
Thales AUV Launch and Recovery System

Operation and Maintenance Manual



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1 Overview

This manual details the operation and maintenance of the Thales AUV Launch and Recovery System (LRS). This manual provides an overview of the major components in the system and recommended procedures for launching and recovering the AUV (Autonomous Underwater Vehicle). It also provides information on installing and maintaining the equipment.

The information provided in this manual is in no way intended to take the place of good and prudent seamanship in the operation of shipboard equipment and the AUV team may well refine these procedures.

For more detailed information on the operation and maintenance of the HIAB crane and CT winch, the reader should refer to the user manuals for these components.

1.1 Introduction

This overview section provides a brief description of the major LRS components. Please refer to subsequent sections of this manual for detailed descriptions of the equipment and procedures.

1.2 Purpose of Equipment

The LRS (Figure 1-01) is designed to safely deploy and recover the AUV at up to 7.8 meters (25.6ft) reach, measured from the crane post to the center of the AUV, from vessels of opportunity in up to Sea State 5 (Beaufort 6) conditions. The LRS is comprised of a crane, constant tension winch, capture mechanism, hydraulic power unit, towing boom, portable control console, line attachment hardware, and an ISO base for storage and transport. The towing boom is positioned approximately 6-10m (20-33ft) forward of the crane and extends approximately 6.1m (20ft) over the ship's side. It is beneficial to locate the boom as close to the ship's side as possible to have maximum boom extension and a wide target for the AUV tow hook.

The LRS incorporates a basic concept used for the handling of payloads at sea; that is, the motion of the payload is brought into phase with that of the ship during transfer to and from the air-sea interface.

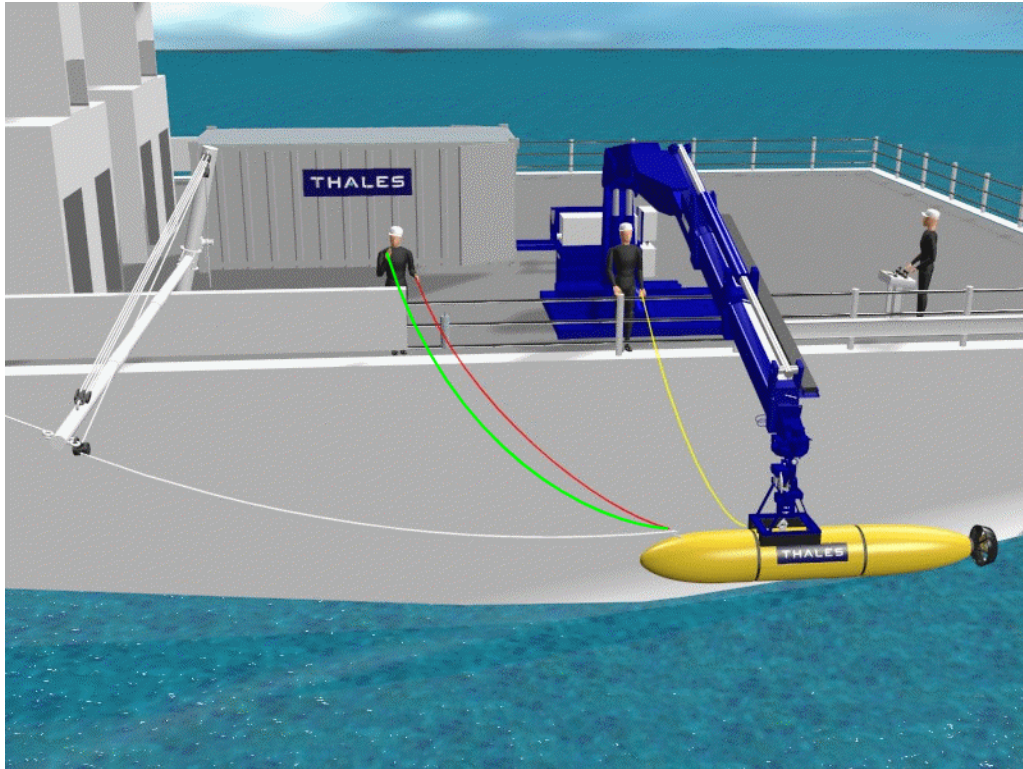


Figure 1-01 – Thales AUV LRS

1.3 Description of Operations

NOTE: The following is a brief description of launch and recovery operations. Please refer to Section 4 for a detailed description of operational procedures.

The LRS is simple in concept. It employs a two-point attachment system (tow line and winch cable) and a crane mounted capture mechanism for launch and recovery. During hoisting to and from the capture mechanism, the tow line is tensioned to substantially reduce the AUV's pendulum motion. The tow line and winch cables are both attached to the AUV using latching hardware and do not require a person in the water.

1.3.1 Recovery of AUV

When the AUV surfaces it should be operated at maximum speed and a constant heading of approximately 15° off a head sea with a lee created for the vehicle. Vessel speed is reduced to 1-2 knots above the AUV's speed. The vessel makes a pass by the AUV from astern while remaining parallel to the AUV. When the LRS passes over the AUV the tow line is lowered and then guided over the body of the AUV until it is captured in the tow hook located at the AUV's nose. The AUV is put under tow.

The crane is then positioned at its maximum outreach in the outboard position and the crane hook is lowered. A guide line, attached to the crane hook, is led to the throat of the AUV lifting

hook using the AUV hull as a guide. Once this connection is made the crane hook is lowered with line handler taking up the slack in the guide line until the crane hook is engaged with the AUV lifting hook. As soon as the hook is engaged the winch is put into constant tension mode. In this mode, cable is paid out and hauled in under constant tension as the AUV moves vertically relative to the mother ship and the crane.

Once the crane hook is attached to the AUV, the crane is positioned directly over the AUV and hoisting commences. During hoisting, sufficient tension is applied to the tow line to significantly reduce pendulum motion. Hoisting continues until the AUV is secured to the capture saddle. To prevent the possibility of over-hoisting, a limit switch cuts power to the winch when the AUV is in the correct position in the capture saddle. At this point, a latching system locks the AUV to the capture mechanism.

Recovery procedures are illustrated in Section 4.6.1.

1.3.1.1 Recovery of a Dead or Disabled AUV

Recovery methods are similar whether the AUV is dead in the water or underway at a constant heading. A dead vehicle may be at a heading that is not consistent with the optimum heading for recovery. If this is the case, once the AUV is under tow the mother ship can alter its heading as required.

For further information on procedures for recovering a dead or disabled AUV refer to Section 4.6.

1.3.2 Launch of AUV

The method of launching the AUV is virtually the reverse of the recovery procedure except simpler. With the vessel underway the AUV is lowered into the water and put under tow. The crane hook (which is attached in the reverse position) is released by pulling the guide line. The tow line, which is attached to AUV with a quick release snap shackle, is then released.

The launch procedures are illustrated in Section 4.5.1.

A detailed outline of launch and recovery procedures is included in Section 4.

2 Equipment Description

2.1 Introduction

This section provides a detailed description of the various components in the AUV LRS. It includes specifications, a description of the controls and references to manufacturer information.

As noted in the overview section, the major components of the AUV LRS are:

- Crane
- Constant Tension (CT) Winch
- Capture Mechanism
- Hydraulic Power Unit (HPU)
- Towing Boom
- Launch/Release Tow Line Assembly
- Crane Hook Assembly
- AUV Lifting Hook, Towing Hook, and Retraction System
- Portable Control Console
- ISO Skid

The LRS is capable of deployment and recovery of the AUV at a reach (measured from the center of the crane post to center of the AUV) of 7.8 meters in sea state 5 conditions. Note: the LRS is designed to operate at a maximum vessel roll of $\pm 15^\circ$. The recommended heading for launch and recovery of the AUV is about 15° into a head sea with a lee created for the AUV.

2.1.1 AUV Modifications

The following modifications have been made to the AUV to provide an interface to the LRS:

- Installation of a tow hook assembly at the AUV's nose and a lifting hook assembly at the AUV's center of gravity.
- Installation of a passive retraction/deployment system for the hooks.

AUV specifications are included in Table 1. An illustration of the AUV with LRS hardware is shown in Figure 2-01.

Table 1 - AUV Specifications

Length	3.9 m (152 in.)
Weight – Dry	547 kg (1205 lb.)
Weight – Flooded	743 kg (1637 lb.)
Maximum Body Diameter	0.53 m (21 in.)
Center of Gravity, in air (measured from the tip of nose)	1.48 m (58.27 in.)



Figure 2-01 – Mockup AUV With LRS Hooks

2.2 AUV LRS Components

2.2.1 Crane

The crane is a Hiab 200 Knuckle Boom Sea Crane with a double extension, telescoping boom, weighing 2700kg. The crane structure is of box-section design and uses self-guiding hexagonal extensions that provide a maximum reach of 7.8m. The crane has a lifting capacity of 2550kg (5622lbs) at a reach of 7.8m. When stowed the crane dimensions are 2.46 x 0.82 x 2.3 meters.

The base of the Sea Crane has three feet which ensure correct support even if the foundation is not quite even, and can be adapted for deck installation. Six M30 threaded rods that are supplied with the crane must be used in each corner of the base to secure the crane to the foundation. The length of the threaded rod allows for a foundation plate (maximum thickness of 50mm) to be used.

A cable tension detector switch, mounted on the crane and further described in Section 2.2.2.1 is used to prevent the winch from being placed in CT mode when there is load on the winch. This safety feature prevents the accidental dropping of the AUV. The crane is interlocked to stop the boom from extending beyond its recovery position and increasing the tension in the winch cable when the AUV is fully captured.

Boom, hoist and slewing operations are hydraulic, with hydraulic power provided from a single pump. Detailed descriptions of the standard crane functions are documented in Hiab 200 Sea Crane Operator's Manual included as Appendix I. Section 2.2.1.1 describes the crane modifications that were made to accommodate the LRS.

2.2.1.1 Modifications to Crane

The following modifications, illustrated in Figure 2-02, were made to the crane to permit integration with the AUV LRS:

- Installed a sheave on the outer boom of the crane.
- Installed an intermediate sheave.
- Installed a tension switch to detect slack cable on the outer boom of the crane.
- Installed the capture mechanism by means of an attachment fitting pinned to the end of the outer boom extension.
- Installed a winch mounting base to the crane post to accommodate the CT winch.
- Routed hydraulic lines and electrical cables to the end of the outer boom, by means of a cat track (Igus energy chain), to interface with the capture mechanism. The cat track is a flexible trombone-type mechanism that follows the motions of the crane and is used to protect the hoses and cables as the crane moves.
- Routed crane hydraulic hoses through crane post.
- Added a bulkhead with quick disconnect hydraulic fittings and electrical connectors.
- Installed light.
- Installed crane interlocks to prevent the crane and winch from applying excessive tension to the winch cable when the crane hook is in the fully captured position.

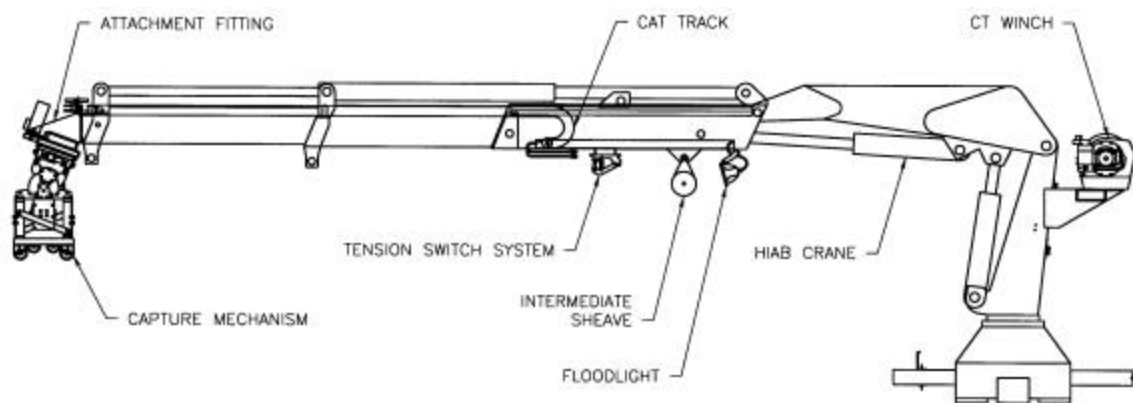


Figure 2-02 – Crane Modifications

2.2.2 Constant Tension (CT) Winch

The CT winch (Allied Systems Company, Model #CT-5), shown in Figure 2-03, is a planetary gear hydraulic winch with specialized hydraulic controls allowing it to operate with constant cable tension when the AUV is in the water, hauling in and paying out cable as required. The CT winch is mounted on the crane post and is used to hoist/lower the AUV between the capture saddle and water.

The winch brake is spring applied/hydraulically released and is equipped with an integral one-way roller clutch. The one-way roller clutch freewheels in the up direction, but prevents the shaft from rotating in the down direction unless the brake is released by hydraulic pressure from “WINCH DN” selection. The line pull of the CT winch, when controlled by the joystick and placed in constant tension mode is between 222-1334N (50-300lbf) and the line speed is 3.4m/s (675ft/min). The nominal line pull of the CT winch in normal mode is 9.8KN (2200 lb.) and the line speed is 0.41-0.51m/s (80-100ft/min).

The winch is further described in the “Technical Manual, CT-5 Winch Package S/N 2014” found in Appendix II.

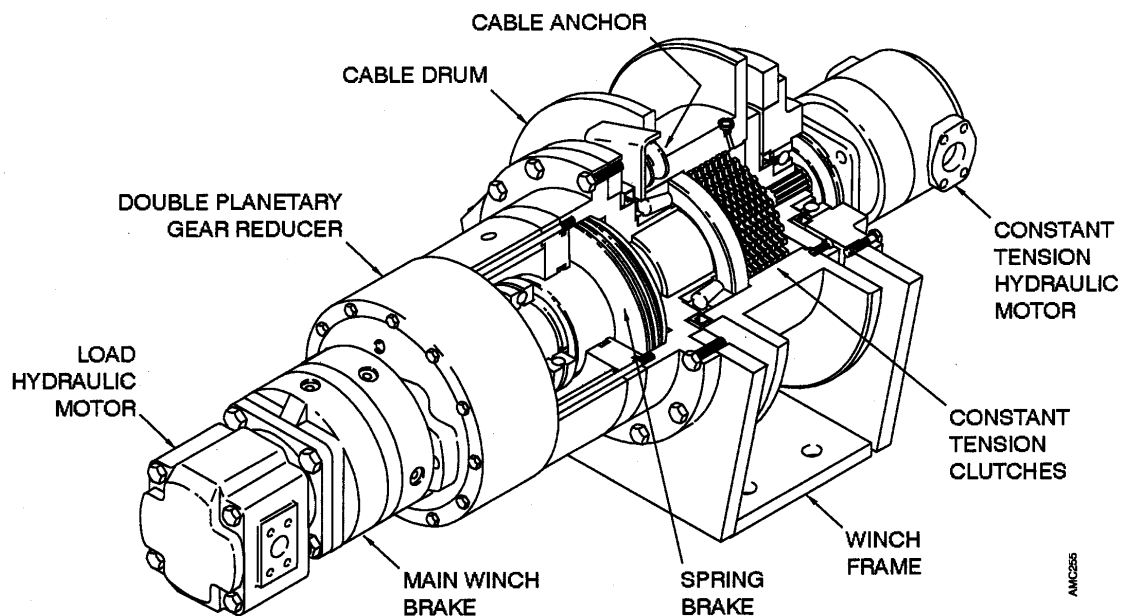


Figure 2-03 – CT Winch

2.2.2.1 Tension Detector Switch System

The CT winch uses a line tension detector switch system to prevent the winch from being placed in constant tension mode when there is a load on the winch. This is a safety feature to prevent the accidental dropping of the AUV. The tension switch system (Figure 2-04) consists of a roller on the end of a spring-loaded arm and a proximity switch. When there is tension in the CT winch cable, the arm is deflected from the rest position and disables the proximity switch. This prevents the CT winch from being placed in CT mode. When there is no tension in the

cable the spring-loaded arm returns to its rest position energizing the proximity switch, allowing the winch to be put in constant tension mode.

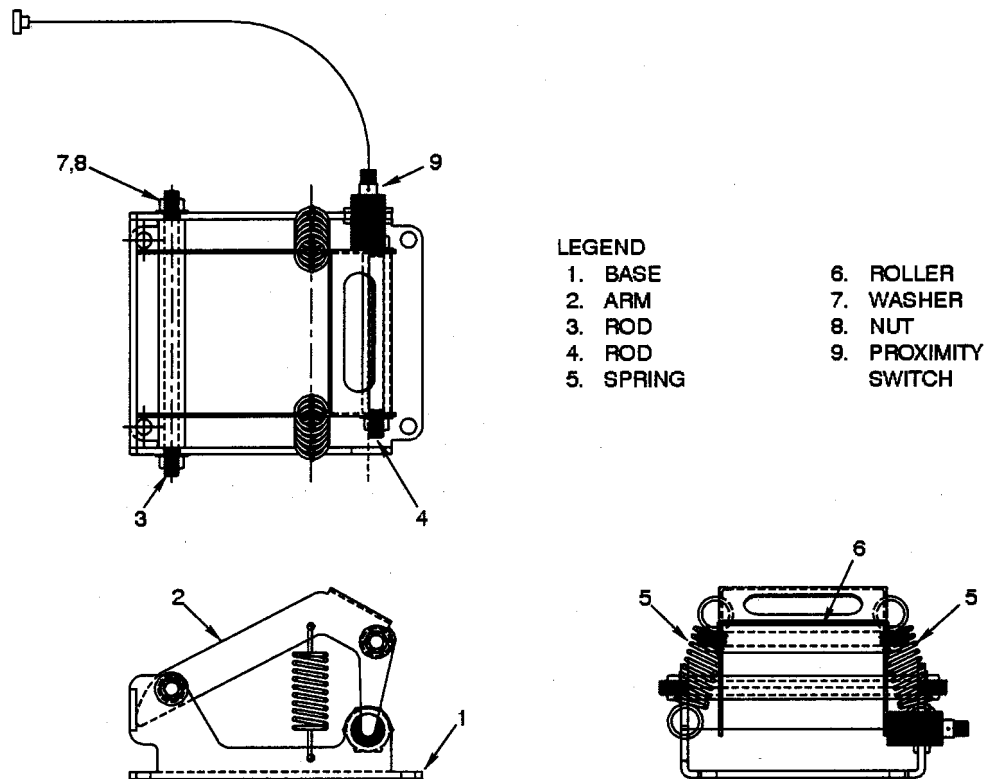


Figure 2-04 – Tension Switch System

The constant tension mode can only be engaged after depressing the “CONSTANT TENSION SELECT” push button when a slack cable occurs as the load rests on the water (during recovery) or by selecting constant tension mode while there is no load on the cable.

2.2.2.2 CT Winch Mounting Base

A mounting base is installed on the crane post and is used to secure the CT winch on the crane. The CT winch bolts to the mounting base with four $\frac{3}{4}$ 10UNC bolts.

2.2.3 Capture Mechanism

The capture mechanism assembly (Figure 2-05) is a pivoting structure that is bolted to an attachment fitting at the end of the crane outer boom. This assembly acts as a sheave for the hoisting cable, and a capture device to lock the AUV to the crane and restrain its motion. The capture mechanism is equipped with a set of caliper brakes that dampens the motion of the AUV when it is captured. A rotator assembly is used to rotate the AUV and a latching mechanism locks the crane hook into place so that the system does not depend on cable tension to hold the AUV securely against the capture saddle.

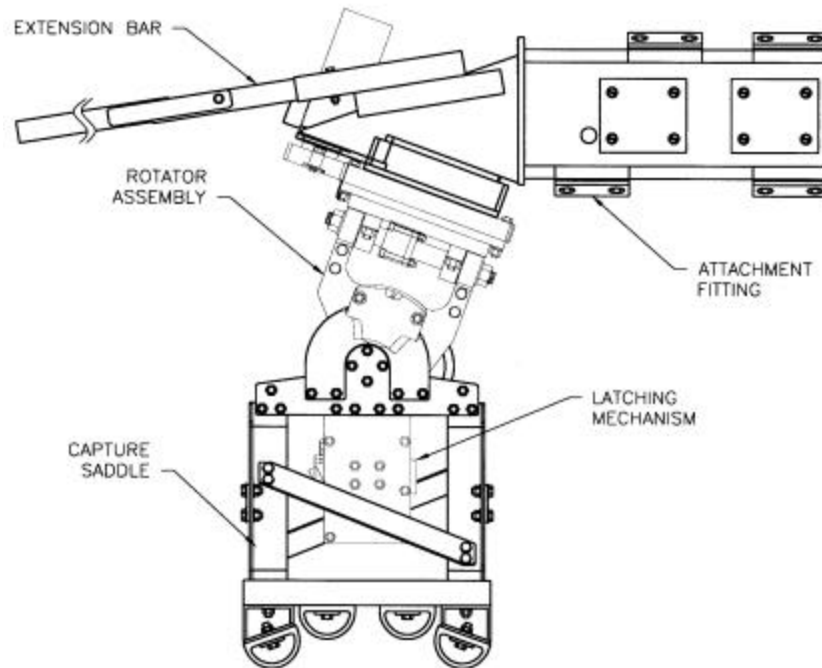


Figure 2-05 – Capture Mechanism With Attachment Fitting

2.2.3.1 Capture Mechanism Braking System

The capture mechanism braking system consists of two hydraulically applied proportional caliper brakes which operate on a partial disk at right angles to each other. When the brakes are released the capture mechanism is free to rotate about the horizontal axes, following any loads suspended from it. When the brakes are applied, motions about both axes is slowed down or stopped. The brake is normally applied once the AUV has been captured. The amount of brake force can be adjusted to suit the needs of the user and/or system.

2.2.3.2 Rotator Assembly

The rotator assembly consists of a large external gear/bearing system driven by a pinion. The pinion is in turn keyed to a drive stack consisting of a hydraulic motor and a spring applied/hydraulically released brake. The rotator system is controlled through a proportional control solenoid valve wired to a paddle switch on the control console. Due to the limitation of the hydraulic hoses continuous rotation of the assembly is prevented through the use of a mechanical stop.

The rotator assembly is interlocked to the tension detector switch and the maximum hoist limit switch to prevent rotation when the cable is under tension. If the capture mechanism is rotating and the tension detector switch is tripped the rotator will stop its rotation. To restart the rotator the winch cable must be slack. Rotation is also prohibited when the maximum hoist limit switch is tripped. Both of these switches can be overridden by depressing the interlock override button located on the control console. Using the interlock override is not recommended unless the

system is being tested or in an emergency. The rotator must be at 90° to the crane during hoisting and lowering of the AUV to ensure cable is properly reeved.

2.2.3.3 Latching Mechanism

The latching mechanism consists of a spring loaded, hydraulically released latch that automatically engages with a fitting integral to the winch cable swivel termination. This mechanism is attached to the capture mechanism and incorporates guide bushings to ensure the winch cable is centered relative to the latch.

Two limit switches are mounted on the latching mechanism. One switch detects when the crane swivel has been hoisted far enough above the latch plates to a position that allows the latch assembly to open. When in this position the “PRESS TO OPEN LATCH WHEN LIT” indicator on the control console should light. This limit switch also prevents over hoisting by inhibiting any crane or winch function that would cause the crane swivel to be raised further into the latching mechanism. The second limit switch indicates that the latch is completely open and that it is safe to lower the crane swivel past the latch. It turns on the indicator light, “LATCH OPEN”, on the control console.

Hydraulic lines and electrical cables used to power latching mechanism functions are reeved to the latching mechanism through a cat track (trombone mechanism) attached to the crane. The hydraulic lines are terminated at the crane end with quick disconnect fittings and two electrical cables (one for each limit switch) are terminated with waterproof connectors for ease of attachment to the capture mechanism.

NOTE: The “PRESS TO OPEN LATCH WHEN LIT” indicator will light when the swivel inside the latching mechanism is lifted off the latch plates far enough to trip the limit switch. It is only necessary to press this button when there is a need for the crane swivel to be lowered below the latch plates.

Figure 2-06 shows the latch plates in the open and closed positions.

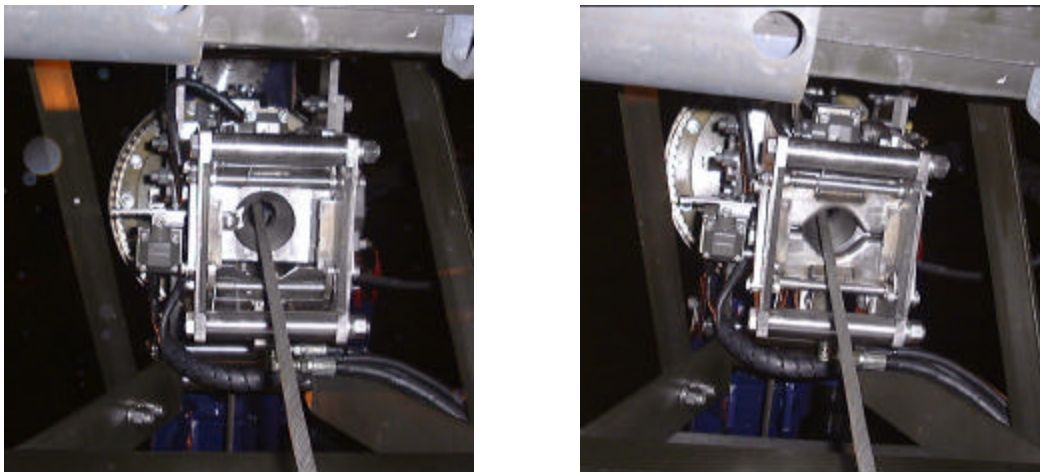


Figure 2-06 – Latch Plates Open and Closed

2.2.3.4 Capture Saddle

The capture saddle (Figure 2-05) consists of an aluminum frame bolted to the rotator assembly and a series of bumpers. It serves to guide and restrain the AUV as it is being captured. The capture saddle may be rotated $\pm 170^\circ$ by the rotator, allowing the AUV to be positioned in a variety of horizontal orientations relative to the crane base. The capture saddle is lined with bumpers at all points where the AUV may contact the structure.

2.2.3.5 Capture Mechanism Attachment Fitting

The capture mechanism (see Section 2.2.3) is bolted to a steel attachment fitting which slides into the end of the outer boom and is held in place with one pin. This fitting is constructed of 50WT structural steel and the attachment fitting with capture mechanism is easily removed from the crane for storage.

The attachment fitting is equipped with a removable extension used to position the tow line as far as possible away from the vessel during the tow line attachment phase of recovery. The tow line is connected to the extension with a break-away link that is overcome by applying tension.

2.2.4 Hydraulic Power Unit (HPU)

The HPU is a stand-alone unit mounted on a base that bolts to the ISO skid. The HPU incorporates an open loop system that powers the winch, crane, rotator, capture mechanism brakes, and latch release. The HPU assembly is shown in Figure 2-07.

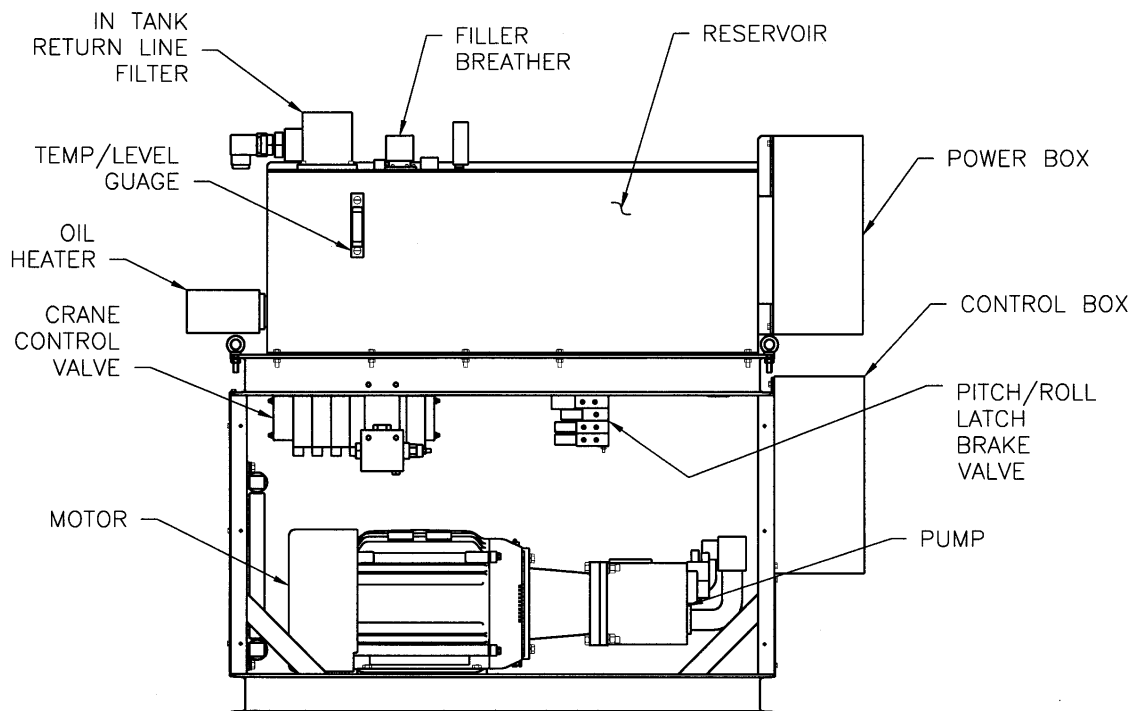


Figure 2-07 – HPU Assembly

A closed center (Danfoss) directional control valve controls the crane, winch, and rotator. The control valve has seven electrically operated sections, six of which can be manually operated, one for each of the following:

- slew (rotation around the vertical axis)
- raising and lowering the inner boom
- raising and lowering the outer boom
- extending and retracting the telescoping boom
- controlling the crane mounted CT winch
- controlling the CT winch in constant tension mode
- controlling the rotator

The directional control valve also contains a pump side module with an integrated electrical, load-sensing, unloading valve. This normally open valve has a manual override option used in the event of electrical failure. When the emergency stop is pressed the valve becomes de-energized and the system goes to standby pressure immediately. At the same time, the pump and motor stop and pressure goes to zero.

The electric motor powers a load sensing hydraulic pump which maintains system pressure requirements. The load-sensing pump, with horse-power limiter set at 30HP can deliver as much pressure, to its maximum pressure rating, as is required by any of the seven sections of the directional control valve. This enables the crane, winch and rotator to function (to their maximum potential) despite increased load requirements without overloading the electric motor. The supply and drain of the pump are connected to the reservoir, as is the return of the directional valves and drain of the crane, winch, and rotator. For further information refer to the hydraulic schematic included as Appendix III.

The HPU is equipped with the following:

- 190 liter (50 gallon) reservoir
- 30 HP electric motor
- variable displacement load sensing pump
- 2 electrical enclosures (power and control)
- baffle plate
- nylon suction strainer with 3psi bypass
- pressure/filler breather rated at 5psi
- Caloritech immersion heater with built in 1-pole thermostat

- Thermal Transfer oil-air cooler with 30psi bypass
- 3µm in-tank return line filter
- temperature and level sight gauge
- high temperature and low level switches

If the oil level in the reservoir is low it will trigger an alarm that will automatically shut down the oil heater. **WARNING: If the heater is not completely immersed in oil it will burn out.**

The pitch and roll brakes are controlled by two solenoid actuated, proportional pressure reducing valves and the latch release uses a non-proportional directional control valve. These valves are not designed to handle the HPU system pressure therefore an additional pressure reducing valve is integrated to reduce the pressure to these valves to a maximum of 300psi. As mentioned in Section 2.2.1.1, hydraulic hoses and electrical cables for the brakes, rotator, and latches are routed through a “cat track” mechanism. Additional hydraulic hoses and a control supply for the crane and CT winch are fed through the center of the crane.

The two electrical enclosures are mounted to the HPU frame and house a) power distribution hardware and b) control hardware for the system. The power enclosure contains an IT solid state starter for the motor and controls for the motor and pump. The control enclosure includes controls for a motor space heater and a 24V/10A DC supply. Start and stop controls for the motor are installed on the portable control console.

The HPU reservoir must remain free of contamination. To accomplish this the HPU has been fitted with an in-tank return line filter. The return line filter is equipped with a color-coded pressure gauge rated for 360psi and uses a 3µm betametricron filter that delivers fine filtration to capture all system-generated contamination.

The HPU oil filter is sized for extended life at the nominal system flow rate. It must be pointed out that new hydraulic fluid, direct from the manufacturer, is seldom filtered better than 40 microns and should be pumped into the reservoir through a 3-micron absolute filter.

2.2.5 Towing Boom

The towing boom is positioned approximately 6-10m (20-33ft) forward of the crane and extends approximately 6m (20ft) over the ship's side. It is beneficial to locate the towing boom as close to the ship's side as possible to have maximum boom extension and a wide target for the AUV tow hook.

The towing boom consists of a king post, inner boom section, middle boom section, and outer boom section and is equipped with a Harken one-speed winch (hand crank optional). The three sections of the towing boom, which can be stored on the container footprint, bolt together as shown in Figure 2-08. When the towing boom is fully assembled the king post will not stand vertical but will lean towards the aft end of the ship. The purpose is to counteract the pull

exerted by the forestay when the AUV is not under tow and to give the boom more stability with the AUV under tow.

When not in use the tow boom can be stowed by rotating the boom towards the upper deck and securing it to the side of the ship. The tow boom can also be stowed by rotating the boom aft and lifting the boom on to the deck. This is not the recommended position for stowing because the boom is difficult to lift.

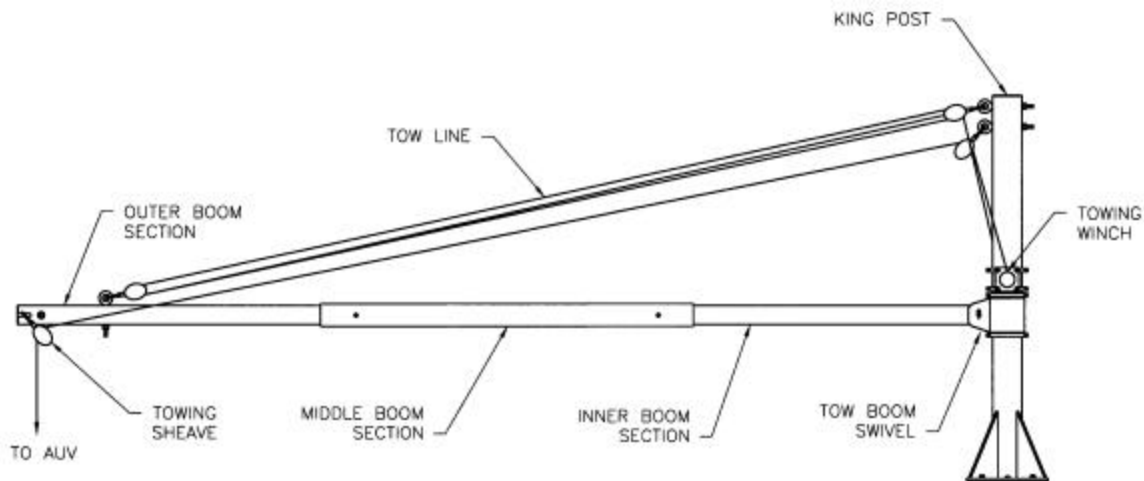


Figure 2-08 – Towing Boom

2.2.5.1 Towing Sheave

The cable from the winch is reeved through a towing sheave attached to the end of the boom. The location of the towing sheave can be adjusted from the tip of the boom to the middle section of the boom by moving the eyebolt to the preferred location along the boom. The length of the boom can also be shortened, in 46mm (18in) intervals, by sliding the outer boom section into the middle boom section and pinning. Adjusting the length of the boom is the preferred method of changing the position of the towing sheave because it reduces the bending stresses that are exerted on the boom.

2.2.5.2 Forestay

The towing boom is connected to the king post by a steel gooseneck. The towing load is restricted by a forestay connected to a pad eye at the end of the boom and side of the vessel. The forestay assembly consists of 13mm (0.5in) diameter rope.

2.2.5.3 Towing Winch

The towing winch is a Harken one-speed hand winch with a removable hand crank. The winch is mounted to the king post and acts like a capstan to give the tow boom handler more control over the tow line. The Harken winch has a line pull of 2669N (600lbf) and is not capable of storing rope. The tow line can be wrapped around the cleats on the king post when not in use (see Figure 2-09).

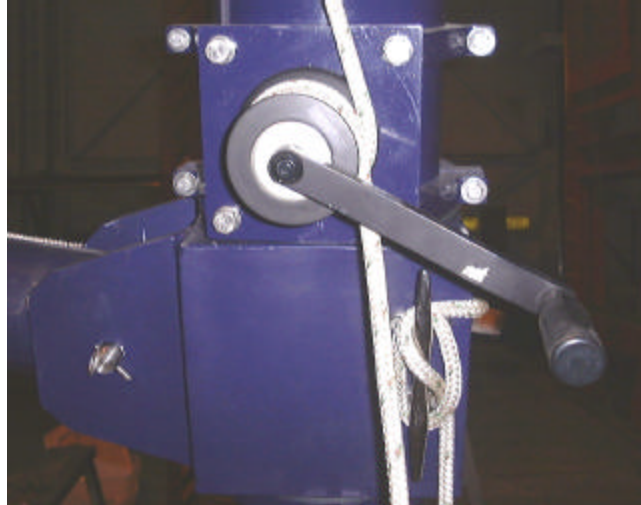


Figure 2-09 – Towing Winch

2.2.6 Launch/Release Tow Line Assembly

The tow line assembly consists of three sections, the line handler section, the AUV capture section, and the tow boom section. Both the line handler and tow boom sections consist of 7mm (0.5in) rope and the AUV capture section consists of PVC covered 4.8mm (0.19in) stainless steel cabling. A link-weight is used to terminate these sections and act as a weight on each end of the rope. The weight is needed to pull the rope more vertical thus giving a wider span of the AUV capture section in which the AUV can be captured. The stainless steel link-weight is designed to stop at the tow hook once the AUV is captured and is rated for the full strength of the tow line.

During launch operations a snap shackle is attached to the tow line between the two link-weights and engaged with the AUV tow hook. The snap shackle is used to detach the AUV from the tow line once launch authorization has been confirmed.

The launch and recovery tow line assemblies are shown in Figures 2-10. Additional illustrations can be found in Section 4.5 and Section 4.6.

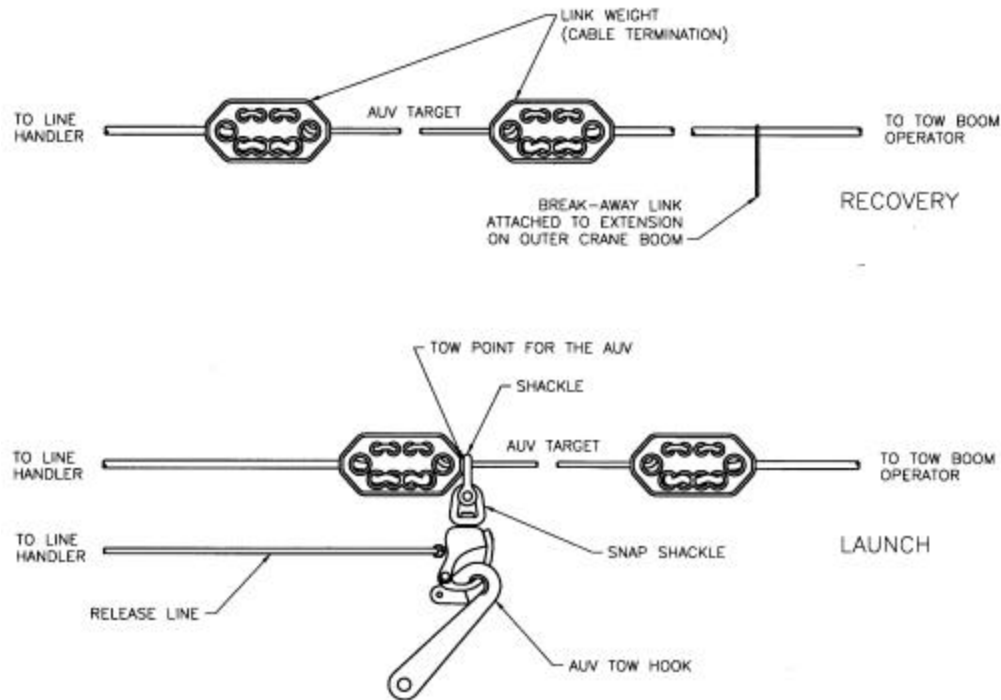


Figure 2-10 – Launch and Recovery Tow Line Assemblies

2.2.7 Crane Hook Assembly

The crane hook assembly (see Figure 2-11) is attached to the end of the CT winch cable. It consists of a swivel-mounted hook with an extended beak to accommodate a guide line. There is also an attachment point at the back of the hook to release the AUV during launch. The swivel is equipped with a ring to present a relatively large, flat, bottom surface that sits on the latch plates. When inside of the latching mechanism, the underside of the ring is just above two spring loaded (hydraulically released) latch plates. When the plates are closed, the hook is lowered a short distance until the ring rests on the plates.



Figure 2-11 – Crane Hook Assembly

2.2.8 Controls

2.2.8.1 Electrical Control System

The ship of opportunity provides 440VAC/3 Φ power to the AUV LRS power distribution and control system. The power distribution system provides three phase power for the HPU motor, single phase power for DC power supply, heaters, and floodlight, and DC power for controls. The control system incorporates a number of interlock and failsafes through a PLC (programmable logic controller). The PLC contains the software that controls the crane and winch operation when in remote mode. It is also used to monitor the high-temperature and low-oil level alarms for the hydraulic reservoir. Figure 2-12 is a block diagram that outlines the LRS components.

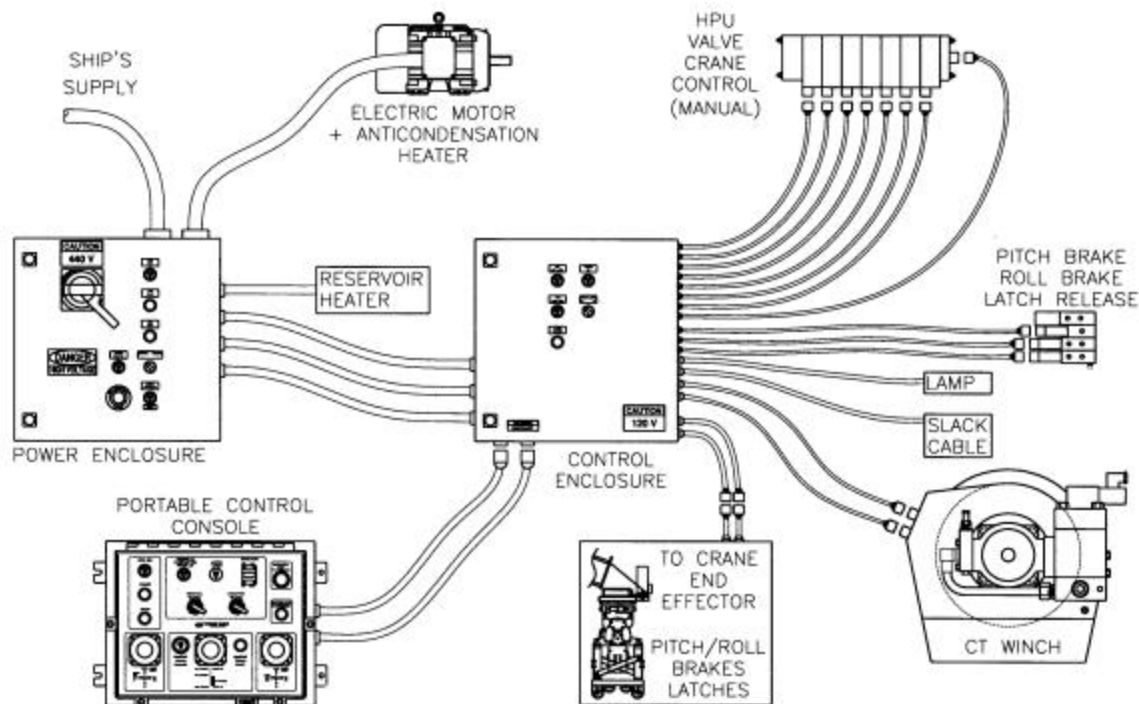


Figure 2-12 LRS Electrical System

For more information on the electrical control system refer to the electrical schematics and wiring diagram found in Appendix IV.

The control box (Figure 2-13) houses the pitch and roll brake valve modulators, a 12V and a 24V power supply, an anti-condensation heater, and PLC0. The following is a list of the indicators and controls located on the control box:

- 1) power on indicator for control system power
- 2) hydraulic fluid low level alarm indicator
- 3) hydraulic fluid high temperature alarm indicator
- 4) audible alarm
- 5) alarm silence pushbutton

6) flood light on/off control switch

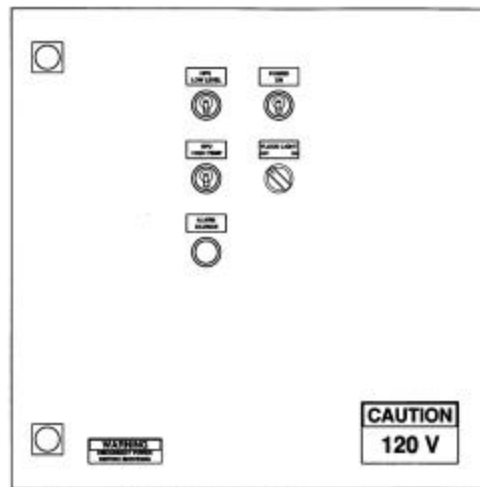


Figure 2-13 – Control Box

The power box (Figure 2-14) houses the 'soft start' motor starter, reservoir heater contactor, 120V power distribution transformer, power supply for the soft start motor starter, anti-condensation heater, motor circuit interrupt, and circuit breakers which make up the power distribution system. The following is a list of the indicators and controls located on the power box:

- 1) main circuit breaker (on/off) control lever
- 2) motor overload reset pushbutton
- 3) motor power control indicator
- 4) emergency stop mushroom head push/pull switch
- 5) HPU start switch
- 6) HPU stop switch
- 7) HPU run indicator
- 8) Manual/remote selector switch

Note: The door on the power box is interlocked with the system power (on/off) control to prevent access if the power control is in any other position than off.

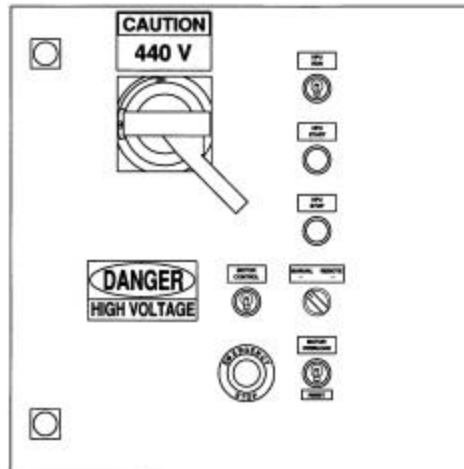


Figure 2-14 – Power Box

2.2.8.2 Portable Control Console

The portable control console (Figure 2-15) is used to operate the LRS from an unobstructed vantage point on the deck. The console is bolted to a stand that can be welded to the ship's deck.



Figure 2-15 - Control Console and Stand

The console is connected to the HPU/control enclosure through 2 x 10m (33 ft) electrical cables. The cables are connectorised and can be disconnected from the control enclosure. The console houses a circuit board for the CT winch, an anti-condensation heater, and PLC1.

The portable control console has the following features:

- two-way joystick for crane slew and crane extension
- two-way joystick for inner boom and outer boom
- single axis joystick for CT winch

- emergency stop
- constant tension select button
- constant tension engaged lamp and audible alarm
- latch release control
- latch open indicator
- HPU start/stop
- HPU ON indicator
- interlock override control
- brake pitch and brake roll proportional control

The crane joysticks use deadman-type thumb switches to prevent accidental operation of the crane. The deadman switch must be pressed before the joystick is moved off-center, else its controls are disabled. (Once the deadman switch is pressed, the joystick must be returned to the center position – then its controls are enabled.)

2.2.9 Spreader Bar Assembly

The spreader bar (Figure 2-16) is used to lift the LRS and consists of the following:

- lifting ring
- two wire rope slings which connect to the spreader bar with shackles
- steel spreader bar
- two lifting rings attached to bottom of spreader bar with shackles
- Four wire rope slings attach to the ISO corner fittings via a shackle and a Tandemlock lifting lug.

The spreader bar, which weighs approximately 250kg, is shown lifting the LRS in drawing 039-F-0-01 found in Appendix V.



Figure 2-16 – Spreader Bar

2.2.10 ISO Skid

The ISO skid, shown in Figure 2-17, forms the base to which all the major LRS components are mounted. The ISO skid is half the size of a typical shipping container and has a footprint of 3.05m x 2.44m (10ft x 8ft). During transport it also acts as the container base for the system, with all LRS components stored within it.

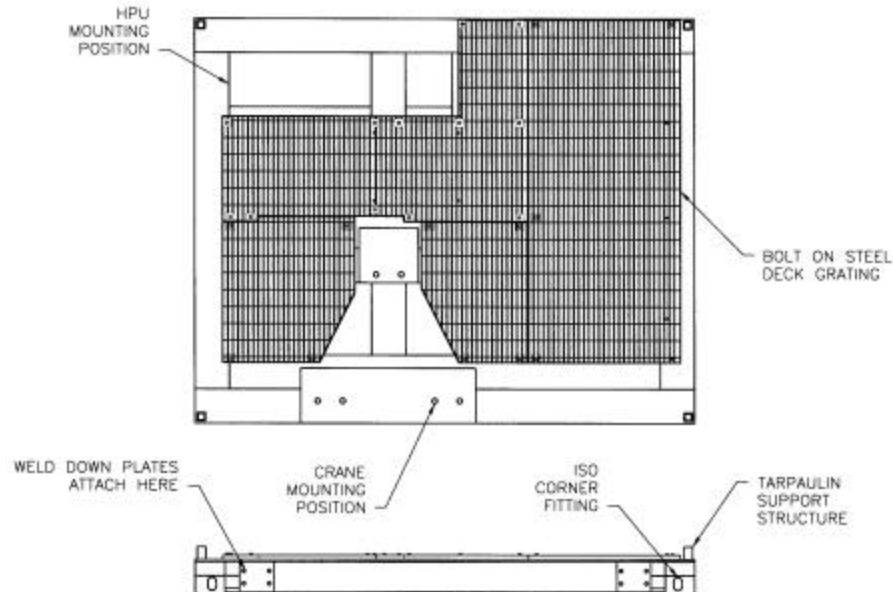


Figure 2-17 – ISO Container Base

The skid can be anchored to the vessel deck in either of the following ways:

- Using the four corner castings on the base of the skid.

- Using 8 renewable weld down plates that are bolted to the skid.

The open areas (between beams) on the skid are covered with a bolt on steel deck grating. The skid also contains sockets for the tarpaulin support structure, and tarpaulin tie-down rings. The container enclosure consists of a heavy-duty tarpaulin and a removable support structure. The support structure consists of 4 posts, one mounted at each corner of the skid.

LRS components that are bolted directly to the ISO skid include the crane, capture mechanism deck cradle, and hydraulic power unit. Other components, including the tow boom, control console, and capture mechanism are bolted to the skid for transport only. Instructions for unpacking and installing the skid are summarized in Section 3.3.

2.2.11 AUV Hooks/Retraction System

The AUV has been modified to incorporate a towing hook, lifting hook, and retraction system, shown in Figure 2-18, to provide the interface between the LRS and the AUV. The complete system consisting of two hooks, a cylinder, rods, springs, and brackets, is used to retract the AUV hooks using hydrostatic pressure when the AUV is submerged (to reduce hydrodynamic drag) and to extend the hooks when the AUV returns to the surface. Both the AUV lifting hook and the AUV tow hook are of titanium construction.

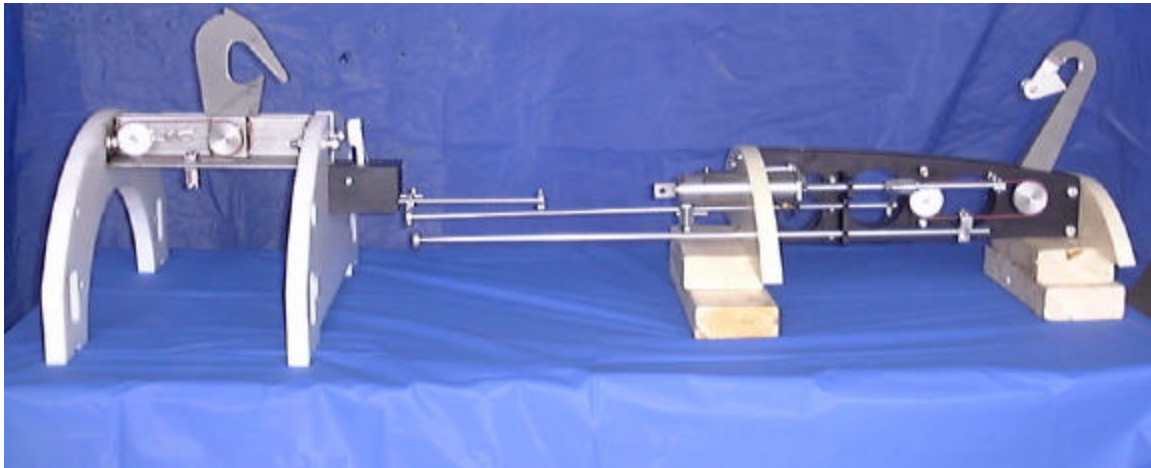


Figure 2-18 – AUV Retraction System

2.2.11.1 AUV Lifting Hook

The lifting hook is used to hoist the AUV and is located at the AUV's center of gravity. The crane hook guide line, attached to the crane hook, is used to aid in the mating of the crane hook with the AUV lifting hook. Once the two hooks are positively engaged lifting commences. The lift hook is constructed of Grade 5 titanium.

2.2.11.2 AUV Tow Hook

The tow hook assembly is mounted in the nose section of the AUV and acts as the tow point during launch and recovery operations. The assembly is designed with a spring-loaded latch to

positively capture the tow cable. A stainless steel link-weight, which forms part of the tow cable termination, comes in hard contact with the towing hook when towing. The tow hook, which is constructed from Grade 5 titanium, is mounted on the AUV with the mouth of the hook pointing toward the stern of the AUV. The mounting bracket for the hook allows it to pivot upwards to align itself with the tow cable.

In operation, a bight of the tow line is hung across the path of the AUV and the tow line makes contact with the AUV tow hook. Once the tow hook gate closes, the slack in the tow line is taken up so that the termination is firmly seated against the hook and the AUV is brought under tow.

2.2.11.3 Retraction System

The retraction system was designed to retract the AUV hooks after launch and to deploy the AUV hooks before recovery. This is accomplished through the use of hydrostatic pressure, which increases as the AUV descends and decreases as the AUV surfaces. The retraction system includes a small air cylinder that must be pre-charged with 69KN/m² (10psi) air pressure to ensure that it will work properly in the field. The rod side of the cylinder is open to seawater pressure through a brass breather vent.

As the AUV goes down, the seawater pressure increases and progressively pushes the piston down. The retraction of the cylinder rod pulls the cable chain and rotates the tow hook to the retracted position. At the same time, a push rod moves towards the lifting hook and again through a cable chain sprocket mechanism, the lifting hook is rotated to the retracted position where it engages a spring-loaded latch. This will happen during the first 36mm (1.40in) of travel. As the air is compressed further, the cylinder body will start to move against the constant tension springs until the piston bottoms out.

When the AUV returns to the surface, the air pressure in the cylinder pushes the cylinder rod out rotating the cable chain and deploys the tow hook. The lifting hook remains latched. When the towing line engages the tow hook and pulls it to its maximum deployment position the cylinder moves forward against the CT springs and the bottom push rod moves aft to release the latch. This releases the spring loaded lifting hook allowing it to deploy.

3 Installation Instructions

This section provides instruction for installing the AUV LRS. It describes how the system is prepared for installation, anchored to the vessel deck, installed and checked.

The AUV LRS is designed to be installed immediately following transport. It can be quickly installed by a crew of two or three persons and started up within a few hours of installation.

3.1 System Transport

The LRS is completely contained on an ISO skid and as such provides an efficient means of system transport. The skid is lifted using a spreader bar assembly. The spreader bar connects to the ISO skid with four lifting slings connected to the ISO corner fittings with tandemlock lifting lugs.

3.1.1 LRS Shipping Requirements

The AUV LRS includes a crane (Hiab 200), HPU, towing boom, capture mechanism assembly, and miscellaneous smaller components which make up the rest of the system. The shipping weight of the LRS is approximately 6805 kg (15000 lb.). Figure 3-01 shows the components as shipped.

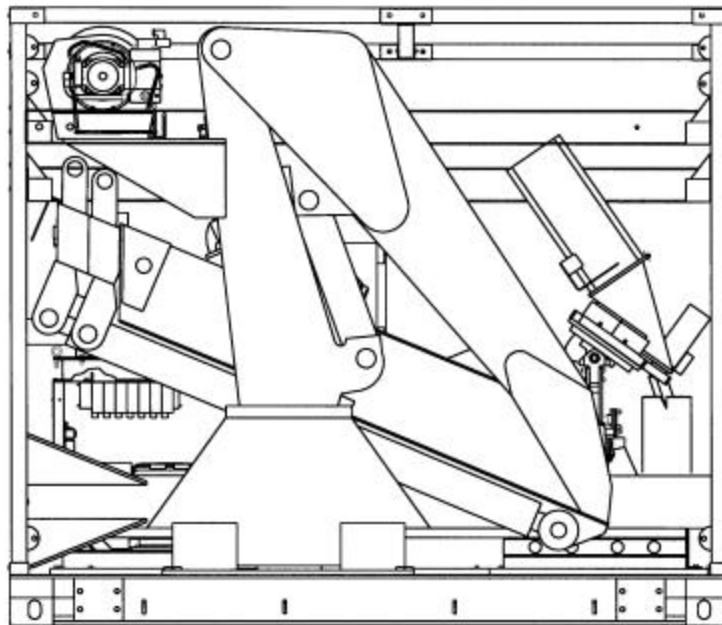


Figure 3-01 – LRS Shipping Configuration

3.2 Installation Requirements

3.2.1 Anchoring of ISO Skid to Ship's Deck

The ISO skid can be mounted to the ship's deck by using the ISO corner fittings or welding the skid weld plates directly to the deck. Installation details are as follows:

A) Skid and Mounted Hardware

Weight	- 5950 kg (13,100 lb.)
Deck reactions	– refer to Dwg. # 039-1-0-06 in Appendix V
Footprint	- 3.05m x 2.44m (10 ft x 8 ft)

B) Tow Boom

Weight	- 215 kg (475 lb.)
Deck reactions	– refer to Dwg. # 039-1-0-04 in Appendix V
Footprint	- (2 ft x 2 ft)

3.2.1.1 Corner Fittings

Some vessels are equipped with mating ISO corner fittings, which will allow the LRS to be quickly installed on deck. The ISO skid corner fittings will be secured to the deck with twistlock stackers. These fittings must have a minimum ultimate strength of 34,060kg (74,930lb) tension, 45,082kg (99,180lb) shear, and 150,273kg (330,600lb) compression. The twistlocks and a means of latching them are to be provided by the end user.

The following is a suggested procedure to anchor the ISO skid to the deck if the corner fittings are to be used. To anchor the ISO skid to the deck, ensure the twistlock stackers are anchored to the deck sockets, the rotatable locking sections are in the unlocked position (parallel to the length of the skid), and the locking handles are facing outside of the ISO skid footprint. Carefully lower the skid until it is resting on the twistlocks. Then lock the twistlocks by rotating the handles 90°. Carefully lift the skid until snug against the twistlocks and insert shims. The shims are metal plates with U-shape profiles that slide between the twistlocks and the skid. Once the twistlocks are inserted, lock the twistlock handles by threading a ¼-20-UNC x 1.25-inch long hex bolt into the tapped hole in the shim.

3.2.1.2 Weld Plates

The ISO skid is equipped with 8 weld down plates that fasten, with ¾10UNC galvanized bolts, to matching plates on the outside I-beams of the skid. For permanent installation the plates are fitted and tack welded to the deck, then the skid is removed to permit welding from both sides. For temporary installation, the plates are fitted and welded on the outside only with the ISO skid in place. For permanent installation the weld plates are to be painted. This is also recommended for temporary installation if it is to be used for an extended period.

To install the skid with weld plates, the plates are bolted to the matching plates on the skid and the bolts torqued to 271Nm (200ft-lb.). The skid is then lowered to the deck and the plates trimmed as necessary so that the LRS is as close to level as possible. The skid can be installed as high as 100mm (4 in) above deck level; if it is necessary to raise higher, the weld plates must be gusseted. **Note: Ensure that the tarpaulin is removed prior to any welding.**

3.2.2 Electrical Power Requirements

The LRS is connected to the power supply through a power cable that runs from the power box to the supply. The cable is 10m (33ft) long. The vessel of opportunity must supply the LRS with a 440V 3-phase power (50 or 60 Hz), rated for 55A minimum.

The control system uses a 'soft start' motor controller, which reduces the peak current drawn during motor startup. The 'soft start' function can limit the number of motor starts in a given hour due to dissipation of heat in the soft-starter during the 'soft start' period. Increasing the starting current will increase the number of re-starts that are possible in a short time period. (See soft-starter users manual in Appendix VI.)

3.3 Installation Procedure

Once the ISO skid has been anchored to the deck, install the AUV LRS as follows: (Many of these tasks can be carried out concurrently.)

- 1) Remove the tarpaulin and store.
- 2) Remove loose gear and tow boom components.
- 3) Remove tarpaulin post and stringers and store with tarpaulin.
- 4) Unbolt the transport bar from the crane.
- 5) Remove the portable control console from the skid and locate on deck so that the operator will have an unobstructed view of all operations. Then weld the base in place. **Note: LRS operations can be conducted with the portable control console located at its storage position on the ISO skid, although this is not recommended.**
- 6) Wire HPU into the ship's electrical panel.
- 7) Uncoil portable control console cables from the HPU skid and connect to the console.
- 8) Fill the HPU unit with oil if not already done. Hydraulic oil is to be filtered during filling with a 3µm filter.

WARNING: Do not fill the HPU tank unless the crane is in folded position. If filled with the crane extended, the tank will overflow due to the volume of oil required to extend the cylinders.

- 9) Check oil levels and review safety procedures before turning the HPU on using start button. After starting the HPU (for the first time) check to see that the motor is rotating in the direction of the arrow. **Note: The 'soft start' function can limit the number of motor starts in a given hour due to dissipation of heat in the soft-starter during the 'soft**

start' period. Increasing the starting current will increase the number of re-starts that are possible in a short time period.

10) Unfold the crane as follows:

- Lift outer boom off parking support, but no more than 13mm (0.5in), by carefully engaging **Outer Boom Down** on the right hand crane joystick. Please note that as the outer boom is upside down at this point, moving the joystick in the down direction causes the boom to move up in the opposite direction.

WARNING: If the outer boom is lifted more than 13mm (0.5in) it will hit the winch mount and cause damage to equipment.

- Lift inner boom up by engaging **Inner Boom Up** on the left hand crane joystick until the outer boom can be unfolded.
- Unfold the outer boom by engaging **Outer Boom Up** on the right hand crane joystick.

11) Locate the tow boom king post weldment at the desired location near the side of the vessel and weld in place.

12) Bolt the king post to the weldment.

13) Pin the boom to the gooseneck on the king post.

14) Assemble the three boom components.

15) Install rigging.

16) Locate a suitable location to anchor forestay or weld a pad eye as an attachment point.

17) Install forestay.

18) Slew the crane to line up with the capture mechanism, ensure that the inner boom is up to its limit, bring the boom extension close to the attachment fitting and carefully extend the boom until the fitting slides into the end of the crane and secure with the pin provided.

19) Carefully retract and raise the outer boom to take the capture mechanism out of its cradle.

20) Place the capture mechanism near deck level and connect the hydraulic hoses and electrical cable.

21) Check the operation of the latch plates and the rotator. Exercise several times to flush air out of the hoses.

3.4 Start-up / System Testing Procedure

3.4.1 Hiab Sea Crane

Note: For SAFE operation of the crane a second spotter person should always be used. An inspection of the area around the crane should be done to ensure it is clear of any obstructions. The crane operator should take directions from one person to avoid confusion.

3.4.1.1 Cold Weather Start-up

When the crane is started up in cold weather the wear on the hydraulic system, particularly on the pump, is greater than in normal operating temperatures. In order to minimize wear, the crane should be started as follows:

- 1) Leave the oil to circulate for a few minutes. Do not touch any of the levers.
- 2) Raise the crane from the parked position.
- 3) Operate the “IN” function of the outer boom for 1-2 minutes.
- 4) Operate the “OUT” function of the outer boom for 1 minute.
- 5) The crane is now ready for use.

3.4.1.2 Crane Functions

- 1) Power the HPU and check that the motor is rotating and the pump is on.
- 2) Raise boom until the capture mechanism is free of the deck.
- 3) Slowly raise and lower the crane inner boom until it bottoms out in each direction.
- 4) Raise and lower the crane outer boom until it bottoms out in each direction
- 5) Extend and retract the crane extension telescoping boom fully.
- 6) Put the crane in a position that will allow for complete rotation and slew of the crane in each direction.

3.4.2 Capture Mechanism Functions

3.4.2.1 Rotator

- 1) With the winch cable slack rotate the capture mechanism to full mechanical stop in cw direction.
- 2) Check that the hoses and cables are not strained.
- 3) With the winch cable slack rotate capture mechanism to full mechanical stop in ccw direction.
- 4) Check that the hoses and cables are not strained.

3.4.2.2 Brakes

- 1) If the brake is in the “ON” position slowly release until the capture mechanism is vertical, then switch the brake to the “OFF” position.
- 2) With the capture mechanism brakes “OFF” slowly raise and lower the boom and check that the capture mechanism pivots freely.
- 3) With the crane boomed in, switch the brake for one of the horizontal axes to the “ON” position
- 4) Slowly raise the boom verifying the capture mechanism brakes do not slip.
- 5) Turn “ON” the brake for the other horizontal axis and verify that the capture mechanism can no longer swing freely. **DO NOT** release the brakes in any other orientation than its natural suspended position.

3.4.3 CT Winch

- 1) Turn on the CT winch and verify that winch is not in CT mode.

- 2) Pay out cable and haul in cable.
- 3) Ensure that the cable is always under tension on the winch to maintain proper spooling.
- 4) Slowly continue hoisting until the latch automatically engages.
- 5) Pay out cable until the termination rests on the latch plates.
- 6) With the latch engaged, slowly haul in cable until the “PRESS TO OPEN LATCH WHEN LIT” indicator is illuminated. (This light indicates maximum hoist and illuminates when the winch cable termination is above the latch plates and the plates close automatically. When in this position, a limit switch that is interlocked to the winch, capture mechanism rotator, and crane is triggered to prevent the crane hook from being over hoisted. Winch haul-in, capture mechanism rotation, and any crane functions that could produce over hoisting are inhibited while this switch is engaged). Carefully attempt the following: cable haul in, main boom up, outer boom up, and extension out.
- 7) With the crane hook at maximum hoist, open the latch plates by depressing the “PRESS TO OPEN LATCH WHEN LIT” button and have a person on deck verify the latches are open when the “LATCH OPEN” light is illuminated. Release the “LATCH OPEN” button and have a person on deck verify the plates are closed.
- 8) Open the latches and lower the crane hook assembly below the capture mechanism.
- 9) Verify the operation of the interlock override by manually depressing the maximum hoist limit switch and interlock override. Then attempt the following: capture mechanism rotation, cable haul in, main boom up, outer boom up, and extension out. Ensure that there is sufficient cable paid out so that the crane hook remains well below the capture mechanism at all times.
- 10) To verify that CT mode is operational, position the capture saddle well above the water or deck. Lower the hook close to the deck.
- 11) Put the winch in minimum CT mode and verify that the cable can be pulled off of the winch by hand, approximately 133N-222N (30-50lb) tension. Engage the hook to a firm place on deck (lug or deck cleat). Clear the deck and have a crewman stationed at an E-stop in case of emergency. Gently pull the joystick to increase tension and the winch will pick-up the slack cable.
- 12) Increase tension until winch is in maximum CT mode. Boom up and down; winch should haul in and pay out cable.

WARNING: Never put the winch in CT mode unless the AUV is being recovered or the winch is being tested.

WARNING: Never put the winch in maximum CT unless the hook is connected to the AUV (recovery) or the hook is connected to a heavy weight of at least 150kg (330lb) or is anchored to the deck.

WARNING: If the winch joystick is moved slowly from “MAX TENSION” position to cancel constant tension, or is allowed to rest in the “MAX TENSION” position, the hook will be retrieved at a speed in excess of 3.4m/s (675 ft/min).

4 Operating Instructions

4.1 Introduction

This section details launch and recovery procedures for the AUV LRS. Each section of the operating instructions includes a summary, which describes the actions required to perform the procedure and a detailed set of instructions to execute the procedure. The following personnel are required for launch and recovery operations:

- LRS Coordinator (also communicates with the bridge)
- Crane Operator
- Tow Boom Operator
- 2 Line Handlers (to handle snap shackle release line, guide line, and one end of tow line)

4.2 Safety Notices

The procedures noted below are not intended to relieve the Master of his responsibility for the safe handling of the vessel and equipment. Brooke Ocean Technology Limited disclaims responsibility for any accident or injury as a result of omissions or errors in the procedures listed below.

4.2.1 Communications and Training

Communication is essential between the crane operator, deck crew, and the bridge crew. Do not begin operations until communication protocols have been understood between the various personnel in the operation.

Ensure that all personnel involved in launch/recovery operations are familiar with the operations as described in this chapter. They must also be properly trained for their individual tasks and familiar with operation and safety procedures.

4.2.2 Winch Cable

Always keep at least 5 dead wraps of winch cable on CT winch drum at all times.

Replace the winch cable immediately if any signs of damage or deterioration are observed, including broken wires, kinks, or significant corrosion.

4.2.3 Electrical System Warnings

Electricity and salt water can kill. Even relatively low voltages are particularly hazardous in a marine environment.

The hydraulic power unit motor and power box are energized at 440V. Break the supply circuit and lock it out before performing any maintenance on the power box.

The control circuits are energized to 120 VAC and 24 VDC. Disconnect supplies by opening circuit breakers and/or removing fuses before performing maintenance on the control systems.

4.2.4 Suspended Loads

Keep clear of the AUV and the crane at all times.

4.2.5 Line Handling

Personal and equipment can become entangled in loops of cable and trailing lines. To avoid this do not wrap cables or lines around hand or body and handle with caution.

The guide line is particularly dangerous because it is secured to the crane hook. If maximum CT mode is accidentally enabled the winch will haul in cable at 3.4m/s (675ft/min) and could pull the line handler overboard and cause serious injury to personnel.

4.2.6 AUV Propeller

Keep clear of the AUV propeller at all times.

4.2.7 Crane Operating Radius

If the vessel is subjected to roll angles in excess of $\pm 10^\circ$ do not slew crane to maximum reach. Reduce reach of the crane to 5m before slewing. Once deployment position or deck cradle is reached the crane can be extended to the required reach with the slew held in position.

4.2.8 Latch Plates

The latch plates close with a substantial force. Keep hands clear of the latching mechanism during pre-operational checks and lock out the hydraulic system before performing maintenance on the latch plates.

4.2.9 CT Winch

If CT mode is disabled while the winch is in the maximum CT position, the winch will immediately begin to haul in at full power and speed. Exercise caution when canceling CT mode from the maximum CT position.

WARNING: If the winch joystick is moved too slowly from “MAX TENSION” position to cancel constant tension, or is allowed to rest in “MAX TENSION” position, the hook will be retrieved at a speed in excess of 3.4m/s (675ft/min).

WARNING: NEVER use CT mode unless the hook is attached to an object that weighs at least 150kg (330lb).

WARNING: If constant tension mode is cancelled while the vessel is moving down a wave, a shock load will occur creating the potential for equipment damage. To ensure

shock loads are avoided, cancel CT and commence hoisting of the AUV when at the top of a wave.

4.2.10 Conditions Precluding a Safe Launch

The LRS is not designed for use in conditions beyond Sea State 5 (Beaufort 6) and/or $\pm 15^\circ$ of roll. Do not launch when conditions are likely to exceed these limits before the scheduled recovery.

4.3 Control and Instrument Functions

The LRS is controlled from the portable control console (see Figure 4-01) which is equipped with the indicators and controls listed in Section 2.2.8.2 of this manual. The function of the various console components is described below.

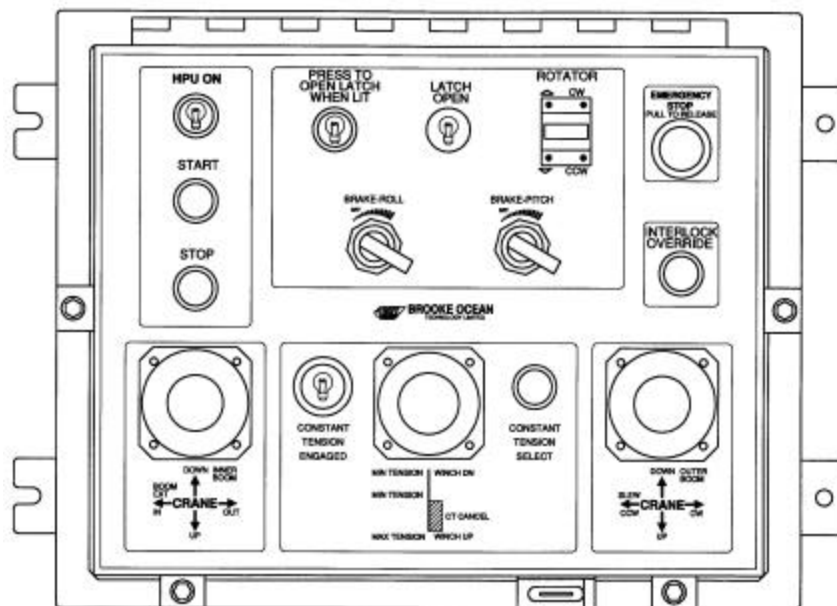


Figure 4-01 – Control Console

1. **Joystick for operating the CT winch.** Moving the joystick away from the operator pays out cable, while moving the joystick toward the operator hauls in cable. The winch speed is proportional to how much the joystick is moved. For detailed operating instruction refer to the CT winch manual.
2. **Lighted push-button switch for opening or closing the capture mechanism latch.** The switch is interlocked with the haul-in limit switch and should only be pressed when the switch is lit (this indicates that the crane hook has been raised above the latching plates). The button has to be held to keep the latch open.

3. **Latch Open Lamp.** Light to indicate the latch open limit switch has been tripped and the latch is open.
4. **Joystick for extending the crane and moving the inner boom up or down.** Moving the joystick to the left retracts the boom, while moving it to the right extends the boom. The boom has two extensions. When it is extending, the inner section first extends fully, then the outer section extends. Moving the joystick away from the operator moves the inner boom down, while moving the joystick toward the operator moves the inner boom up. The speed of all functions is proportional to how much the joystick is moved. The dead-man switch on the end of the stick must be pressed for the function to be active. If the stick is moved before the dead-man switch is depressed then the joystick command will not be acknowledged. The joystick must be returned to the center position and then the dead-man switch depressed to enable the joystick controls.
5. **Joystick for slewing the crane and moving the outer boom up or down.** Moving the joystick to the left causes the crane to rotate in a counter-clockwise direction, while moving it to the right causes the crane to rotate in a clockwise direction. Moving the joystick away from the operator moves the outer boom down, while moving the joystick toward the operator moves the outer boom up. The speed of all functions is proportional to how much the joystick is moved. The dead-man switch on the end of the stick must be pressed for the function to be active. If the stick is moved before the dead-man switch is depressed then the joystick command will not be acknowledged. The joystick must be returned to the center position and then the dead-man switch depressed to enable the joystick controls.
6. **Constant Tension Select button places the winch in constant tension (CT) mode.** When the constant tension feature is activated, keep the joystick at the minimum tension position to prevent the winch from hauling in at a high rate of speed. The CT mode will only be activated if the tension switch is open (i.e. the cable is slack). For more detailed operating instructions refer to the CT winch manual. When CT mode is selected, the CT Tension Select button will illuminate and an alarm will sound until CT mode is cancelled.

WARNING: Only use the constant tension feature during recovery when the capture mechanism is positioned over the water and the crane hook is latched to the AUV. Do not use this feature for latching or unlatching or for any operations when the capture mechanism is on deck.

WARNING: NEVER use CT mode unless the hook is attached to an object that weighs at least 150kg (330lb).

7. **Spring-loaded push-button switch for interlock override.** Pushing this switch allows use of crane and winch functions that are disabled when the latching limit switch has been activated or is not connected.

WARNING: Only use the interlock override switch in an emergency or to test system functions. Improper use of this switch could result in damage to the LRS or injury to personnel.

8. **Mushroom head push/pull switch for emergency stop.** Pushing the button shuts down the HPU, applies the winch brake, and inhibits crane/winch movement. An identical switch is mounted on the power box. **Note: if this switch is pressed, it must be pulled to the release position before the HPU can be re-started.**
9. **Spring loaded push button switch for starting the HPU.** Pushing the button for at least a ½second will cause the HPU motor to start. (Note – this button is only operational when Remote mode has been selected. The Start/Stop buttons on the HPU power enclosure can be used in both Manual and Remote modes.)
10. **Rotator paddle switch to rotate the capture mechanism.** Moving the toggle away from the operator rotates the capture mechanism in a clockwise direction, while moving the toggle switch toward the operator rotates the capture mechanism in a counter-clockwise direction.
11. **Spring loaded push button switch for stopping the HPU.** Pushing this button will stop the HPU motor. (Note – this button is only operational when Remote mode has been selected. The Start/Stop buttons on the HPU power enclosure can be used in both Manual and Remote modes.)
12. **Rotary potentiometer for roll-brake adjustment.** Braking force is increased in the roll axis by rotating the switch CW, while braking force is decreased, until the brakes are off, by rotating the switch CCW.
13. **HPU light to indicate that the HPU is running.**
14. **Rotary potentiometer for pitch-brake adjustment.** Braking force is increased in the pitch axis by rotating the switch CW, while braking force is decreased, until the brakes are off, by rotating the switch CCW.

4.4 AUV Launch and Recovery Pre-Operational Checks

Prior to launching, the following pre-operational checks should be made:

Table 2 - LRS Pre-Operational Checks

Crane	Crane pre-operational checks complete as per Section 3.5.1.2 of LRS manual.	
CT Winch	CT winch pre-operational checks complete as per Section 3.5.3 of LRS manual.	
Capture Mechanism	Capture mechanism pivots freely when brakes are off	
	Fully captured limit switch and indicator light working	
	Latch plate indicator lights working	
	Latch plates operating	
	Rotator operating	
	Check that capture mechanism safety keeper pin is installed	
	Capture saddle rubber bumpers are undamaged	
HPU	Hydraulic pump is operating	
	Tarp is removed (if temperature exceeds 20°C)	
	Hydraulic system is free of leaks	
Towing Boom	Tow boom secure (nuts, bolts, and cotter pins installed)	
	Towline attached in appropriate configuration	
	Snap shackle attached (launch)	
	Tow winch functional	
	Forestay taut	
Crane Hook	Swivel is free to rotate	
	Pin securing the hook to the swivel is tight	
	Hook is free of damage, wear and deformation	
	Cable termination nut is tight	
Cable and Handling Lines	Winch cable is free of corrosion, kinks, broken wires, and separated strands	
	Verify that lines tied into link weights are properly reeved and free from damage	
	Firmly pull lines on either side of link weights to verify they are secure	
AUV	Tow hook assembly free to operate, held by spring in up position	
	AUV cylinder is charged to 69KN/m2 (10psi)	
	Crane hook assembly free to rotate, held by spring in up position	

4.5 Launch

Launching the AUV involves two distinct operations. The pre-launch phase involves preliminary equipment checks and the process of latching the AUV to the crane prior to deployment. The launch phase involves placing the AUV in the water under tow and then releasing the crane hook and the tow line. A launch may be aborted at any stage in the process up to the final release of the tow line without making a full recovery.

The images shown below are representative of the LRS being installed on the port side of the ship. It should be noted that for starboard installation the procedures would be the same, starboard installation being a mirror image of port side installation. The lines used for launch and recovery are attached in the same manner despite the direction of crane slew.

4.5.1 Launch Procedures

Launch (and recovery) should be completed with the vessel heading 10 to 15° off a head sea. This will minimize roll motions and at the same time provide a lee for the AUV.

1. Complete all pre-operational system checks.
2. Connect the guide line to the shackle at back of the crane hook.
3. Attach and secure towing boom forestay and then put towing boom into position.
4. Pay out sufficient tow cable on deck to reach the bow of the AUV.
5. Attach the snap shackle to a 3/8" shackle at the tow line midpoint between the two link-weights.
6. Attach the snap shackle to the AUV tow hook. The snap shackle release line should be orientated so that it will face the ship when the AUV is under tow. Rig the release line to the snap shackle pin as shown in Figure 4-02.

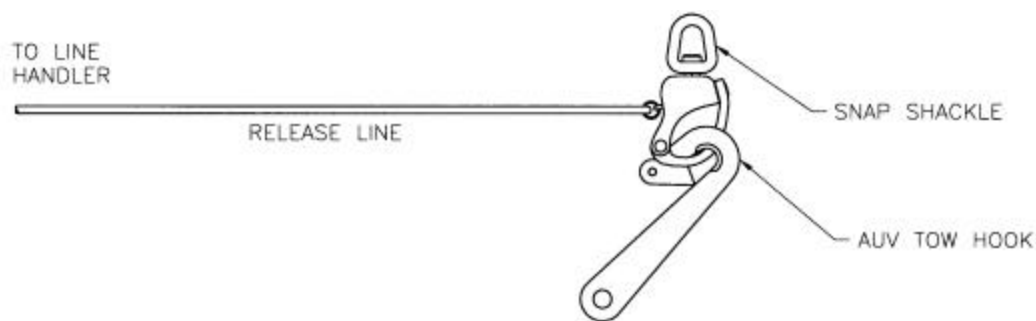


Figure 4-02 – Release Line to Snap Shackle

7. Remove the AUV tie-downs.
8. Slew the crane and capture mechanism over the AUV.
9. Lower crane hook and engage with the AUV lifting hook.

10. Release capture mechanism brakes.
11. Lower capture mechanism until it is almost in contact with the AUV's hull at the same time manually taking up the slack winch cable. Ensure that the gap between the hull and the capture mechanism bumpers is equal, both fore and aft and side to side. Continue to lower down until the bumpers are slightly compressed (Figure 4-03). Also, continue to manually keep tension in the cable.
12. Once the bumpers start to compress the crane hook will automatically latch with the latching mechanism. Visually check to see that plates are latched. **Note: The “PRESS TO OPEN LATCH” button is NOT USED at this stage of the launch sequence**
13. Boom up slightly until the swivel is resting on the latch plates and the “PRESS TO OPEN LATCH” light is out.
14. Carefully raise the AUV from the deck cradle (Figure 4-04). Then apply the capture mechanism brakes.
15. Carefully slew the crane until the AUV is clear of the deck cradle. Ensure that there is sufficient slack in the tow line.



Figure 4-03

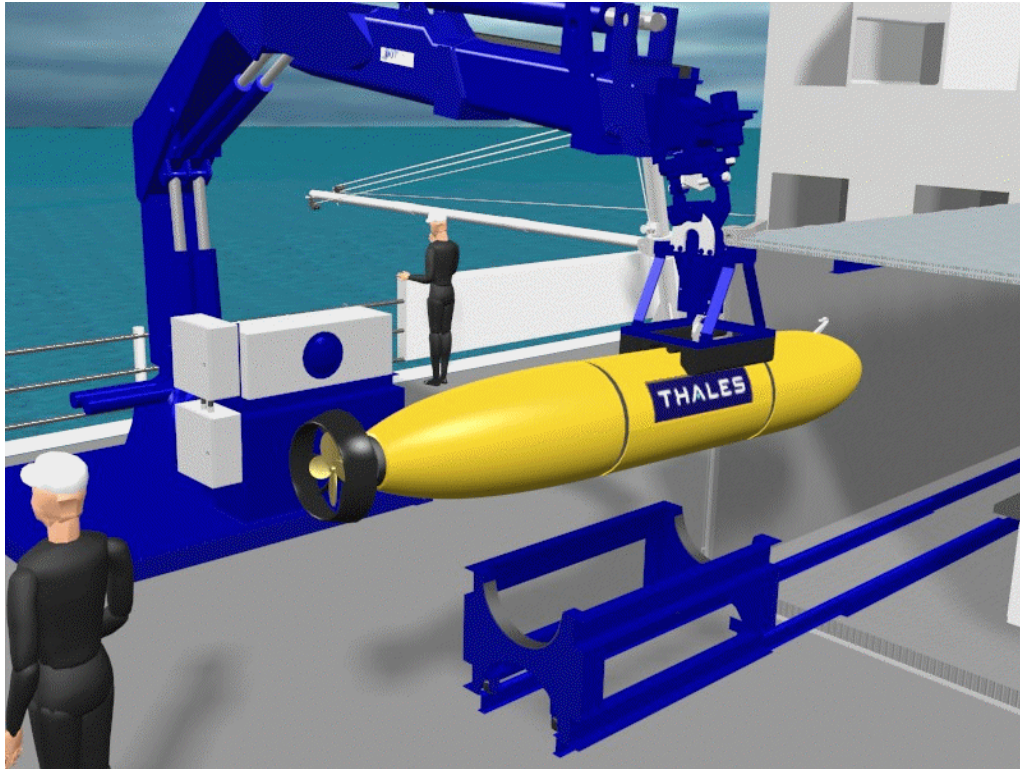


Figure 4-04

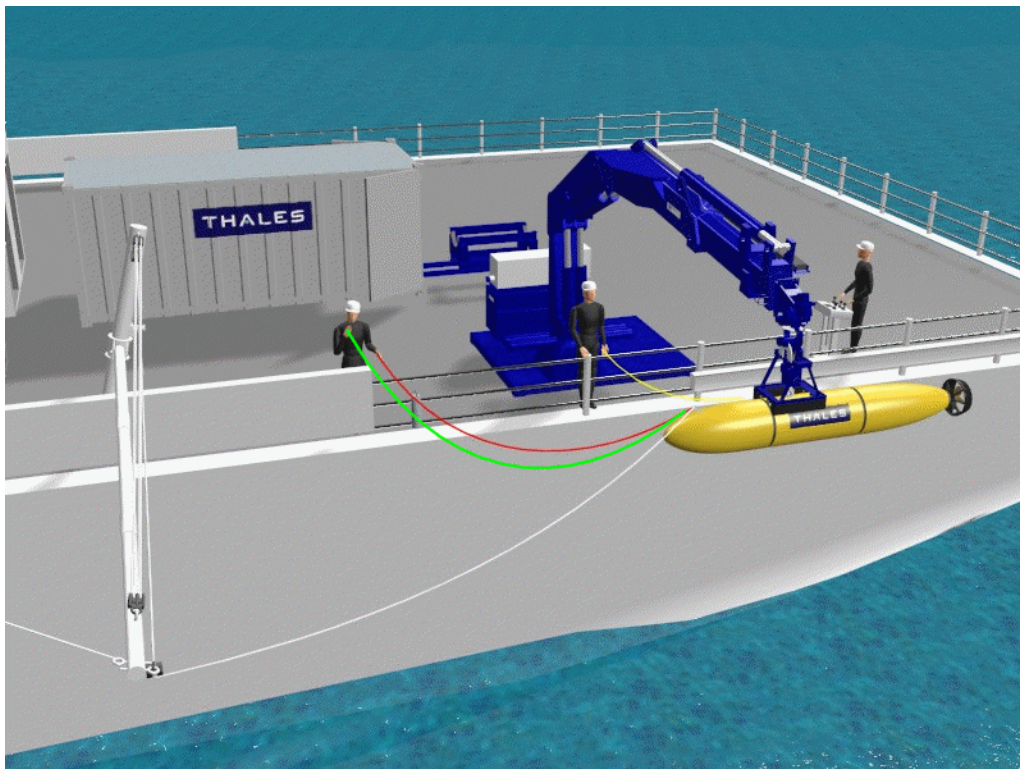


Figure 4-05

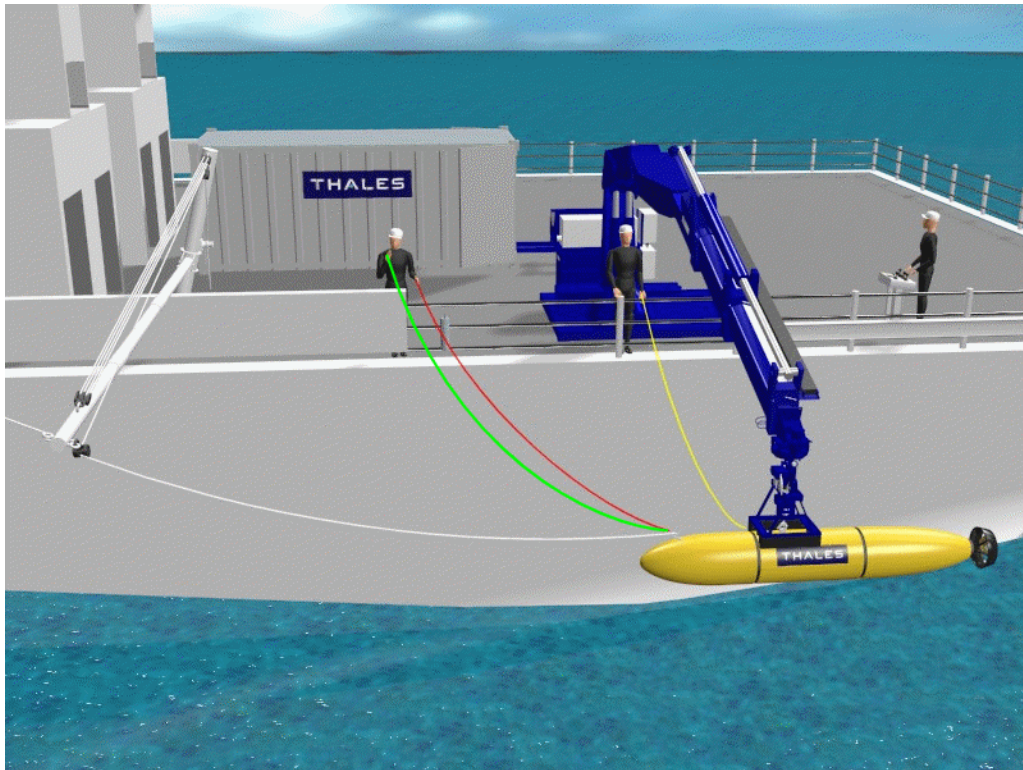


Figure 4-06

16. Slew the crane until the boom is perpendicular with the ship and rotate the AUV until it is perpendicular to the crane boom (Figure 4-05) using the alignment marks as a guide. In rough weather (greater than $\pm 10^\circ$ of roll) do not exceed reach of 5 meters while slewing.

CAUTION: Do not put the winch cable under tension unless the capture mechanism is perpendicular to the crane boom. Also, do not rotate the capture mechanism unless the winch cable is slack.

17. Ensure the capture mechanism is the same distance from the ship's side as the towing sheave.
18. Once the crane is in the launch position, boom out to maximum extension and release the capture mechanism brakes (Figure 4-06). If vessel roll causes excessive motion, do not release the brakes until just before launch. **Note: Always position the capture mechanism as close to the water as possible while avoiding the risk of hitting the water.**
19. Instruct the LRS Coordinator to head the vessel 10 to 15 degrees to port off a head sea and maintain a speed of 2-3 knots.
20. Inform the bridge that the AUV is ready to launch.

21. Take up slack tow cable but **do not put the tow cable under tension**.
22. On receiving clearance to launch from the LRS Coordinator, slowly haul in the wire rope until the “PRESS TO OPEN LATCH” light is lit. Then press button to open the latch plates. Wait until “LATCH OPEN” light is lit then still holding the button, slowly lower the crane hook assembly below the capture mechanism. Once the assembly has cleared the capture mechanism, release the “PRESS TO OPEN LATCH” button.
23. As soon as the cable termination is clear of the latch apply tension to the towline.
24. Commence lowering the AUV into the water. While lowering the tow boom operator maintains sufficient tension on the tow line to prevent yaw and pitch (Figure 4-07).

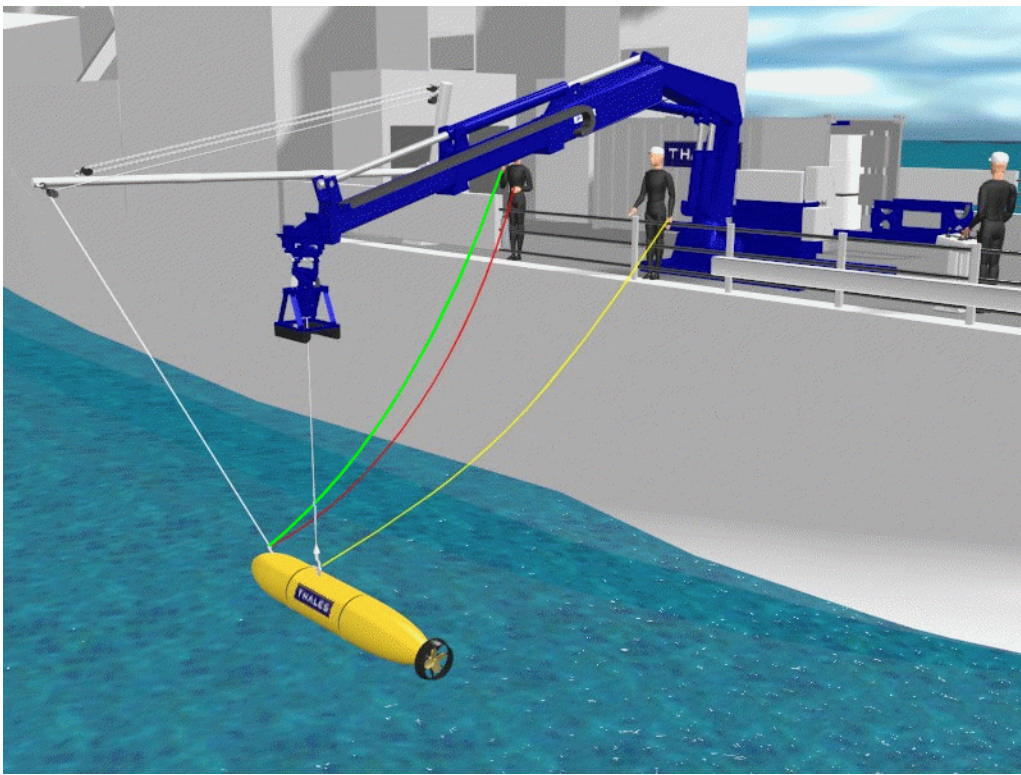


Figure 4-07

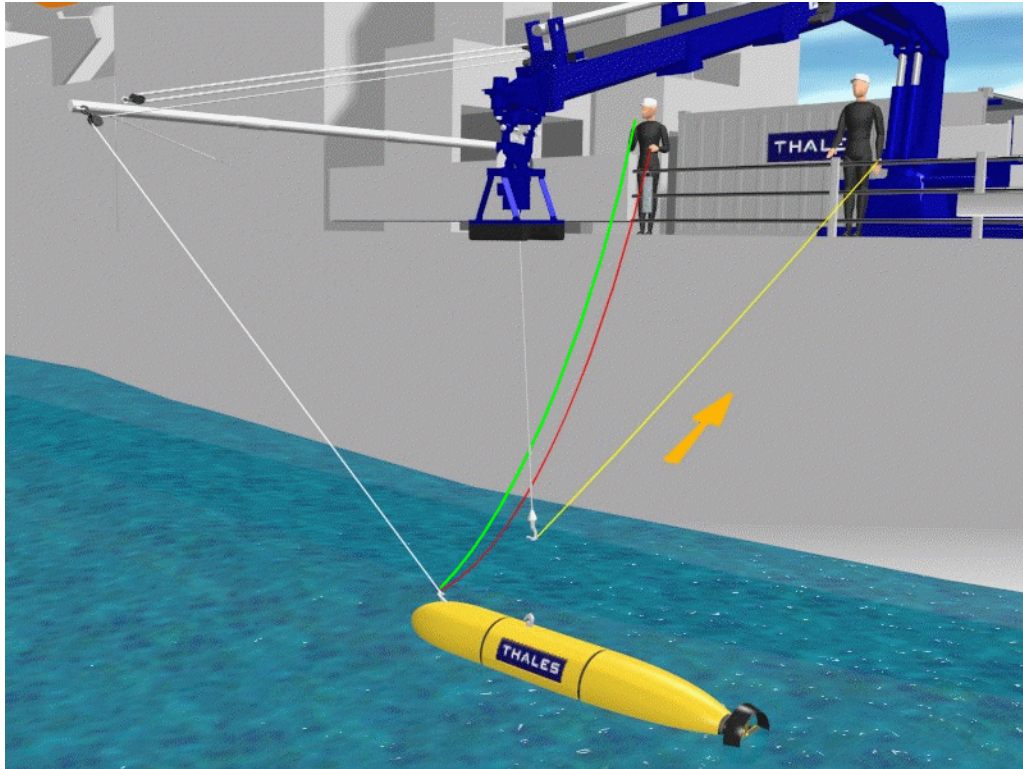


Figure 4-08

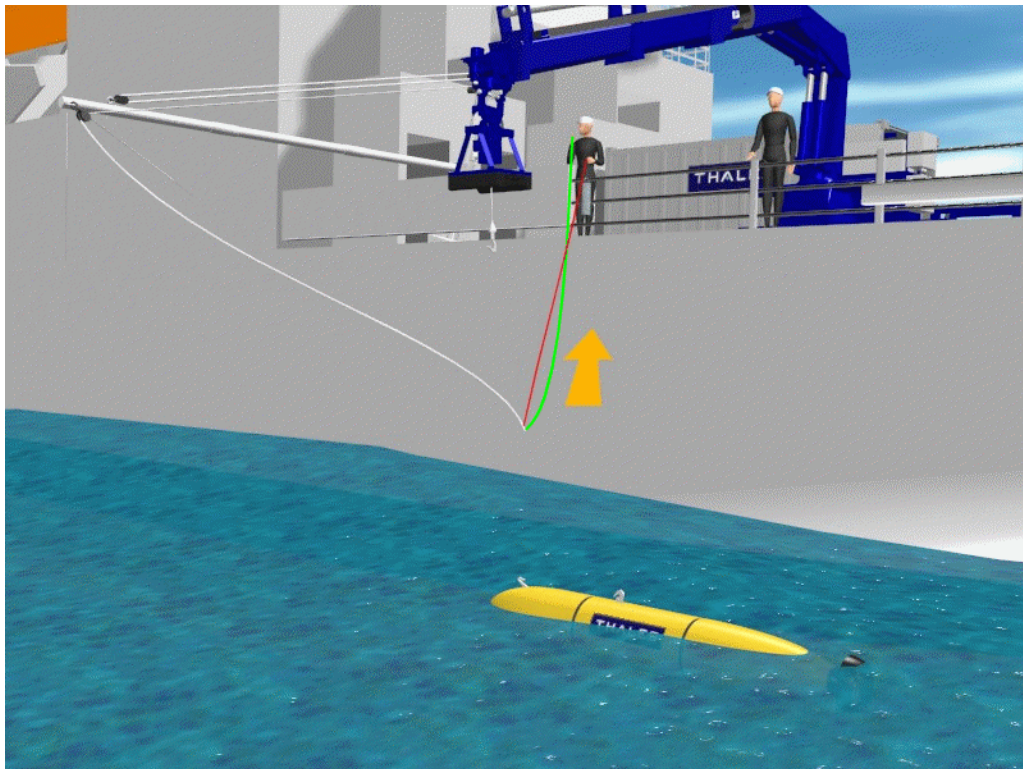


Figure 4-09

25. As soon as the AUV is waterborne and tension comes off the CT winch cable, release the crane hook from the AUV lifting hook by pulling on the guide line (Figure 4-08). **Note: Do not use CT mode when launching AUV.**
26. Advise the LRS Coordinator that the AUV is under tow.
27. Release the tow line by pulling on the snap shackle release line. As soon as release occurs, quickly haul in the tow line (Figure 4-09).
28. Stow the crane and towing boom.

4.6 Recovery

Recovery of the AUV should be completed at the same heading as launch operations. Pre-operational checks of all hardware should also be completed prior to commencement of operations.

There may be instances where it is necessary to recover an AUV that is “dead” in the water. The basic concept behind a dead vehicle recovery is to attach a tow line to the vehicle and get it under tow, at which point the crane hook can be attached and the vehicle recovered in a normal manner.

For recovery, set the ship on a parallel heading with the AUV and approach the AUV from astern. At minimum speed attach the tow line as stated in Section 4.6.1. Once the AUV is under tow alter course, if necessary, into a head sea ensuring that the AUV is a safe distance away from the ship while turning. The remainder of the recovery sequence proceeds as normal. **Note: The tow hook is designed to automatically release the lifting hook when at the surface. If the tow and/or lifting hook is not deployed then it will be necessary to manually deploy them.**

The images shown below are representative of the LRS being installed on the port side of the ship. It should be noted that for starboard installation the procedures would be the same, starboard installation being a mirror image of port side installation. The lines used for launch and recovery are attached in the same manner despite the direction of crane slew.

4.6.1 Recovery Procedures

1. Complete Pre-Operational Checks.
2. Bring the end of the tow line to the rail adjacent to the crane and deploy the towing boom and forestay. Ensure the forestay is taut.
3. Remove the snap shackle from the tow line and attach the tow line at marked position (position to be marked at time of installation) to the break-away link located on the capture mechanism extension. Both link-weights should be outboard of the break-away link as shown in Figure 4-10. Ensure the length of tow line between the towing boom and the crane

boom extension is such that when the crane is in the recovery position, there is not too much slack.

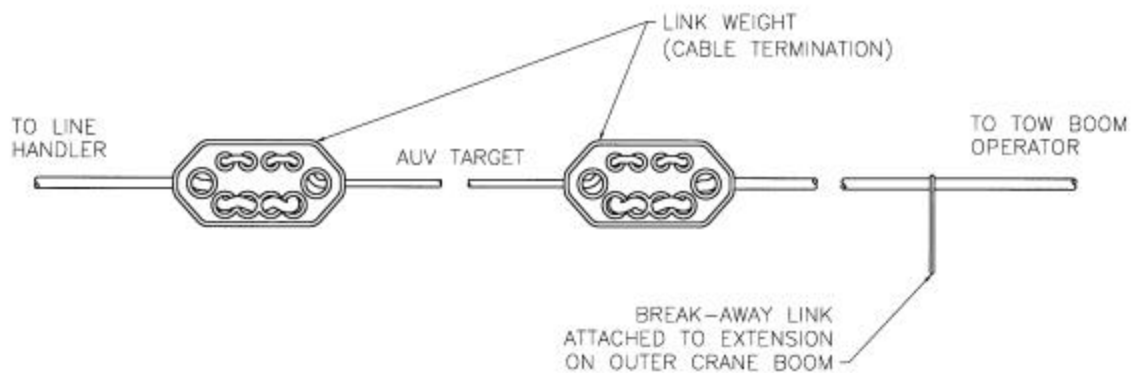


Figure 4-10 – Tow Line (Recovery Arrangement)

4. Remove the guide line and shackle from the back of the crane hook and reconnect the guide line to the beak of the crane hook as shown in Figure 4-11.

WARNING: Personnel and equipment can become entangled in loops of cable and trailing lines. To avoid this handle lines with caution. Also, never wrap lines around your hand, arm or body.

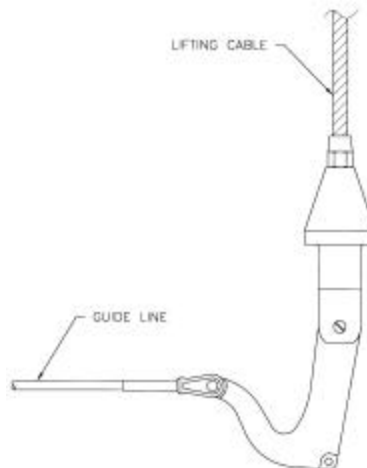


Figure 4-11 – Crane Hook (Recovery)

5. Swing the crane outboard and boom out to maximum extension as shown in Figure 4-12. Be careful to keep the tow line clear of obstructions. Adjust the length of the tow line so that the U-shape bight of line is just above the water creating a target for the AUV.
6. Alert the bridge that the deck crew is ready to attach a tow line to the AUV.
7. The AUV surfaces and maintains a constant heading. The vessel approaches the AUV, at minimum speed, from behind with tow line target deployed.
8. As soon as the target passes the AUV propeller shroud, the target is lowered onto the AUV hull and moves forward until it is engaged in the tow hook (Figure 4-13).

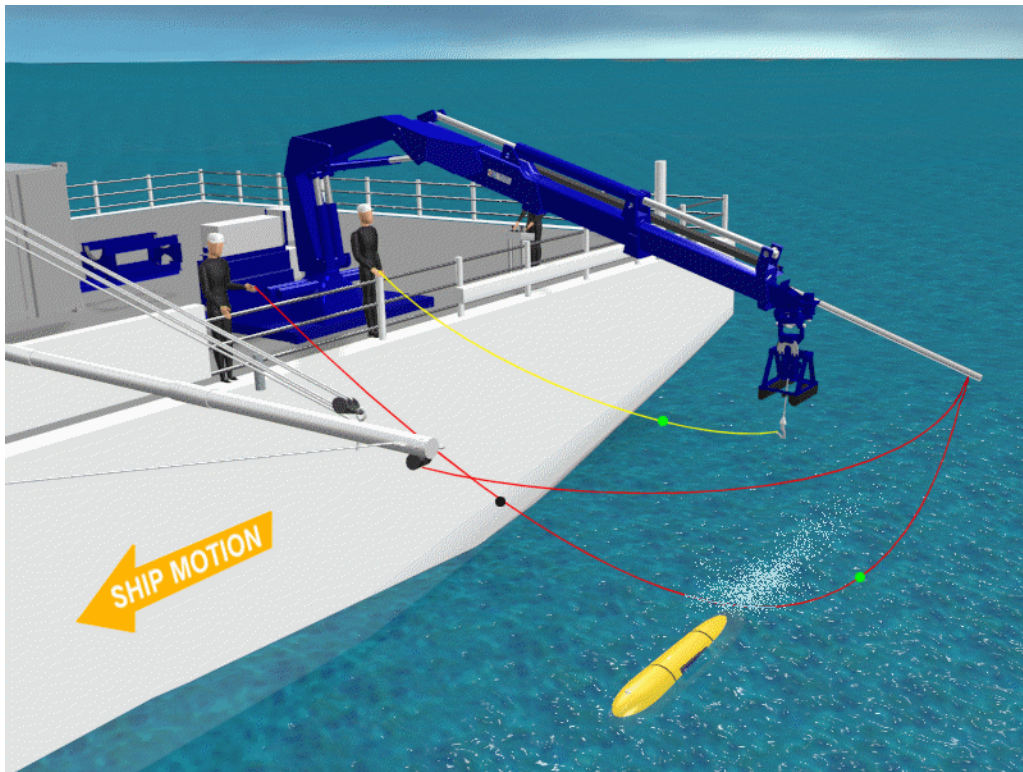


Figure 4-12

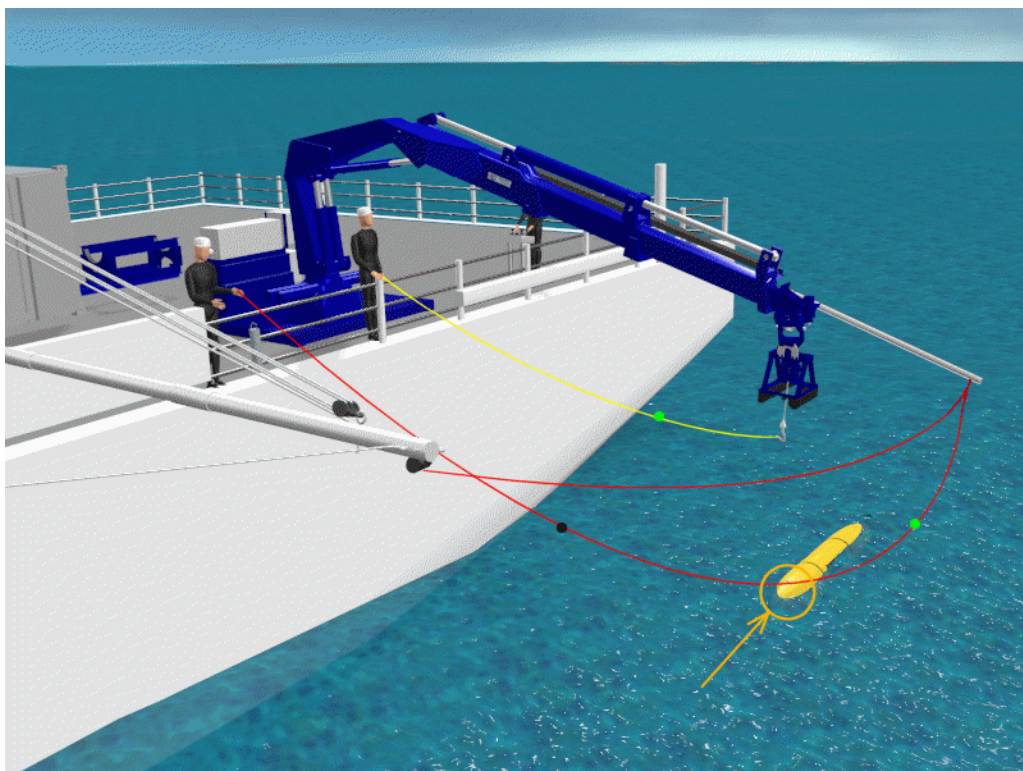


Figure 4-13

9. Once the cable is in the tow hook the vessel reduces its speed to 2-3 knots.
10. Release the tow line from the break-away link by pulling on the line. Slack cable is immediately taken up by the tow boom operator with a single turn of line around the tow winch at all times.
11. The tow boom operator continues to take up cable while a line handler allows cable to be paid out. When the link-weight seats in the tow hook the tow boom operator allows a small amount of slack to be paid out to absorb the initial surge load.
12. The tow line is hauled in until the AUV is under tow. Adjust the length of the tow line until the AUV lift hook is aligned with the crane hook.
13. Verify the capture mechanism is perpendicular to the crane boom using the alignment marks.

CAUTION: Do not put the winch cable under tension unless the capture mechanism is perpendicular to the crane boom. Also, do not rotate the capture mechanism unless the winch cable is slack.

14. Boom out the crane to maximum reach so that the capture saddle is outboard of the AUV.
15. Position the guide line between the nose of the AUV and the tow hook.
16. Pay out the guide line until it just reaches the water, then drop the line onto the AUV hull and move aft until engaged with the AUV lifting hook as shown in Figure 4-14.
17. With the capture mechanism still outboard of the AUV, lower the crane hook, taking up the slack in the guide line (Figure 4-15). Allow the hook to be lowered slightly below the AUV hook. Then enable CT but leave the winch in minimum CT.
18. Pull the hooks together until engaged. Then slowly increase CT until the winch is in maximum CT. **Note: The line handler should maintain tension on the guide line at all times to prevent hooks from disengaging.**

Warning: Do not go to maximum CT until the hooks are engaged.

Warning: Line handler should handle guide line with extreme caution and be prepared to release the line at all times. There is potential for the cable to be hauled in at 3.4m/s (675ft/min) if maximum CT mode is accidentally engaged or the winch is put into maximum CT with no load on the cable (ie. hooks are not engaged).

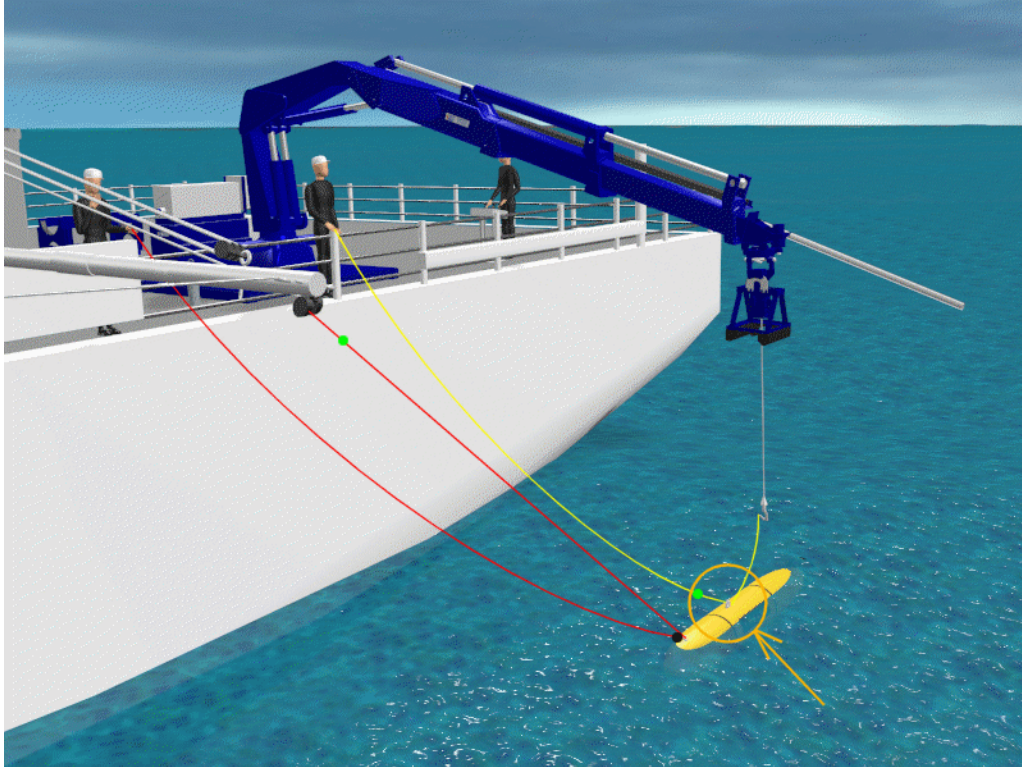


Figure 4-14

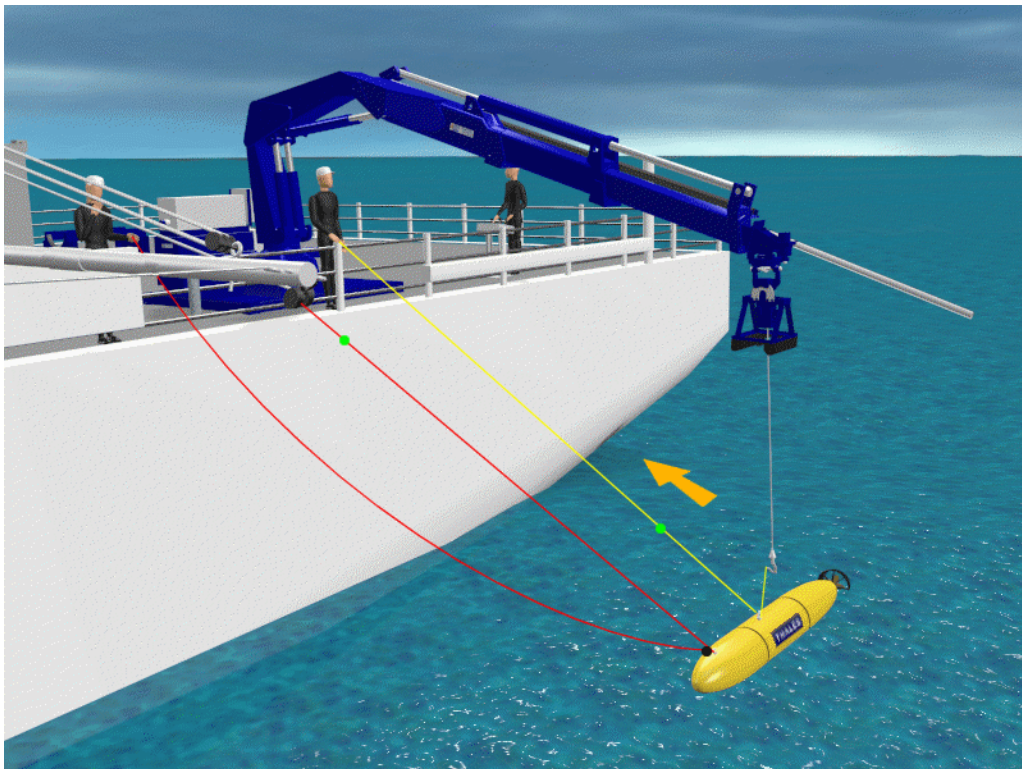


Figure 4-15

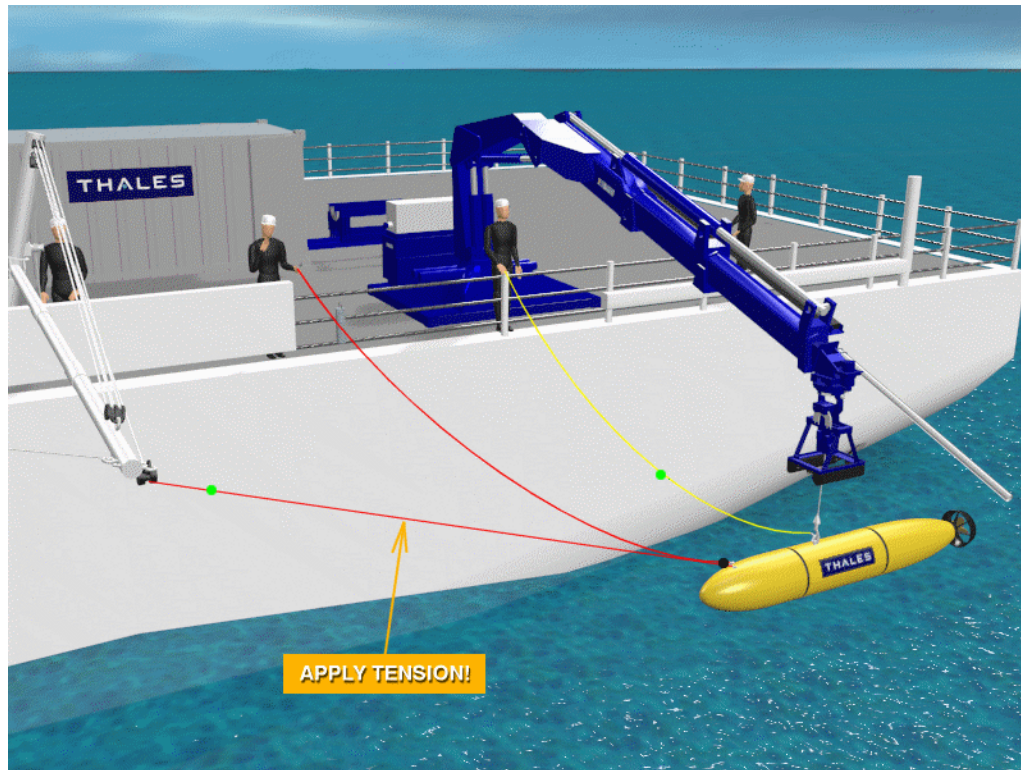


Figure 4-16

19. Boom in until the center of the capture mechanism is the same distance from the ship's side as the towing sheave.

Note: Always position the capture mechanism as close to the water as possible without the risk of submerging.

20. Reposition the AUV until the lifting hook is slightly forward of the crane with an angle of about 5° from the vertical. This will ensure that adequate tow line tension is maintained once hoisting commences.

21. When the AUV is at the crest of a wave or just as the CT winch cable starts to be paid out, commence hoisting by canceling CT and lifting the AUV at maximum speed. Maintain tow line tension during hoisting (Figure 4-16 above). **Note: The winch must be in the maximum tension position when canceling CT for a smooth transition.**

19. Once the AUV is clear of the water and as it approaches the capture saddle, reduce hoisting speed. If yaw is present, put additional tension on the towline and take extra care to ensure the AUV is properly aligned with the capture saddle before hoisting the rest of the way. **Note: If the vehicle is not parallel to the length of the capture saddle then the AUV could be damaged.**

20. Hoisting continues until the AUV is secure in the capture saddle and the “PRESS TO OPEN LATCH” light comes on indicating that the AUV is in the maximum hoist position.
Note: The “PRESS TO OPEN LATCH” button is NOT USED at this stage of the recovery sequence. The latch plates are now shut capturing the swivel inside of the latching mechanism.
21. Lower the AUV slightly until the swivel is resting on the latch plates and the “PRESS TO OPEN LATCH” light goes out.
22. Slacken the tow line (Figure 4-17).
23. Engage the capture mechanism brakes.

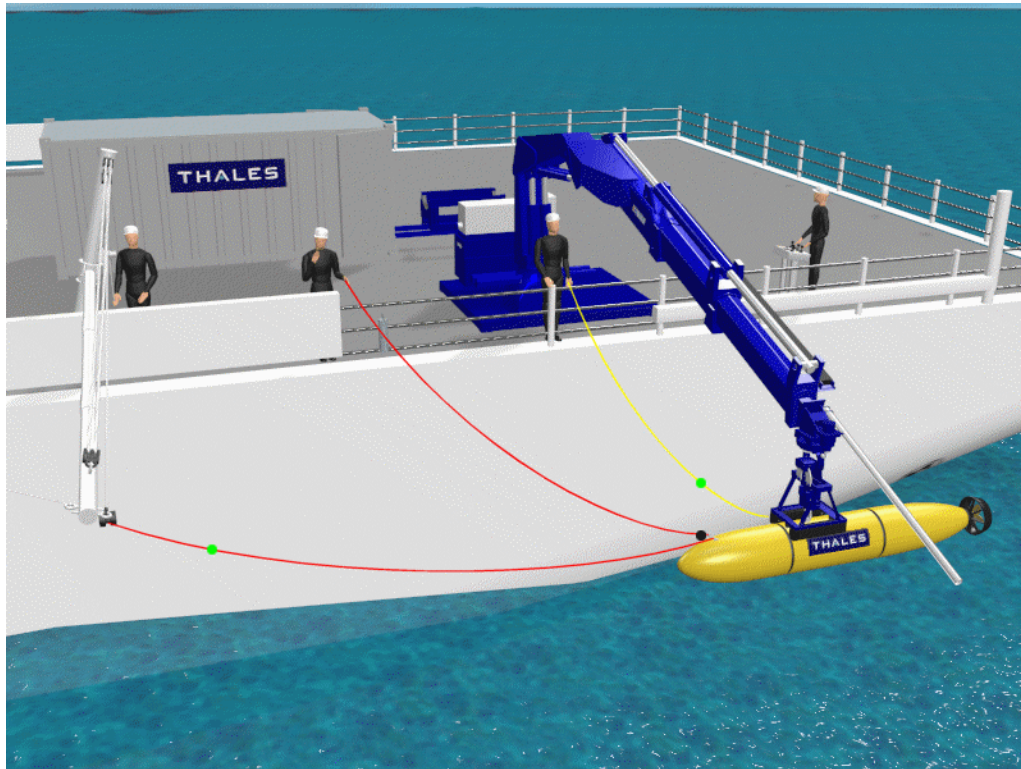


Figure 4-17

24. If vessel roll exceeds $\pm 10^\circ$ do not slew the crane. Retract the crane inboard until at a reach of 5 meters and then slew the crane until the AUV is aligned with the deck cradle.
25. Telescope the crane (if necessary) and rotate the capture mechanism until the AUV is aligned with the cradle. Then carefully lower the AUV (and capture mechanism) until the crane is just above the cradle. Disengage the brakes if necessary to permit alignment with the cradle.
26. When the AUV is aligned with the deck cradle carefully lower the AUV (and capture mechanism) until the bumpers are slightly compressed.
27. Once the full weight of the AUV is on the deck cradle slowly pay out cable.

28. Manually apply tension to the slack cable until the “PRESS TO OPEN LATCH” light comes on. Then press the button to open the latch plates.
29. Wait until the “LATCH OPEN” light is lit and then slowly raise the crane. Unhook the crane hook from the AUV lifting hook and hoist clear.
30. Slew the crane until clear of the deck cradle.
31. Store the crane by placing the capture mechanism on deck.
32. Disconnect the tow line from the AUV.
33. Install the AUV tie-downs.
34. Inform the bridge that the AUV is secure on deck.
35. Stow the towing boom.

5 Maintenance Instructions

5.1 Safety Precautions

The following precautions will reduce the possibility of injury during routine maintenance operations that require dismantling and/or repair.

- a. Whenever possible, disconnect the LRS from ship's power during maintenance.
- b. Before making hydraulic repairs, verify that the hydraulic system is depressurized.
- c. Before attempting to remove any crane hydraulic cylinder, support the inner and outer boom.
- d. Do not allow oil or grease to accumulate in the work area.

5.2 Maintenance Capability

Personnel carrying out preventative maintenance on the LRS should have some formal training as a mechanic, mechanical technician or equivalent trade.

5.3 Test Equipment and Special Tools

The following test equipment and special tools are required for performing specific preventative maintenance routines.

Grease gun

Metric and standard wrenches

Metric and standard socket set

Torque wrench (1,000 ft-lb) with 36" extension (for the crane tie down bolts)

Voltmeter

Vice grip pliers

Vice

Vice jaws (BOT supplied)

Tape or hose clamps for termination of wire rope

Plug drivers (BOT supplied)

5.4 Preventative Maintenance

This section contains service information which will help to ensure trouble free operation of the LRS. Failure to comply with the recommended maintenance intervals or lubricants can result in excessive wear and premature failure of the LRS components.

5.4.1 System Level Preventative Maintenance

1. Annual proof-testing of lifting system. **Every 48 months**, the LRS should be tested and re-certified to ensure that all lifting components meet the LRS equipment specification.
2. Touch-up painting of LRS.

Crane: To repaint, first grind the spot to clean metal. Then touch-up the area with a gray, polyamide zinc epoxy (2 part) primer, painting only the ground area. Subsequent coats may be painted after a minimum of 4 hours at 23° C, or 8 hours at 10° C. The lowest

hardening temperature is 10° C. Sand the edges of the primed spots. Blow clean and apply a mid-coat of white-beige, (2 part) polyamide epoxy. Drying specifications for the mid-coat are the same as for the primer. When mid-coat is dry apply a topcoat using (2 part) high gloss aliphatic polyurethane and let dry for 4-6 hours at 20° C. The topcoat should contain 85%± 5 gloss and is dry to the touch after 1-2 at 20° C.

LRS: To repaint, follow the instructions for the crane primer and mid-coat. When the mid-coat is dry mix the Amersheild aliphatic polyurethane resin with the Amersheild cure and Amercoat thinner and apply a topcoat. Allow paint to through dry for 10 hours at 20° C, or 72 hours at 10° C. **Note: 2 cans of touch up paint are provided, one for the crane and towing boom, the other for the skid and capture mechanism.**

3. **Fresh water wash-down.** As often as possible and at least monthly it is advised to wash down the LRS with fresh water to remove salt deposits that occur during normal use. Make sure that hard to reach areas are rinsed clear of salt. Pay special attention to the capture mechanism for it has many small pieces and will be the closest to the water.
4. **Seizing shackles.** When replacing any shackles, or while performing general equipment inspections, make sure that all shackles are seized, to prevent accidental disassembly.

5.4.2 Lubrication Schedule

Table 3 (below) provides a complete lubrication schedule for the LRS. The lubrication schedule also includes information for hydraulic return line filter replacement.

Lubrication points for the LRS crane is shown in Figures 5-01.

Table 3 - LRS Lubrication & Filter Replacement Schedule

Equipment	Action	Lubrication	Frequency
Return filter	Change	N/A	When pop-up indicator shows replacement is required (oil at 20°C)
Reservoir Pressure Breather	Change	N/A	If damaged
Hydraulic Fluid	Check Level	N/A	Daily
Crane Slew Drive	Check Level	SAE 80 w/90 hypoid oil. For temps. , -20°C, use 75W hypoid oil	Daily
Crane Boom Pins	Grease	EP-2 Grease	Twice/week
Crane Boom Sliders	Grease	EP-2 Grease	Twice/week

Crane Extension Pins	Grease	SAE 20W30 Oil	Weekly
Crane Cylinder	Oil	HVI 22 or equivalent	Monthly

Rods			
Capture Mechanism Shims	Grease	EP-2 Grease	Monthly
Capture Mechanism Rotator Bearing & Pinion	Grease	EP-2 Grease	Monthly
CT Winch Cable	Grease	Prelube-19 Grease or equivalent	6 months
Capture Mechanism Sheave	Grease	EP-2 Grease	6 months
Hydraulic Fluid	Change Oil	HVI 22 or equivalent	Yearly (sooner if contaminated by water)

5.4.3 Preventative Maintenance Chart

In addition to the above lubrication and filter change procedures, the following preventive maintenance activities (Table 4) are prescribed for major components of the LRS, at the time intervals indicated below:

Table 4 – Preventive Maintenance Activities

ACTIVITY	FREQUENCY
Consult lubrication chart and perform necessary lubrication	Pre-Operational
Check the oil level in the hydraulic oil tank.	Pre-Operational
Check the wire rope and spreader bar assembly for damage. Refer to sections 5.5.1.8 and 5.5.1.9 for more detailed inspection procedures.	Pre-Operational
Check the stays, shackles, terminations, hooks and other attachments used with the LRS to ensure that they are free from damage.	Pre-Operational
Check that the crane hook swivel pin is tight. Check that the cable termination nut is tight.	Pre-Operational
Inspect the lines, connections and other components of the hydraulic system in order to detect any oil leakage.	Pre-Operational
Check that the crane can be operated with ease and that the controls automatically return to their neutral position.	Pre-Operational
Verify that the crane is free from damage.	Pre-Operational
Repair crane components that are damaged.	As soon as noticed
Check that capture mechanism latches, including indicators and controls are functioning properly	Pre-Operational
Check that the tow boom is properly reeved and all lines and fittings are undamaged.	Pre-Operational
Inspect line attachment hardware for damage or wear.	Pre-Operational

Check that the AUV tow and lifting hooks are free of ocean debris and organisms and all fasteners are torqued.	Pre-Operational
Replace tow line (see Section 5.5.1.8)	As Required
Replace winch cable (see Section 5.5.1.10)	As Required
Oil exposed crane cylinders.	Weekly
Run crane through necessary motions to lubricate all exposed cylinder surfaces.	Bi-Weekly
Check that CT winch mounting bolts are secure and re-torque if necessary.	Monthly
Touch up painting	Monthly
Check cylinder rod seals for leakage	Monthly
Check and tighten screwed connections in accordance with Table 5, Table 6 & the exceptions noted	Monthly
Check that latches on electrical enclosures and electrical connectors at capture mechanism are secure.	Monthly
Check hooks, stays, spreader bar and all other lifting gear	Monthly
Check that all prescribed notices are in place	Monthly
Check portable control console, electrical enclosure for water ingress	Monthly
Check and tighten electrical feed through and penetrations on portable control console and electrical enclosure	Monthly
Check the function of the control valve levers mounted on the HPU.	Monthly
Carry out a visual inspection of structural parts to detect any cracks, deformations, play in joints, etc.	Monthly
Put the LRS through a test run and listen for any suspicious noises	Monthly
Fresh water wash down	Monthly
Inspect hoses inside of crane pedestal for chafing and wear.	Monthly
Check that all LRS fasteners for tightness and ensure that all replacement parts meet the original load ratings and are of the same quality	Monthly
Re-torque crane M30 threaded rods to 1000 ft-lbs.	3 Months
Check overall structure for corrosion, removing paint and carrying out hammer test as necessary	3 Months
Inspect welds for cracks	6 Months
Ensure sheaves are free from cracks and examine rope groove for scoring	6 Months
Test sample of hydraulic oil	6 Months
Clean LRS thoroughly with fresh water pressure washer	6 Months
Check all linkages, joints, bearings and guides for play	6 Months
Re-terminate winch cable termination (see Section 5.5.1.10)	12 Months
Overhaul capture mechanism	12 Months

Disassemble CT winch , inspect all wear items	12 Months
Replace desiccant in portable control console and electrical enclosures	12 Months
Change HPU oil and filter	12 Months
Proof test LRS	48 Months

5.4.4 Additional Preventative Maintenance

In addition to the above tables, the following preventive maintenance routines must be conducted.

5.4.4.1 Oil Filtration

The HPU contains a hydraulic return line oil filter that must be maintained. The return filter provides filtration for oil returning from the crane circuit. It is located on the top of the reservoir. It is equipped with a 43 psi bypass valve and a pop-up indicator to show when the element needs replacing. The element is serviced by removing the four bolts on the filter cover (clean the area around the filter before removal).

5.4.4.2 Oil Maintenance

The oil in the hydraulic system should be checked on a regular basis for any signs of water or foreign matter. If the oil appears "milky", it is probable that water is emulsified in the oil and the oil must be changed immediately. The hydraulic reservoir should be kept closed at all times. When filling or topping up the tank, the new oil should be pumped into the reservoir using a transfer pump equipped with a 3 micron (absolute) filter on its outlet. Be sure that the pump does not contain any residue or fluid different from the oil being transferred. The breather cap should only be removed for cleaning.

Note: The hydraulic reservoir should not be opened as part of routine maintenance. There should be no reason to drain and open the tank and risk contamination. Only when severe contamination of the system has occurred can this action be justified.

The recommended hydraulic oil for this system is Petrocan HVI 22 or equivalent. This oil is capable of operation at temperatures ranging from -20°C to 60°C.

5.4.4.3 Crane

The crane should always be stowed when it is not being used. If the crane is to be stowed in a position that exposes the cylinder piston rods the exposed rods must be wiped clean and coated with hydraulic oil weekly by retracting cylinders or applying oil manually. If the cylinders can not be fully retracted remove the capture mechanism monthly and retract. During periods of non-use of any more than a few days the capture mechanism should be removed and the crane folded.

The oil level in the slewing house at the filling stud must be checked daily and refilled, when necessary, with hypoid oil SAE 80W/90. Figure 5-01 diagrams the critical lubrication points for the Hiab Sea Crane. For more detailed crane maintenance see crane manual.

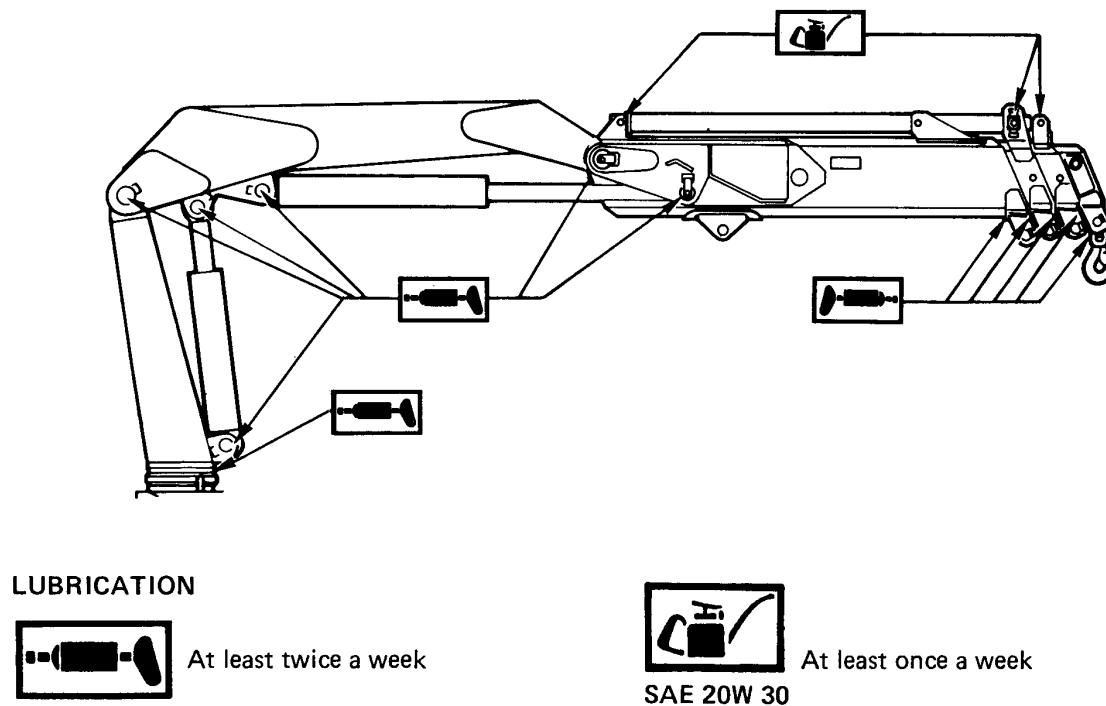


Figure 5-01 – Hiab Lubrication Chart (Hiab Manual, section 10)

5.5 Corrective Maintenance

This chapter identifies problems that may occur with the AUV LRS and recommends corrective action.

5.5.1 Trouble Shooting

In the following table are listed problems, the probable cause(s) and corrective action necessary. For the Hiab 200 crane and the CT winch, further information can be found in their respective manuals.

5.5.1.1 Hiab 200 Crane

SYMPTOM	CAUSE	CORRECTIVE ACTION
Crane does not respond to	Loss of electrical power.	Check 24 Volt supplies

joystick commands.	Dead-man switch is not depressed.	Press dead-man switch on top of joystick before moving off-center. See 'PLC IO.doc' in Appendix VII
Slew housing oil level increases during operations. (Oil overflows from the bottom of the crane post through the site gauge during system operations)	Oil level increased due to thermal expansion of oil. Slew cylinder seals are leaking into the housing.	If overflow continues check slew seals. The slew drive seals must be replaced before the crane is used again
The crane has insufficient lifting capacity	Working pressure too low Main pressure relief valve faulty Pressure relief cartridge faulty Internal leakage in cylinder Pump faulty (see increasing noise in pump)	Attach pressure gauge and check working pressure. If too low adjust main pressure relief valve to correct value. Change the valve. Seal. Change the valve Change piston sealing i.e. all sealings Change or repair the pump

Boom or slew drive does not hold its position when under load.	Load exceeds the safe working load for the crane.	Reduce load.
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	Cylinder is leaking or counter balance valve is leaking. Valve lever may be jammed.	Identify cylinder and control valve associated with this cylinder. Check that the control levers on the valve return to the neutral position. Repair as necessary. If linkage is not jammed there is likely a problem with the valve.
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5.5.1.2 CT Winch

SYMPTOM	CAUSE	CORRECTIVE ACTION
CT winch will not haul in cable.	System is in Manual mode Cable has tripped the 'hoist' limit switch. AUV is in fully captured position.	Switch to Remote mode. Check that the switch arm moves freely. Lower AUV until the "PRESS TO OPEN LATCH WHEN LIT" light goes out. See 'PLC IO.doc' in Appendix VII
Winch will not hold load.	Defective counterbalance valve. Defective winch brake. High back pressure affecting winch brake of counterbalance valve.	Adjust winch control potentiometers as per manual. Repair or replace winch brake. Locate and eliminate restriction in return line (check return filter).

Winch will not lift the load.	Winch overload.	Reduce load.
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	Defective or improperly adjusted pump controller. Defective pump. Defective motor. Davit 2-blocked, or anti-2-block control defective if improperly adjusted.	Adjust, repair, or replace. Repair or replace pump. Repair or replace motor. Lower load. Adjust or repair anti-2-block control.
No response to joystick commands.	No power.	Check that power is on and power cable is secure. Check power supply. See 'PLC IO.doc' in Appendix VII
CT mode will not engage.	No power to the switch. Slack cable sensor not closing the circuit. Solenoid valve not operating.	Check CT winch tension detector switch. Repair solenoid valve. See 'PLC IO.doc' in Appendix VII

5.5.1.3 Capture Mechanism

SYMPTOM	CAUSE	CORRECTIVE ACTION
Latch plates do not open or close when button is pressed.	Hydraulic cylinder not operating.	Check that the quick disconnects are fully engaged. Check all lines, valves and fittings for leaks. Check solenoid valve. Check that limit switch is operating and repair and adjust if necessary. See 'PLC IO.doc' in

		Appendix VII.
Latch plates will not open or close.	Latch plates have jammed.	Check for damage; replace/repair as necessary.
Brake will not engage.	Solenoid valve not working. No power going to the solenoid. Calipers seized. Obstruction in hydraulic system.	Repair or replace valve. Check that the solenoid is receiving a power supply Remove and disassemble brake. Check hydraulic lines for fluid and pressure. See 'PLC IO.doc' in Appendix VII
If the latch is open and "LATCH OPEN" light does not illuminate.	Switch lever is out of adjustment. There is no power at the switch. Bulb is burned out. Limit switch is damaged.	Examine the latch assembly to ensure that there is no damage or foreign material that could affect latch rotation. Check power supply Replace bulb. Check limit switch and repair or adjust as necessary. See 'PLC IO.doc' in Appendix VII
Capture saddle will not rotate	No power going to the valve Valve not responding to signal. Motor not responding to hydraulic power.	Check the power supply and paddle control. Replace electrical actuator Repair brake-motor. See 'PLC IO.doc' in Appendix VII

5.5.1.4 Hydraulic Power Unit

SYMPTOM	CAUSE	CORRECTIVE ACTION
Shaft is not rotating.	Pump malfunction	Shut down HPU and disassemble pump to determine what is broken.
Unusual noise.	Intake not clear	Shut down HPU and clear the intake.
	Leak in suction line	Repair leak.
Press the start button for the electric motor and nothing happens.	Main power switch is not on. No power from ship. Emergency Stop button is depressed. Control system failure.	Turn the main power switch on. Check ship's power supply. Pull out Emergency Stop button. Place system in Manual mode and press 'Start' on the power enclosure. See 'PLC IO.doc' in Appendix VII

5.5.1.5 Portable Control Console

SYMPTOM	CAUSE	CORRECTIVE ACTION
Controls and indicators on the console are not operating.	Electrical power cables are not properly connected to the electrical enclosure. Water inside console or electrical enclosure. Control system failure.	Check connections and engage connectors if necessary. Remove covers from control console and electrical enclosure and check for water damage. Replace damaged components. Place system in Manual mode and recover manually.

		See 'PLC IO.doc' in Appendix VII
--	--	----------------------------------

5.5.1.6 ISO Skid

The ISO skid is constructed of welded steel with bolt on deck grating. There are no field repairable parts in the ISO skid.

5.5.1.7 Forestay

The stay must be replaced as soon as the rope develops kinks or a heavy spiral twist.

5.5.1.8 Tow Line

The rope sections of the tow line must be replaced as soon as signs of wear are noticed. The AUV target section should be replaced as soon as it develops kinks, a heavy spiral twist or if the wires are corroded at the cable terminations.

5.5.1.9 Spreader Bar Assembly

The spreader bar cannot be repaired in the field.

The slings must be replaced as soon as any of the following occur:

- more than two wires are broken along one foot length of rope
- five percent of wires in any length of ten rope diameters are worn or corroded
- the diameter of the winch rope visibly changes in comparison with the normal stretching and diameter reduction of a newly fitted rope
- the rope develops kinks or a heavy spiral twist
- the wires at the terminations are broken and corroded

5.5.1.10 CT Winch Cable

The winch cable must be replaced as soon as any of the following occur:

- more than two wires are broken along one foot length of rope
- five percent of wires in any length of ten rope diameters are worn or corroded
- the diameter of the winch rope visibly changes in comparison with the normal stretching and diameter reduction of a newly fitted rope
- the rope develops kinks or a heavy spiral twist
- the wires at the terminations are broken and corroded

5.6 Torque values

Table 5 provides bolt torque information for the LARS winch, crane, PL7 winch and weld down plate fasteners.

Table 5 - Torque Values for LARS Structural Fasteners

ITEM	QUANTITY	FASTENER SIZE	DRY TORQUE (Nm [foot pound])
CT Winch	4	¾10 UNC	200 [150]
Hiab Crane	6	M30	1,400 [1,000]
Weld Plate Fasteners	40	3/4-10 UNC	270 [200]

Table 6 - Recommended Torque Values for 304 Stainless Steel Fasteners

BOLT SIZE	DRY TORQUE (Nm [foot pound])
10-24	2.7 [2]
10-32	3.7 [2.7]
1/4-20	9 [6]
1/4-28	11 [8]
5/16-18	15 [11]
5/16-24	16 [12]
3/8-16	27 [20]
3/8-24	29 [22]
7/16-14	42 [31]
7/16-20	45 [33]
1/2-13	58 [43]
½20	61 [45]
¾10	173 [128]
¾16	168 [124]

Note: Torque values are for dry threads only. For plated threads reduce torque values by **40%**.
This table is only valid for 304 stainless steel.

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HYDRAULIC SCHEMATIC

APPENDIX IV
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APPENDIX VI
COMPONENT DATA SHEETS

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HIAB SEA CRANE 200 MANUAL

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List of Acronyms

BOT	Brooke Ocean Technology Ltd.
LRS	Launch and Recovery System
HPU	Hydraulic Power Unit
AUV	Autonomous Underwater Vehicle
CT	Constant Tension
ISO	International Standards Organization
WT	Weight
SAE	
HVI	viscosity index
kg	Kilograms
ft	Feet
lb	Pounds
psi	Pounds per inch squared
HP	Horse Power
V	Volts
AC	Alternate Circuit
DC	Direct Circuit
m	Meters
SS#	Sea State #
N	Newton
A	Amps