlets are installed.

**Control Console**

The console is designed for two operators, a pilot and a co-pilot. The control console physical and visual environment is ergonomically designed for operator comfort, with information display and controls selected to minimize operator fatigue resulting from prolonged work periods.

The console consists of three vertical 19” rack units combined into one integral structure. The whole console assembly is attached to the cabin through anti-vibration mounts. The individual rack mounted components can be removed and replaced with the minimum of disturbance. Access to the rear of the console is gained from the maintenance area via the rear doors so that the operators need not be disturbed during fault finding and minor maintenance tasks. All connectors and cables are labelled in accordance with the system circuit diagrams to facilitate maintenance and fault finding.

The sloping desk area of the console houses the main Plough controls including joysticks, keypads, switches and indicators. Two chairs are provided for the Plough operators.

**Domestic Services**

The control cabin is air conditioned so that both equipment and personnel are maintained in a suitable environment whilst the external temperature does not exceed 45 °C. An extractor fan is fitted to provide fresh air forced ventilation when necessary. Air circulation fans are also fitted to some of the equipment cabinets.

Full domestic services are provided in the control cabin including heating, fluorescent lighting, power outlets and fire extinguishers. Residual current devices (RCD) protect power outlets. Dimmable lighting is also provided for use during operations to reduce glare and operator fatigue.
Power System

The control cabin requires a three phase supply at 440V @ 60 Hz. This supply is transformed and distributed by equipment fitted in the maintenance area of the cabin. The supply voltage, current frequency and phase balance are monitored by the power system so that in the event of a supply fault either the supply is shut down or the operators are alerted, depending in the nature of the fault.

There are 24 V and 110V circuits available within the control cabin. Domestic outlets are provided in both the operating and maintenance area. Residual Current Devices (RCDs) in addition to overcurrent protection protect all 240V and 110V circuits.

An Uninterruptible Power Supply (UPS) is provided. During normal operation this conditions the power supplies to the control cabin processors. In the event of a power failure, the UPS will provide backup power to essential systems including the processors and graphics displays, and the fire alarms. This allows the operators to carry out a controlled system shutdown following a power failure.

Isolated subsea power is supplied to the Plough at 2,000V for the subsea motor and 1,000V for the subsea electronics. Isolating transformers are used for the subsea supplies to enhance safety, particularly for divers. All the subsea supplies are protected by Line Insulation Monitoring (LIM) systems. This combination of isolating transformers and line insulation monitors ensures that an insulation fault on a single phase conductor, although not necessarily dangerous due to the isolated supply, would be detected by the LIM and cause supply shutdown. This system offers enhances safety for divers in comparison with a conventional earthed neutral RCD type system.

The subsea supplies are also by an Earth Continuity Monitoring (ECM) system that ensures that the subsea supplies can not be applied unless a secure earth connection is made at the vehicle. Conventional overcurrent devices also protect the subsea supplies. In addition, the subsea motor supplies are protected by Motor Protection Relays.

Conventional fuses protect low voltage DC circuits within the cabin.

Meters and power system status warning lights are sited in 4th console bay so that the operators can monitor essential power system parameters.

The power system design follows guidelines laid down in Code Of Practice for the Safe Use of Electricity Under the Sea (AODC, September 1985).
Graphics Displays

Two main 17” VGA monitors are fitted to the control console, one at the pilot position and one at the co-pilot position. These monitors will display the screens provided by the plough control software.

Two additional 17” graphics displays are fitted to the control console one for the sonar processor the other, located at the co-pilot position, for navigation.

Processor System

The Plough control system is based on standard PC based processors. There are two Pentium based “desktop” type PCs situated in the control cabin plus one rack mounted processor. Their main functions are:

- Interface with operator inputs joysticks, keypads and switches.
- Provide visual and audible feedback via the graphics screens and other indicators.
- Communicate with, control and gather information from the subsea electronics.
- Control equipment such as chart recorders, printers, contractors and relays.
- Interface with vessel systems such as DGPS, survey or subsea positioning systems.
- Provide data logging facilities.
- Monitor system status and alert operators in the event of alarm conditions and under certain circumstance shutdown the relevant system. For example, if the subsea data link fails then the topside processors will shut down the subsea power.

Data Logger

The PC control system includes an internal data logging system. The operator can select any of the system variables to be logged using the keypad and the logging menu on the graphics screens. The logging menu on the graphics screens. The logging rate can also be set by the operator up to a maximum rate of once per second. The selected variables are then logged to the PC hard disk at the selected rate in ASCII format. The files created on the hard disk have the system date embedded in their filename so that they can be easily recognized. All files are less than 1.44Mb so that they can be easily transferred to floppy disk for later analysis. If the amount of data to be logged on a particular day exceeds 1.44 Mb, a new hard disk file is automatically opened with the next sequential serial number as a suffix. The logged files can easily be read using a standard spreadsheet such as Microsoft Excel.
Video System

The console is fitted with a bank of 9” video monitors. These are used to view any of the video signals available from the system. A video matrix allows the operators to select the signals source for the monitors using the integral keypad. Typical inputs to the video matrix would be subsea camera pictures and PAL encoded VGA signals such as sonar and pilot graphics display. In some installations a survey picture from vessel could be routed to the video matrix.

Two multi-standard VHS video recorders are provided in the control console. The picture source is selected using the video matrix so that any of the available video signals can be recorded. The output of the VCRs can be monitored on any of the available 9” monitors in the console. A video overlay facility is also provided so that text can be overlaid onto one of the VCR recordings. The input and output of the video overlay are connected to the video matrix.

Communications System

A UHF radio base station may be installed in the cabin external antenna, 4 hand held units with charging units are provided.

Full duplex wired “clearcoms” system with 2 separate linkable channels, 6 belt packs and headsets are provided, plus the facility to add extra speaker stations or headsets.

Control Cabin Summary Specification

General Specification

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
</table>
| 20’ISO container External dimensions: | Length = 6058 mm  
 Width = 2438 mm  
 Height = 2591 mm |
| Weight: | 8500 kg |
| Access: | 1 Personnel door, 1 emergency exit door |
| Lighting: | General lighting provided by fluorescent strips. Dimmer controlled lights are provided for operations. |
| Climate control: | 7kW air conditioning unit provides necessary cooling. Two background heaters are provided. |
| An extractor fan provides air circulation. |
| Fire alarm: | 2 x smoke detectors |
| Fire Extinguichers: | 1 x CO2 extinguisher |
Power Input Connections

Mainly Supply: 70 kVA – 380/415/440 V, 3 phase, 50/60 Hz
Storage Supply: 230V/32A Single Phase

Power Output Connections

Subsea Motor: 30kVA – 2000V 3Ph 50/60 Hz
Subsea Pod: 3kVA – 1000V Single Phase
Umb. Winch Fibre Optics: 110V/6A Single Phase
External Socket 110V: 110V/10A Single Phase
External Socket 240V: 240V/16A Single Phase
External Socket: 415V/16A 3Ph
External Socket: 240V/63A Single Phase

Data Signals

Subsea Pod Telemetry: Arcnet
Bridge Link: RS422
Sonar Telemetry: Two wire (Simrad Type)
Telephone Socket: 1 x RJ11
Analogue Inputs: 12 available inputs ZIATECH
Analogue outputs: available inputs from ZIATECH

Video Signals

NTSC Video Inputs: 6 x Surge protected
VGA Video Inputs: 1 x Nav Screen (5 x Coax.)
Video Outputs: Surge Protected

Audio Signals

Radio communication: Clearcomms system
### Power Monitoring

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Insulation Monitor:</td>
<td>IRD1007 Line Insulation Monitor</td>
</tr>
<tr>
<td>Pod Insulation Monitor:</td>
<td>IRD1007 Line Insulation Monitor</td>
</tr>
<tr>
<td>Earth continuity:</td>
<td>Monitoring on Pod and Motor earth connections</td>
</tr>
<tr>
<td>Motor Overload Protection:</td>
<td>Current monitoring device</td>
</tr>
<tr>
<td>Pod protection:</td>
<td>Fused on transformer primary supply</td>
</tr>
<tr>
<td>Supply monitoring:</td>
<td>Frequency and voltage relays monitor the incoming supply</td>
</tr>
<tr>
<td>Computer power supply:</td>
<td>Protection by uninterruptable power supply</td>
</tr>
</tbody>
</table>

### Power Display Panel

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Supply (from vessel):</td>
<td>3 x Voltmeters, 3 x Ammeters, 1 x Frequency meter</td>
</tr>
<tr>
<td>Motor Supply:</td>
<td>3 x Voltmeters, 3 x Ammeters, 1 x Insulation meter</td>
</tr>
<tr>
<td>Pod Supply:</td>
<td>1 x Volt meter, 1 x Ammeter, Insulation meter</td>
</tr>
</tbody>
</table>

### Console

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>General:</td>
<td>3 x 19” Bays + 1 x 19” Bay</td>
</tr>
<tr>
<td>Graphics Monitor:</td>
<td>4 x 17” Sony SVGA; Pilot, Co-pilot, Sonar, Navigation</td>
</tr>
<tr>
<td>Video Monitors (B&amp;W):</td>
<td>4 x 9” Sony PVM95E, 2 x 9” Sony PVM9042QM</td>
</tr>
<tr>
<td>Video Switcher:</td>
<td>16 inputs x 20 outputs Molynx</td>
</tr>
</tbody>
</table>
Sonar Processor: Simrad MS900
ZIATECH Unit: 1 x ZIATECH Rack c/w
1 x Power Supply Unit
1 x Central Processor Unit
1 x Arcnet Card
1 x Ethernet Card
1 x Digital Input/Output Card
1 x Hard Disk
1 x Floppy Disk
1 x Keypads
1 x Analogue card
1 x Dell Optiplex Pentium 233

Video Converters: 2 x VGA to PAL converters to allow recording of pilots graphics and video overlay

Software

Control Software: ZIATECH control & display programs for the control of SMD built Plough

Logging Software: SMD logging Software loaded onto one of the Dell computers
CONTROL CABIN OPERATION

Connecting Power Supplies

Main Supply

The incoming power cable is connected into the left hand enclosure at the rear of the cabin (See Figure 1). The enclosure should be fitted with a gland to suit the cable. The earth connection for the cabin is located in the side of the cabin below the mains connection enclosure.

Storage Supply

The storage supply is connected to a socket underneath the auxiliary power outlets at the rear of the control cabin. A suitable 13A extension lead connected into the socket is sufficient.

When power is provided on to this external socket and the miniature circuit breaker no. 2 (MCB 2) is switched on, power is available from the twin socket inside the power area to the rear to the uninterruptable power supply (UPS).

The UPS can be plugged into this socket and activated, which will provide power to some lights, fire alarm and computers within the console. The background heater, in the power cabinet, can also be plugged into socket of the cabin is to be left in storage for long periods.

Umbilical Connections

The umbilical is connected into the right hand enclosure at the rear of the cabin (Figure 1). The enclosure should be fitted with a gland to suit the cables.

See the drawing PH3276 for the power and the signal routing connections. Check insulation of the umbilical system each time the system is disconnected and re-connected before power is switched on.
Auxiliary Power Outputs

The 110V & 415V outputs are supplied direct from the main supply and will be energized as soon as the cabin is powered and the appropriate MCB is switched on. All of these outputs are located at the rear of the cabin underneath the power.

<table>
<thead>
<tr>
<th>Output Socket</th>
<th>Circuit Breaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>110V AC 10A</td>
<td>MCB 5</td>
</tr>
<tr>
<td>240V AC 16A</td>
<td>MCB 19</td>
</tr>
<tr>
<td>240V AC 63A</td>
<td>MCB 20 &amp; 21</td>
</tr>
<tr>
<td>415V AC 16A 3 PHASE</td>
<td>MCB 1</td>
</tr>
</tbody>
</table>

Auxiliary Connections

All other connections (serial links, analogue inputs/outputs) to the cabin are made through a separate enclosure which is located at the rear of the cabin. All connections should be made through the base of the enclosure with appropriate glands.

See the drawing PH3276 for the power and the signal routing connections.

Switching on the Cabin

Active the cabin as follows:

1) Ensure ships supply to the cabin is energized
2) Ensure switched fuse 2&3 (SWF2 & SWF3) are switched off – Motor & Pod supplies
3) Switch on main supply (Switched fuse – FS1)
4) Volt meters in Bay 4 should now display supply voltage
5) Press the illuminated mains reset push – botton

Power is now supplied to the console at the voltage shown on the voltmeter unless the supply fault indicator is lit. The supply fault light will illuminate if: -

1) Supply frequency is not ± 3Hz of 50 or 60 Hz
2) Supply Voltage is not connected to the correct tapping of the domestic transformer TX2, causing console supply voltage to be outside the limits of the under and over voltage relays (210-250V)

Carry out the following checks if this is the case: -

1) Switch off supply and check the tappings on the transformer
2) Switch on the UPS outputs
3) Check that all the circuit breakers in the power area are switched on. Power should now be available to all items within the control cabin except the subsea supplies

**Subsea Power Supplies Safety System**

**General**

The subsea safety system has been designed in accordance with the “Code of Practice for the Safe Use of Electricity Underwater” produced by the UK Department of Energy. The safety system consists of two main departments elements, the earth continuity monitors (ECM) and line insulation monitors (LIM). The overloading of the motors and over current relays that protect the system from short circuit faults. Indication and operation of the units is collected together on the power display panel.

**Principle of Operation**

The subsea power circuits for the plough are fed from isolating transformers. With an isolated system, a “first fault” condition is not in itself dangerous. A first fault exists if the insulation between one phase and earth breaks down. In this situation, the potential of the faulty phase is forced to the same potential as the earth.

The line insulation monitoring system continuously monitors the insulation value between the live conductors and earth. Line insulation monitoring therefore relies on there being a reliable connecting the control cabin monitors the integrity of the earthing system.

If the insulation value decreased below a present limit, a warning is given. If the insulation value is sufficiently low, the subsea power is shut down. The line insulation monitors will therefore detect a “first fault condition”.

**Earth Continuity Monitors**

The function of the ECMs is to ensure that there is always a safe electrical path to earth back from the plough. There are two ECMs – one for the motor and one for the main electronics pod.

The main earth connection to the Plough is through one of the main umbilical power cores. This conductor is connected to the control cabin earth at the surface end and to the electrical termination at the vehicle end. The umbilical outer armour and inner braided screen are also earthed. The armouring and the screen surround the power cores throughout the full length of the umbilical down to the subsea termination. Both are connected to the cabin earth stud, through the winch slip ring and to the winch structure. The armouring of the umbilical is used as the return path for the ECM.

The subsea electrical termination, electronics pod and motor are each connected to the Plough structure via individual earth straps.
The pod earth loop monitor wire in the umbilical is connected through the umbilical electrical termination to the pod main power harness. Inside the pod it is connected to the pod faceplate and chassis.

Motor earth loop monitor wire connects via the fourth pin of the motor power connector to the inside of the motor housing.

Each loop monitor circuit in the cabin comprises a relay whose coil in connected across a 24V supply in the cabin and the umbilical loop monitor wire. The other side of the 24V supply is connected to the cabin earth. In order that the ECM relay is energized, the circuit must be completed by a connection between the pod or motor housing and the control cabin. This connection is made through the plough structure and umbilical earth.

The normally open contacts of the motor ECM relay is connected in series with the coil circuit of the motor contractor coil. If the ECM connection is not complete then the motor cannot be switched on. When the loop is complete, an indicator light is illuminated at the PDF for the motor.

The key switch is used to isolate (disable) the subsea supplies regardless of the condition of the earth loop. The white “VEHICLE ISOLATED” indicator lamp will come on when the UER supply is isolated. This facility is provided to protect personnel when working on the plough on deck.

The isolate key may be removed to prevent accidental switch on. The system should be isolated in this manner whenever welding is being carried out on the Plough. To enable the subsea circuits, the isolate key switch should be turned such that the white indicator lamp is extinguished. The orange “ECM RESET” push button indicator/switch will illuminate. Pressing this momentary switch energises the coil of the UER and the green “Pod ECM On” and the green motor “ECM” indicators will illuminate if the earth loops are intact. If either the motor ECM loop or the pod ECM loop is not made, then the relevant ECM indicator will not illuminate and the orange “ECM Reset” button will remain illuminated indicating a fault remains. Healthy ECms will be reset.

The relay hold circuit for both ECms will be interrupted if the normally closed underwater emergency stop push-button on the console is pressed. The latter is provided for additional safety and is within easy reach of the pilot and co-pilot. If the emergency stop is pressed the reset indicator will illuminate and the earth will go out. Pressing the reset button restores the circuit- If any of the earth loops are broken or disconnected then the ECM can only be reset at the PDP (following repairs or reconnection).
Line Insulation Monitoring (LIM)

Two line insulation monitors are used, one for the 1000V to the pod and one for the 2000V motor. The LIMs are mounted on the display panel. HT couples connect each monitor to the high voltage. The HT coupler is connected to the live secondary line of the single phase pod supply and to the motor outgoing terminal for the motor supply.

These LIM units have two adjustable levels or trip:

a) "WARNING"
b) "DANGER"

It is suggested that the warning level is set around 8 M Ohms and the danger level is set around 800K Ohms. The actual relays the LIM unit. The warning relay is used to power an indicator lamp only.

The danger relay is used to power an indicator and control a relay in series with the appropriate contactor control circuit. This is set up in a fail-safe mode i.e the relay coil activated only when the system is safe.

It may be required to override a LIM in an emergency. This is done using the key switches on the display panel. Exercise great caution as this jeopardises the integrity of the system.

**WARNING**  Divers must NEVER be allowed near the Plough when the LIM is overridden.

If the danger level is tripped it may be possible to operate a motor or the pod normally if only one line has been shorted to earth since the supply is floating. However this is dangerous in that by overriding the LIM shorting of the other lines cannot be detected, except when fuses blow.

The pod LIM monitors the insulation of the 1000V down to the pod-isolating transformer. A separate monitor in the pod monitors the subsea 110V circuits to the pan and tilt units.
Motor protection relay (MPR)

The secondary of the motor circuit is coupled to a motor protection relay that monitors the motor current via a current transformer on each motor phase. The motor protection relay will switch off the contractor if the motor experiences a sustained overload or a phase failure. The relay has several adjustments including auto-reset time, current setting and trip delay. Normally these would be set as follows:

a) Auto-reset time = 2 minutes (Minimum)
b) Trip Delay = Minimum
c) Current = 70% Full load current

A lamp on the power display panel indicates motor overload.

Vehicle Isolate

There is a vehicle isolate key switch on the power display panel. This operation prevents the ECM circuit operating, and prevents power being transmitted down the umbilical. Operate the key switch and remove the key when working on the Plough or umbilical system.

Umbilical Discharging

Even when the subsea power is apparently switched off or isolated, there can still be dangerous voltages on the umbilical due to build up of charge.

Although charge will leak away over a period of time, it is important to discharge the umbilical after isolating the system and before working on any part of the power system. This is done using the earth probe provided in the umbilical connection enclosure at the rear of the cabin (see Figure 1). Always ensure that the subsea power is isolated when this is done.

WARNING Always isolate the Plough and discharge the umbilical before working on any part of the power system.

Switching on the Subsea Electrics

Before the motor or pod are switched on make ensure that:

• All personnel are clear of the vehicle. The earth lead should be attached if the motor is being operated on deck
• All enclosures are closed and secure

To start the pod:

• Depress the green pod start button for 5 seconds after which the pod should start
It will take a few seconds for telemetry to be established. When telemetry is established, the pod status indication on the plough graphics screen will change from red to green.

Reasons that the pod may fail to start:

- Umbilical winch is not powered up and hence surface multiplexing unit is not powered
- There is power fault. (check indications on power display panel for ECM. Phase faults, vehicle isolated etc)

To start the motor:

- Depress the green motor start button for 5 seconds after winch the motor should starts

Reasons that the motor may fail to start:

- There is a power fault (check indications on power display panel for ECM, phase faults, vehicle isolated etc)
- Telemetry has not been established or the ZIATECH is not operating correctly
- Motor stop, pod stop or underwater stops are depressed
CONTROL CONSOLE OPERATION

Control Console Lay-Out

The control console is a suite of 3 bays mounted on a common frame that is securely fixed to the cabin structure by anti-vibration mounts. Each bay has a desk section with handrail and is fitted with standard 19” rack mounts. The position of the control cabin is shown in drawing PG5847. The pilot station is bay 1, and the co-pilot station is in bay 3. ZIATECH PC and Sonar PC are housed in the middle, bay 2.

Three full height doors at the rear give access to each bay and three short doors at the front give access to component mounted in the lower half of each bay. Where possible components are mounted on standard 19” centres to provide easy removal and flexibility for later modification. Both side panels are removable although access should not normally be required.

All cables to the console are mounted through wall mounted trunking and pass through the console at floor level.

The mains power circuits inside the console are supplied by two separate 230V supplies:-

- UPS supplies 230V. This is distributed by terminals in each console bay and two 7-way BS1363 mains multiple units (one in each of bays 2&3)
- Non-UPS supplies 230V. This is distributed by terminals in each console bay and also by one 7-way BS1363 mains multiple unit in bay 2.

Three fans mounted in the top rear of each console blow warm air of the console and cold drawn in through louvers at the bottom of each door. The doors should all be kept closed during normal operation. The maximum permissible ambient temperature within the console is 40 °C. The air conditioner maintains ambient temperature below this. The console is fitted with background heaters that should be powered up during storage.

Subsea Power Controls

See section 4.4 for motor and pod start up procedure.

Motor start & stop: The green start button illuminates when the motor is running
Pod start & stop: The green light illuminates when the pod is running
Underwater: Located in bay 2 above the console desks. This will switch off all subsea circuits when activated

Plough Control Keypads

There are two keypads, one at the pilot station and one at the co-pilot station. They both have the same layout (See Figure 5.3) and functionality.
Hydraulic Functions

The orange or red (guarded) keys operate the hydraulic functions on the plough, as does the steering joystick adjacent to the pilot and co-pilot keypads. To operate a hydraulic function the following requirements must be met:

- Pod supply and telemetry established
- Motor running
- “CONTROL ENABLE” key must be pressed

The control on the key has a latching action and one press enables the hydraulic functions and this state is indicated by a LED on the “CONTROL ON” key. Pressing again disables all hydraulic functions.

Each double acting function is operated via two keys (each indicating direction) with identifying text. Action of the directional keys is momentary i.e. the function will operate for a long as the key is pressed. The keypad will only accept input from one key at a time. It is not possible to operate two functions simultaneously. Single keys are provided for paired operation of the front skids and the rear stabilizers.

The “FLOAT” keys do not require the motor and have a latching action. Press once to active float mote (LED comes on, Red). Press again to deactivate float mode (LED goes off).

The steering control joystick behaves in exactly the same manner as the keypad double acting keys.

Guarded Functions

Functions with potentially dangerous operational sequences are “guarded”. To operate there functions the “GUARD” illuminated push-button on the console must be pressed after which the LED on the push –button will flash and guarded functions may be operated. After a period of 10 seconds (approx.) the LED stops flashing and the functions become guarded again. If operation is to be completed before the end of the period then the guard timer will continue to run until the key is released.

The guarded functions are:

- **Cable Highway:** Depressor Float
  Depressor Accumulator Charge
  Depressor Accumulator Discharge

- **Plough Handling:** Stabilizers Float

- **Power:** Pod LIM Test/Reset

**WARNING** Stabilizers and depressor will rapidly under their own weight when in float mode. Ensure that nobody is standing near these items and that all personnel are aware that the function is going to be put into float mode, before the operation.
**Surveillance Equipment**

These keys are used to enable power to the plough surveillance equipment. The power to each of the cameras, lamps, echosounder, etc, is individually switched. These keys all have a latching operation (i.e. press once to activate (LED on), press again to de-activate (LED off). The power supplied to the surveillance equipment will only be enabled if the pod power is on and the data link is active.

**Alarm Accept**

If any one of the variables reaches a pre-set alarm level then the graphics screen indications is accompanied by an audible alarm.

Pressing (ALARM ACCEPT) cancels the audible alarm but does not remove the alarm message form the screen until the alarm condition is no longer active. It should only be pressed after an alarm has been noted and appropriate action taken.

**Special Functions**

These keys are located along the top of each keypad. The functionality of some of the more peripheral functions is limited to the co-pilot keypad thereby allowing the pilot to concentrate in fundamental plough operation.

Note that once these functions are selected, further can be made using the keypads. Instructions on what keypad keys to use are displayed within most of the screens. The PC keypad or mouse is not required during normal operation.

1) (GRAPHICS DISPLAY) & (ANALYSIS DISPLAY): The pair of buttons work together allowing the operator to toggle between either the plough graphics screen and the plough analysis screen. This option is only available to the Co-pilot console.

2) (SET CATENARY): Brings up a window for inputting tow and lay cable parameters. This is only active within the graphics display screen. Pressing the key again removes the screen. Note that catenary calculations are approximate and for guidance only.

3) (TREND/CATENARY): Toggles between the catenary display and the trend display (See Figure 5.3.5 )

4) (SET UCA): This key is used to display the system data selection menu. This allows the operator to select which variables are shown on the User Configurable Area of the plough graphics screen.

Operation is best explained with an example. Suppose we wish to display `Tow Length Out` in the system data (User configurable area):

- Press (SET UCA)
- Press the right arrow key and move the cursor to the `Tow Winch` box
- The `Tow Winch Box` should be highlighted in blue
- Move the red cursor box down along to `Ploughing area`
• Press the down arrow key
• Highlight ‘Tow Length’ in red. We want to put this in slot 2
• Press the right arrow key and highlight the second item in the list. Press (ENTER)
• The system data area will change accordingly. Note that only the first ten items on the list will be displayed.

5) (SET SYSTEM): Used to set time and print the current analysis screen data. There is also provision for SMD maintenance. DO NOT press this unless you are qualified to do so
6) (LOGGER): Displays and removes the logger configuration screen
7) (DATA SOURCE, (PRINT SETTINGS), (LOG SETTING), DATA ITEM LIST) & (LOG ITEM) keys are active when the logger configuration screen has been accessed.

Plough Display Screens

Plough Graphics Screen

The display screen utilities are automatically started when the console is powered up. The plough graphics (see Figure 5.4.1) shows a real-time graphical representation of the status of the various components of the plough system. The screen divided logically into areas representing each main component of the system.

1) SYSTEM STATUS DISPLAYS: These areas graphically indicate important plough system parameters directly related to ploughing in various graphical formats e.g. Bar Charts
2) SYSTEM ALARMS AREAS: This display list ensures that important alarms relevant to the plough are immediately available to the operator. When an alarm occurs, it is displayed in RED, when the operator presses (ALARM ACCEPT), the alarms will change to BLUE but will remain displayed until the alarm condition has cleared. If alarm has not been ACCEPTED it will be displayed, regardless of whether the condition has cleared or not until accepted.
3) SYSTEM DATA AREA: This user definable display can show up to 12 system variables that are selected from the full range via the SET UCA key in the keypad.
4) TREND MONITORING DISPLAY AREA/CATENARY AREA: Shows the burial depth and trench depth over the last 4 minutes or the catenary display if this has been selected. (see Figure 5.4.4)
Plough Analysis Screen

This display shows a table containing the control database (Figure 5.4.2). The data shown is used to define all machine data channels including analogue, digital, counter inputs and outputs and user definable system variable types. The system has been set-up and defined during commissioning and should, under normal circumstances, not require any modification during operations. Linear scaling is performed using the analysis screen on the co-pilot console. The control system automatically e-scale outputs after new scaling parameters have been input.

To move around the spreadsheet using the arrow keys ^<>V, (PAGE UP), (PAGE DOWN). Edit the scaling values by moving the cursor to the required scaling item and typing in the new value. Press (ENTER) to confirm the change.

To prevent accidental modification, the analysis screen is password protected. The user should place the cursor over any channel name field, and type “1342” (ENTER) at the keypad. The editing status field in the screen title will change from “(0)” to “(1)” indicating that editing is enabled. Inputting the password again then write protects the data and the editing status field reverts back to “(0)”.

The data item type can be by moving to the appropriate position on the screen and pressing (ENTER). The type displayed steps through the available types, eventually returning to the original value. The data item type should NEVER be changed during normal operation.

Linear Scaling is carried out using the following formula:

\[
\text{Final Value} = \left(\frac{\text{Raw Value}}{(R_{\text{max}} - (R_{\text{min}})} \right) \times (S_{\text{max}} - S_{\text{min}}) + S_{\text{offset}}
\]

Normally the only values the user has to change are to adjust scaling are:

- Rmin  Raw data minimum value
- Rmax  Raw data maximum value
- Smin  Scale data minimum value
- Smax  Scale data maximum value

It is not normally necessary to modify the other scaling parameters listed below.

- Smul:  Scale multiplier = S_{\text{max}} – S_{\text{min}}
- Sdiv:  Scale divisor = R_{\text{max}} – R_{\text{min}}
- Sofs:  Scale offset

Alarm fields can also be changed to suit operator requirements:

- Amin  Alarm limit minimum value
- Amax  Alarm limit maximum value
The alarm options also include the ability to enable or disable alarm monitoring for any channel. Move to the appropriate circle icon adjacent to the alarm settings and press (ENTER) to toggle the alarm on/off.

The RAW values represent the actual value, returned by the hardware connected to each channel for analogue, digital and counter inputs. It is not possible to alter actual raw or processed data item values for hardware controlled channels. However user definable or system variables types can be modified by the operator as required.

Data Logger System

The logger configuration screen is split into the following sections:

1) DATA SOURCE: This enables the user to select the source of data (for example, data can be provided from the plough database or from the tow/umbilical winch)
2) PRINT SETTINGS: This area shows the time interval between printing information and enables/disables printing. The print time interval can be changed using the Up and Down cursor keys on the keypad.
3) LOG SETTINGS: This area shows the interval between logging information to the hard disk. The logging time interval can be changed using the Up and Down cursor keys on the keypad.
4) DATA ITEMS LIST: This area shows a list of variables provided from the currently selected data source.
5) PRINT ITEM LIST: Lists variables selected for logging to the printer.
6) LOG ITEM LIST: List variables selected for logging.

Access is each of these areas is explained in the example. Suppose we wish to log the `Lay Distance` on both the printed and computer logs:

- Press (F1 DATASOURCE). The `Datasource` area should now be highlighted in red since it is the active area. Use the keypad arrow keys to highlight the `Plough` box.
- Now press (F4 DATA ITEM LIST`. The `selection items` title should be highlighted in red and the selected item in the `datasource` box will have turned blue. Move down/up the list as required using the (PAGE DOWN), (PAGE UP) and arrow keys, to position the highlighted box on the `Lay Distance`.
- Nor press (F5 PRINT ITEM) once and the `Lay Distance` will appear as one of the items to be printed. (Pressing the key again will remove it from the list).
- Nor press (F6 LOG ITEM) once and the `Lay Distance` will appear as one of the items to be logged to hard disk. (Pressing the key again will remove it from the list).
- Press (F2 PRINT SETTINGS). Use the up/down arrow keys to modify the print interval. Pressing (ENTER) toggles printing on/off.
• Press (F3 LOG SETTINGS). Use the arrow keys to increase and decrease the logging interval. Pressing (ENTER) toggles logging on/off.
• Press (BACKSPACE) to toggle LOG BACKUP FILE window. This will display a list of log files available. These files either be deleted using the (DEL) key or copied to a DOS formatted floppy disk in the floppy drive of the co-pilot computer. Log filenames are generated automatically.

Software Configuration

WARNING: Operator needs to be familiar with using QNX, in particular with changing directories, moving/copying files, network navigation and editing. Detailed instruction on QNX is outside the scope of this manual. The operator must not modify any configuration files unless qualified to do so. This is to ensure safe and efficient operation of the control system. Instructions included in this manual are for guidance only.

This section describes the structure and format of the files within the Plough Software Control System. It is to give the operator an overview of the file locations and configuration procedures.

The software control system uses a QNX operating system. During normal operation it is necessary for the operator to access the QNX operating system.

The user should be familiar with the operating system as they may be required to undertake some basic tasks. It is important that great care is the control system may not operate correctly if the configuration files are incorrectly set up.

There are four PC’s used on the plough control system. A node number within the QNX operating system refers to each PC.

• Node 1: Cabin ZIATECH Industrialised PC
• Node 2: Pod ZIATECH industrialised PC
• Node 3: Pilot Graphics PC
• Node 4: Co-pilot Graphics PC

All control software used to run the plough is held on the Cabin Ziatech, making backups and installation of new software easy. Note that the sonar PC’s on both cabin and the bridge use Microsoft Windows. They are not part of the control PC’s running QNX.

Access to Operating System

WARNING Operator needs to be familiar with using QNX, in particular with changing directories, Moving/copying files, network navigation and editing. Detailed instruction on QNX is outside the scope of this manual. The operator must not modify any configuration files unless qualified to do so. This is to ensure safe and efficient operation of the control system. Instructions included in this manual are for guidance only.
There are a couple of ways to access the operating system. The preferred method is to access it via co-pilot machine through the `SET SYSTEM` module. On older versions of the software this function was not available and so instructions are included for historical reference only.

NOTE: Before making any changes to the software it is wise to make a backup copy to both the hard disk and a floppy disk described in section 4.5.2

**Preferred Method:**

- Press (SET SYSTEM) on the co-pilot keypad
- Select (SMD SYSTEM MAINTENANCE) and press (ENTER)
- Type in the password 6661 and press (ENTER). A QNX terminal window will now be created on the co-pilot PC.
- Typing `pwd` (RETURN) will confirm the present working directory. This should be on the ZIATECH (node 1) and in control system directory i.e. `//1/cw_pl/bin`.
- If necessary, the present working directory can be changed using `//1/cw_pl/bin` (RETURN) to point to the correct directory.
- Typing `pwd` (RETURN) will confirm the present working directory
- Make necessary changes
- Type EXIT once complete to exit the window

**Alternative Method:**

Normally the operator will be modifying/viewing the control system files, and so it is advisable to log into the Cabin Ziatech PC, located in bay 2 of the cabin. The operating system can be entered by first terminating the graphical display program and logging in as follows:

- Access is via the Pilot or Co-Pilot PC keyboards. Press (CTRL) (ATL) (SHIPT) and (BACKSPACE) keys simultaneously.
- Press (RETURN) to bring up the login screen
- The login name is ROOT and the password is ROOT

Any changes that operators need make will be to the files stores on ZIATECH node 1

- Type `cd //1/cw_pl/bin` (RETURN) to point to the correct directory
- Typing `pwd` (RETURN) will confirm the current working directory

Once changes have been made, it is advisable to point to the correct directory re-start the control system. This is achieved as follows:

- Type `sync` (RETURN). Failing to type this in could result In corruption of file when the PC is turned off or rest.
- Wait for at least 10 seconds and then cycle the power on the appropriate PC.
Alternatively, a `soft` reboot can be carried out:

- Type SHUTDOWN – F (RETURN)

Software Backup

Firstly a directory structure needs to be created to copy and store the unmodified version of the software.

- Change directory to node 1, cw_pl, type: cd//1/cw_pl (RETURN)
- Check that you are in the correct directory, type: pwd (RETURN)
- List files and directories, typ: 1s (RETURN)
- If there is no directory called old, create one: mkdir old (RETURN)
- Change directory to `old`: cd OLD (RETURN)
- Create a new directory using the date: MKDIR MOTHDAY_YEAR (RETURN) E.g. Oct24_99, Nov01:99 etc.
- Move to this directory, type CD MONTHDAY_YEAR (RETURN)
- Create a directory to copy the control files into: MKDIR BIN (RETURN)
- Type CP – RC//1/CW_PL/BIN BIN (RETURN). This copies the old control software into the new backup directory.

There is now second copy of the software stored on the cabin ZIATECH hard disk. The next stage is to compress the files to a suitable size and copy them to a floppy disk.

- Change subdirectory to `bin`in the `monthday__year`directory:
- Join all the files in this directory infot a single file with a suitable name (e.g. monthday_year.tar: tar-cvf filename.tar (RETURN)
- Compress this file, type: gzip filename.tar (RETURN). The resulting compressed file will be called filename.tar.gz

It is possible to create floppy disks in QNX format or MSDOS format. The latter format would be required if it is necessary to send software back to SMD via email for future enhancements.
Transfer to QNX disk:

- Insert a blank floppy disk and type: dinit /dev/fd0 (RETURN) to format the disk into QNX format
- Type: mount /dev/fd0/fd (RETURN). This creates a directory called ‘fd’ which is how QNX recognizes the floppy disk.
- Copy the compressed file to QNX floppy disk: cp filename.tar.gz /fd (RETURN)
- Now the system initialization files can be backed up, by typing:
  Cp //1/etc/config/sysinit.1/fd (RETURN)
  Cp //1/etc/config/netmap/fd (RETURN)
  Cp //3/etc/config/sysinit.3/fd (RETURN)
  Cp //4/etc/config/sysinit.4/fd (RETURN)
- Backup process is now complete. Re-boot the PC as described in section 5.5.1 if required.

Transfer to MSDOS disk:

The floppy disk drive in the co-pilot machine is configured as a MSDOS disk drive, which is why backups of logged data are sent to this particular drive.

- The compressed file `filename.tar.gz` must first be renamed to comply with the DOS filename format. Type: mv filename.tar.gz filename.tgz (RETURN)
- Copy the renamed file to the floppy disk typing: cp filename.tgz /dos/a (RETURN)
- Now the system initialization files can be backed up, by typing:
  Cp //1/etc/config/sysinit.1 /dos/a (RETURN)
  Cp //1/etc/config/netmap/dos/a (RETURN)
  Cp //3/etc/config/sysinit.3/dos/a (RETURN)
  Cp //4/etc/config/sysinit.4/dos/a (RETURN)
- Backup process is now complete. Re-boot the PC as described in section 5.5.1 if required.
Installing New Software from QNX Floppy Disk

- Create a backup of the old software to floppy disk and then to the hard disk as described in section 5.5.2, except use the move command instead of the copy command when copying the software `bin` directory to the `old` directory. I.e. mv//1/cw_pl/bin/*bin (RETURN)
- Insert QNX floppy disk with new version of software. List the files on the floppy disk and note the filename: 1s/fd (RETURN)
- Change to the software directory, type: cs//1/cw_pl/bin (RETURN)
- Copy compressed version of new software from floppy disk: cp/fd/filename.tar.gz //1/cw_pl/bin (RETURN)
- Uncompress the file and then expand it back into separate files: gunzip filename.tar.gz (RETURN), tar – xvf filename.tar (RETURN)
- New software should now be installed, re-boot the PC as described in section 5.5.1

Installing New Software from MSDOS Disk

- Create a backup of the old software to floppy disk and then to the hard disk as described in section 5.5.2, except use the move command instead of the copy command when copying the software `bin` directory to the `Old` directory. I.e. mv//1/cw_pl/bin/* (RETURN)
- Insert DOS floppy disk with new version of software in co-pilot disk drive. List the files on the floppy disk and note the filename: 1s /dos/a (RETURN)
- Change to the software directory, type: cp/fd/filename.tgz//1cw_pl/bin (RETURN)
- Uncompress the file and then expand it back into separate files: gunzip filename.tgz (RETURN) tar-xvf filename.tar (RETURN)
- New software should now be installed, re-boot the PC as described in section 5.5.1

Non Linear Scaling

Non linear scaling is performed on some analogue input channels, where the processed (final) value does not follow the raw value in a linear fashion.

The Preferred method of charging non-linear scaling is via the “SET SYSTEM” module on the co-pilot screen. On older versions of the software this function was not available and so instructions are included for changing the scaling via the operating system for historical reference only.
Alternative Method: Via Co-Pilot console

- Press (SET SYSTEM) on the co-pilot keypad to bring up the set system dialogue window (see figure 5.4.5)
- Use the arrow keys to highlight the “Edit non-linear scaling” box and press the (ENTER) key. It will take a few seconds for the next dialogue box to appear (see Figure 5.4.6)
- Use the left and right arrow keys to select the appropriate function e.g. Port Skid, drawbar, lay cable tension etc.
- Move to the “Enable Password” box and enable the editing by inputting the password 1342 and then press (ENTER). The words “ENABLED” will appear if this is successful.
- The user can now input the non-linear data points obtained during plough calibration tests. Use the left and right arrow keys to select the appropriate point. The (INSERT) and (DELETE) keys can be used to add or remove points. If the user moves past the last point, a new point will be created automatically. Type in the “Raw Value” and “Final Value” for each point followed by (ENTER).
- Once all points have been completed, use the arrow keys to move to the “USER OPTIONS” box. The left and right arrow keys may now be used to select from Save, Restore, Print or Exit. If the inputted values are correct select the Save option. The Restore option will reinstate scaled values from the last file saved. Selecting Print will dump all the scaled values to the printer. You will need to confirm Yes or No on exit.
- Re-boot the system so that the new scaling takes effect

Alternative Method: Via Operating System

Details of non-linear scaled functions are contained in a configuration file in the software directory. This file is used to configure many aspects of the control system, and so extreme care MUST be used when editing this file.

- Access the QNX operating system, node 1 as described in section 5.5.1
- Within the cw_pl/bin directory there is a file cw_pl.ini. To edit this file type: vedit cw_pl.ini (RETURN)
- A text editor will now appear with with a listing of the contents of this file. The editor is fairly standard and user friendly. Modify the non-linear scaling as described below and exit the editor, ensuring that your changes are saved if required. Pressing (ESC) will bring up a short exit menu. Alternatively hold down (ALT) and (F) for a more comprehensive menu.
- Reboot the system as described in section 5.1.1 to effect changes

The section (NON_LINEAR_DATA) defines how many channels are non linear. A section will appear for each channel of the format (NL_X), where X identifies the non-linear channel section, starting from 1. For each non-linear channel, the channel name must be identified, and a set of points identified giving the raw and final values. For examples:
The points are defined with the raw value first, followed by the required final value (e.g. point 1 defines that the port skid height has a height of 110cm for a raw input of 510mv). The list must be ordered by ascending RAW values (i.e. the lowest raw value must be point 1).

The system will extrapolate between points to determine the scaled value for any given raw value. Note that any-linear channels will ignore any linear scaling values that operators input on the analysis screen. The maximum number of points for each channel is 20.

### Changing Video Overlay Text

The top and bottom title block text on the video overlay may be changed as follows using the keyboard in console bay 2.

- Press the (F5) function key. This will clear the text in the top block
- Type in the required text. Default text is “CALDWELL MD3 PLOUGH I”
- Press the (F%) Function again. This will toggle to the text in the bottom title block and clear area.
- Type in the required text. Default text “User Defined Area”

Note that changes made in this way are temporary and the default text will reappear when software is re-booted.

### Sonar Processor

The Mesotech MS900 sonar processor is mounted in Bay 2 of the console. It has a dedicated VGA 14” colour monitor. The VGA output from the processor is sent to the sonar monitor and also converted into a PAL video signal that can be connected to the video switcher. A full description of the sonar processor is given in the proprietary manual.

### Video System

A video switcher is installed in Bay 1 of the console. The switcher is set up to route any of this video signal inputs (i.e. plough cameras, encoded sonar display, VCR outputs, etc) to any of its outputs (monochrome monitors, VCR’s, remote displays, etc). The video switcher is controlled via the keypad on the co-pilot console.

Two video records are installed in Bay 4 of the console. They are multi-standard, and variable speed, so they can record and playback NTSC, PAL or SECAM). However, it is

<table>
<thead>
<tr>
<th>NL_1</th>
<th>ChannelName=Port Skid Height</th>
<th>TotalPoints=4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Point1= 510 110</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Point2= 1870 75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Point3= 3320 39</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Point4= 4880 10</td>
<td></td>
</tr>
</tbody>
</table>
important to remember that they cannot convert from one video standard to another. A full description of the video recorders is given in the proprietary manual supplied in Volume 4.

The video overlay is routed through the video switcher also. The size and overall position of the overlay text controlled using the video overlay unit’s own remote control. The title block text can be modified as described in section 4.5.6.

Audio System

The audio panel is located in Bay 4 underneath the power display area. It houses the stereo set with CD stacker unit underneath, three signal routing controls marked underneath with “AMP”, VCR1” and VCR2” and a “VOLUME” control for the video recorder outputs and hydrophone. Note that the stereo set has its own separate speakers and volume control. Details on how to operate the stereo system are contained in the proprietary information.

Each switch position represents an audio input from the hydrophone or video players. Selecting “HYD” on the “AMP” control routes the hydrophone output to the speakers whereas selecting “VCR1” routes audio output from video recorder 1 to the speakers.

Selecting “VCR2” on the “VCR1” control routes the audio output from video recorder 1 into recorder 2, and via versa. This would be used when copying videos. Selecting “HYD” on either VCR1” or VCR2” would route the hydrophone output to the appropriate video recorder. No audio is recorded on the video recorder when the VCR control switches are set to “OFF”.
CONTROL SYSTEM MAINTENANCE

General

Regularly check all warning lamps operate correctly. A lamp check button on the POWER DISPLAY PANEL activates all lamp simultaneously.

Storage Procedure

The control system should be stored in a dry place. If power is available, the control system should be wired up. Three phase 380V 60kVA minimum is ideal as it allows the system to be powered up whereas single phase, 220/240V (50/60Hz) 3kVA can be used while the system is in storage.

The minimum storage requirement is power to the panel heaters to prevent condensation. These are all wired together to a UK style mains plug in the power room (200 W required power). If three phase power is wired into the power room is available during storage, then this plug can simply be plugged into an extension lead.

If the UPS is powered up during storage then it will in turn power the computer, printer and half control van lightning. Hence it is useful to connect this storage. If 3 phase power is on this will be automatically witched on.

NOTE: A 3 phase supply is required to power up the subsea pod subsea motor and the remainder of the console.

If the Plough is in storage with the control can then the presence of 3 phase enables the whole system to be operated. This can be done through the winch using the full umbilical.

Routine Maintenance

Beyond the obvious requirements of keeping all components clean and dry there are few specific requirements for routine maintenance.
UMBILICAL WINCH OUTLINE DESCRIPTION AND SPECIFICATION

Outline Description

The umbilical winch is a single drum winch driven by a hydraulic motor via reduction gearing. The power source is a separate electro-hydraulic power pack.

The winch is designed to be as compact as possible, making its transportation and manoeuvrability simpler. It has a rugged frame structure suitable for shipboard mounting and is fitted with shackle type lifting Corners.

A level wind mechanism is supplied which responds to drum rotation and changes cable fleet angle to ensure proper reeling of the Cable onto the drum.

The winch assembly includes slip ring and local and remote control systems.

The drive motor is equipped with a mechanical brake. This is normally held off hydraulically. Its setting is not adjustable and it is set to hold a minimum of 4.5 tonnes. Hydraulically adjustable rendering is available whilst the hydraulic power Source is active.

The winch has been designed with the facility for interconnection to an SMD Plough System Control Wan and SMD hydraulic power unit (HPU). The drum has capacity for 4000m of the Ø31 mm, plough umbilical. The fleeting mechanism can cope with cables of different diameter, although a new sheave and sheave arm may be required to suit the change in umbilical diameter or bend radius. The fleeting sheave axis is perpendicular to the drum axis, resulting in a fixed umbilical exit position.
A load cell installed through the pivot of the fleeting sheave measures umbilical tension at the winch. Sheave rotation is monitored as cable is paid out or hauled in. From this, the length of cable paid out is calculated.

**Specification**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
<td>2.5m (width) x 2.6m (height) x 4.15m (length)</td>
</tr>
<tr>
<td>Weight</td>
<td>7 tonnes with empty drum</td>
</tr>
<tr>
<td></td>
<td>17 tonnes with full drum (4000m of 231 mm, plough umbilical)</td>
</tr>
<tr>
<td>Max cable capacity</td>
<td>4000m of 31 mm diameter Cable</td>
</tr>
<tr>
<td></td>
<td>(4000m supplied)</td>
</tr>
<tr>
<td>Sheave bend radius</td>
<td>500mm</td>
</tr>
<tr>
<td>Pull force/speed</td>
<td>3.0 tonnes maximum at 15 m/min</td>
</tr>
<tr>
<td>Adjustable hydraulic rendering</td>
<td>Max force 3.5 tonnes at 60m/min</td>
</tr>
<tr>
<td>Drive, main drum</td>
<td>Single Poclain MS18 hydraulic motor via slew ring reduction gearing</td>
</tr>
<tr>
<td>Drive, fleeting mechanism</td>
<td>Single Danfoss OMT 315 hydraulic motor. Direct drive to fleeting lead</td>
</tr>
<tr>
<td></td>
<td>SCIEW</td>
</tr>
<tr>
<td>Drum access</td>
<td>Internal access provided for slip ring termination at non-drive end of drum.</td>
</tr>
<tr>
<td>Paint</td>
<td>-Post fabrication shot-blasting to SA2</td>
</tr>
<tr>
<td></td>
<td>-Primer Coat : 100 micron DFT Epigrip L425.</td>
</tr>
<tr>
<td></td>
<td>-UnderCOat : 150 micron DFT Epigrip L653.</td>
</tr>
<tr>
<td></td>
<td>-Finish : 50 miiCrOn DFT Resistex M475 Final Colour – Yellow</td>
</tr>
<tr>
<td>Cooling water requirements</td>
<td>120 litres /min, max 10 bar Sea/fresh water</td>
</tr>
</tbody>
</table>
## Control System (Local Station)

### Controls
- HPU Motor Start
- HPU Motor Stop
- Proportional joystick control for winch speed and direction
- Hydraulic rendering adjustment.

### Instrumentation
- Cable length out
- Cable tension
- System Pressure
- Render Pressure
- Brake Pressure
- Boost Pressure

### Indicators
- Motor A Run
- Motor A Run
- HPU Fault
- Low Boost Pressure
- Local/remote control active

### Switches
- Winch Emergency Stop
- Fleeting Automatic/Manual
- Manual Fleet Left
- Manual Fleet Right
- Local/remote Control Select
- Reset Length Out
Control System (Remote Station)

| Controls                  | Rotary dial for winch speed               |
|                          | Selector switch for winch direction       |
| Indicators               | Motor A Run                                |
|                          | Motor B Run                                |
|                          | HPU Fault                                  |
|                          | Low Boost Pressure                         |
|                          | Local/remote control active                |
| Switches                 | Winch Emergency Stop                       |

**Optical Control System**

| Slip ring                 | A slip ring assembly containing all the required electrical passes is provided. |
|                          | 16 x rings 3300 VAC / 10A max             |
|                          | 4 x sets of rings for Screened Quad       |
|                          | 4 x sets of rings for Coax                |
|                          | 9 x rings 1000 V AC / 5 A max.            |
|                          | 3 m Electrical Tails                      |

| Optical to electrical conversion | Mounted inside the winch drum, Contains Prizm Junction Box and Opto/Electrical Converter. |
|                                 | IP65 Protection.                          |
|                                 | 110 VAC Power Supply from the Plough control console via the slip ring assembly. |
Umbilical Terminations

Subsea Terminations

The subsea termination is in two parts, electrical and mechanical. The electrical termination is oil filled and pressure compensated and contains the electrical joints and fibre-optic connectors. A bend limiter should be attached to the umbilical cable at the plough termination point. The umbilical, the motor and pod power cables, and the optical penetrator assembly all emerge from the one end of the termination housing.

The mechanical termination is a machined socket potted with epoxy resin (wirelock). To ensure full strength, a spacer is included to terminate each wire strand individually. Information on terminating the umbilical is given in Plough Volume 1, Part 4.

Shipboard Termination

The umbilical is terminated in the umbilical winch drum at a junction box. The junction box is connected through the slip rings and a suitably protected stainless steel external junction box, to the 50m deck cable(s) which terminates at the control Cabin.
TOWING WINCH
Dimensions and Weights

Length: 4.16m  
Height: 2.73m  
Width: 2.79m (3.76m with fleeting arm)  
Weight: 14.5 tonnes (empty)  
42 tonnes (including 3500m of Ø40mm wire)  
Drum Size: Core diameter 1.60m  
Between flanges 2.28m  
Cable Capacity: 3500m of Ø40mm cable in 14 layers

Specification

Haul in force. 350kN on top layer  
Haul in speed: 30 m/min at 100kN on mid layer  
Brake capacity: 550kN on the top layer  
Automatic fail-safe system  
Rendering Force: Adjustable from 100kN to 500kN  
Render Speed: 60 m/min maximum at 100kN to 500kN  
Winch Controls: Proportional joystick control for winch speed and direction.  
Render Control: Rotary dial for rendering adjustment.  
Instrumentation: Cable length out  
Cable tension  
Render Pressure  

Local Controls: Emergency Stop  

Remote Controls: Fleeting Automatic/Manual  
Fleet Left / Right  
Brake on/off  
Length Out Reset  
Layer Number Setting (PLC Controlled)
MECHANICAL EQUIPMENT

Main Frame

The main frame is fabricated mainly from the BS 4360 Grade 50D plate and square hollow box sections. The frame provides suitable mounting points for the drum assembly, fleeting carriage assembly and hydraulic system. At each corner is a pad with 7 X 232 holes for bolting the Winch to a suitable ship sub-structure.

The four hydraulic drive motors (Poclain MS35) are bolted to a motor mounting plate. This plate is pivoted to the main frame by three floating link plates. One of these link plates contains a load cell pin to provide an accurate value of rope tension in all operating modes. The load cell reading has to be corrected to account for the variation in moment with drum layer. The calculation of drum layers is covered in a later Section.

A 14 tooth, spur pinion is mounted to the splined drive shaft of each of the four hydraulic drive motors. The drum is supported at the drive end by a large diameter slew ring bearing (supplied by Roballo). The static outer race is bolted to the motor plate and the rotating inner race is bolted to the drum. This inner race has internal spur gear teeth that are driven by the four pinions. Both the slew ring bearing and drive motors are mounted on machined spigots which transmit the radial forces generated by the winch rope. There is no facility for altering the backlash of the gear mesh. This should be between 0.5 and 2.2mm.

A lifting beam has been supplied with two pairs of lift points; one to lift the drum and winch as a single assembly and a second pair to lift the Winch drum.

Winch Drum

The winch drum is manufactured from high strength steel (Weldox 700/RQT701) and is designed to carry 3500m of Ø40mm rope in 14 layers.

The rope end is secured to the inside of the drum by six "U" clamps. The rope passes through the drum access hole and wraps half a revolution parallel to the drum flanges. For the next half wrap it is progressively pushed across one rope diameter. The bottom layer is thus wound on with the rope fleeting one rope diameter each turn over one half wrap.

The drum is mounted on a self-aligning roller bearing at one end and a large diameter slew ring at the other. The fixed side of the slew ring is bolted to the motor mounting plate and the rotating side is attached to the drum (72 XM24 bolts).

To remove the drum the 72 x M24 bolts must be undone and the non-drive end, pin removed from the frame. The drum may be lifted off four shackle holes (two per (SMD)

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ITO Confidential
A lifting beam and Y-sling has been supplied along with the 8 x 17 tonne shackles necessary to lift the drum. This arrangement is designed to lift the complete tow winch as well as for changing drums.

**Fleeting Assembly**

The fleeting assembly guides the cable onto the drum. The fleeting assembly is designed to accept the tow cable at side lead angles up to + 7.5°, whilst the vertical angles are defined by upper and lower mechanical stops positioned to suit the final ship layout. A lower mechanical stop has been installed prior to installation on the vessel.

The assembly comprises an arm pivoted off the main frame on two pins. A fleeting carriage is driven along the main box section of the arm by a lead screw powered by a Danfoss OMT 315 hydraulic motor. Oil is directed to the hydraulic motor from a directional solenoid valve. The control signal to the solenoid valve comes from a trailing arm fleeting sensor. This sensor identifies when the horizontal position of the fleeting carriage is lagging or leading the tow wire and the hydraulic fleeting motor drives the lead screw and nut to correct this horizontal misalignment.

The carriage has two vertical axis rollers that guide the rope horizontally and a single horizontal axis roller that rests on the tow wire. The tow wire is captured between the two vertical rollers, the horizontal roller above and a bolted lower cable guide.

Two proximity sensors, one at each end of the movement of the carriage are used to determine when the direction of carriage fleet should be reversed.

(SMDS)

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Safety Summary

The hazards and protective measures (cautions and warnings) applicable to this equipment are summarised in section 5.1 (Operating Instructions) and 6.1 (Maintenance).
**Main Data**

All together the 60 T SWL A-Frame w/25T SWL active hydraulic swinging beam is covered in this manual.

<table>
<thead>
<tr>
<th>Equipment type:</th>
<th>60T SWL A-Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine number:</td>
<td>T2237.3000</td>
</tr>
<tr>
<td>Gen. Arrangement:</td>
<td>T2237-D1220-G0026</td>
</tr>
<tr>
<td>Classification society:</td>
<td>The machinery is designed in accordance with the</td>
</tr>
<tr>
<td></td>
<td>- European FEM rules</td>
</tr>
<tr>
<td></td>
<td>- Class of utilisation: T6</td>
</tr>
<tr>
<td></td>
<td>- Class of load spectrum: L3</td>
</tr>
<tr>
<td></td>
<td>- Mechanism group: M7</td>
</tr>
<tr>
<td>Weight:</td>
<td>75T</td>
</tr>
<tr>
<td>Capacity A-Frame:</td>
<td>60T SWL</td>
</tr>
<tr>
<td>Capacity hoisting system:</td>
<td>25T SWL (block lowering system)</td>
</tr>
<tr>
<td>Pivot distance inward:</td>
<td>8800 mm</td>
</tr>
<tr>
<td>Pivot time inward stroke:</td>
<td>155 sec (full pivot angle)</td>
</tr>
<tr>
<td>Pivot distance outward:</td>
<td>11200 mm</td>
</tr>
<tr>
<td>Pivot time outward stroke:</td>
<td>245 sec (full pivot angle)</td>
</tr>
<tr>
<td>A-Frame portal height:</td>
<td>15747 mm</td>
</tr>
<tr>
<td>A-Frame width at deck:</td>
<td>13000 mm</td>
</tr>
<tr>
<td>A-Frame width at top:</td>
<td>9670 mm</td>
</tr>
<tr>
<td>Heel – Trim:</td>
<td>5° + 2° C</td>
</tr>
<tr>
<td>Hoisting/Lowering speed:</td>
<td>6,5 sec/m</td>
</tr>
<tr>
<td>Telescope up 3780 mm:</td>
<td>65 sec</td>
</tr>
<tr>
<td>Telescope down 3780 mm:</td>
<td>65 sec</td>
</tr>
<tr>
<td>Beam width:</td>
<td>3400 mm</td>
</tr>
<tr>
<td>Telescope action:</td>
<td>3780 mm</td>
</tr>
<tr>
<td>Sideway sliding:</td>
<td>Port side 2750 mm, Starboard side 2750 mm</td>
</tr>
<tr>
<td>Total sliding/distance:</td>
<td>5500 mm</td>
</tr>
</tbody>
</table>

**External Connections**

The equipment is externally hooked up as follows:

- **Pneumatic connections:** N/A
- **Hydraulic connections:** See dwg. T2237-D1220-H0001 / H0002 / H0003
- **Electric connections:** See dwg. T2237-D1220-E0034
Restrictions in Use

Subject equipment must only be used for the prescribed purpose within the specified limitations. The operator must be qualified and authorized for the task.

Repairs and modifications must be carried out without prior written approval from Hydralift ASA (Hydralift), except for the minor corrections that are described in the maintenance chapter. If such work is carried out by others, Hydralift's procedures for this kind of work must be followed. Lead sealings must not be broken without Hydralift's written approval. Only approved materials and original spare parts must be used.

Restrictions in Guarantee

Hydralift refuses all responsibility caused by breach of the restrictions described in section 2.4 (above). The guarantee for good performance is strictly linked to the correct and careful restrictions are breached, the warranty/guarantee shall no longer be valid.
MAIN DATA

Safety Summary
The hazards and protective measures (cautions and warnings) applicable to this equipment are summarised in sections 5.1 (Operating Instructions) and 6.1 (Maintenance).

Main Data

All together one 20T LCE is covered in this manual.

Equipment type: 20T Linear Cable Engine (LCE)
Classification society: The machinery is designed in accordance with

- European FEM rules
- Class of utilisation: T6
- Class of load spectrum: L3
- Mechanism group: M7

Machine number: T2231-3400
Gen. Arrangement: T2231-D 1221-G0032

Weight: 3OT
SWL: 20T
Pulling capacity: 20T
Static brake load: 25T
No. of wheelpairs: 20 Sets
No. of independent power packs: 5 pcs
No. of wheelpairs per. power pack: 4
Max air wheel pressure: 90 psi

Pick up mode
20 tons: 0-55 m/min
10 tons: 0-105 m/min
4 tons: 0-185 m/min
0.5 tons: 0-185 m/min

Pay out mode
20 tons: 0-75 m/min
10 tons: 0-160 m/min
7.5 tons: 0-220 m/min
0-3 tons: 0-246 m/min

Dimensions
Width: 2651 mm
Length: 14503 mm
Height: 2154 mm

External Connections
The equipment is externally hooked up as follows:

Hydraulic connections: N/A (the unit is self-supplied)
Pneumatic connections: N/A
Electric connections: See dwg. T2231-D-1221-E001 / E002/E003 / E004/E005
Water connections: See dwg. T2231-D1221-H0012
Restrictions in Use

Subject equipment must only be used for the prescribed purpose and within the specified limitations. The operator must be qualified and authorized for the task.

Repairs and modifications must not be carried out without prior written approval from Hydralist ASA (Hydralift), except for the minor corrections that are described in the maintenance chapter. If such work is carried out by others, Hydralift's procedures for this kind of work must be followed. Lead sealings must not be broken without Hydralift's Written approval. Only approved materials and original spare parts must be used.

Restrictions in Guarantee

Hydralift refuses all responsibility caused by breach of the restrictions described in section 2.4 (above). The guarantee for good performance is strictly linked to the correct and careful application of the instructions in this user manual. If, during the warranty period, these restrictions are breached, the warranty/guarantee shall no longer be valid.

TECHNICAL DESCRIPTION

General

The unit is designed with 20 pairs of rubber tyred pneumatic wheels arranged vertically in opposing positions. The friction will facilitate a pull of about 1 ton per wheel pair, using a pinching force of 1000 kp.

Cable guide plates are arranged at each end of the machinery to keep the cable in position and guide shackles and repeaters into the linear transfer wheels.

The wheels are working in pairs and opens symmetrically to the cable line. The closing force of the wheel pairs are adjustable and normally set at 1000 kp.

The wheel pairs open and close automatically to let objects of different size pass.

All wheels have a built in high torque wheel motor. The torque and speed of each of the two pairs are synchronised by the hydraulic system flow dividers.

The winch is able to operate with all wheel pairs engaged or with either one pair of wheels retracted. Retracted wheel pairs will automatically stop.

The vertical pivot movement of the wheels are synchronous about the cable line.

Opening of wheel pairs are operated remotely from the cable control room or locally on the winch.

The cable guides opens symmetrically about the cable line to give a max clear opening of 380 mm. Cable joints, repeaters and shackles are able to force the guides
to open during pick up or pay out operations. The cable guides will close automatically and maintain guiding the cable after repeaters, shackles etc. have passed through. Care should be taken during this operation.

The cable guides can be opened locally at the winch and have adjustments to set the width to suit the cable diameters used.

An accumulator system will maintain the preset pinching force for at least 30 minutes, in case of power failure.

The 20T Linear Cable Engine is supplied as one self contained unit with built in power pack’s on each of the five units that constitutes the winch. The only external connections necessary will be the electric power supply and the electric connections to the control system. For this we use a single information cable that will transmit all data.

The Hydrostatic Drive system will be equipped with a water cooler of sufficient capacity. Tempered water/glycol will be used as a coolant. All heat generated at the pay out mode will be dissipated through the el.system as the elimotor will work as a generator. Hence the hydrostatic system is very well suited for cable laying.

**Hydraulic Power Pack**

Access to the power pack is made easy by use of large watertight doors. The engine room has internal light fixtures.

Use of integrated valve blocks make the system clean and easy to understand.

The hydrostatic drive provides an ideal system for linear winches. The hydraulic circuit has one variable displacement pump and fixed displacement motors. The pump will operate as a motor when running in tension mode and the electric motor will be driven as a generator dissipating the brake energy into the ships electric system.

**Sub-systems / Main Components**

The Linear Cable Engine is comprised of a number of electrical, hydraulic and mechanical Subsystems or parts.

**Sub-systems**

The unit is comprised of the following sub-systems:

One Linear Cable Engine with built-in hydraulic power pack’s and drives Foundation Bracket Control Desk (placed inside the cable winch control room) Portable control unit Cable Load Sensing System integrated into the engine system Motion Relative Unit installed as a surge accelerometer
Main Components

The following components constitutes the Linear Cable Engine:

Four pumps - Variable Displacement Pumps /main pumps (2 pcs.). Delivers oil to the main fluid transmission lines - Replenishment pump. This pump delivers oil to low-pressure side of the main pumps. - Servo pump. This pump delivers oil for controlling main pumps and for auxiliary systems as for instance guideplates and pinch-force cylinders.

Wheelmotors (40 pcs.) These motors have constant displacement and the rotational speed of them will therefore be a function of oil-flow. The wheel torque moment is a function of the pressure drop Over the motors.

Flow Dividers This component ensures that each Winch motor gets the same oil flow independent of both time and total pump flow. This results in an equal rotational speed of all motors.

Wheelarm systems (20 pcs.) Each upper and lower wheelarm is controlled by a cylinder and this makes an opening and closing motion possible. The pinch-force of the cable wheel is a function of the working pressure of the cylinder.

User Manual-20T Linear Cable Engine

Guide system
The guide-system's purpose is to center the cable on the rubber-wheels. The pinch force of the sideguides is a function of the pressure on the guide cylinder.

Water cooler
The water cooler uses tempered water of about 38 degrees as a coolant. The pump has to run to cool the oil.

Filtration system
The filtration system consist of filters on the replenishment- and servo pump and at the return- and drain line.

Stonker brake system
A hydraulic operated emergency brake system is placed on the aft side of the linear engine.
**Dual length encoder**

Two counterbalanced pick-up wheels (length encoders) for picking up cable length are placed on the right hand side of the linear engine.

**Other components**

The auxiliary system is comprised of a combination of directional-, pressure relief- and pressure reduction valves that performs a specified function.

**Functional Description**

The winch-section is driven by a hydrostatic transmission. A hydrostatic transmission is a generic term for fluid power systems characterised by the absence of control valves in the main fluid transmission lines. Instead we are using a variable displacement pump that modulates the pump flow to control the speed and torque of the hydraulic motor. The important point is that the displacement of the pump is continuously variable and this fact results in a stepless control of the speed and torque of the hydraulic wheel motor within the max values of the pump displacement. Another argument for choosing a closed loop hydraulic system is the high requirements concerning response-time in a constant-tension system. This system is also more energy-efficient than conventional hydraulics with constant displacement pumps. The power consumption is never more than the power needed for keeping the wanted tension/speed level.

**Control System / Instrumentation**

The main control of the unit is remote from control desk inside the cable winch control room, or from a portable control unit. Also local control of the Winch (speed control) and operation of wheel pairs (open - close) are provided. The controls are integrated in a logic PLC system. Speeds and tension values are stepless controlled over the entire range of operation.

**Operating from Local Control Unit**

The following can be operated locally from the winch:

Guide In/Out; push button for operating guideboard in and out Wheelpair Up/Down; push button for operating the wheelpairs up and down Emergency stop, an emergency stop button for shutting down all winch functions.
Operating from Portable Control Unit

The following can be operated from the portable control unit:

Winch speed by use of a speed controller
Start/Stop of the main motors by use of push buttons
An emergency button placed at the upper left corner
Triggering the emergency stop button will shut down all winch motions / operations.
Remote mode has to be selected from control panel inside the control room before using this control unit.

Control Desk inside Control Room

The linear winch is normally controlled from within the cable winch control room. The control desk is equipped with necessary buttons, tension and speed controls and a touch screen terminal as the operator interface.

Touch screen for information to the operator and for input to the system
Speed controller
Tension controller
Mode selection button (selection between 'constant tension mode and 'normal mode')
Lamps / buzzer for major alarms
Start / Stop / Emergency stop buttons
Main Power key-switch for turning system on/off
Wheel and guide plate open/close are operated from the touch screen
Switch between Local and Remote control station

Power Failure Functionality

This option makes it possible to perform a controlled stop without cable damage in case of a power failure.

For a winch operating as a cable engine it is important that no unwanted friction is added to the cable in case of a power failure. To avoid this the winch is equipped with a function that will hold the mechanical brakes off by default. This will allow the wheels to rotate with only the internal friction in case of a power failure.

In addition there is an accumulator based system for opening wheel pairs when power are lost.

Integrated Load Cells

To achieve a good accuracy of the load measuring and tension values, an electric load cell is integrated in the winch structure. For the modern thin cables with low breaking load values, it is very important to have a precise control of the actual load to avoid cable damage.
Dual Length Encoder

Two counter balanced pick up wheels (length encoders) are installed on the aft side of the linear engine, for accurate measurement of the cable pay out length. One of the wheel ride on top of the cable while supported by a spring loaded lower wheel. Guide tables are installed on each side of the pick up wheels to control the linear direction of the cable. The support wheel will give room for passing repeaters.

Stonker Brake System

A hydraulic operated stonker brake is integrated at the aft end of the unit as an emergency brake. The brake has an opening suitable for the specified range of cable dimensions and maximum repeater size and has the following characteristics:
- Max. braking load 25T
- Operated from touch-screen and locally on LCE
- An accumulator for activating the Stonker Brake in case of power loss and for fast response.

Monitoring Instruments

Cable tension indicator, analogue, scale 0-20T / 0-10T
Touch screen (on control desk) with: - Cable speed indicator - Digital tension indicator - Cable total length indicator, continuos digital with set/reset functionality - Cable leg length indicator, continuos digital - Status information about control system - Alarm informations

One or both counter wheels picks up the cable length. An electric load cell picks up the cable tension and values are monitored by a separate analogue instrument (0-20T / 0-10T). The readout is based on the system work pressure and carefully calibrated in the PLC system. The readout is digital.

The winch will communicate with the main cable winch through the PLC communication cable to correct monitored values for tension in the cable system.

Alarms - Alarm panel indicators
- Minor alarms (oil temperature level and pressure replenishment pump filter)
Details believe to be correct but not guaranteed