

X SERIES



350X
MST
WORKSHOP MANUAL

mjp
MARINE JET POWER

A FORCE TO TRUST

DRAFT

Marine Jet Power is not liable or bound by warranty if these instructions are not adhered to during installation, operation or maintenance, or if the equipment is modified without written consent from the manufacturer.

Copyright © Marine Jet Power AB

Marine Jet Power AB can accept no responsibility for possible errors in catalogues, brochures, and other printed material. Marine Jet Power AB reserves the right to alter its products without notice. This also applies to products already on order provided that such alterations can be made without subsequent changes being necessary for specifications already agreed.

All rights reserved.

All other trademarks are the properties of their respective owners.

1 Introduction	5
1.1 About This Manual	5
1.1.1 General	5
1.1.2 Intended Use	5
1.1.3 How to Read This Manual	5
1.1.4 Skill Level	5
1.1.5 Facility Level.....	6
2 Safety.....	7
2.1 Safety Instructions.....	7
2.1.1 General	7
2.1.2 Local Regulations	7
2.1.3 Symbol Levels	7
2.1.4 Symbols	8
2.1.5 Personal Safety Equipment.....	9
2.1.6 Disposal	9
3 Service	10
3.1 Preventive Maintenance	10
3.1.1 Preventive Maintenance Schedule	10
3.2 Mechanical.....	13
3.2.1 Intake and pump, Inspect.....	13
3.2.2 Pump Unit, Inspect Impeller Blade Tip Clearance	15
3.2.3 Waterjet Unit, Dismount.....	18
3.2.4 Water Lubricated Bearing, Inspect.....	22
3.2.5 Water Lubricated Bearing, Replace	25
3.2.6 Waterjet Unit, Assemble	28
3.2.7 Thrust Bearing, Drainage hole, Clean	32
3.2.8 Thrust Bearing and Shaft Seal, Inspect Leakage and Oil Level	34
3.2.9 Thrust Bearing Unit, Replace Thrust Bearing and Radial Seals.....	37
3.2.10 Thrust Bearing Unit, Replace Shaft Seal	50
3.2.11 Waterjet Unit, Inspect.....	54
3.2.12 Waterjet Unit, Clean	57
3.2.13 Waterjet Unit, Paint During Service	59
3.2.14 Waterjet Unit, Replace the Anodes	63
3.2.15 Waterjet Unit, Inspect Bushings and Pin Shafts.....	66
3.2.16 Waterjet Unit, Replace Bushings and Pin Shafts	68
3.3 Hydraulics	72
3.3.1 Hydraulic Cylinders and Hoses, Inspect	72
3.3.2 Hydraulic Hoses, Replace.....	74
3.3.3 Hydraulic Reversing Cylinder, Replace	78
3.3.4 Hydraulic Steering Cylinder, Replace	84
3.3.5 Hydraulic Reversing Cylinder, Replace Seals	89
3.3.6 Hydraulic Steering Cylinder, Replace Seals.....	96
3.3.7 Hydraulic Steering Cylinder, Replace Feedback Sensor	104
3.3.8 Hydraulic Reversing Cylinder, Replace Feedback Sensor	107
3.3.9 Hydraulic and Lubrication System, Replace Filler Breather Filter.....	110
3.3.10 Hydraulic System, Inspect Oil Level	112
3.3.11 Hydraulic System, Inspect Oil Temperature	114
3.3.12 Hydraulic System, Inspect Oil Quality	115
3.3.13 Hydraulic System, Add Oil.....	117
3.3.14 Hydraulic Tank, Replace Oil	119
3.3.15 Lubrication System, Add Oil	123
3.3.16 Thrust Bearing, Replace Oil	125
3.3.17 Hydraulic Tank, Inspect Oil Level Switch	128
3.3.18 Hydraulic Tank, Replace Oil Level Switch.....	129
3.3.19 Hydraulic System, Inspect Working Pressure	132
3.3.20 Hydraulic System, Adjust Working Pressure	133
3.3.21 Hydraulic System, Inspect Pressure Limit.....	135

3.3.22 Hydraulic System, Adjust Pressure Limit	138
3.3.23 Hydraulic System, Inspect Pressure Gauge.....	141
3.3.24 Hydraulic System, Replace Pressure Gauge	143
3.3.25 Hydraulic System, Replace Oil Filter	145
3.3.26 Hydraulic System, Replace Directional Control Valves	147
3.3.27 Hydraulic System, Replace Load Control Valves.....	150
3.3.28 Hydraulic System, Replace Solenoid Coils	152
3.3.29 Hydraulic Pump, Inspect	155
3.3.30 Hydraulic System, Replace the Pump	157
3.3.31 V-Belts, Inspect and Adjust	163
3.3.32 V-Belts, Replace	166
3.4 Control System.....	169
3.4.1 Control System Components, inspect for wear and damages	169
3.4.2 Jet autocalibration	172
3.4.3 Control Levers, Calibrate	174
3.4.4 Display Panel, Service Menu	178
3.4.5 Combinator Controller, Replace	192
3.4.6 Command Panel BUS, Replace	195
3.4.7 Control System, Inspect and Replace Cables	198
3.4.8 Display Panel, Replace.....	199
3.4.9 External Alarm Buzzer, Replace	202
3.4.10 Indoor Panels, Lenses and LEDs, Inspect	204
3.4.11 Indoor Panels, Lenses and LEDs, Replace	205
3.4.12 Main Control Unit, Replace	207
3.4.13 Steer Wheel, Replace Steer Controller.....	209
3.4.14 VCS Panel (BUS), Replace	211
3.4.15 Control System Components and Waterjet operation test	213
4 Fault Indication	215
4.1 Troubleshooting	215
4.1.1 How to Read.....	215
4.1.2 Troubleshooting Procedure	215
4.2 Alarms	217
4.2.1 Display Panel, Acknowledge the Alarms	217
4.2.2 Alarm List	219
5 Appendix	224
5.1 Paint Program.....	224
5.1.1 General	224
5.1.2 Touch Up Paint or Repaint	224
5.2 Torque	225
5.2.1 Screws and washers	225
5.2.2 Specifications for Screws with Nordlock Washer.....	226
5.2.3 Specifications for Screws with Plain Washer.....	227
5.2.4 Specifications for Lock Nuts	228
5.3 Impeller Clearance Protocol	229
5.4 Oil Contamination Limits	231
5.4.1 Water Content per DIN ISO 3733	232
5.5 Weld Specifications	233
5.6 Fluids and Lubricants.....	234
5.6.1 Hazardous Substances	234
5.6.2 Assembly Adhesives, Sealants and Lubricants	234
5.6.3 Oil Specifications	234
5.6.4 Grease Specifications	235
5.7 Equipment Disposal	237

1 Introduction

1.1 About This Manual

1.1.1 General

This manual is a comprehensive handbook which has been developed to provide information on the equipment supplied by Marine Jet Power (MJP).

1.1.2 Intended Use

This manual is intended for crew and maintenance personnel. It can be used on board, in the dockyard or whenever detailed information about the equipment is required. It will serve as a guideline for maintenance of the complete MJP system: mechanical, hydraulic, lubrication and control system.

1.1.3 How to Read This Manual

All recommended preventive maintenance tasks are listed in the Preventive Maintenance Schedule.

This manual contains both Preventive and Corrective Maintenance tasks. The chapters Mechanical, Hydraulics, Lubrication and Control System have a separate sub chapter for each task.

The preventive and corrective maintenance tasks included in this manual cover maintenance and troubleshooting that can be handled by the vessel's own crew (see maintenance skill levels below).

The qualified maintenance tasks, must be performed by an Authorized Service Technician trained by Marine Jet Power.

Instructions regarding installation of the equipment are described in the **Installation Manual** and instructions for operating the waterjet system are described in the **Operations Manual**.

Maintenance Levels

For each task there are two levels specified, skill level and facility level. These two levels determine the maintenance level of a task.

1.1.4 Skill Level

The skill levels indicate the skill level required of the person undertaking the maintenance task.

Skill level	Description
Crew	General technical knowledge about the Marine Jet Power system.
Chief Engineer	Basic technical training on the Marine Jet Power system.
Task Specialist	Specific technical training in a specific field: welder, painter, electrician etc. Could also be within mechanical, hydraulic, lubrication or control system.
Authorized Service Technician	Personnel trained in Marine Jet Power certified training course.

1.1.5 Facility Level

The facility indicates the recommended operational status of the vessel during the maintenance procedure.
The facility levels are:

- On equipment / at sea
- Dockside
- Dock, workshop / dry dock
- MJP workshop

DRAFT

2 Safety

2.1 Safety Instructions

2.1.1 General

Read this manual thoroughly before starting activities.

This document contains personal safety information that applies when working with Marine Jet Power's products. These instructions are mandatory to keep personal safety.

Use all equipment in strict accordance with these instructions, or the instructions supplied by the equipment manufacturer.

2.1.2 Local Regulations

Local regulations, principally national regulations, override the information in this document. When no applicable local regulations are available, use the regulations in this document.

2.1.3 Symbol Levels



Warning!

A warning means that injury or death is possible if the instructions are not obeyed.



Caution!

A caution means that damage to equipment is possible.

Note!

Notes are added to give more information, usually in a procedure.

2.1.4 Symbols

Symbol	Type	Description
	General warning or caution	Risk to people or equipment (specified by a supplementary sign).
	Electrical hazard	Avoid potential injury or death from electric shock or burn.
	High pressure	Avoid exposure to hot oil or hot vapour.
	Burn risk	Avoid contact with hot surface.
	Rotating parts	Avoid being caught between rotating parts.
	Hanging loads	Avoid standing or walking under hanging loads.
	Environmental chemical hazard	Avoid pollution of the environment from chemicals. Read the material safety data sheets to find information of the products and contact the manufacturer for more information.
	Personal chemical hazard	Avoid potential injury or death from exposure to chemicals. Read the material safety data sheets to find information of the products and contact the manufacturer for more information.
	Corrosive substances	Avoid material damage and personal injury from exposure to corrosive substances. Read the material safety data sheets to find information of the products and contact the manufacturer for more information.
	Burn risk	—
	Pinch point hazard	Avoid being pinched between moving parts.
	ESD-sensitive electronic component.	Semiconductors and circuit boards can be damaged by electrostatic discharge (ESD). When handling, care must be taken so that the devices are not damaged.

2.1.5 Personal Safety Equipment

Personal safety equipment must be used when there is a risk involved.



Wear hearing protection.
Risk of hearing loss and accidental injury from loud noises.



Wear eye protection.
Risk of injury to eyes from flying sparks, metal splatter and slag chips.



Use safety footwear.
Risk of injury to feet from falling objects and heavy equipment.



Use protective gloves.
Risk of injury to hands from chemicals, corrosive substances and sharp edges.



Wear hard hat.
Risk of accidental head injury from falling objects, sharp edges and when working in narrow spaces.

2.1.6 Disposal

Discharge of hazardous substances must be done in accordance to local regulations.



Please contact an authorized representative of the manufacturer for information concerning the decommissioning of equipment.

3 Service

3.1 Preventive Maintenance

3.1.1 Preventive Maintenance Schedule

Daily inspections		
Task description	Task number	Skill level
Inspect the cylinders and hoses in the hydraulic system.	3.3.1 <i>Hydraulic Cylinders and Hoses, Inspect</i>	Crew
Inspect oil level in the hydraulic system.	3.3.10 <i>Hydraulic System, Inspect Oil Level</i>	Crew
Inspect the working pressure.	3.3.19 <i>Hydraulic System, Inspect Working Pressure</i>	Crew
Check the condition of the thrust bearing and shaft seal by inspection of leakage and oil level on the bearing housing assembly.	3.2.8 <i>Thrust Bearing and Shaft Seal, Inspect Leakage and Oil Level</i>	Crew

Monthly inspections		
Task description	Task number	Skill level
Clean drain hole in thrust bearing house.	3.2.7 <i>Thrust Bearing, Drainage hole, Clean</i>	Crew

Running hours replacements			
Task interval	Task description	Task number	Skill level
Every 500 operating hours *	Replace the oil in the thrust bearing system.	3.3.16 <i>Thrust Bearing, Replace Oil</i>	Chief Engineer

* Replace the oil after the first 50 hours. After that every 500 hours as per maintenance schedule.

Yearly inspections, adjustments and replacements		
Task description	Task number	Skill level
Inspect the control system components.	3.4.1 <i>Control System Components, inspect for wear and damages</i>	Chief Engineer
Inspect the waterjet intake for mechanical damages and debris.	3.2.1 <i>Intake and pump, Inspect</i>	Chief Engineer
Measure the impeller tip clearance.	3.2.2 <i>Pump Unit, Inspect Impeller Blade Tip Clearance</i>	Authorized Service Technician
Inspect water lubricated bearing and the bearing sleeve.	3.2.4 <i>Water Lubricated Bearing, Inspect</i>	Chief Engineer or Authorized Service Technician
Inspect the waterjet (pump unit, pin shafts and anodes) for damages and corrosion.	3.2.11 <i>Waterjet Unit, Inspect</i>	Chief Engineer
Inspect the oil level switch on the hydraulic tank.	3.3.17 <i>Hydraulic Tank, Inspect Oil Level Switch</i>	Chief Engineer

Replace hydraulic and lubrication filler breather filters.	3.3.9 <i>Hydraulic and Lubrication System, Replace Filler Breather Filter</i>	Chief Engineer
Inspect the hydraulic pump.	3.3.29 <i>Hydraulic Pump, Inspect</i>	Chief Engineer
Inspect the hydraulic oil quality on the hydraulic system.	3.3.12 <i>Hydraulic System, Inspect Oil Quality</i>	Crew
Inspect the hydraulic pressure limit.	3.3.21 <i>Hydraulic System, Inspect Pressure Limit</i>	Authorized Service Technician and Crew
Adjust the hydraulic pressure limit.	3.3.22 <i>Hydraulic System, Adjust Pressure Limit</i>	Authorized Service Technician and Crew
Replace the oil filter.	3.3.25 <i>Hydraulic System, Replace Oil Filter</i>	Chief Engineer
Inspect and adjust the V-belt.	3.3.31 <i>V-Belts, Inspect and Adjust</i>	Chief Engineer
Inspect bushings and pin shafts on the waterjet.	3.2.15 <i>Waterjet Unit, Inspect Bushings and Pin Shafts</i>	Chief Engineer
Test that all control system components and Waterjets works trouble-free in operation	3.4.15 <i>Control System Components and Waterjet operation test</i>	Authorized Service Technician and Crew

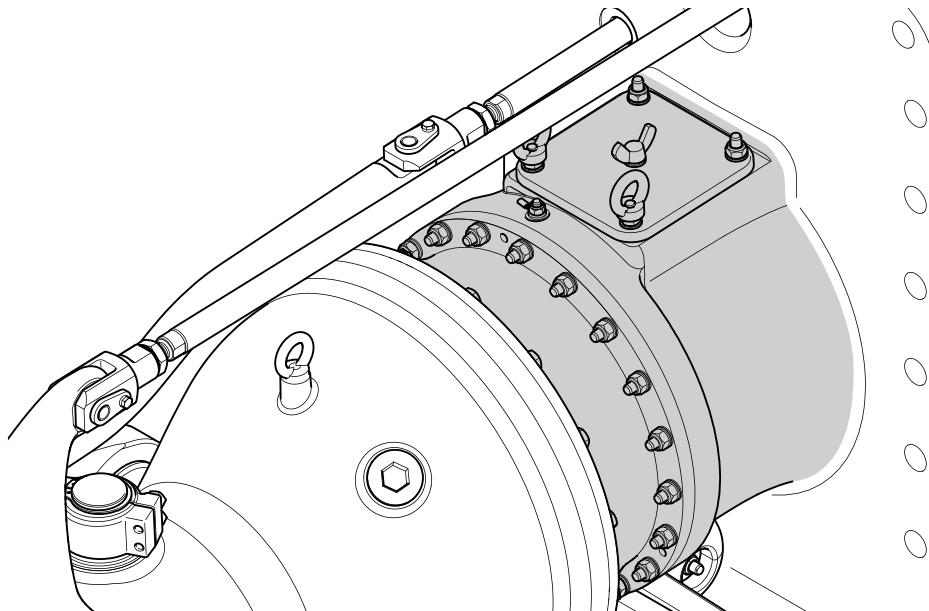
Years or running hours - inspections, replacements and overhaul			
Task interval	Task description	Task number	Skill level
Every 2 years or every 4000 hours	Replace seals on the hydraulic reversing cylinder.	3.3.5 <i>Hydraulic Reversing Cylinder, Replace Seals</i>	Authorized Service Technician
Every 2 years or every 4000 hours	Replace seals on the hydraulic steering cylinder.	3.3.6 <i>Hydraulic Steering Cylinder, Replace Seals</i>	Authorized Service Technician
Every 2 years	Replace oil in the hydraulic tank.	3.3.14 <i>Hydraulic Tank, Replace Oil</i>	Chief Engineer
Every 5 years or every 8000 operating hours	Replace thrust bearing and radial seals on the thrust bearing unit.	3.2.9 <i>Thrust Bearing Unit, Replace Thrust Bearing and Radial Seals</i>	Authorized Service Technician
Every 5 years or every 8000 operating hours	Replace the shaft seal on the thrust bearing unit.	3.2.10 <i>Thrust Bearing Unit, Replace Shaft Seal</i>	Authorized Service Technician
Every 5 years	Hydraulic Hoses, Replace	3.3.2 <i>Hydraulic Hoses, Replace</i>	Authorized Service Technician

Every 5 year	Inspect pressure gauge on the hydraulic system.	3.3.23 <i>Hydraulic System, Inspect Pressure Gauge</i>	Chief Engineer
Every 5 years or every 8000 hours	Replace the V-belt.	3.3.32 <i>V-Belts, Replace</i>	Chief Engineer
Every 5 years or every 8000 operating hours	Water lubricated bearing, Replace	3.2.5 <i>Water Lubricated Bearing, Replace</i>	Authorized Service Technician

DRAFT

3.2 Mechanical

3.2.1 Intake and pump, Inspect



GEN-2563-01

Figure 1

Task Summary

The task is to inspect the waterjet intake for mechanical damages and debris.



Warning!

Hard hat is required. Be cautious when entering the intake.

Task Interval

Do this task during:

- Preventive maintenance, yearly.
- Corrective maintenance, at indication of blockage and pump damage.

Prerequisites

Conditions

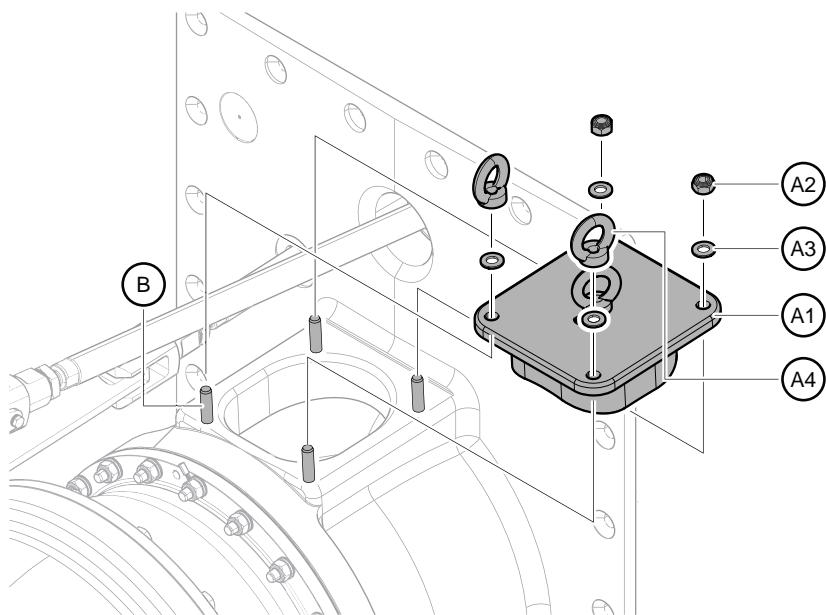
None

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Chief Engineer	Dock, workshop / dry dock	30 minutes

Reference document

5.1 Paint Program

Procedure

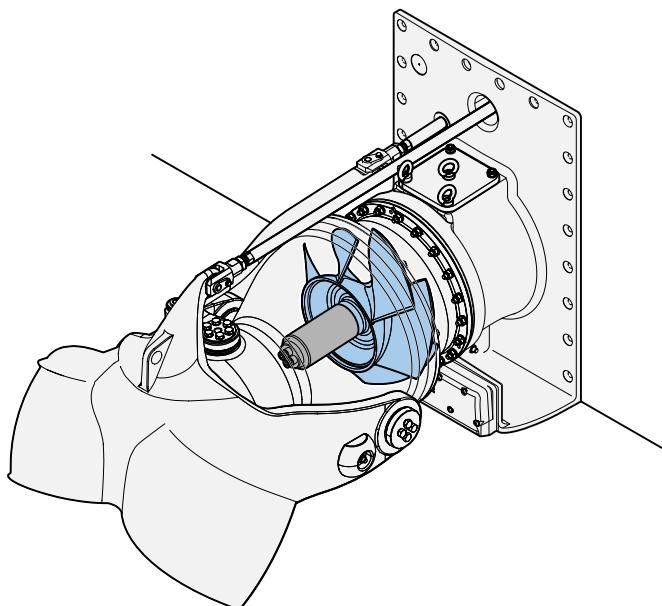


GEN-2562-01

Figure 2

- 1 Open the inspection hatch (A1) on the intake:
 - 1.1 Remove the nuts (A2), washers (A3) and lifting eyes (A4) from the studs (B) on the intake.
 - 1.2 Remove the inspection hatch (A1).
- 2 Inspect the intake for debris in the pump and/or impeller.
- 3 Inspect the intake for debris in the grid.
- 4 Inspect for any mechanical damages or damages to the paint.
- 5 Inspect the intake for ropes in the impeller or around the shaft.
- 6 Remove any debris or ropes found in the intake.
- 7 Close the inspection hatch (A1) on the intake again:
 - 7.1 Attach the inspection hatch (A1) to the studs (B).
 - 7.2 Apply Loctite® 243 to the nuts (A2) and the lifting eyes (A4).
 - 7.3 Install the nuts (A2), washers (A3) and lifting eyes (A4) to the inspection hatch (A1).
 - 7.4 Tighten the nuts (A2) to torque 34 Nm.
 - 7.5 Firmly tighten the lifting eyes (A4).
- 8 Task completed.

3.2.2 Pump Unit, Inspect Impeller Blade Tip Clearance



GEN-1632-01

Figure 3

Task Summary

The task is to measure the impeller blade tip clearance.

Task Interval

Do this task during:

- Preventive maintenance, annually / while docked

Prerequisites

Conditions

None

Personnel number	Skill level	Maintenance facility level (choose one)	Estimated time
1	Authorized Service Technician	Dock, workshop / dry dock	60 min

Consumables	Quantity	Part number
Pencil Loctite® 243	- -	- -

Reference document

5.3 Impeller Clearance Protocol

Procedure

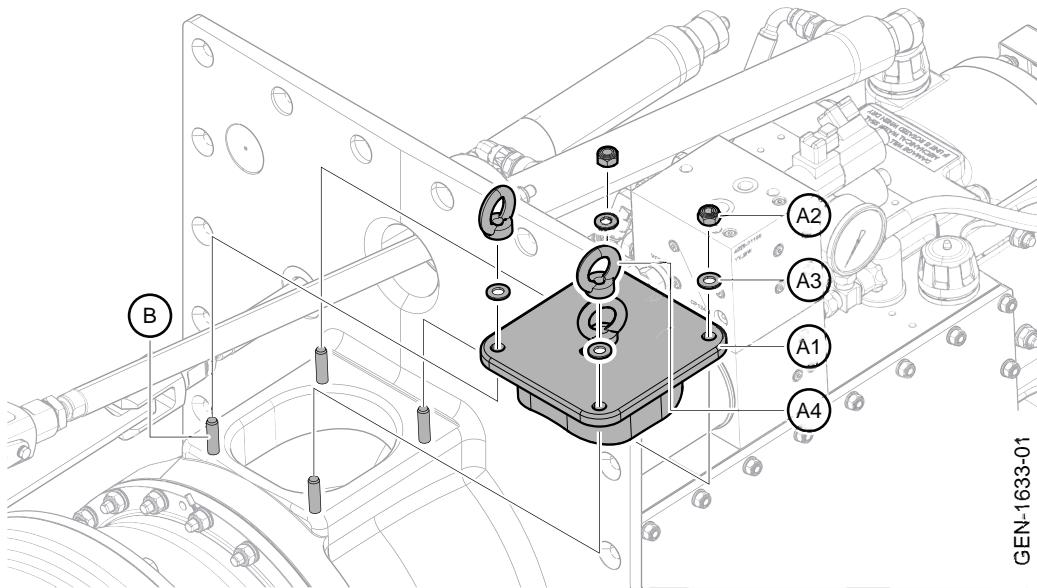


Figure 4

- 1 Open the inspection hatch (A1) on the intake:
 - 1.1 Remove the nuts (A2), washers (A3) and lifting eyes (A4) from the studs (B) on the intake.
 - 1.2 Remove the inspection hatch (A1).

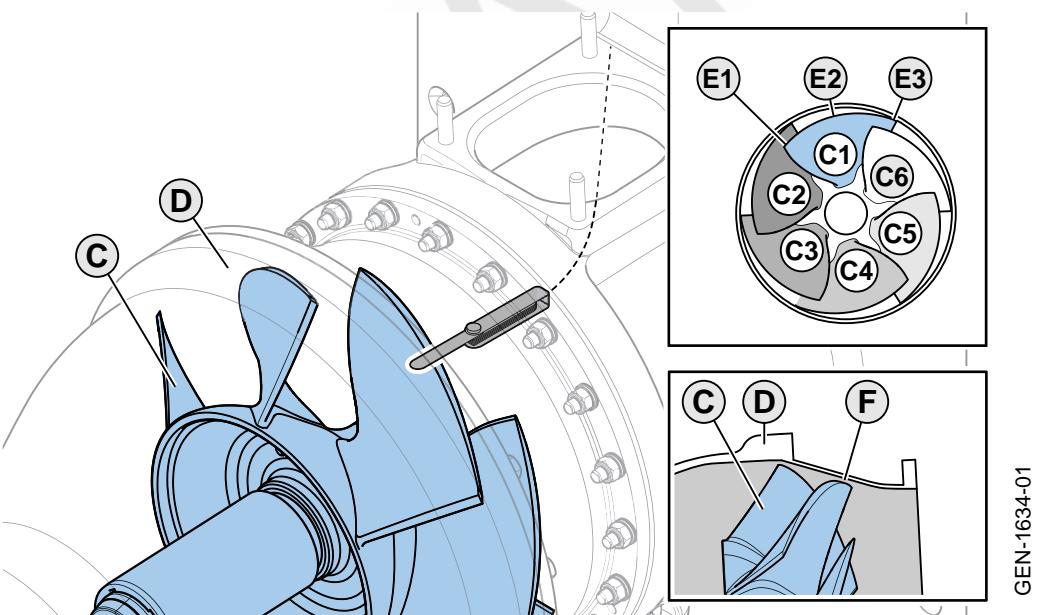


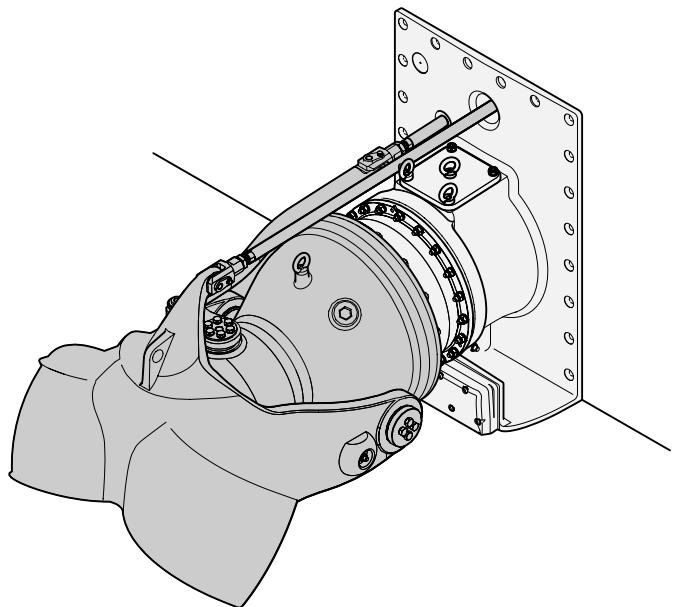
Figure 5

- 2 Turn the impeller (C) clockwise by hand so that impeller blade (C1) is at top position.
- 3 Measure the distance (F) between the impeller blade (C1) and impeller housing (D):
 - 3.1 Put a feeler gauge between the impeller blade (C1) and impeller housing (D) at leading edge position (E1), at middle position (E2) and at trailing edge position (E3).
 - 3.2 Record the distance in the impeller clearance protocol. See *5.3 Impeller Clearance Protocol*.
- 4 Turn the impeller (C) clockwise by hand so that impeller blade (C1) is at left position.
- 5 Do step 3 again.

- 6 Turn the impeller (C) clockwise by hand so that impeller blade (C1) is at bottom position.
- 7 Do step 3 again.
- 8 Turn the impeller (C) clockwise by hand so that impeller blade (C1) is at right position.
- 9 Do step 3 again.
- 10 Do steps 2 to 9 again with impeller blades (C2), (C3), (C4), (C5), and (C6).
- 11 If the average gap between the impeller (C) and impeller housing (D) is more than 1 mm the impeller needs a renovation.
- 12 Close the inspection hatch (A1) on the intake again:
 - 12.1 Attach the inspection hatch (A1) to the studs (B).
 - 12.2 Apply Loctite® 243 to the nuts (A2) and the lifting eyes (A4).
 - 12.3 Install the nuts (A2), washers (A3) and lifting eyes (A4) to the inspection hatch (A1).
 - 12.4 Tighten the nuts (A2) to torque 34 Nm.
 - 12.5 Firmly tighten the lifting eyes (A4).
- 13 Task completed.

DRAFT

3.2.3 Waterjet Unit, Dismount



GEN-2408-01

Figure 6

Task Summary

The task is to dismount the waterjet unit when necessary to be able to perform maintenance.

Task Interval

Prerequisite for other tasks.

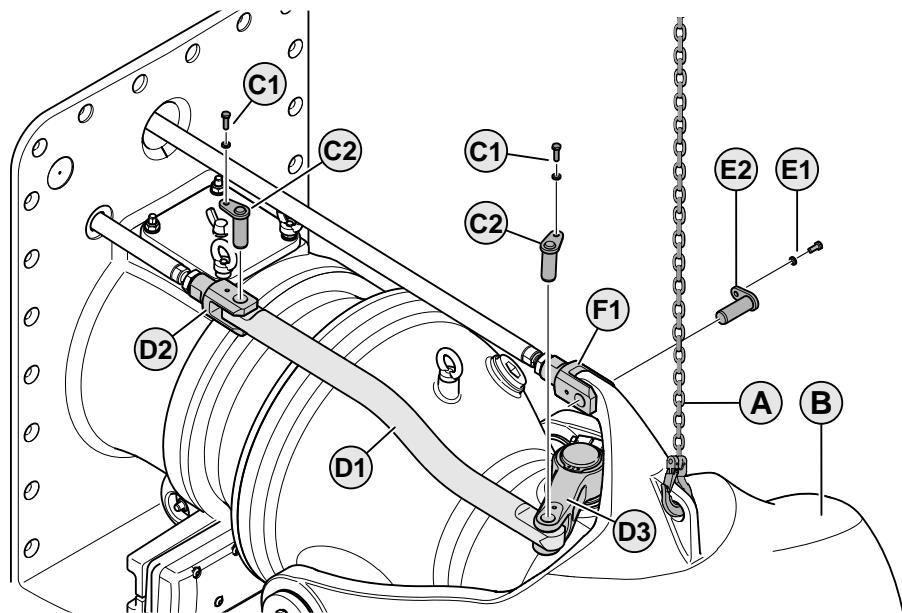
Prerequisites

Conditions

Necessary scaffolding to access unit.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dock, workshop / dry dock	60 minutes

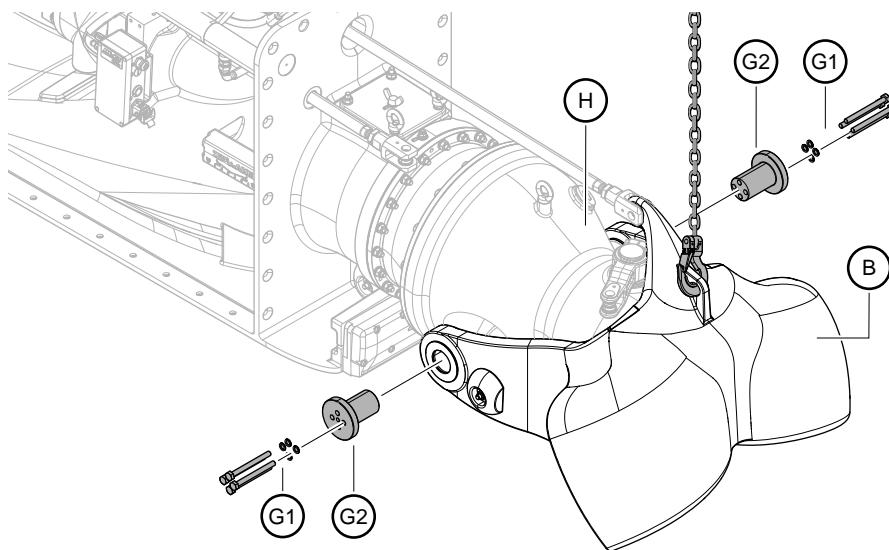
Procedure



GEN-2404-01

Figure 7

- 1 Attach a lifting device (A) to the bucket (B).
- 2 Remove the screws and washers (C1) from the pin shafts (C2).
- 3 Use a sliding hammer to remove the pin shafts (C2) from the push rod (D1).
- 4 Remove the push rod (D1) from the steering rod clevis (D2) and the tiller arm (D3).
- 5 Remove the screw and washer (E1) from the reversing rod clevis (F1).
- 6 Use a sliding hammer to remove the pin shaft (E2) from the reversing rod clevis (F1) and the bucket (B).



GEN-2405-01

Figure 8

- 7 Remove the screws, washers (G1) and the pivot pins (G2) from the bucket (B) and the diffuser assembly (H).
- 8 Remove the bucket (B) from the diffuser assembly (H).

- 9 Put the bucket (B) on a wooden pallet.

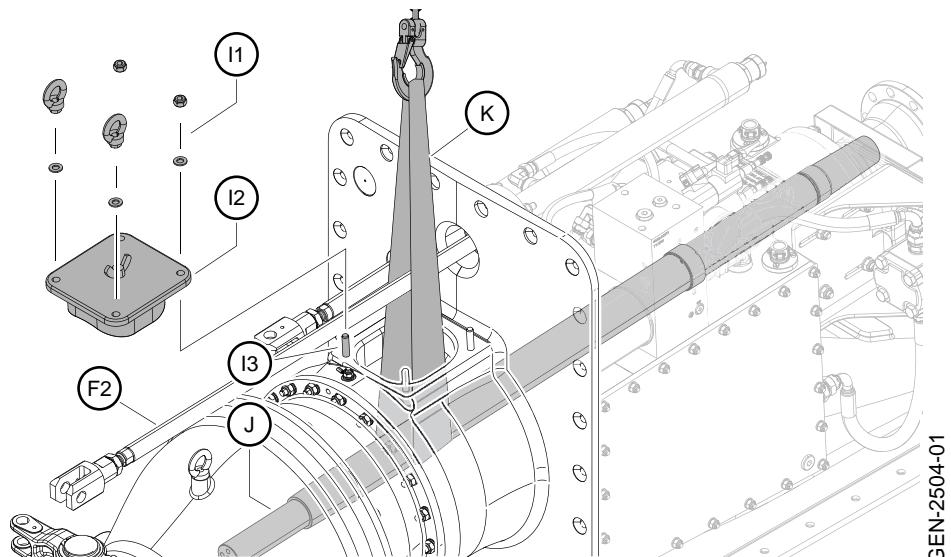


Figure 9

- 10 Remove the nuts and washers (I1) from the inspection hatch (I2)
11 Remove the inspection hatch (I2) from the studs (I3) on the intake.
12 Secure the drive shaft (J) with slings (K).



Caution!

Make sure that the reversing cylinder (F2) is cleared from the slings (K), this will help to prevent damage to the cylinder.

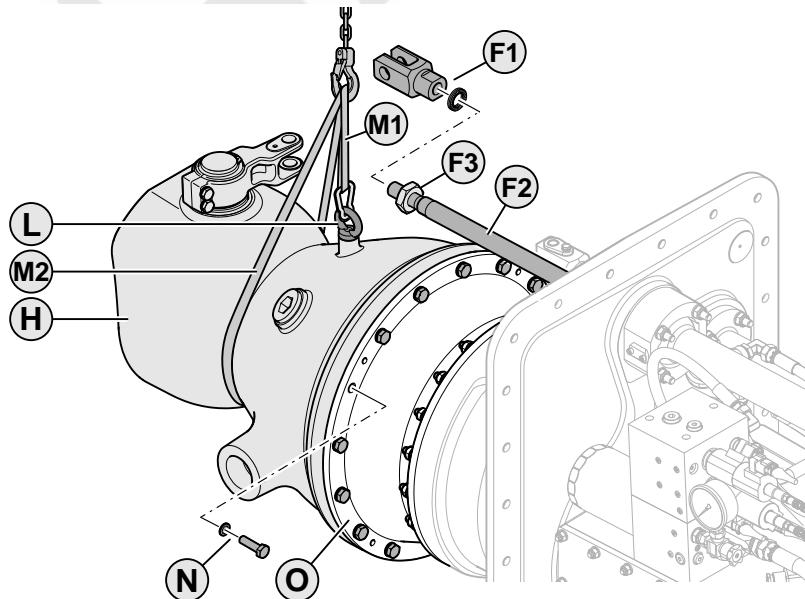


Figure 10

- 13 Put the reversing cylinder (F2) in full ahead.
14 Remove the reversing rod clevis, nut and washer (F1) from the reversing cylinder (F2).

- 15 Put one sling (M2) around the diffuser assembly (H) and attach one sling (M1) to the lifting eye (L) on the diffuser assembly.



Caution!

Make sure that the reversing cylinder (F2) is cleared from the slings, this will help to prevent damage to the cylinder.

- 16 Remove the screws and washers (N) from the impeller housing (O) and the diffuser assembly (H).



Caution!

Make sure that the diffuser assembly (H) is fully supported by the slings, this will help to prevent damage to the drive shaft and water jet.

- 17 Carefully move the diffuser assembly (H) aft to remove it from the impeller housing (O).

- 18 Put the diffuser assembly (H) on a wooden pallet.

- 19 Task completed.

3.2.4 Water Lubricated Bearing, Inspect

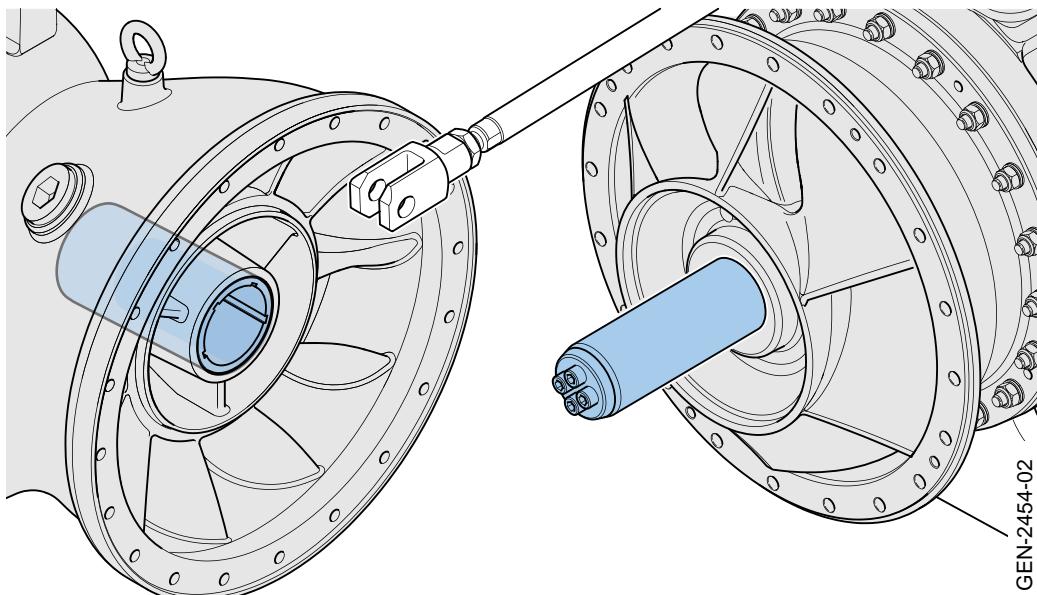


Figure 11

Task Summary

The task is to inspect the water lubricated bearing and the bearing sleeve.

This task can be performed using two alternating procedures.

Task Interval

Do this task during:

- Preventive maintenance, annually

Prerequisites

Conditions

Necessary scaffolding to access unit.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Chief Engineer only Alternative 1	Dock, workshop / dry dock	15 minutes
1	Authorized Service Technician Alternative 1 / 2	Dock, workshop / dry dock	15 / 60 minutes

Procedure Alternative 1

- 1 Read the distances recorded in the impeller clearance protocol from *Pump Unit, Inspect Impeller Blade Tip Clearance*. See *5.3 Impeller Clearance Protocol*.

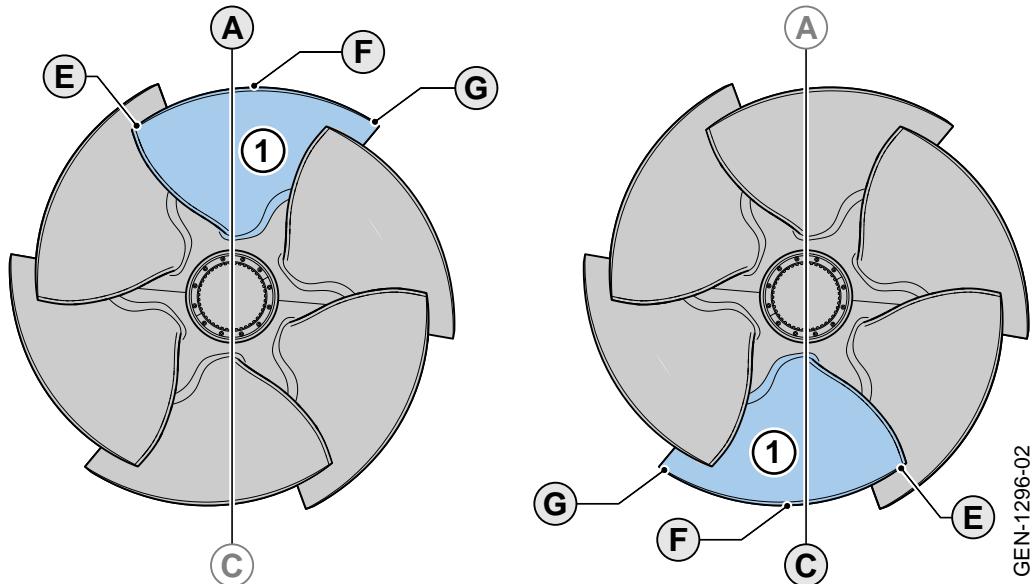


Figure 12

- 2 Use the recordings from one impeller blade (1) at twelve o'clock position (A) and six o'clock position (C).
- 3 If the measured distance between the impeller blade (1) and impeller housing at the twelve o'clock position, and the six o'clock position differs 0,6 millimetres, replace the water lubricated bearing. See *3.2.5 Water Lubricated Bearing, Replace*.
- 4 Task completed.

Procedure Alternative 2

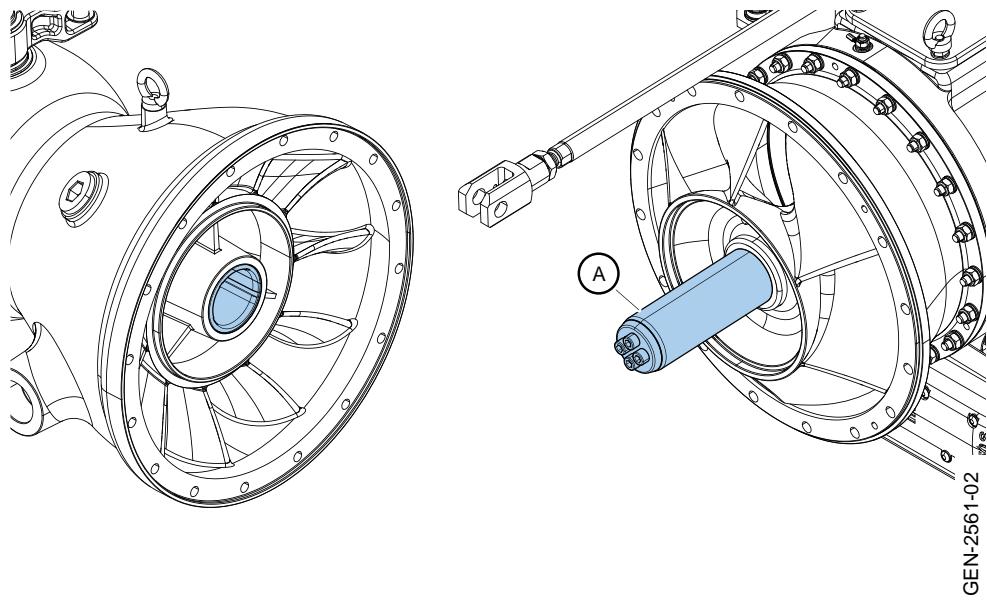


Figure 13

- 1 Dismount the waterjet. See 3.2.3 *Waterjet Unit, Dismount*
- 2 Inspect the wear sleeve (A) for damage and measure the diameter. The nominal value is 80 h7 (80 mm +0/-0,030).
- 3 If the surface of the wear sleeve (A) is damaged or if the diameter is 0,2 millimetres less than the nominal value on measured points on the wear sleeve, replace the water lubricated bearing. See 3.2.5 *Water Lubricated Bearing, Replace*.
- 4 Task completed.

3.2.5 Water Lubricated Bearing, Replace

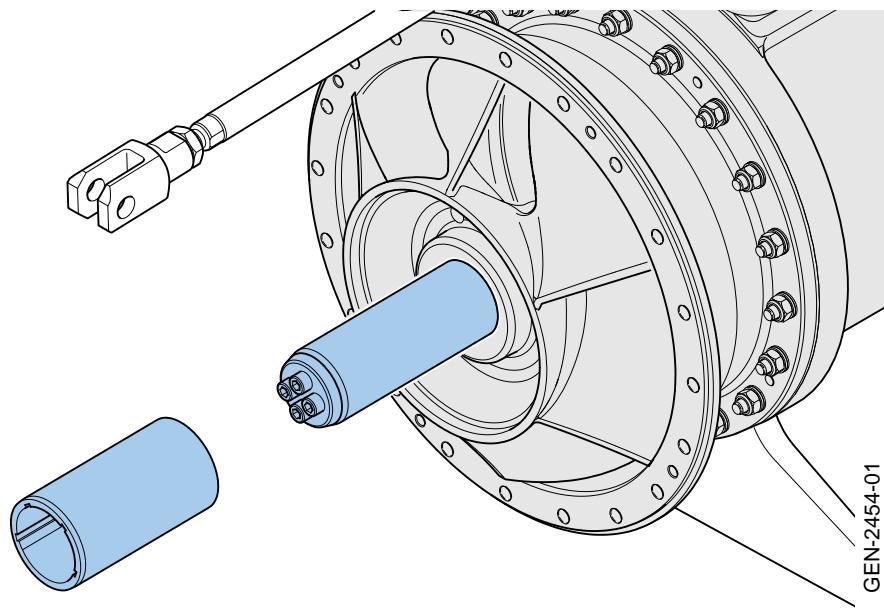


Figure 14

Task Summary

The task is to replace the water lubricated bearing and the bearing sleeve.

Task Interval

Do this task during:

- Preventive maintenance every 5 years or 8 000 operating hours
- Corrective maintenance

Prerequisites

Conditions

Necessary scaffolding to access unit.

Waterjet unit dismounted. See 3.2.3 *Waterjet Unit, Dismount*

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dock, workshop / dry dock	60 minutes

Spare parts	Quantity	Part number
X350 Spare water lubricated bearing set	1	X350-1101-2-SP

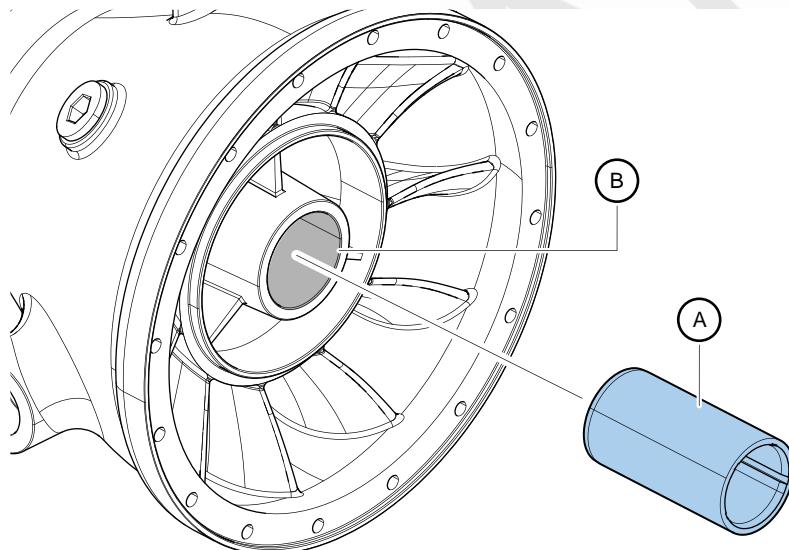
Recommendations

Bearing can be fitted either by press fitting or shrink fitting.

Press fitting requires hydraulic press.

Shrink fitting requires the bearing to be cooled to minimum -18 Celsius at least 12 hours. Alternatively liquid nitrogen, time for cooling approximately 20 minutes.

Procedure



GEN-2446-01

Figure 15

- 1 Use a sliding hammer to remove the aft bearing (A) from the diffuser assembly (B).
- 2 Install the new aft bearing in the diffuser assembly (B).

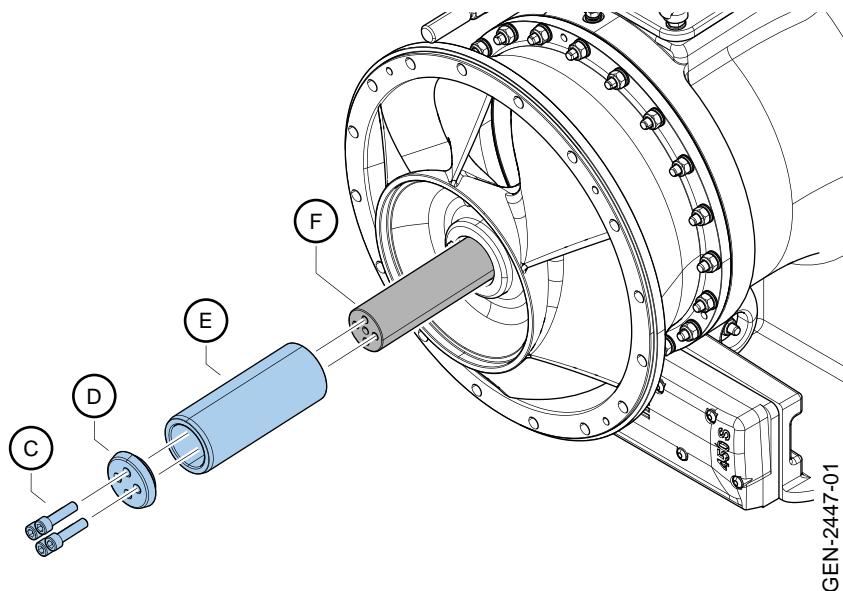


Figure 16

- 3 Remove the screws (C) from the sleeve washer (D) and the drive shaft (F).
- 4 Discard the old screws.
- 5 Remove the sleeve washer (D) and the wear sleeve (E) from the drive shaft (F).
- 6 Install the new wear sleeve on the drive shaft (F).
- 7 Align the sleeve washer (D) to the wear sleeve (E) and drive shaft (F).
- 8 Use new screws.
- 9 Apply Molykote DX paste to the screw heads (C) and Loctite® 243 in the holes on the sleeve washer (D) and drive shaft (F).
- 10 Install the screws (C) to the sleeve washer (D) and the drive shaft (F).
- 11 In a crisscross pattern gradually tighten the screws (C) to torque 44 Nm.
- 12 Install the diffuser again. See *3.2.6 Waterjet Unit, Assemble*.
- 13 Measure the impeller blade tip clearance. See *3.2.2 Pump Unit, Inspect Impeller Blade Tip Clearance* for the correct instructions.
- 14 Task completed.

3.2.6 Waterjet Unit, Assemble

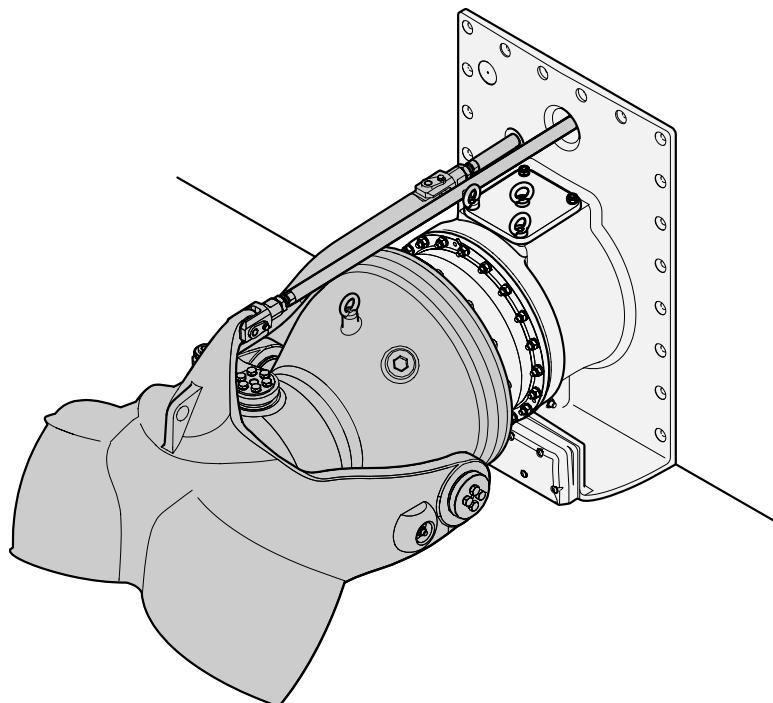


Figure 17

GEN-2408-01

Task Summary

The task is to assemble the waterjet unit after maintenance.

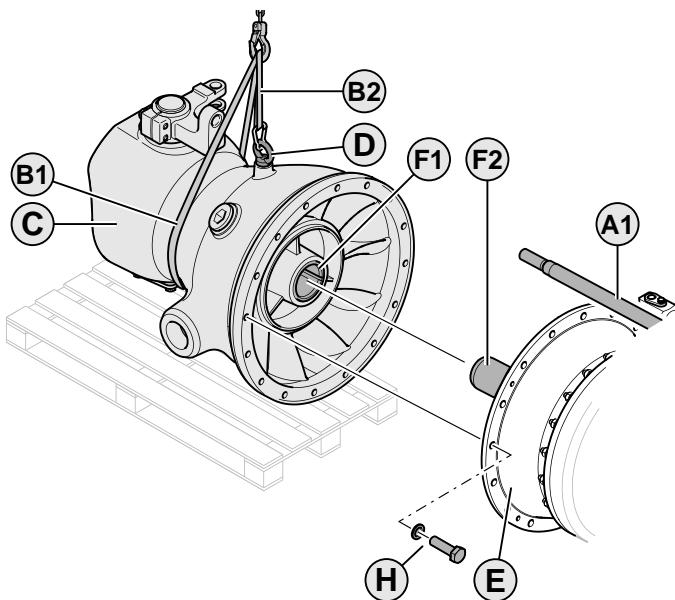
Prerequisites

Conditions

Necessary scaffolding to access unit.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized service technician	Dock, workshop / dry dock	60 minutes
Consumables	Quantity	Part number	
Loctite® 243	-	-	

Procedure



GEN-2409-01

Figure 18

- 1 Make sure that the reversing cylinder (A1) is in full ahead position.
- 2 Put one sling (B1) around the diffuser assembly (C) and attach one sling (B2) to the lifting eye (D) on the diffuser assembly.
- 3 Align the diffuser assembly (C) with the impeller housing (E).
- 4 Align the diffuser assembly (C) and the aft bearing (F1) to the sleeve (F2) on the drive shaft.
- 5 Carefully fit the diffuser assembly (C) to the Impeller housing (E).



Caution!

Make sure that the aft bearing (F1) is perfectly aligned to the sleeve (F2) on the drive shaft, this will help to prevent damage to the drive shaft and the waterjet.



Caution!

Make sure that the reversing cylinder (A1) is cleared from the slings (B1) and (B2), this will help to prevent damage to the cylinder.

- 6 Apply Molykote 111 compound to the screws (H).
- 7 Install the screws and washers (H) to the impeller housing (E) and diffuser assembly (C).
- 8 Tighten the screws (H) gradually in sequence to torque 68 Nm.
- 9 Remove the slings (B1) and (B2) from the diffuser assembly (C).

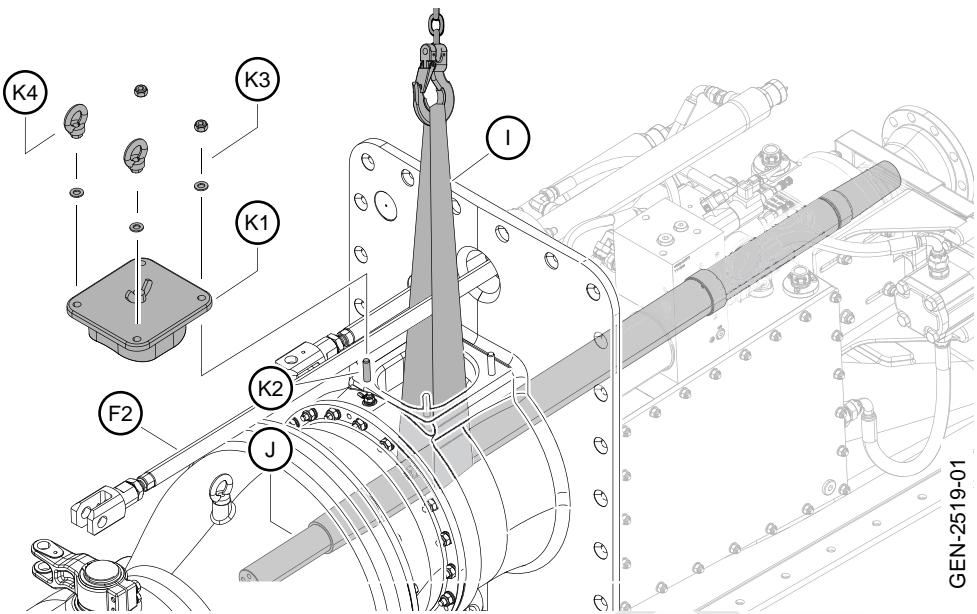


Figure 19

- 10 Remove the sling (I) from the drive shaft (J).
- 11 Close the inspection hatch (K1) on the intake:
 - 11.1 Attach the inspection hatch (K1) to the studs (K2).
 - 11.2 Apply Loctite® 243 to the nuts (K3) and the lifting eyes (K4).
 - 11.3 Install the lock washers and nuts (K3) to the studs (K2).
 - 11.4 Tighten the nuts (K3) to torque 34 Nm.
 - 11.5 Install the lock washers and lifting eyes (K4) to the studs (K2).
 - 11.6 Firmly tighten the lifting eyes (K4).

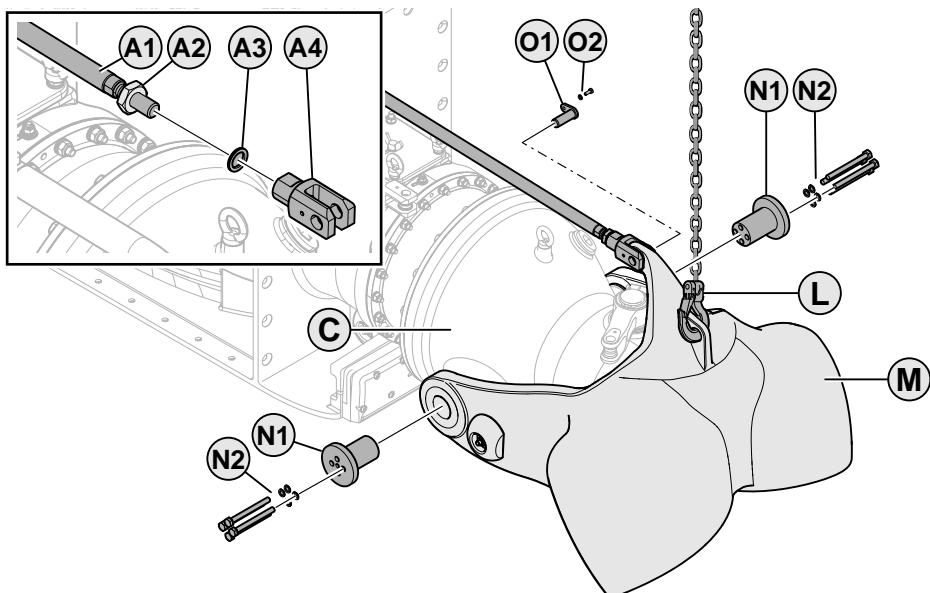
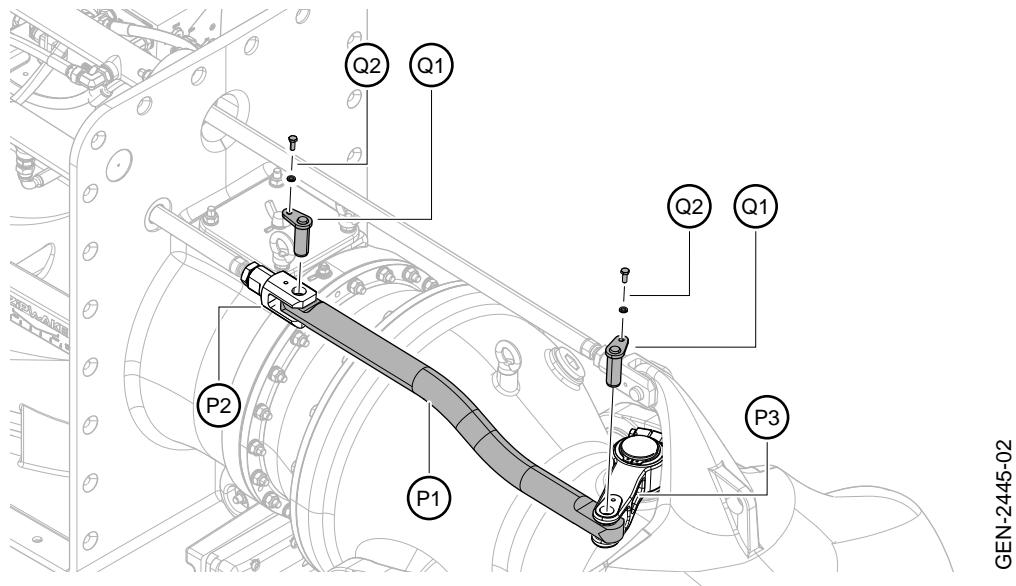


Figure 20

- 12 Attach a lifting device (L) to the bucket (M).
- 13 Align the bucket (M) to the mounting holes on the diffuser assembly (C).
- 14 Apply Molykote DX paste to the screws (N2).

- 15 Install the pivot pins (N1), screws and washers (N2) to the bucket (M) and the diffuser assembly (C).
- 16 Tighten the screws (N2) to torque 39 Nm.
- 17 Put the washer (A3) on the reversing cylinder (A1).
- 18 Install the reversing rod clevis (A4) to the reversing cylinder.
- 19 Tighten the locknut (A2) to torque 200 Nm.
- 20 Apply Molykote DX paste to the screw (O2).
- 21 Install the pin shaft (O1), screw and washer (O2) to the reversing rod clevis (A3) and the bucket (M).
- 22 Tighten the screw (O2) to torque 8.4 Nm.
- 23 Remove the lifting device (L).



GEN-2445-02

Figure 21

- 24 Install the push rod (P1) to the steering rod clevis (P2) and the tiller arm (P3).
- 25 Apply Molykote DX paste to the screws (Q2).
- 26 Install the pin shafts (Q1), screws and washers (Q2) to the steering rod clevis (P2), push rod (P1) and the tiller arm (P3).
- 27 Tighten the screws (Q2) to torque 8,4 Nm.
- 28 Task completed.

3.2.7 Thrust Bearing, Drainage hole, Clean

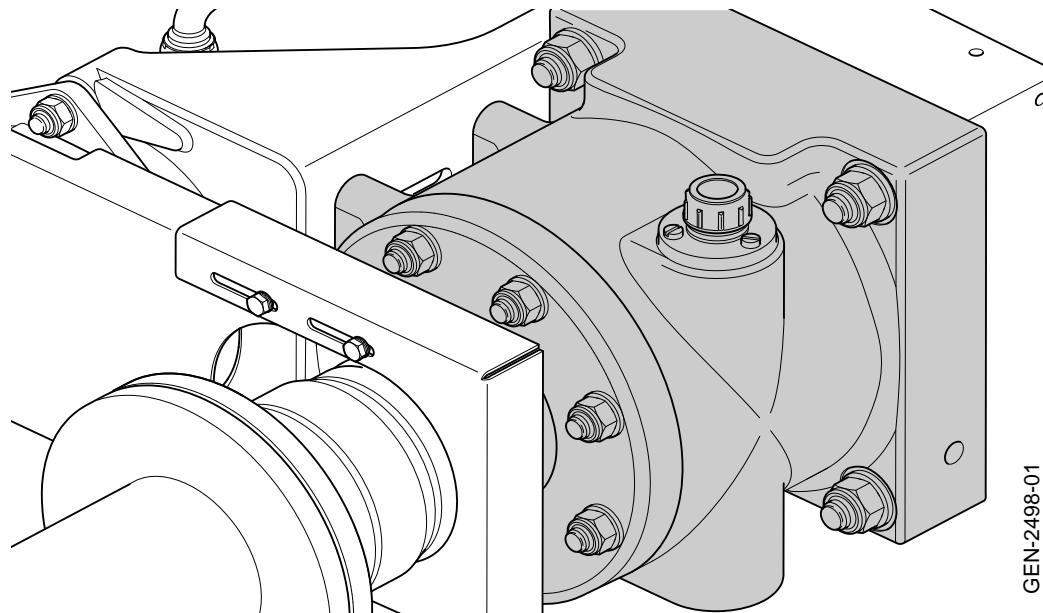


Figure 22

Task Summary

The task is to clean the drainage hole.

Task Interval

Do this task during:

- Preventive maintenance, monthly

Prerequisites

Conditions

None

Personnel number	Skill level	Maintenance facility level	Estimated time
1	Crew	Dockside	10 min
Consumables	Quantity		Part number
Bottle brush Ø10 mm	1	-	

Procedure

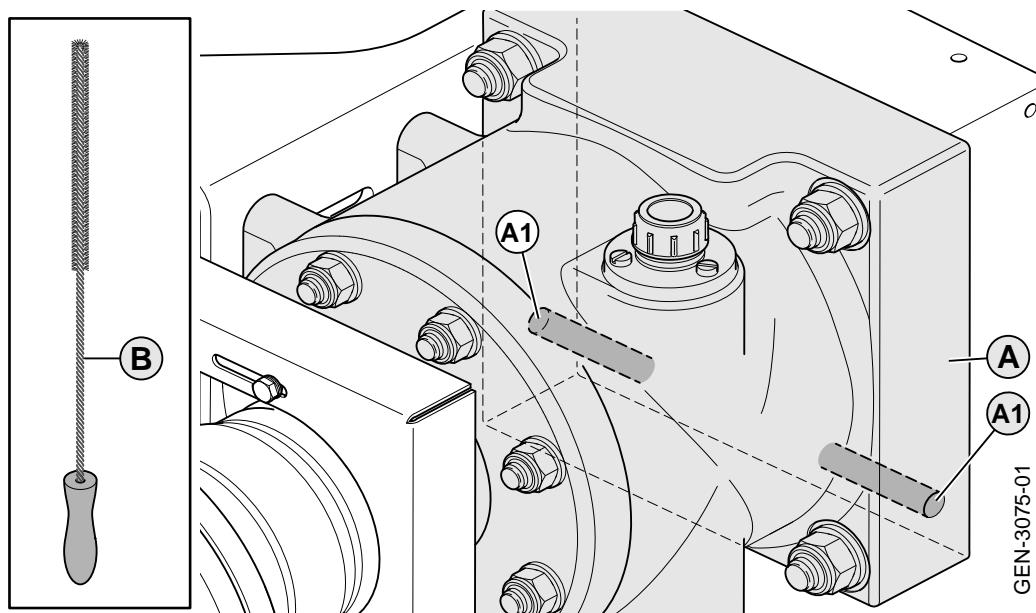


Figure 23

- 1 Clean the holes (A1) with a bottle brush (B) until they are clear and not clogged.
- 2 Task completed.

3.2.8 Thrust Bearing and Shaft Seal, Inspect Leakage and Oil Level

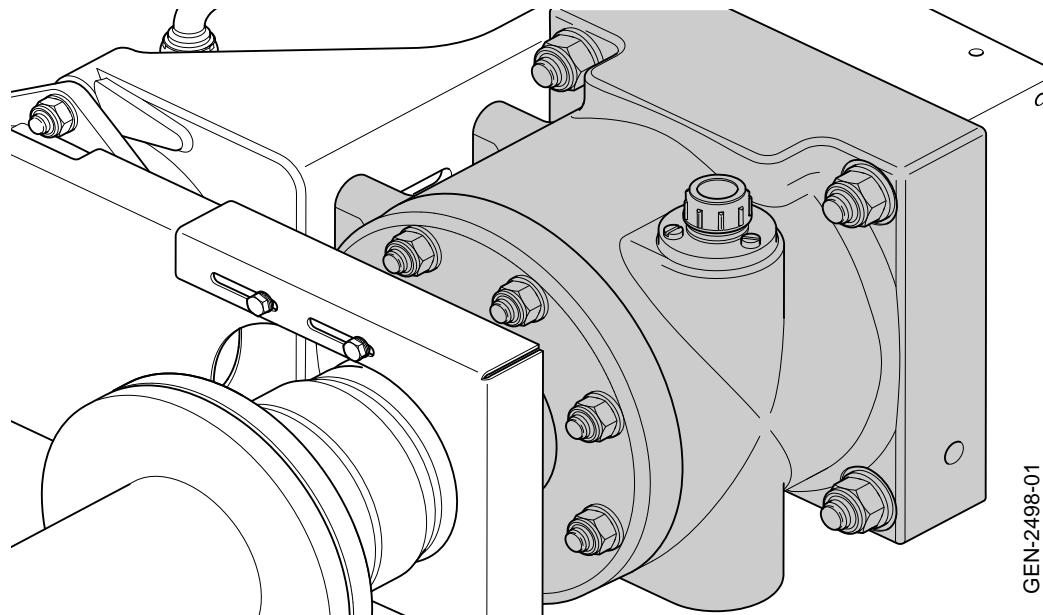


Figure 24

Task Summary

The task is to check the condition of the thrust bearing and shaft seal by inspection of leakage and oil level on the bearing housing assembly.

Task Interval

Do this task during:

- Preventive maintenance, daily
- Corrective maintenance

Prerequisites

Conditions

None

Personnel number	Skill level (choose one)	Maintenance facility level (choose one)	Estimated time
1	Crew	Dock, workshop / dry dock	10 min

Procedure

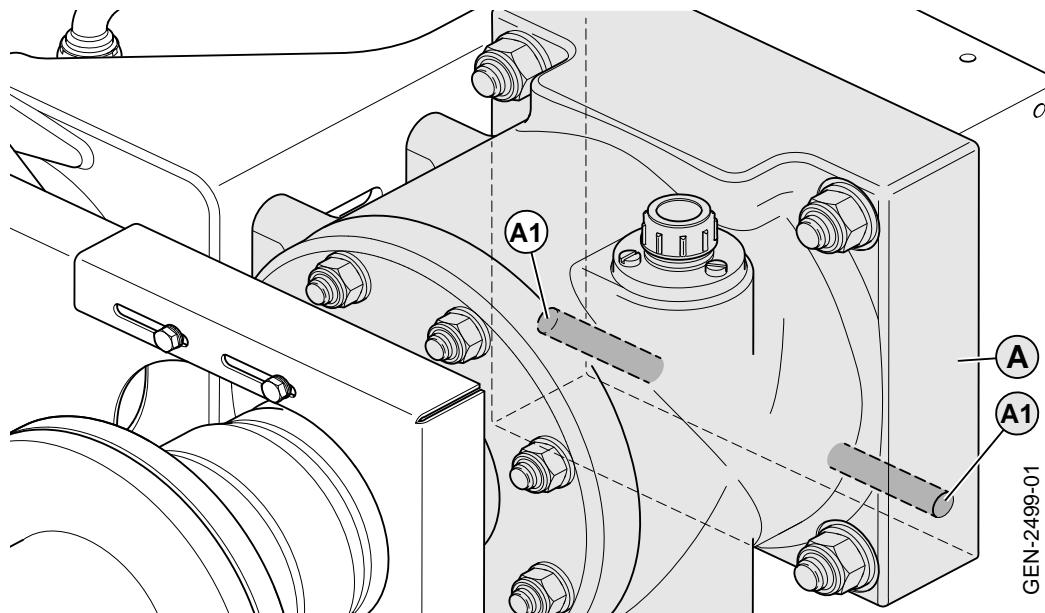


Figure 25

- 1 Make sure that the holes (A1) is clear and not clogged.
- 2 Inspect the area around the holes (A1) on the bearing housing assembly (A) for leakage.
 - a. If oil is leaking out of the holes (A1) on the bearing housing assembly (A) the thrust bearing or the radial seals may be damaged or worn out. Contact MJP.
 - b. If water is leaking out of the holes (A1) on the bearing housing assembly (A) the shaft seal may be damaged or worn out. Contact MJP.

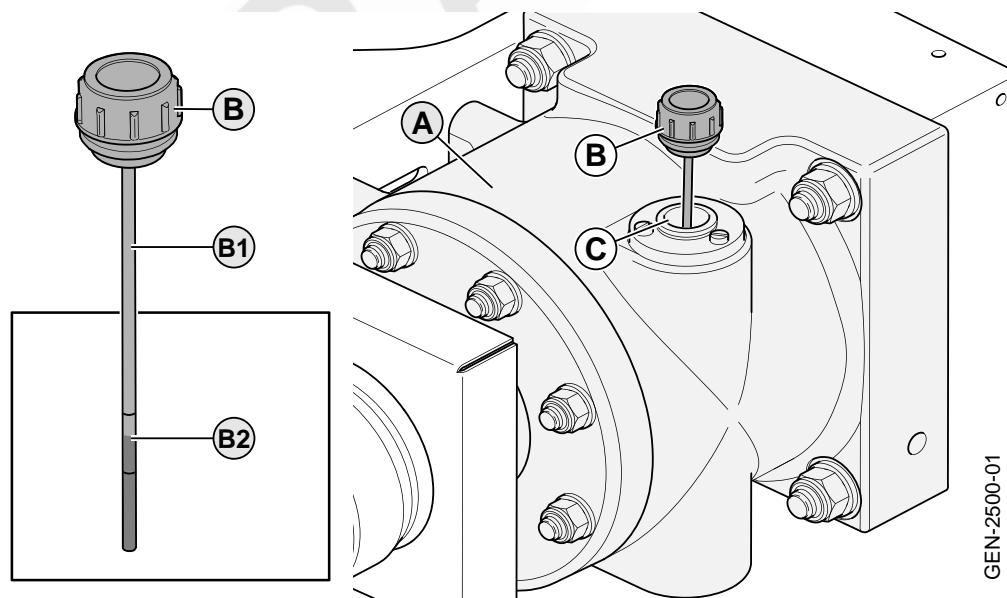


Figure 26

- 3 Remove the air filter (B) with the attached dipstick (B1) from the bearing housing assembly (A).
- 4 Inspect the oil on the dipstick (B1).



Caution!

If the oil is grey and dirty, contact MJP.

- 5 Wipe the dipstick (B1) clean.
- 6 Install the air filter (B) with the dipstick (B1) until it is fully seated.
- 7 Remove the air filter (B) with the dipstick (B1) again.
- 8 View the oil level (B2) on the dipstick (B1) to confirm that the oil level is within the safe operating range.

Note!

In V-shape hulls the actual oil level will be different with different mounting angles. This will be reflected in the dipstick markings.

- 9 Add oil if required. For more information, see procedure in .
- 10 Task completed.

DRAFT

3.2.9 Thrust Bearing Unit, Replace Thrust Bearing and Radial Seals

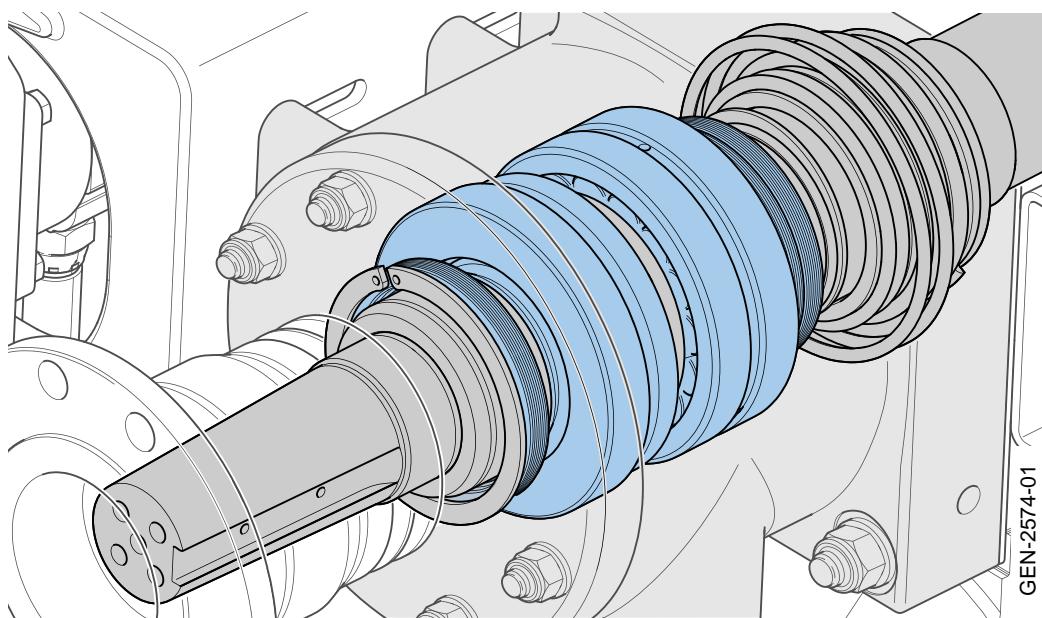


Figure 27

Task Summary

The task is to replace the thrust bearing and the radial seals.

Due to easy access when this task is being performed, it is recommended that the shaft seal, the O-rings and the circlip also are replaced.

Task Interval

Do this task during:

- Preventive maintenance, every 5th year or 8 000 operating hours.
- Corrective maintenance

Prerequisites

Conditions

Intermediate shafting removed to create space in front of the waterjet.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dock, workshop / dry dock	120 minutes

Spare parts	Quantity	Part number
X350 Spare Bearing & Seals Kit	1	X350-1111-SP

Special tools and test equipment	Quantity	Part number
Flange/Impeller extractor	1	100-004

Recommended replacement

- 3.2.10 Thrust Bearing Unit, Replace Shaft Seal
- 3.3.16 Thrust Bearing, Replace Oil
- 3.3.25 Hydraulic System, Replace Oil Filter

Procedure

- 1 Empty the oil from the thrust bearing unit. See 3.3.16 Thrust Bearing, Replace Oil
- 2 Remove the belt guards and the V-belts. See 3.3.32 V-Belts, Replace step 1 to step 1.6.

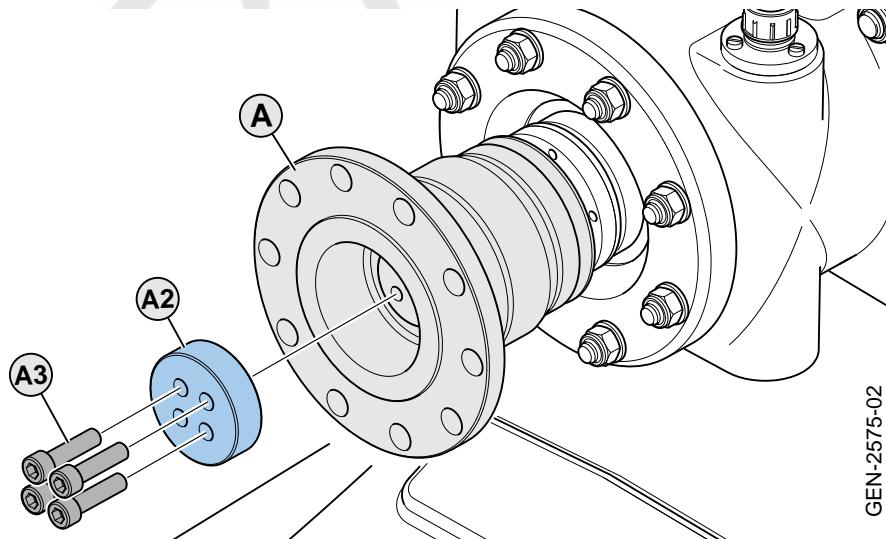
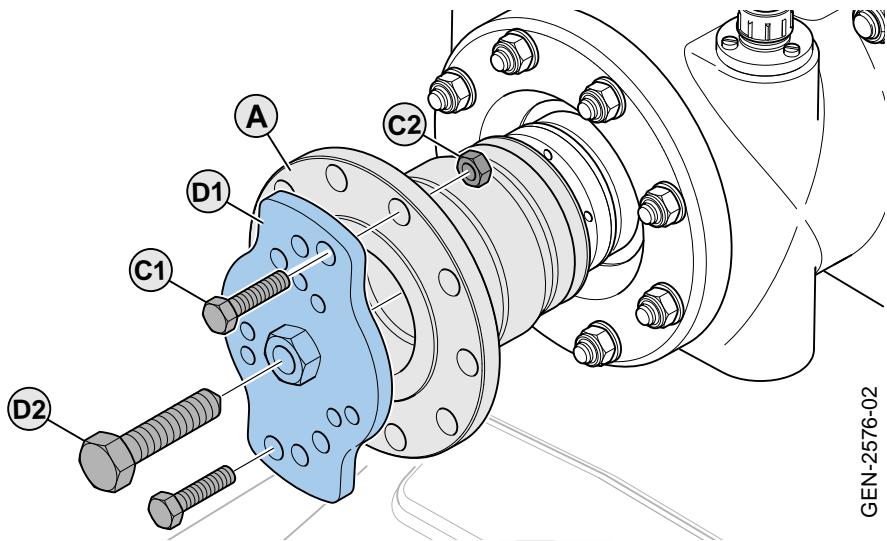


Figure 28

- 3 Remove the drive shaft flange (A) from the drive shaft:
 - 3.1 Remove the screws (A3) and the flange washer (A2) from the drive shaft flange (A).



- 3.2 Use screws (C1) and nuts (C2) to install a pull-off plate (D1-D2) to the drive shaft flange (A). Put lubricant on D2, before installing it, to protect the threads of the pull-off plate.

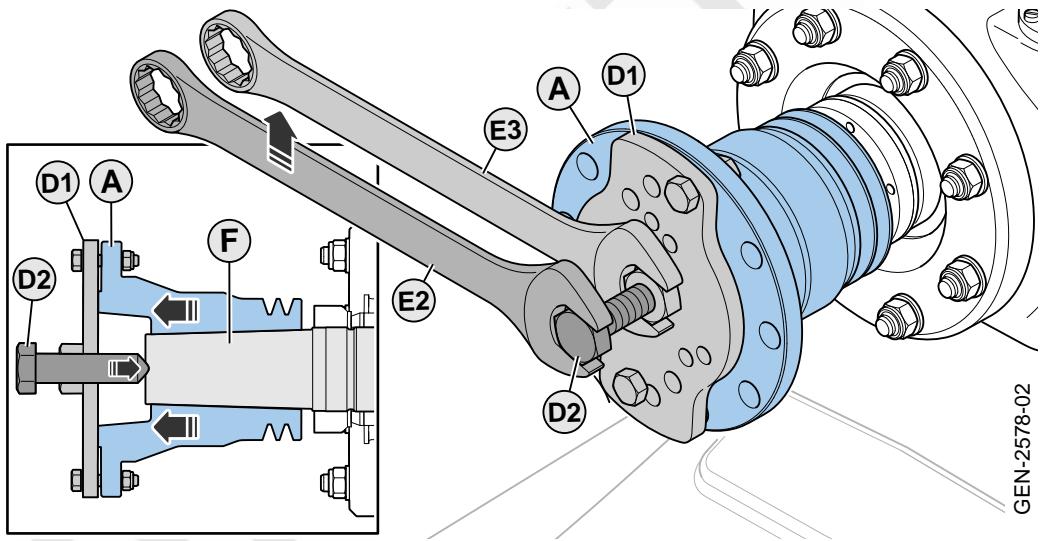
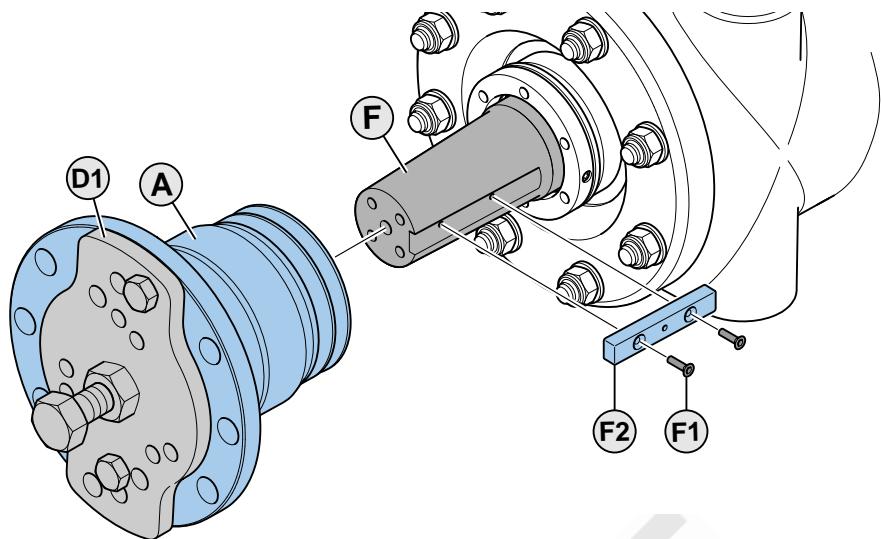


Figure 29

- 3.3 Use a large wrench (E2) on the screw (D2) on the pull-off plate (D1) and turn clockwise to pull off the drive shaft flange (A) from the taper of the drive shaft (F). Use another wrench (E3) to hold the pull-off plate in place.



GEN-2579-02

Figure 30

- 3.4 Remove the drive shaft flange (A) from the taper of the drive shaft (F).
- 3.5 Remove pull-off plate (D1) from the drive shaft flange.
- 3.6 Remove the screws (F1) and the key (F2) from the drive shaft.

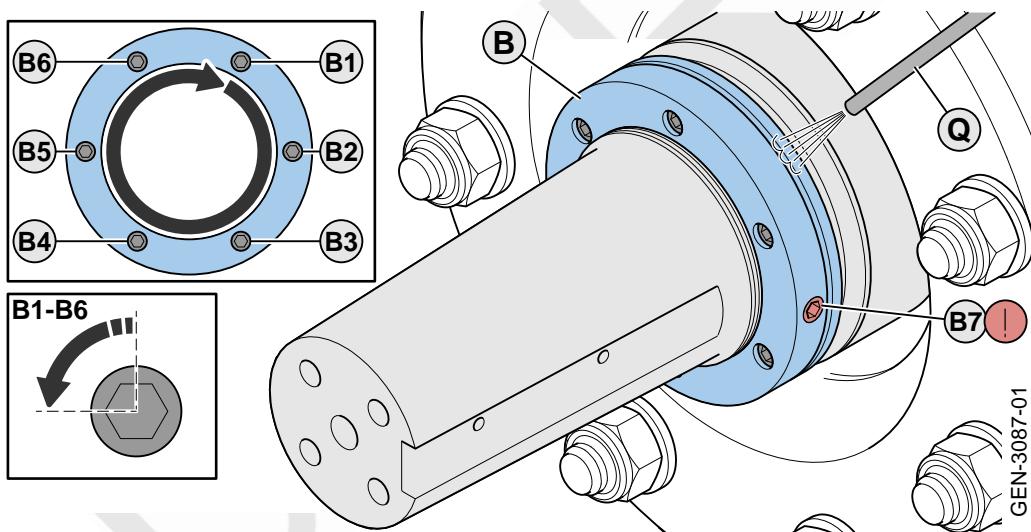


Figure 31

- 4 Remove the jackbolt tensioner (B) from the drive shaft.

**Warning!**

Loosening requires an exact procedure. The jackbolts (B1–B6) must be unloaded gradually. Under no circumstances unload a single jackbolt completely. The remaining jackbolts would have to carry the entire load and could deform, making loosening impossible.

- 4.1 Before loosening, apply penetrating oil (Q) in between the tensioner and the washer.
- 4.2 First unscrew the bolt (B7) so that it goes clear of the threads on the drive shaft.
- 4.3 Starting with one jackbolt (B1), loosen every jackbolt in a circular pattern approximately a quarter turn. (Breaking loose is sufficient.) After the first round, jackbolt (B1) will be tight again, but now with a lower load level.
- 4.4 Repeat the quarter turn circular loosening sequence on all jackbolts until all tension is relieved.

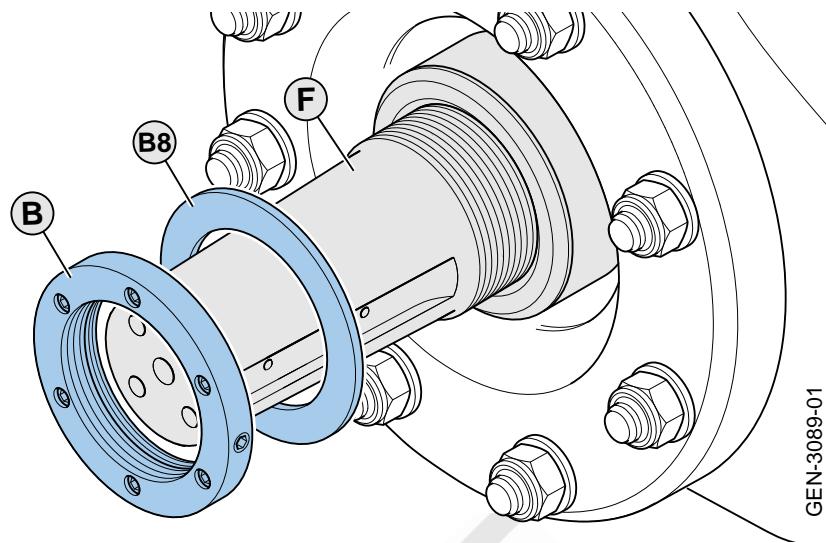


Figure 32

- 4.5 When all tension is relieved the jackbolt tensioner can be unscrewed from the drive shaft by hand. Remove the washer (B8).

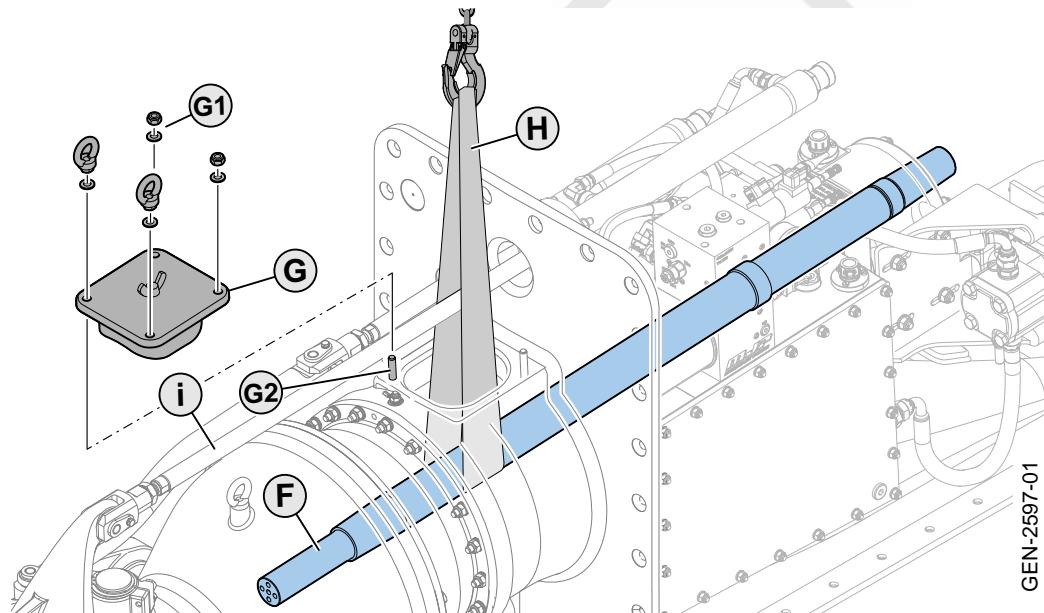


Figure 33

5 Secure the drive shaft (F):

- 5.1 Remove the nuts and washers (G1) from the inspection hatch (G)
- 5.2 Remove the inspection hatch (G) from the studs (G2).
- 5.3 Secure the drive shaft (F) with slings (H).



Caution!

Make sure that the reversing cylinder (i) is cleared from the slings (H), this will help to prevent damage to the cylinder.

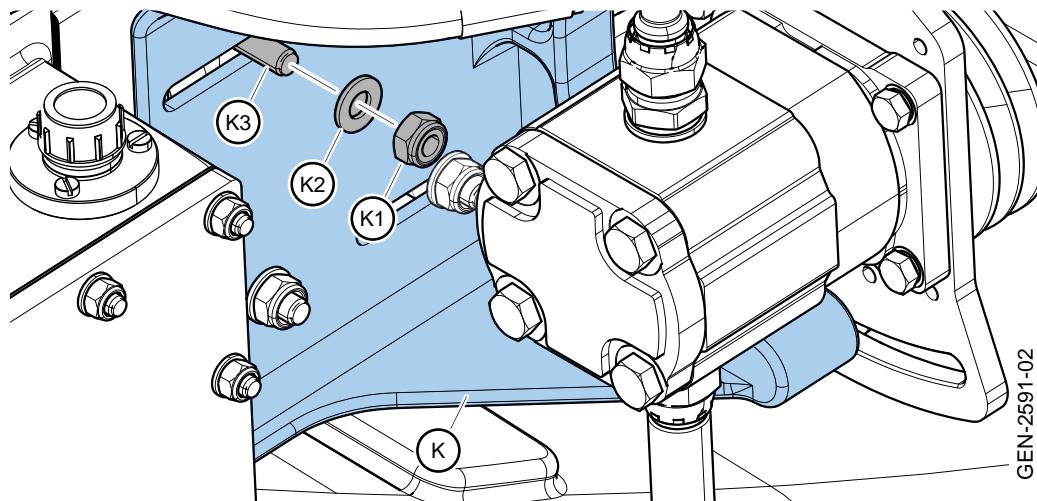


Figure 34

6 Remove the bearing unit (J):

- 6.1 Remove the nuts (K1) and the washers (K2) from the studs (K3) to detach the bearing unit from the bracket (K).

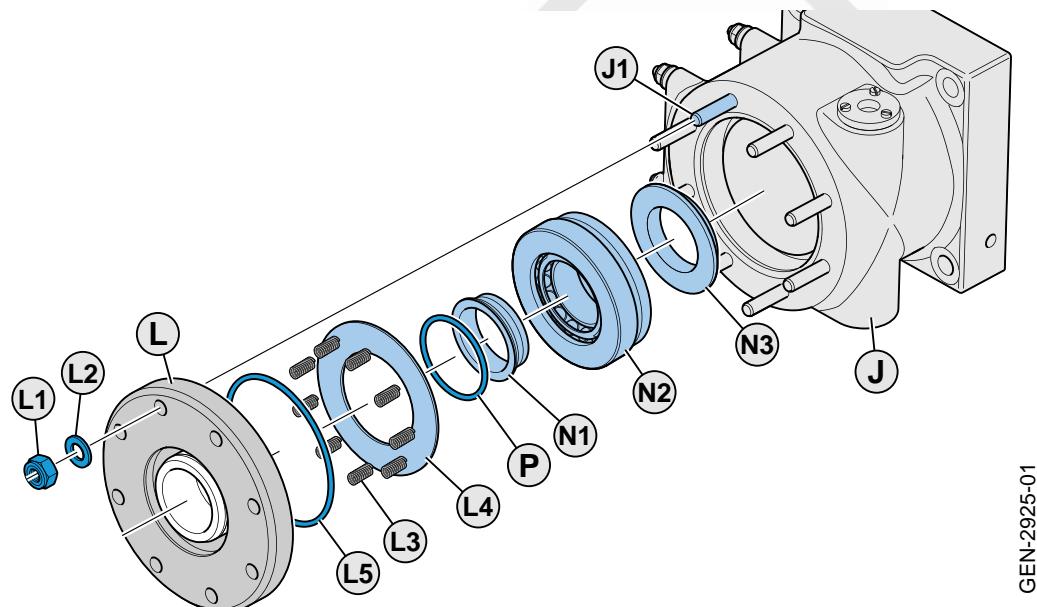


Figure 35

- 6.2 Remove the nuts (L1) and washers (L2) from the studs (J1).
 6.3 Carefully remove the lid (L) from the bearing unit (J).
 6.4 Remove the springs (L3) and the shim (L4) from the bearing unit (J).

Note!

Make sure no springs are lost.

- 6.5 Remove the O-ring (P) and bearing spacer (N1).
 6.6 Remove and replace the roller thrust bearing (N2).
 6.7 Remove the bearing spacer (N3).

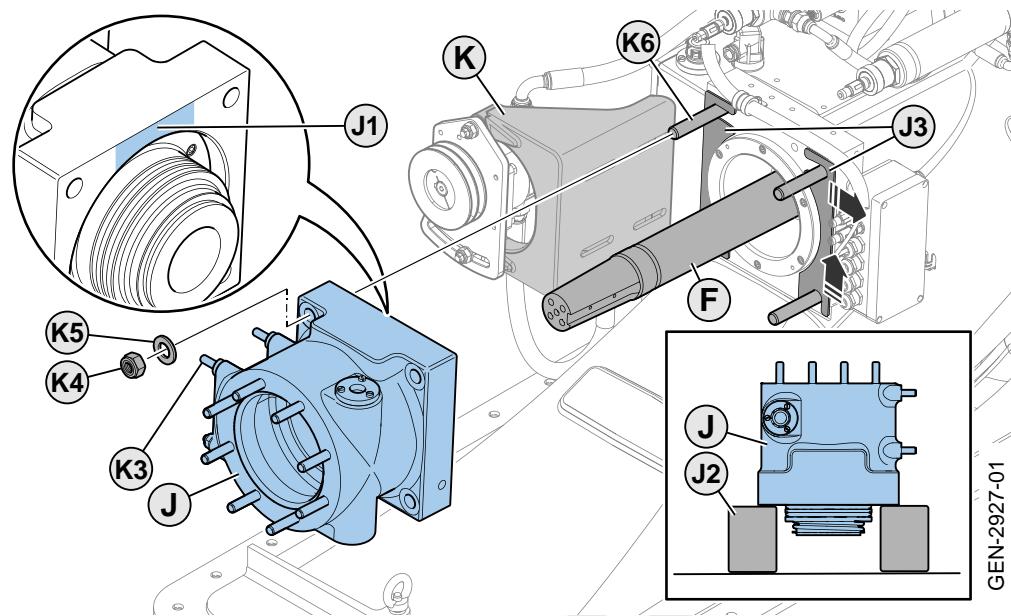


Figure 36

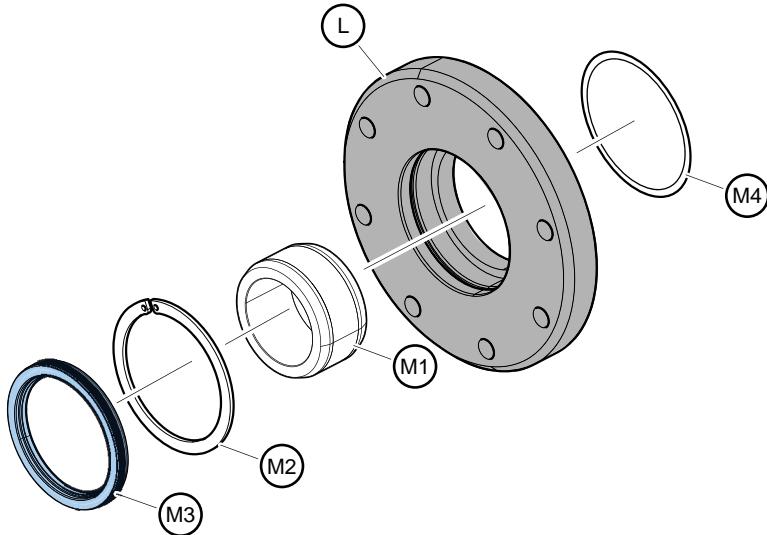
- 6.8 Remove the nuts (K4) and the washers (K5) from the studs (K6) on the intake.
- 6.9 Carefully move the bracket (K) with the attached pump off from the studs (K3) on the bearing unit (J).
- 6.10 Loosen the bearing unit by levering in the gap at the top (J1). When a larger gap is achieved the shims on both sides (J3) can be removed so that levering is possible all around the bearing unit.
- 6.11 With applicable lifting equipment, carefully pull off the complete bearing unit (J) from the studs (K6) and the drive shaft (F).
- 6.12 Place the bearing unit (J) vertically in a clean space.

Note!

To make sure the shaft seal is not damaged, use blocks (J2) to support the bearing unit (J).

Note!

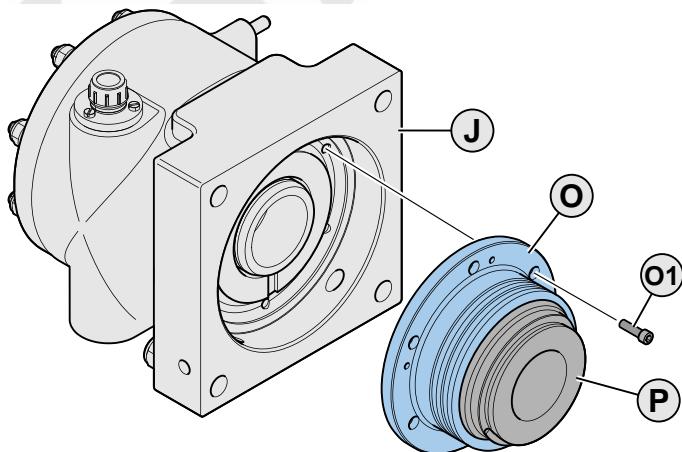
Cover the bearing unit (J) in cloth and/or plastic to protect the bearings.



GEN-2931-01

Figure 37

- 7 Replace the radial seal (M3) in the lid (L):
 - 7.1 Remove the o-ring (M4) from the lid (L).
 - 7.2 Remove the seal sleeve (M1) from the lid (L).
 - 7.3 Remove the circlip (M2) from the lid (L).
 - 7.4 Remove the radial seal (M3) from the lid (L).
 - 7.5 Install a new radial seal in the lid (L).
 - 7.6 Put water resistant grease on the seal face.
 - 7.7 Install the circlip (M2) and the seal sleeve (M1) into the lid (L).



GEN-2581-03

Figure 38

- 8 Remove the seal carrier from the thrust bearing unit.
 - 8.1 Remove the screws (O1) from the static seal carrier (O).
 - 8.2 Remove the static seal carrier (O) and the seal carrier (P) with attached components from the thrust bearing unit (J).

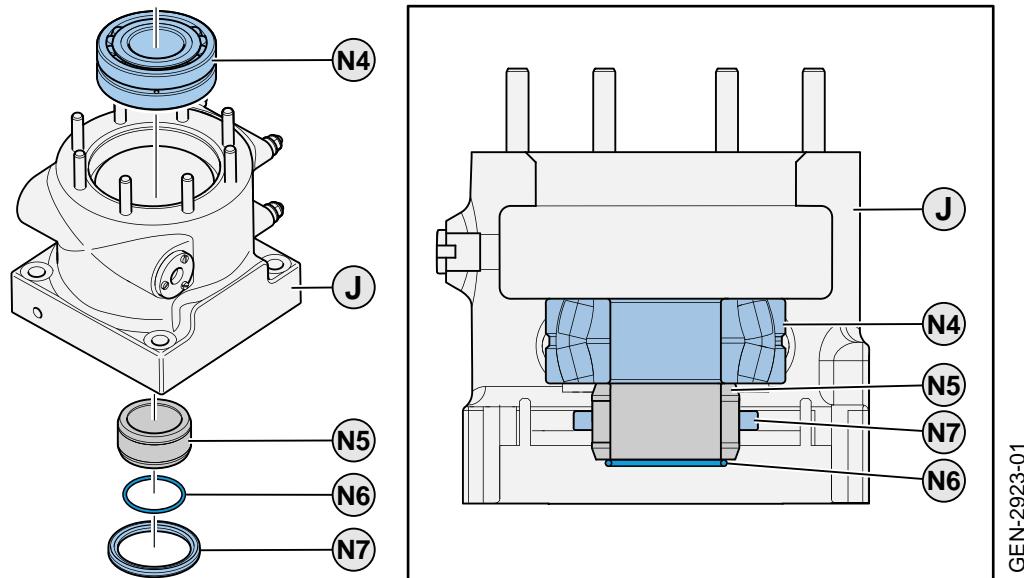


Figure 39

- 9 Replace the bearing (N4) and the seal sleeve (N5) in the bearing unit (J):
- 9.1 Carefully remove the components in the following order.
 - 9.2 Remove and replace the spherical roller bearing (N4).
 - 9.3 Remove and replace the O-ring (N6) and the seal sleeve (N5) but do not install the new.
 - 9.4 Remove and replace the seal (N7).
 - 9.5 Due to easy access when this task is being performed it is recommended that also the shaft seal is replaced. See *3.2.10 Thrust Bearing Unit, Replace Shaft Seal*.

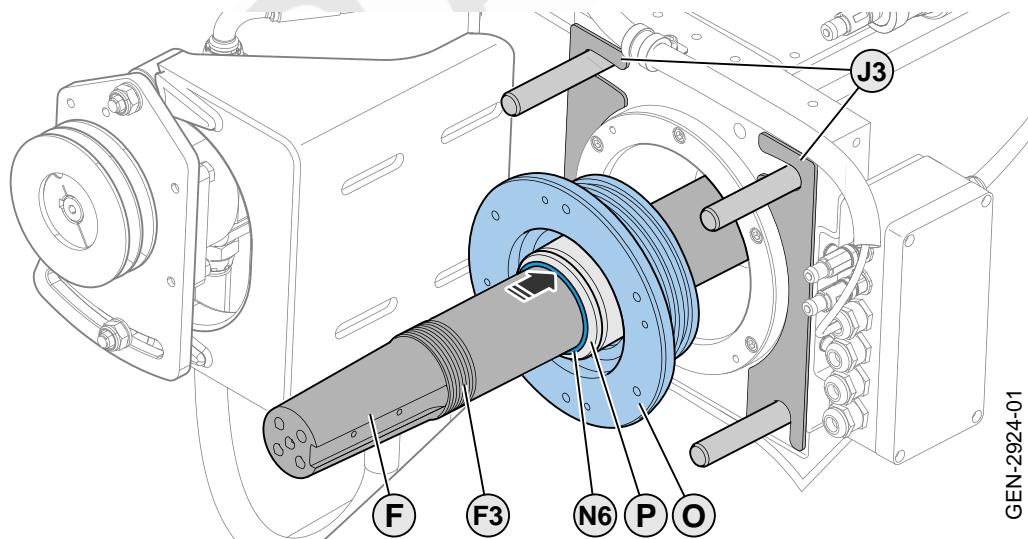


Figure 40

- 10 Install the bearing unit:
- 10.1 Install the shims (J3) on both sides on the studs.
 - 10.2 Carefully install the seal carrier (O) on the drive shaft (F). Do not push it all the way into position.
 - 10.3 Carefully install the O-ring (N6) on the drive shaft (F), push it all the way to the seal carrier (P). Make sure that the O-ring do not get damaged by the shaft threads (F3).

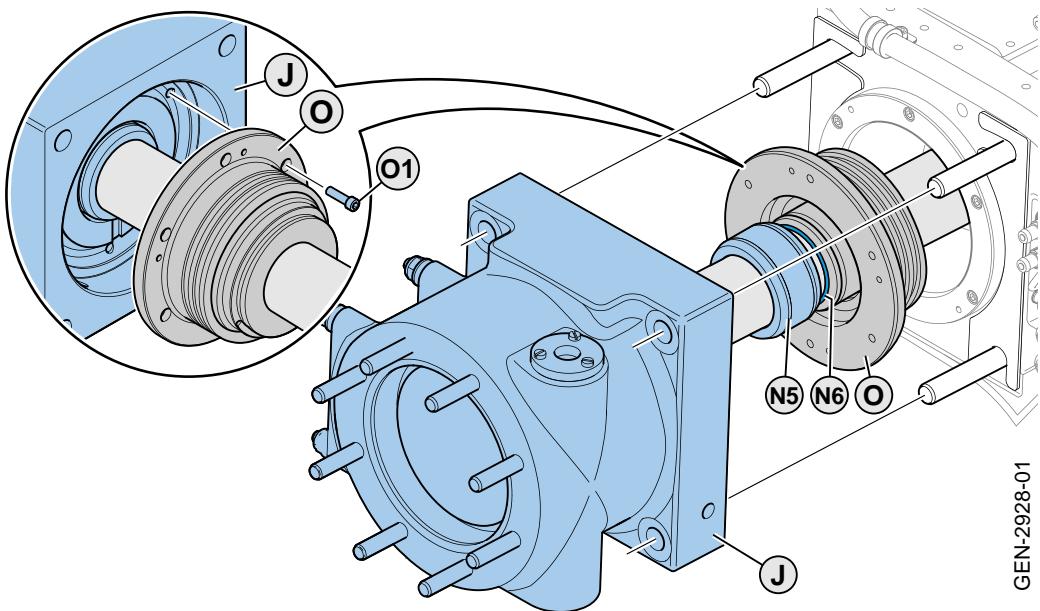


Figure 41

- 10.4 Install the seal sleeve (N5) all the way to the O-ring (N6).
- 10.5 Install the bearing housing (J) on drive shaft. Make sure not to damage the seal sleeve (N5).
- 10.6 Install the seal carrier (O) to the bearing housing (J) with bolts (O1). Tighten to torque.

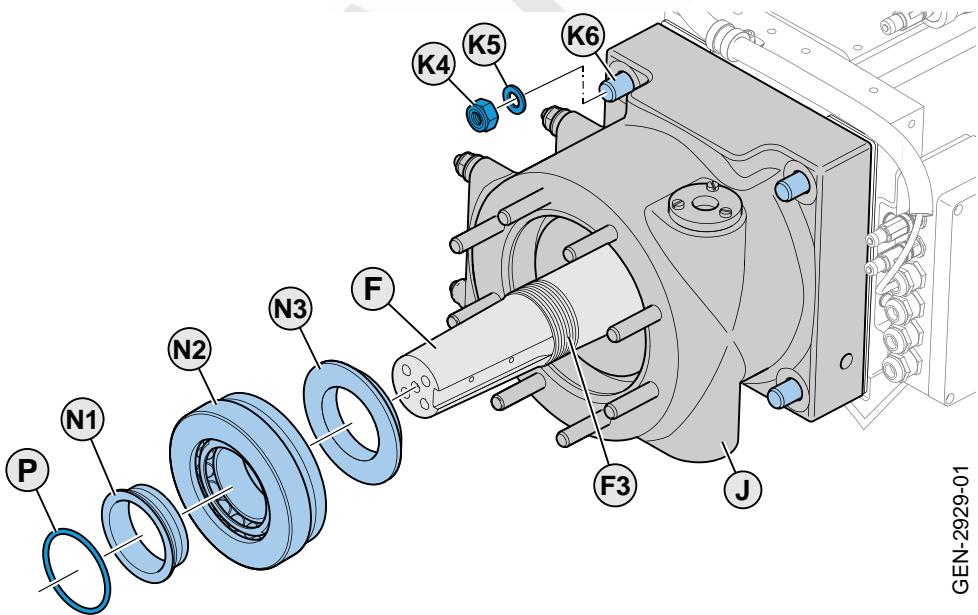
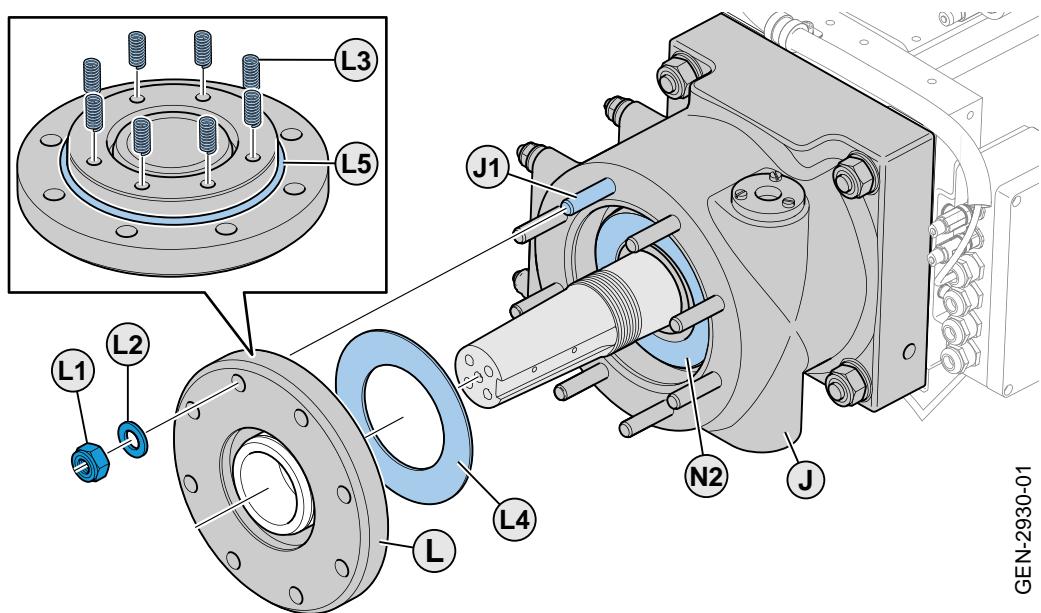


Figure 42

- 10.7 Install the bearing housing (J) to the intake.
- 10.8 Apply Loctite® 243 to the nuts (K4).
- 10.9 Install the washers (K5) and nuts (K4) on the studs (K6) to attach the bearing unit (J) to the intake. Tighten the nuts (K4) to torque 120 Nm.
- 10.10 Carefully install the bearing spacer (N3), the roller thrust bearing (N2) and the bearing spacer (N1) on the drive shaft (F).
- 10.11 Install the O-ring (P) on the shaft. Make sure that the O-ring do not get damaged by the shaft threads (F3).



GEN-2930-01

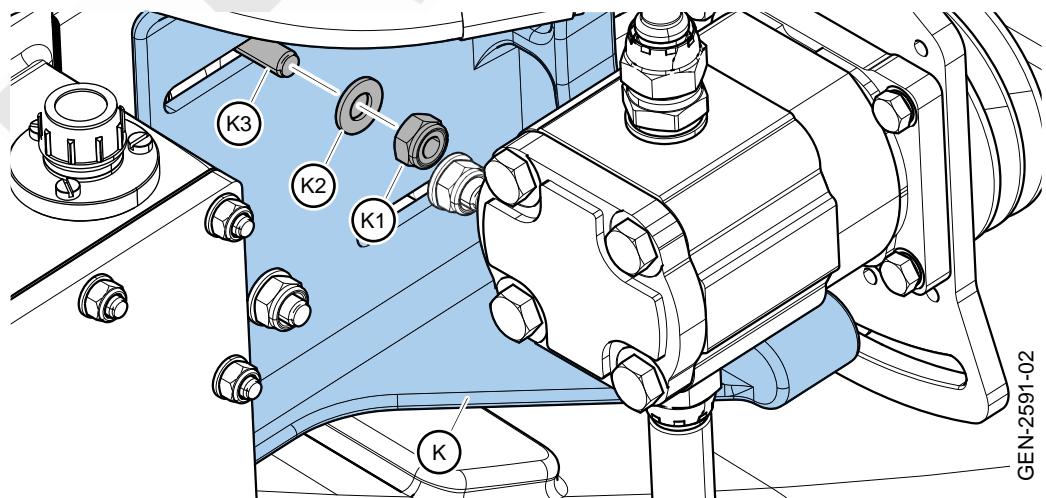
Figure 43

- 10.12 Install the O-ring (L5) on the back of the lid.
- 10.13 Install the springs (L3) in the back of the lid (L) and secure them with grease.
- 10.14 Smear a thin layer of grease on the inside of the shim (L4) and mount it against the roller thrust bearing (N2). Make sure it is centered around the drive shaft, and stays in place.
- 10.15 Carefully install the lid (L) with the springs, on the studs (J1) of the bearing unit (J).

Note!

Make sure that the springs (L3) are kept in place.

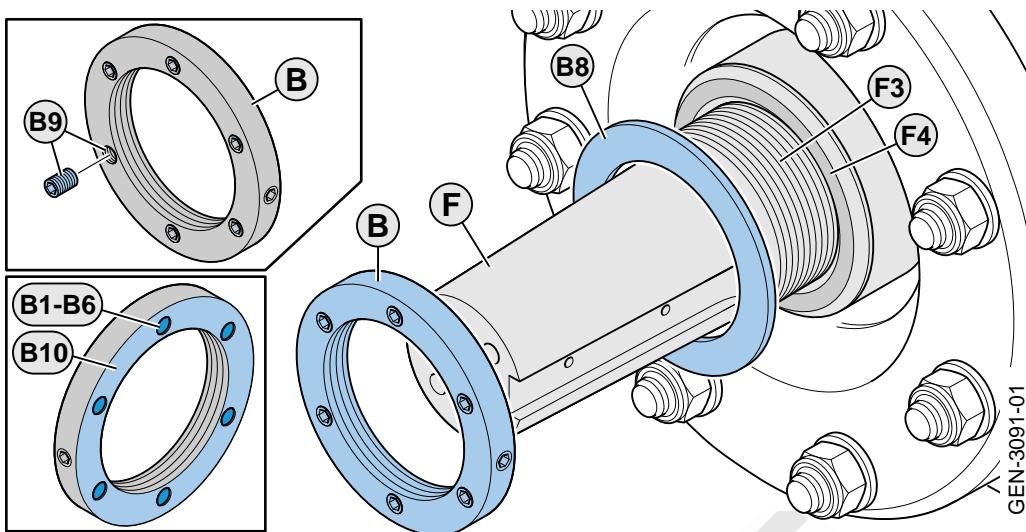
- 10.16 Apply Loctite® 243 to the nuts (L1).
- 10.17 Install the washers (L2) and the lock nuts (L1). Tighten the nuts to torque 65 Nm.



GEN-2591-02

Figure 44

- 10.18 Apply Loctite® 243 on the nuts (K1).
- 10.19 Install the nuts (K1) and the washers (K2) on the studs (K3) to attach the bearing unit to the bracket (K). Tighten the nuts (K1) to torque to 34 Nm.



GEN-3091-01

Figure 45

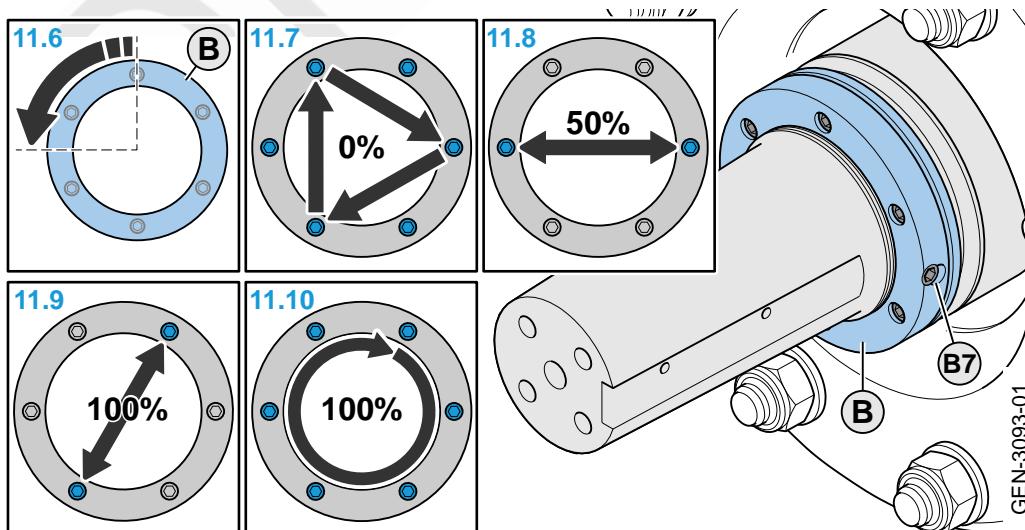
11 Install the jackbolt tensioner to drive shaft.

- 11.1 Before reusing the jackbolt tensioner, remove all the jackbolts (B1-B6), clean the threads (B9) and lubricate with anti-seize lubricant. Put the jackbolts back into the tensioner (B).
- 11.2 Make sure that the jackbolts (B1-B6) do not protrude beyond the load surface (B10) and are well lubricated on the end.
- 11.3 Clean the drive shaft threads (F3) and contact area (F4). Lubricate the threads with anti-seize lubricant.
- 11.4 Put the washer (B8) all the way to the contact area (F4).

Note!

When reusing a hardened washer, turn the previous used side away from the jackbolt tensioner.

- 11.5 Screw the jackbolt tensioner on to the drive shaft by hand. Firmly tighten the tensioner by hand against the washer .



GEN-3093-01

Figure 46

- 11.6 Turn back the tensioner a quarter turn to create a gap to the washer (1-3 mm).
- 11.7 Tighten all jackbolts (B1-B6) by hand crosswise.

- 11.8 Tighten two opposite jackbolts to 50% of recommended torque.

Note!

Recommended Torque is 8 Nm.

- 11.9 Tighten two other opposite jackbolts to 100% of recommended torque.
- 11.10 Tighten all jackbolts in a circular pattern to 100% of recommended torque until fully tightened.
- 11.11 If torque can not be achieved, the thrust bearing was not fully compressed. Loosen the jackbolt and install again. (Steps 11.2 + 11.4-11.10)
- 11.12 Tighten screw (B7) to lock the jackbolt tensioner to the shaft threads.

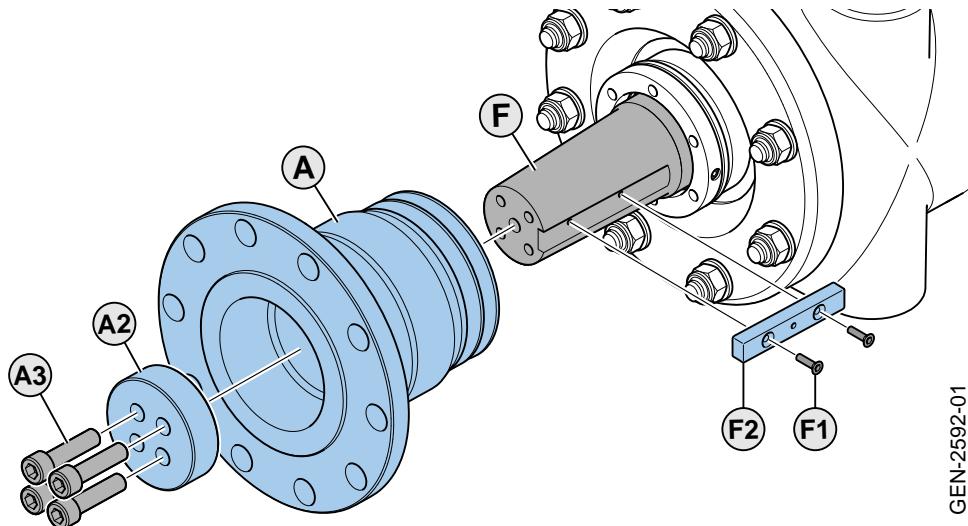


Figure 47

- 12 Install the shaft flange to the drive shaft.
- 12.1 Apply Loctite® 243 to the screws (F1).
 - 12.2 Install the key (F2) on the drive shaft (F) with the screws (F1) and tighten to torque 4.8 Nm.
 - 12.3 Centre the drive shaft flange (A) on the key (F2).
 - 12.4 Apply Loctite® 243 to the screws (A3).
 - 12.5 Fit the flange washer (A2) on the drive shaft (F) and gradually tighten the screws (A3) diagonally to push the drive shaft flange on to the taper of the drive shaft (F). Tighten the screws (A3) to torque 44 Nm.
- 13 Install the belt guards and the V-belts again. See 3.3.32 *V-Belts, Replace* step 2.
- 14 Fill new oil to the thrust bearing unit. See 3.3.16 *Thrust Bearing, Replace Oil*
- 15 With new oil, It is recommended to also change the air filter. See 3.3.9 *Hydraulic and Lubrication System, Replace Filler Breather Filter*
- 16 Task completed.

3.2.10 Thrust Bearing Unit, Replace Shaft Seal

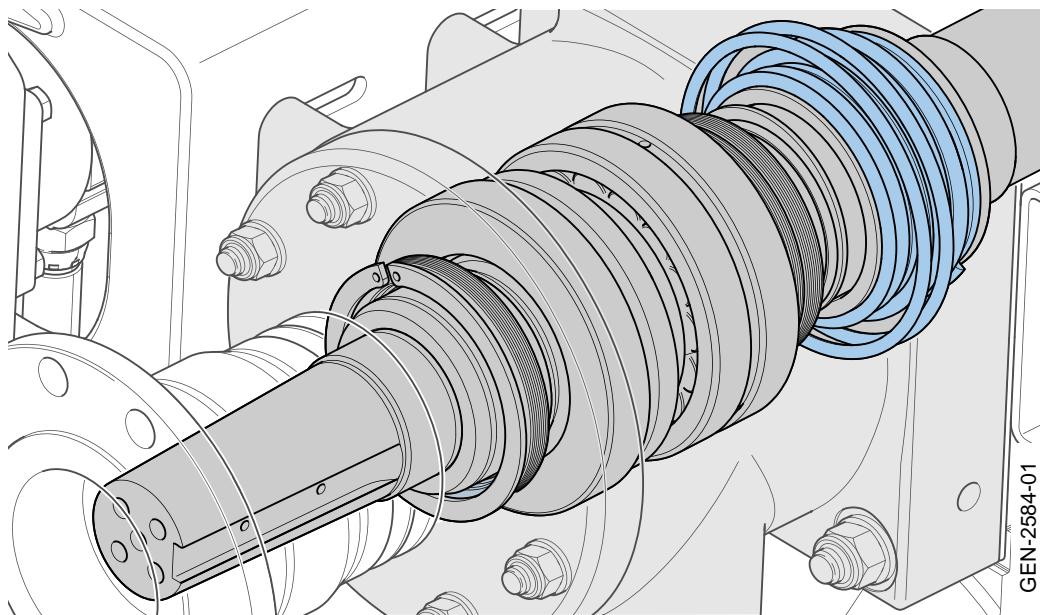


Figure 48

Task Summary

The task is to replace the shaft seal, the O-rings and the static face.

Task Interval

Do this task during:

- Preventive maintenance, every 5th year or 8 000 operating hours.
- Corrective maintenance.

Prerequisites

Conditions

Intermediate shafting removed to create space in front of the waterjet.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dock, workshop / dry dock	60 minutes

Spare parts	Quantity	Part number
X350 Spare Mechanical seal kit	1	X350-1110-SP

Consumables	Quantity	Part number
Loctite SF 7063 Parts Cleaner / CRC Brakleen	-	-
Wiping cloth (lint-free)	-	-
Molykote 111 compound	-	-

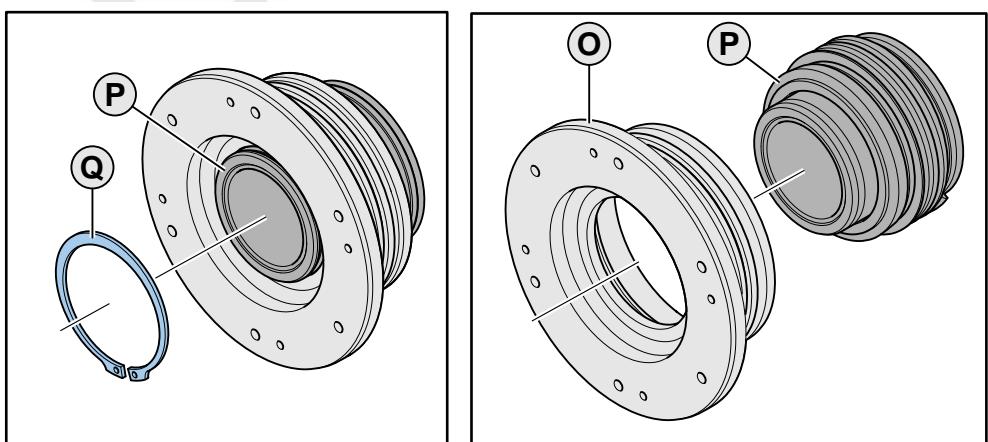
Special tools and test equipment	Quantity	Part number
Pull-off plate	1	-

Reference document

3.3.32 V-Belts, Replace
3.2.9 Thrust Bearing Unit, Replace Thrust Bearing and Radial Seals

Procedure

- 1 Remove the belt guards and the V-belts. See 3.3.32 V-Belts, Replace step 1 to step 1.6.
- 2 Remove the bearing unit from the drive shaft and the seal carrier from the thrust bearing unit. See 3.2.9 Thrust Bearing Unit, Replace Thrust Bearing and Radial Seals, step 3 -6 + step 8.
- 3 Replace the shaft seal, the O-ring, the static seal face and the rotary seal face:



GEN-2594-01

Figure 49

- 3.1 Remove the circlip (Q) from the seal carrier (P).

- 3.2 Remove the seal carrier (P) with attached components from the static seal carrier (O).

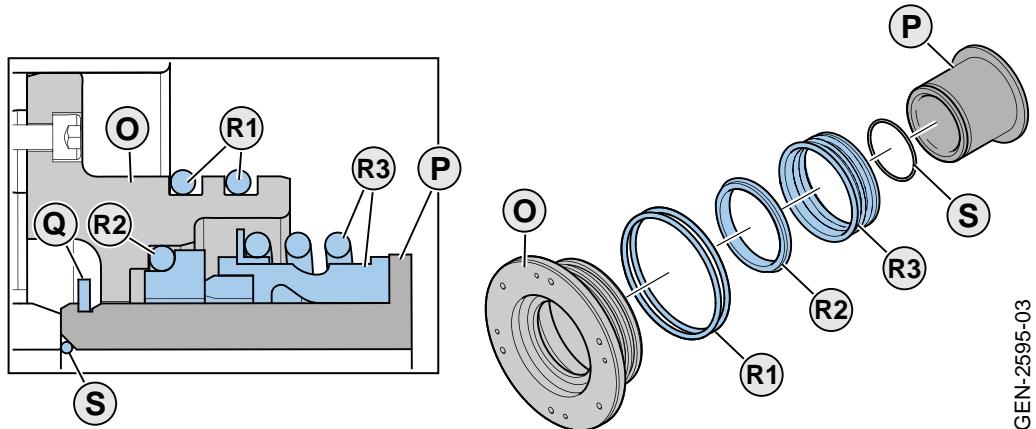


Figure 50

- 3.3 Remove the O-rings (R1) and the static seal face of the shaft seal (R2) from the static seal carrier (O).
- 3.4 Smear the new O-rings with Molykote 111 Compound and insert onto the static seal carrier (O).
- 3.5 Insert new static part of shaft seal (R2) into the static seal carrier (O). Use water onto O-rings outer surface of static part of shaft seal to facilitate fit in static seal carrier (O).
- 3.6 Clean the sealing surface of static face of the shaft seal (R2) with prescribed cleaning fluids. Wipe of the surface with lint free cloth.
- 3.7 Remove rotating part of shaft seal (R3) from the seal carrier (P).
- 3.8 Put a new rotating part of shaft seal (R3) onto the seal carrier (P). Use water onto internal surface of rubber bellow to facilitate installation onto the seal carrier (P).
- 3.9 Replace the O-ring (S). Smear with Molykote 111 compound.

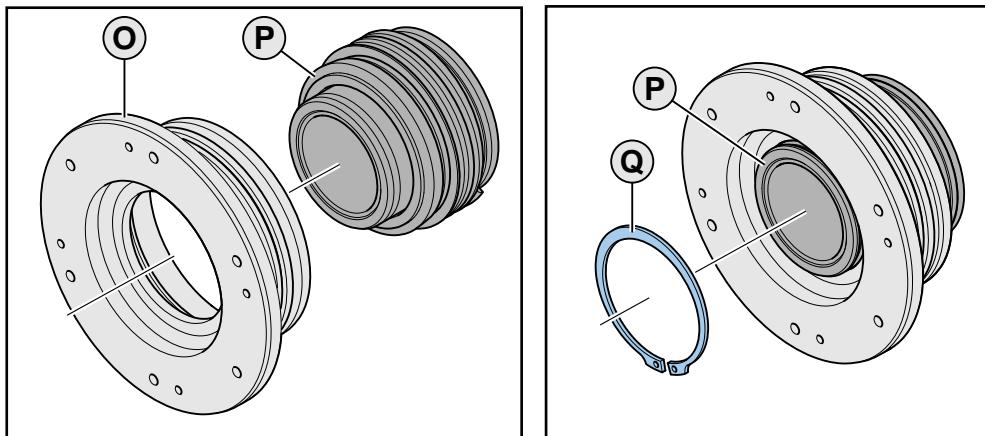


Figure 51

- 3.10 Clean surface of rotating part of shaft seal (R3) with prescribed cleaning fluid and wipe of with lint-free cloth.
- 3.11 Install the seal carrier (P) with attached components into the static seal carrier (O).
- 3.12 Install a new circlip (Q) on the seal carrier (P).

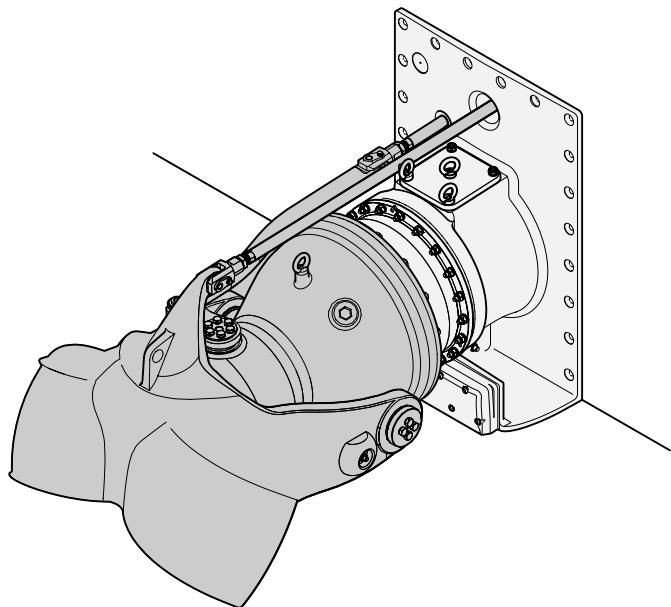
Note!

Due to easy access it is recommended that the circlip (Q) also is replaced when this task is being performed.

- 4 Install the bearing unit (J) on the drive shaft. See 3.2.9 *Thrust Bearing Unit, Replace Thrust Bearing and Radial Seals* from step 10 .
- 5 Install the belt guards and the V-belts again. See 3.3.32 *V-Belts, Replace* step 2.
- 6 Task completed.

DRAFT

3.2.11 Waterjet Unit, Inspect



GEN-2408-01

Figure 52

Task Summary

The task is to inspect the waterjet (pump unit, pin shafts and anodes) for damages or corrosion.

Task Interval

Do this task during:

- Preventive maintenance, annually / while docked.

Prerequisites

Conditions

The vessel is dry docked and supported properly.

The intake is clean.

Necessary scaffolding to access intake.

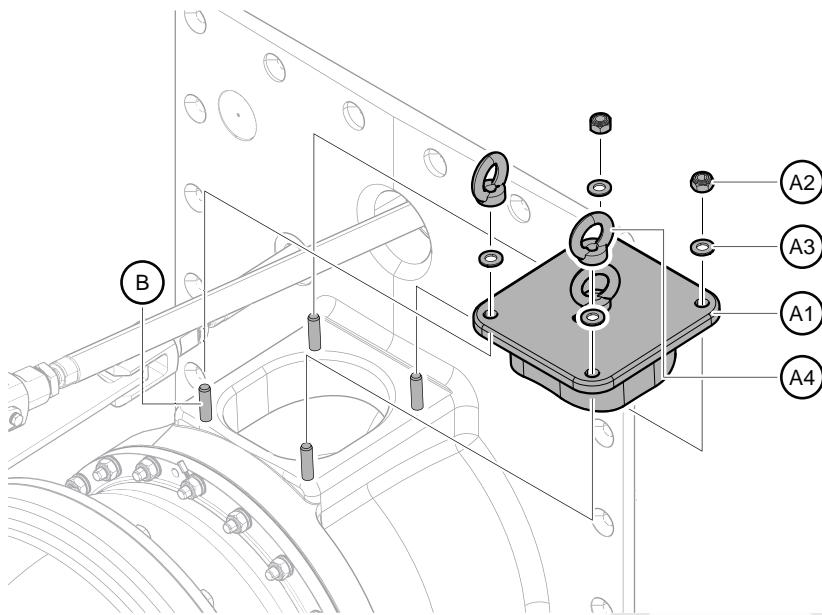
Number of personnel	Skill level	Maintenance facility level (choose one)	Estimated time
1	Chief Engineer	Dock, workshop / dry dock	30 minutes

Reference document

5.1 Paint Program

5.2 Torque

Procedure



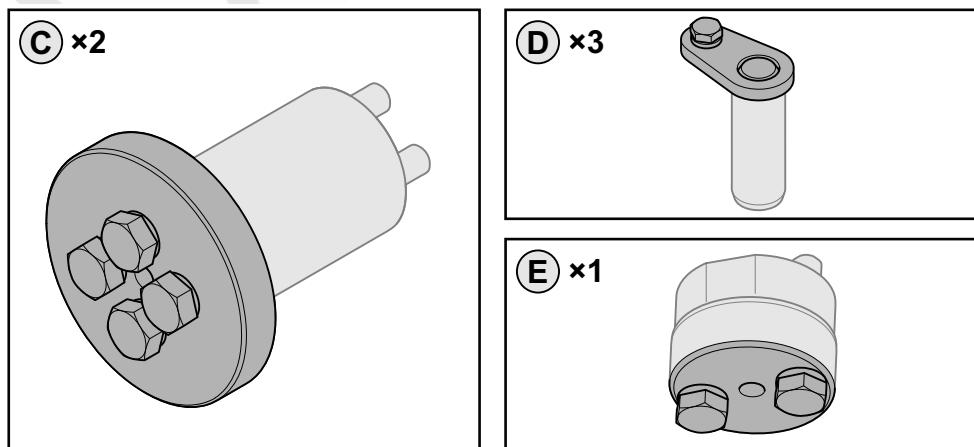
GEN-2562-01

Figure 53

- 1 Open the inspection hatch (A1) on the intake (B):
 - 1.1 Remove the nuts (A2), washers (A3) and lifting eyes (A4).
 - 1.2 Remove the inspection hatch (A1).
- 2 Carefully inspect the impeller condition. Grind out small dents or scratches. If a large renovation is needed, contact MJP.
- 3 Inspect blade tip clearance and adjust if needed.
- 4 Inspect the intake. Repair damage to bars, geometry (grind out) or paint. See


Caution!

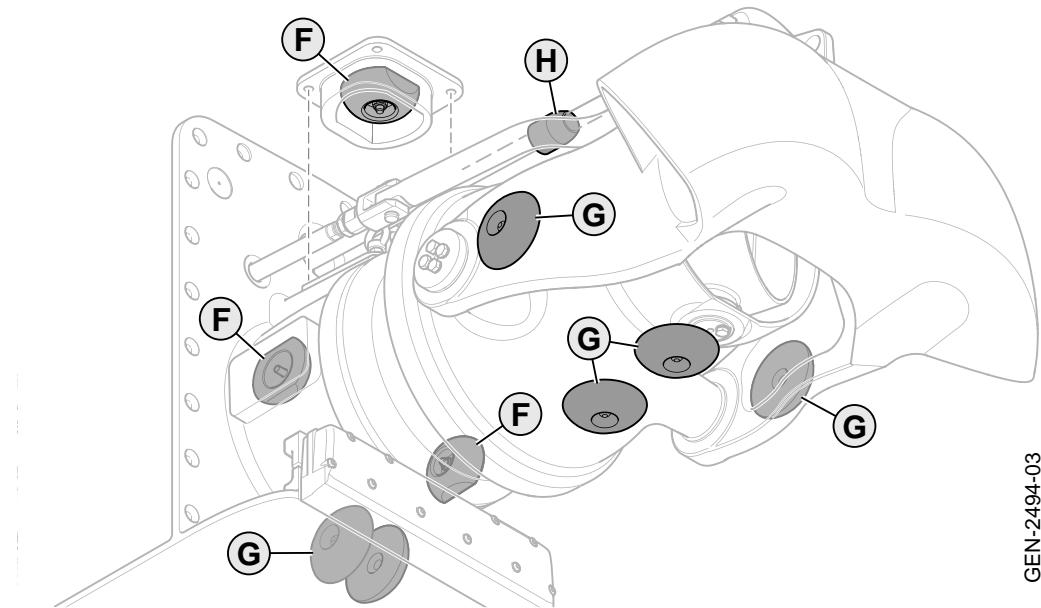
Even small paint defects can be onset to rapid corrosion seriously affecting the product life time.



GEN-2493-02

Figure 54

- 5 Inspect the tightening torque on the pin shafts (C), (D) and (E). See .

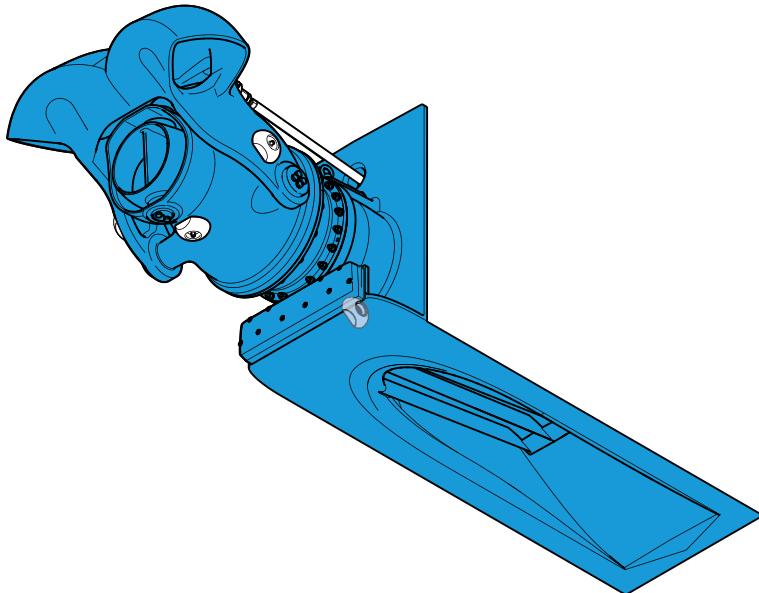


GEN-2494-03

Figure 55

- 6 Inspect the anodes (F), (G) and (H). If consumed to more than 50%, change the anodes. See 3.2.14 *Waterjet Unit, Replace the Anodes*.
- 7 Inspect the paint for damages or exfoliation. If damaged or exfoliated, repaint according to .
- 8 Close the inspection hatch (A1) on the intake again:
 - 8.1 Apply Loctite® 2701 to the studs (B) on the intake.
 - 8.2 Attach the inspection hatch (A1) to the studs (B).
 - 8.3 Apply Loctite® 243 to the nuts (A2) and the lifting eyes (A4).
 - 8.4 Install the washers (A3) nuts (A2) and lifting eyes (A4) to the inspection hatch (A1).
 - 8.5 Tighten the nuts (A2) to torque 34 Nm.
 - 8.6 Firmly tighten the lifting eyes (A4).
- 9 Task completed.

3.2.12 Waterjet Unit, Clean



GEN-2567-01

Figure 56

Task Summary

The task is to clean the waterjet, steering unit, pump unit and intake.

Task Interval

Do this task during:

- Corrective maintenance, annually / while docked

Prerequisites

Conditions

The vessel is dry docked and supported properly.

All parts outside of hull are clean.

Necessary scaffolding to access waterjet in a safe manner.

Pressure washer (water) available.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Task Specialist	Dock, workshop / dry dock	40 minutes

Procedure

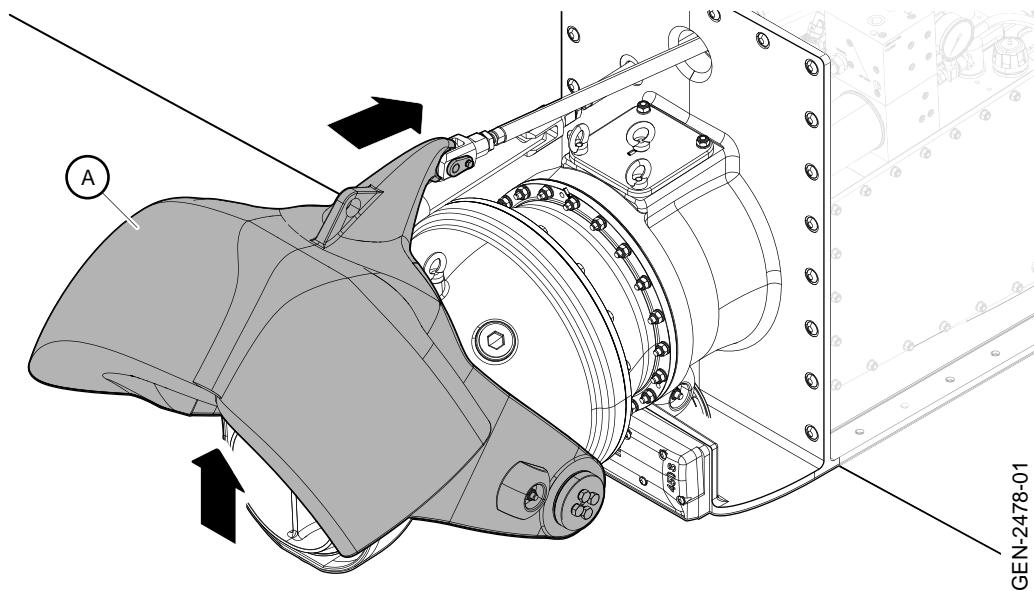


Figure 57

- 1 Put the bucket (A) in fully forward position.

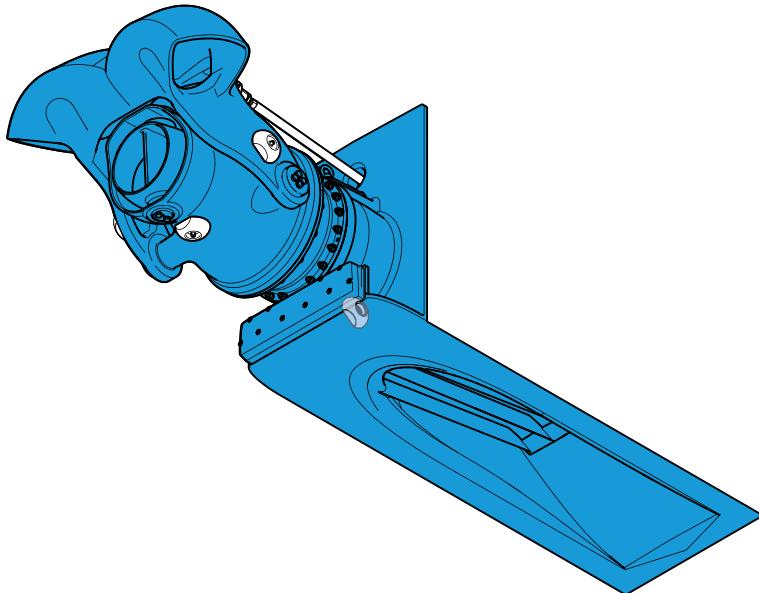


Caution!

Do not aim high pressured water directly at sealing areas on hydraulic cylinders. This will help to prevent damage to the equipment.

- 2 Clean the inside of the intake and the pump unit, from top to bottom. Make sure to remove all unwanted material.
- 3 Clean the outside of the waterjet unit, from top to bottom. Make sure to remove all unwanted material.
- 4 Task completed.

3.2.13 Waterjet Unit, Paint During Service



GEN-2567-01

Figure 58

Task Summary

The task is to paint the waterjet unit when in need of a touch up.

Note!

MJP recommends to paint the waterjet unit with anti-fouling paint. The anti-fouling paint must be suitable for use on aluminium and stainless steel components and compatible with the epoxy paint finish of the unit.



Caution!

Do not use metallic based paint with anti-fouling properties, it can cause galvanic corrosion and damage the equipment.

Task Interval

Do this task during:

- Corrective maintenance, annually / while docked

Prerequisites

Conditions

The boat is dry docked and supported properly.

The waterjet unit is clean and dry.

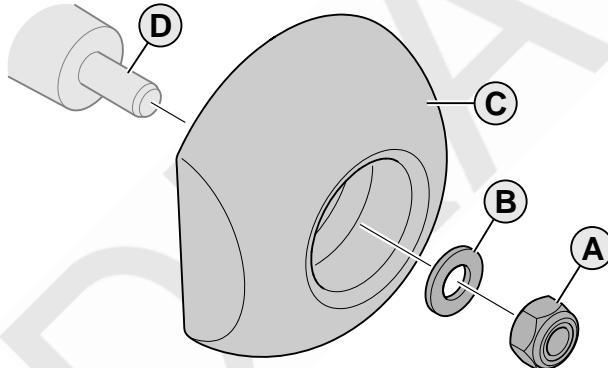
Piston rods and hoses / surrounding areas are masked adequately to avoid unintentional painting.

Necessary scaffolding to access unit in a safe manner.

Mineral grit available.

Number of personnel	Skill level	Maintenance facility level	Estimated time		
1	Task specialist	Dock, workshop / dry dock	30 minutes		
Consumables	Quantity	Part number			
Paint. See reference document.	-	-			
Emulsion cleaner	-	-			
Reference document					
5.1 Paint Program					

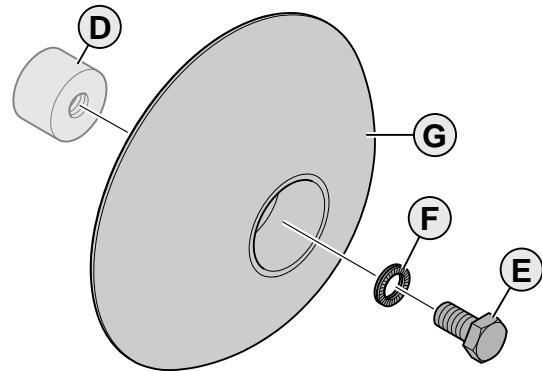
Procedure



GEN-2243-01

Figure 59

- 1 Remove the anodes:
 - 1.1 Remove the lock nuts (A) and washers (B) from the anode mounts (D).
 - 1.2 Remove the anodes (C) from the anode mounts.



GEN-0382-02

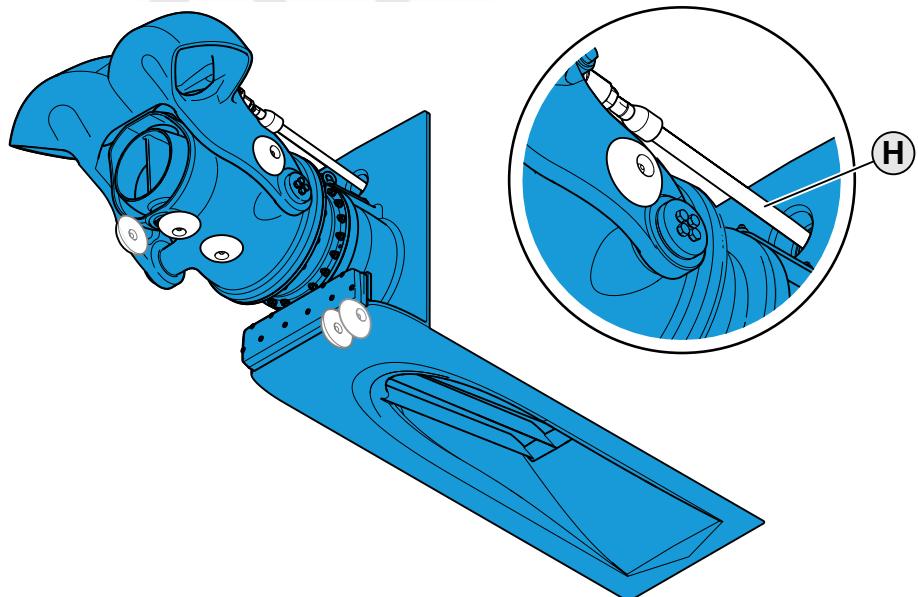
Figure 60

- 2 Remove the anodes:
 - 2.1 Remove the screws (E) and lock washers (F) from the anode mounts (D).
 - 2.2 Remove the anodes (G) from the anode mounts.
- 3 Clean the anode mounts (D).

**Caution!**

Before you install the new anodes, make sure that the anode mount is clean from oxide, paint and dirt. This will help prevent damage to the equipment.

- 4 Remove oil and grease with an emulsion cleaner.
- 5 Clean the entire area with high pressure fresh water in order to remove salts and other impurities.
- 6 Let the surface dry.
- 7 Remove dust from all areas.



GEN-2568-02

Figure 61

- 8 Make sure to mask the cylinder rod and the cylinder openings (H), in the impeller house, to protect it from paint.
- 9 Paint the waterjet surfaces and the inside of the intake.



Caution!

Do not paint the anodes, anode mount (D) surface or threads. The paint can decrease the corrosion protection from the anodes. This can cause damage to the equipment.



Caution!

Make sure that the anti-foul paint does not come in contact with the cylinder rod. This can cause damage to the equipment.



Caution!

Do not paint the impeller. This can cause damage to the equipment.



Caution!

Do not paint interceptors if installed. This can cause damage to the equipment.

10 Install the anodes (C) again:

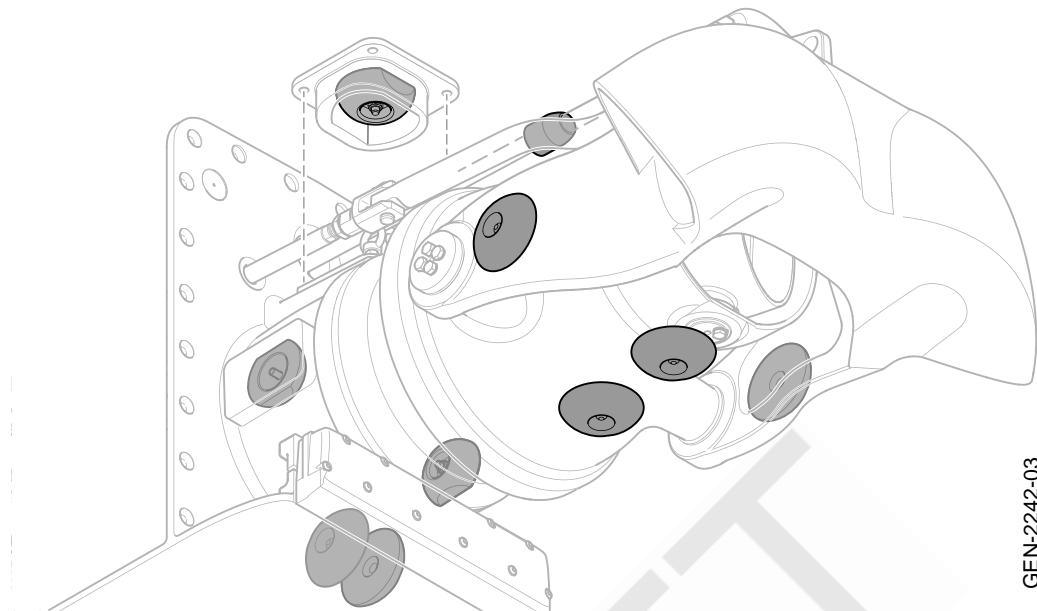
- 10.1 Apply Loctite® 243 to the lock nuts (A).
- 10.2 Install the anodes (C) to the anode mounts (D).
- 10.3 Install the washers and the lock nuts to the anode mounts (D).
- 10.4 Tighten the nuts to torque 31-34 Nm.

11 Install the anodes (G) again:

- 11.1 Apply Loctite® 243 to the screws.
- 11.2 Install the anodes to the anode mounts (D).
- 11.3 Install the lock washers (F) and screws (E) to the anode mounts (D).
- 11.4 Tighten the screws to torque 31-34 Nm.

12 Task completed.

3.2.14 Waterjet Unit, Replace the Anodes



GEN-2242-03

Figure 62

Task Summary

The task is to replace the anodes on the waterjet unit.

Task Interval

Do this task during:

- Corrective maintenance, if the anodes are consumed to ≥50%

Prerequisites

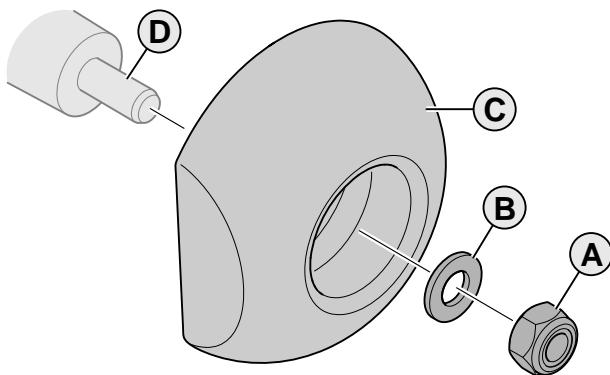
Conditions

None

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Chief Engineer	Dockside	20 minutes

Spare parts	Quantity	Part number
X350 Spare Anode Kit (Zink) (Alu) (Magn)	1 per jet	X350-1350-SP(Z)

Procedure



GEN-2243-01

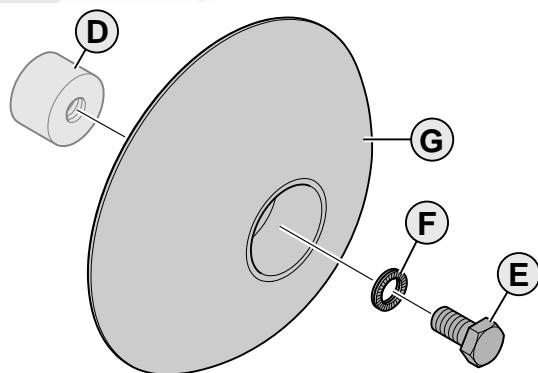
Figure 63

- 1 Remove the anodes:
 - 1.1 Remove the lock nuts (A) and washers (B) from the anode mounts (D).
 - 1.2 Remove the anodes (C) from the anode mounts.
- 2 Clean the anode mounts (D).

**Caution!**

Before you install the new anodes, make sure that the anode mounts is clean from oxide, paint and dirt. This will help prevent damage to the equipment.

- 3 Install the new anodes:
 - 3.1 Apply Loctite® 243 to the new lock nuts.
 - 3.2 Install the new anodes to the anode mounts (D).
 - 3.3 Install the new washers and lock nuts to the anode mounts (D).
 - 3.4 Tighten the new nuts to torque 31-34 Nm.



GEN-0382-02

Figure 64

- 4 Remove the anodes:
 - 4.1 Remove the screws (E) and lock washers (F) from the anode mounts (D).
 - 4.2 Remove the anodes (G) from the anode mounts.
- 5 Clean the anode mounts (D).

**Caution!**

Before you install the new anode, make sure that the anode mounts is clean from oxide, paint and dirt. This will help prevent damage to the equipment.

- 6 Install the new anodes:
 - 6.1 Apply Loctite® 243 to the new screws.
 - 6.2 Install the new anodes to the anode mounts (D).
 - 6.3 Install the new lock washers (F) and screws to the anode mounts (D).
 - 6.4 Tighten the new screws to torque 31-34 Nm.
- 7 Task completed.

DRAFT

3.2.15 Waterjet Unit, Inspect Bushings and Pin Shafts

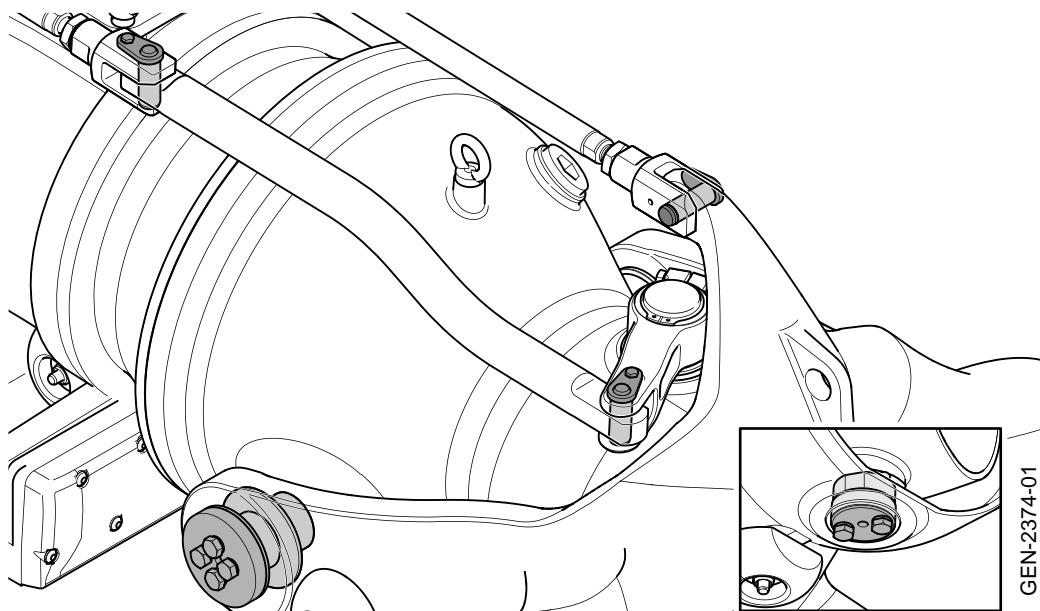


Figure 65

Task Summary

The task is to inspect bushings and pin shafts on the waterjet unit.

Task Interval

Do this task during:

- Preventive maintenance, annually

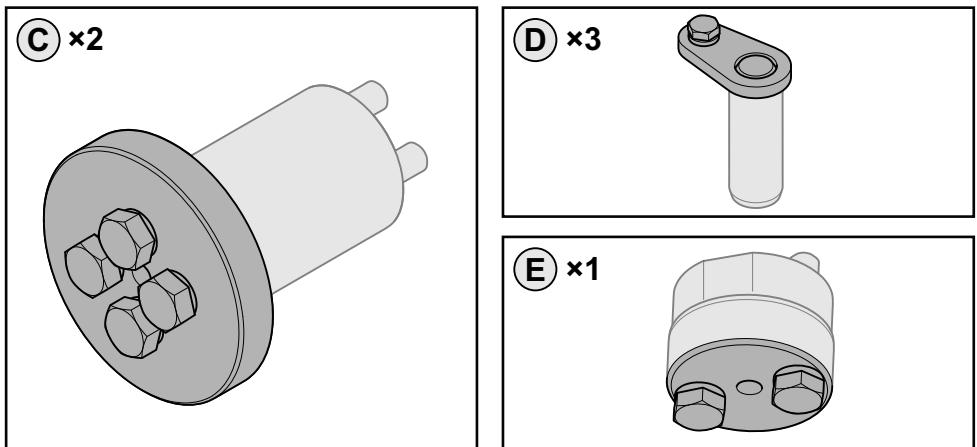
Prerequisites

Conditions

Necessary scaffolding to access unit.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Chief Engineer	Dock, workshop / dry dock	1 hour

Procedure



GEN-2493-02

Figure 66

- 1 Locate all joints (C), (D) and (E) on the steering unit.
- 2 Insert a crow bar and press / bend at each joint. If the parts attached to the joint are moving radially from the bushing or pin, change bushings and pin shafts. See 3.2.16 Waterjet Unit, Replace Bushings and Pin Shafts.
- 3 Task completed.

3.2.16 Waterjet Unit, Replace Bushings and Pin Shafts

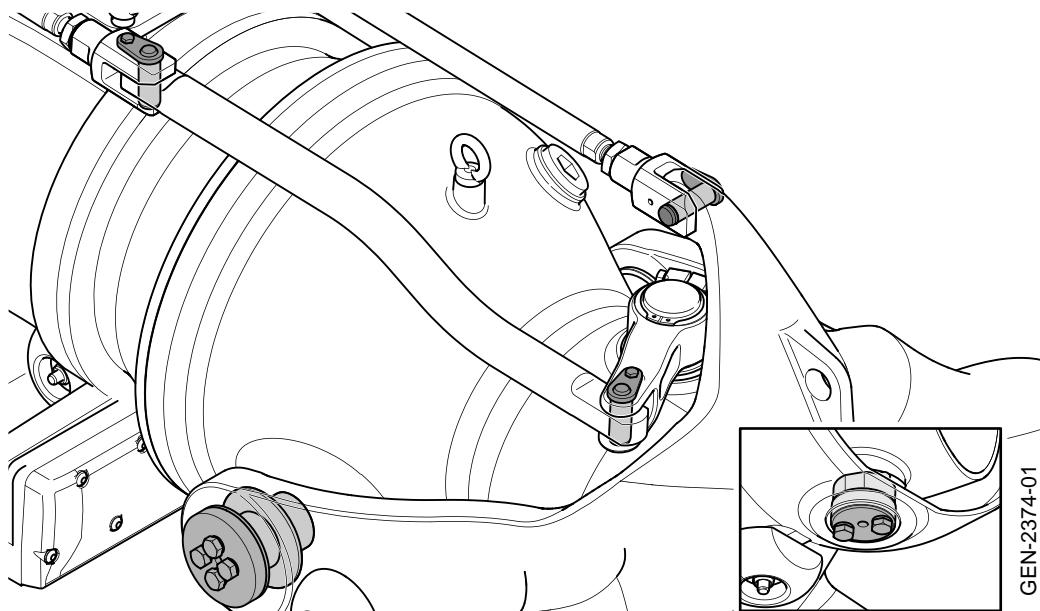


Figure 67

Task Summary

The task is to replace all bushings and pin shafts on the waterjet unit.



Warning!

Before you disassemble the waterjet unit, make sure to wear protective equipment. This will help prevent injury to personnel.

Task Interval

Do this task during:

- Condition based/Corrective maintenance

Prerequisites

Conditions

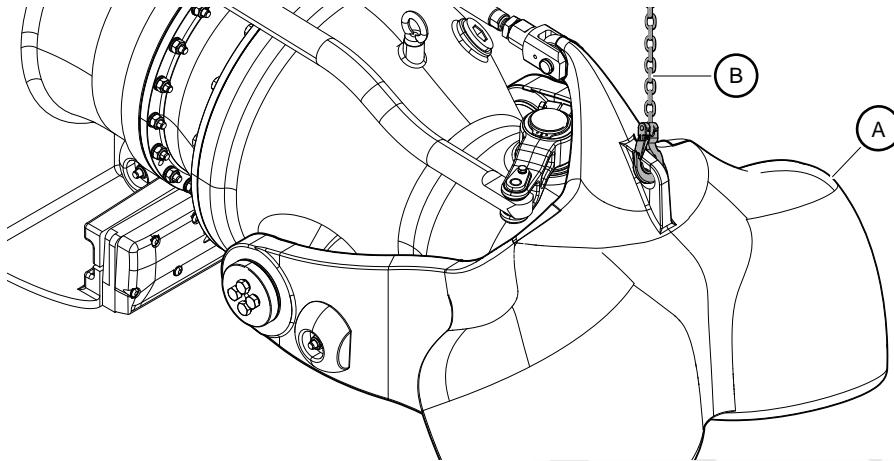
Sliding hammer available

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Chief Engineer	Dock, workshop / dry dock	8 hours

Spare parts	Quantity	Part number
X350 Spare Bushing Set	1 per jet	X350-1208-SP
X350 Spare Pinshaft Set	1 per jet	X350-1205-SP

Consumables	Quantity	Part number
Anti seize paste	-	-
Thread locking paste	-	-

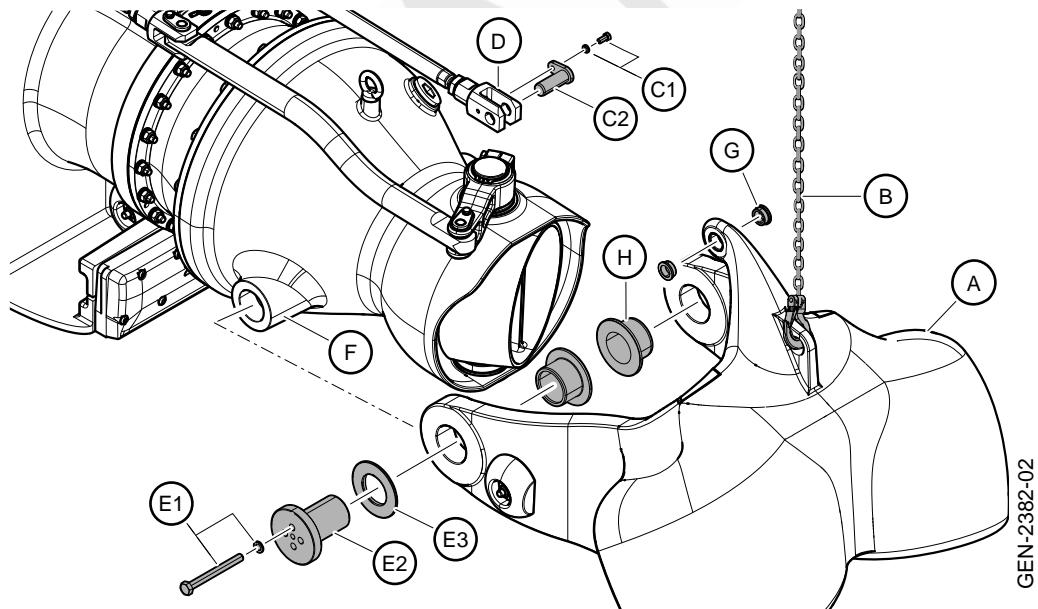
Procedure



GEN-2381-02

Figure 68

- 1 Use a lifting device (B) to secure the bucket (A).



GEN-2382-02

Figure 69

- 2 Remove the screw and the washer (C1) from the pin shaft (C2).

Note!

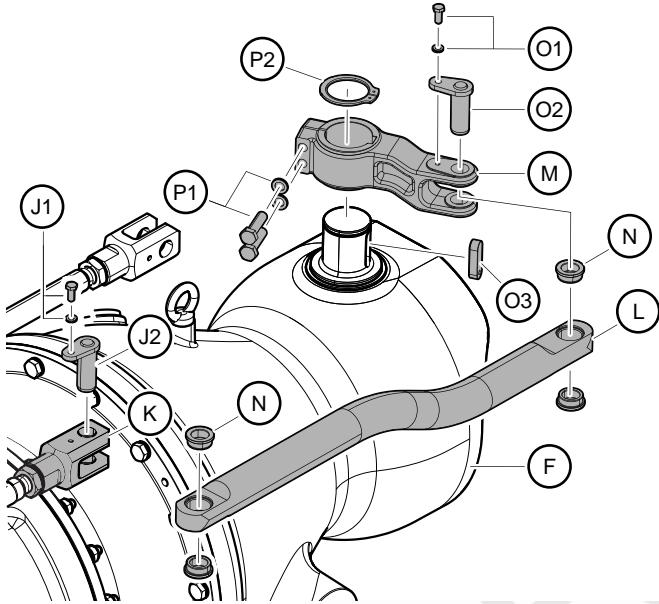
On assembly, apply Molykote DX paste to the screw (C1) and tighten to torque 8.4 Nm.

- 3 Use a sliding hammer to remove the pin shaft (C2) from the steering rod clevis (D).
- 4 Remove the screws and the washers (E1) from the pivot pins (E2).

Note!

On assembly, apply Molykote DX paste to the screws (E1) and tighten to torque 39 Nm.

- 5 Remove the pivot pins (E2) and the washers (E3) from the diffuser assembly (F).
- 6 Remove the bucket (A).
- 7 Remove the bushings (G) from the bucket (A).
- 8 Remove the bushings (H) from the bucket (A).
- 9 Use a plastic mallet to gently install the new bushings on the bucket (A).



GEN-2383-02

Figure 70

- 10 Remove the screw and the washer (J1) from the pin shaft (J2).

Note!

On assembly, apply Molykote DX paste to the screw (J1) and tighten to torque 8.4 Nm.

- 11 Use a sliding hammer to remove the pin shaft (J2) from the reversing rod clevis (K).
- 12 Remove the push rod (L) from the reversing rod clevis (K) and the steering tiller arm (M).
- 13 Remove the bushings (N) from the push rod (L).
- 14 Use a plastic mallet to gently install the new bushings on the push rod (L).
- 15 Remove the screw and the washer (O1) from the pin shaft (O2).

Note!

On assembly, apply Molykote DX paste to the screw (O1) and tighten to torque 8.4 Nm.

- 16 Use a sliding hammer to remove the pin shaft (O2) from the steering tiller arm (M).
- 17 Remove the screws and washers (P1) from the steering tiller arm (M).

Note!

On assembly, apply Molykote DX paste to the screw (P1) and tighten to torque 39 Nm.

- 18 Remove the retaining ring (P2) from the steering tiller arm (M).
- 19 Remove the steering tiller arm (M) from the diffuser assembly (F).

- 20 Remove the steel key (O3).

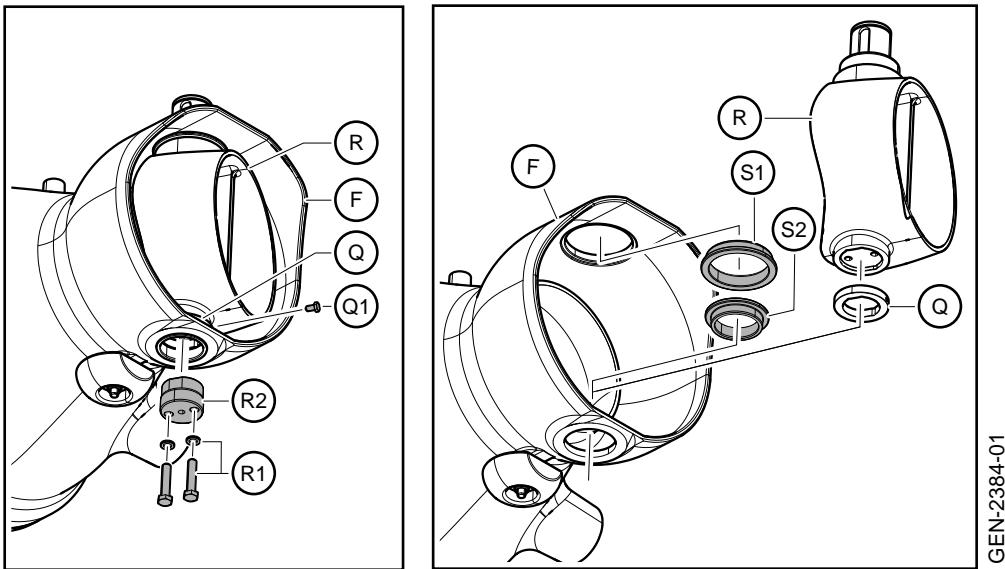


Figure 71

- 21 Remove the lock screw (Q1) from the spacer (Q).

Note!

On assembly, apply Molykote DX paste to the screw (Q1) and tighten to torque 7 Nm.

- 22 Remove the screws and washers (R1) from the steering pin shaft (R2).

Note!

On assembly, apply Molykote DX paste to the screw (R1) and tighten to torque 39 Nm.

- 23 Remove the steering pin shaft (R2) from the diffuser assembly (F).
- 24 Remove the spacer (Q) and the steering nozzle (R) from the diffuser assembly (F).
- 25 Remove the bushings (S1-S2) from diffuser assembly (F).
- 26 Use a plastic mallet to gently install the new bushings on the diffuser assembly (F).
- 27 Apply Molykote® D paste or equivalent on all the new pin shafts.
- 28 Assemble the steering unit in reverse order. See notes in this instruction for torque specifications.
- 29 Apply Molykote® D paste or equivalent to the screws before installation.
- 30 Task completed.

3.3 Hydraulics

3.3.1 Hydraulic Cylinders and Hoses, Inspect

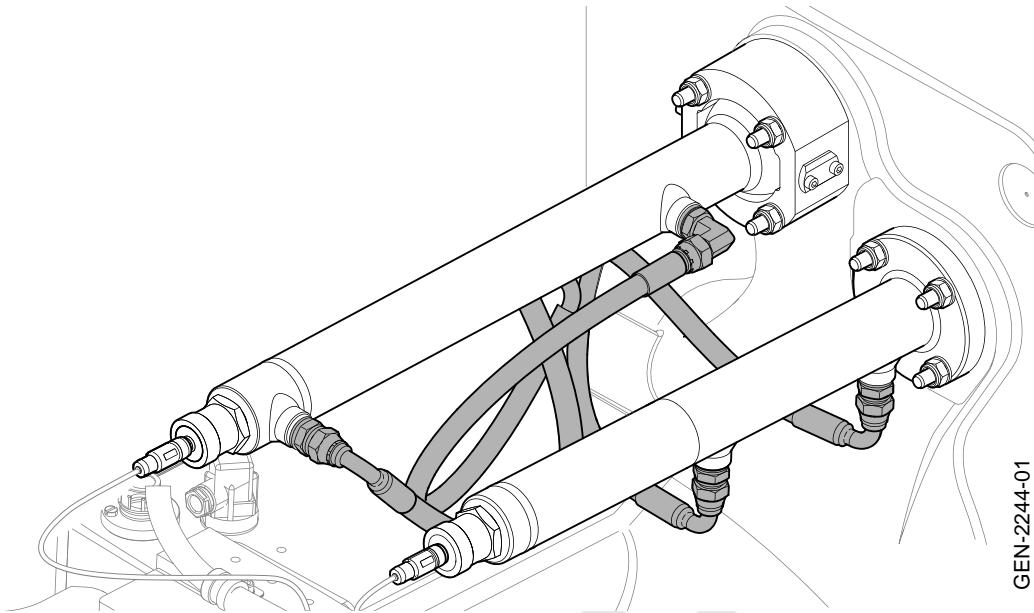


Figure 72

Task Summary

The task is to do a general inspection of the hydraulic cylinders and the hoses.

Task Interval

Do this task during:

- Preventive maintenance, during daily operation

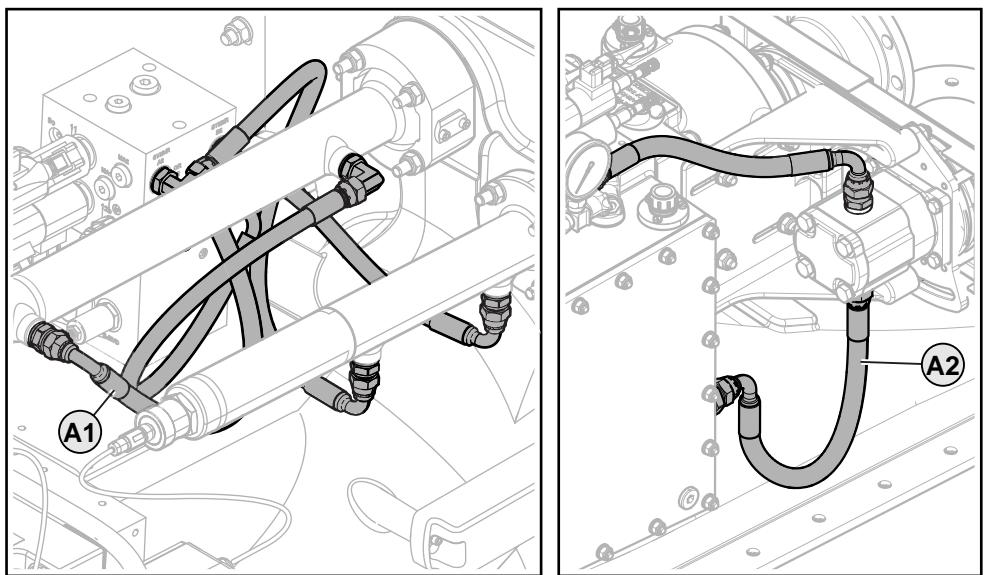
Prerequisites

Conditions

Main engine running.

Number of personnel	Skill level	Maintenance facility level	Estimated time
2	Crew	On equipment / at sea	10 minutes

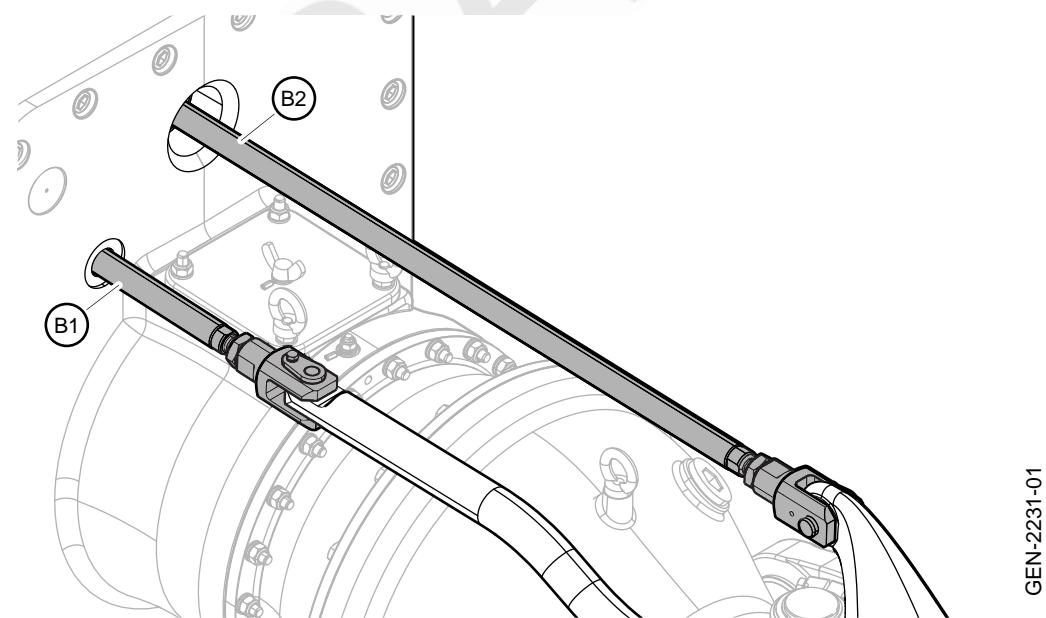
Procedure



GEN-2245-02

Figure 73

- 1 Inspect the bilge water for oil leaks from hoses and cylinders.
- 2 Inspect all connections for leakage. Repair any leakage immediately.
- 3 Inspect the hoses (A1-A2) for mechanical wear. Replace damaged hoses.
- 4 Operate the hydraulic system (steering and reversing) while inspecting all hoses for leakage. Replace damaged hoses.



GEN-22231-01

Figure 74

- 5 Inspect the piston rods (B1) and (B2) for leakage, visible damage and wear. Replace damaged cylinders.
- 6 Task complete.

3.3.2 Hydraulic Hoses, Replace

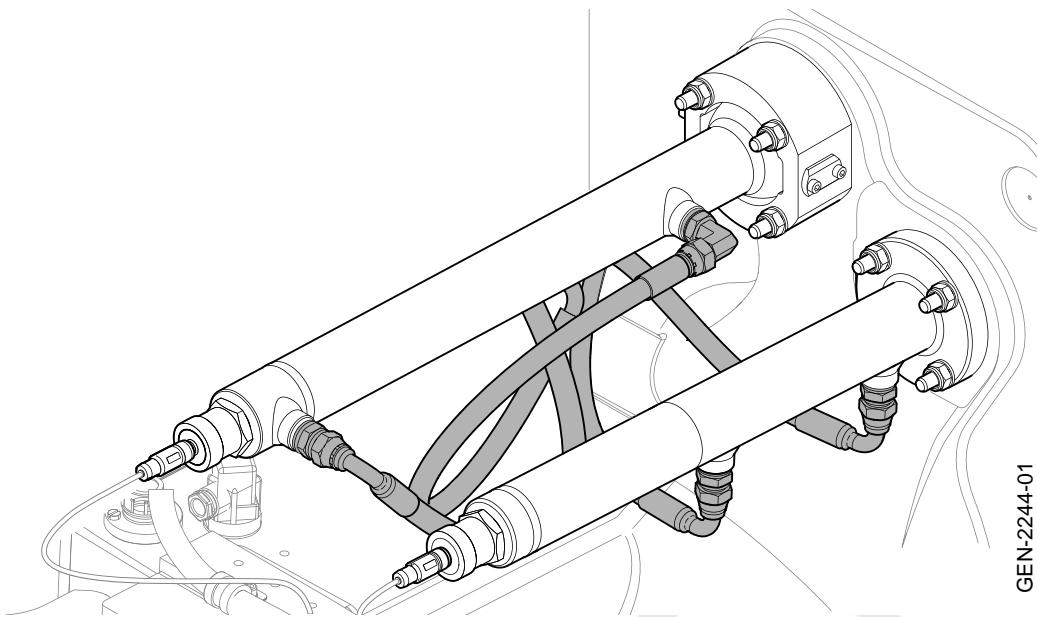


Figure 75

Task Summary

The task is to replace the hoses.



Warning!

Pressurized system! There may be residual pressure in the cylinders.

Task Interval

Do this task during:

- Corrective maintenance, while docked
- Preventive maintenance, every 5th year

Prerequisites

Conditions

The vessel is up-slipped / dry docked and supported properly.

Necessary scaffolding to access unit safely.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dry docked	40 minutes

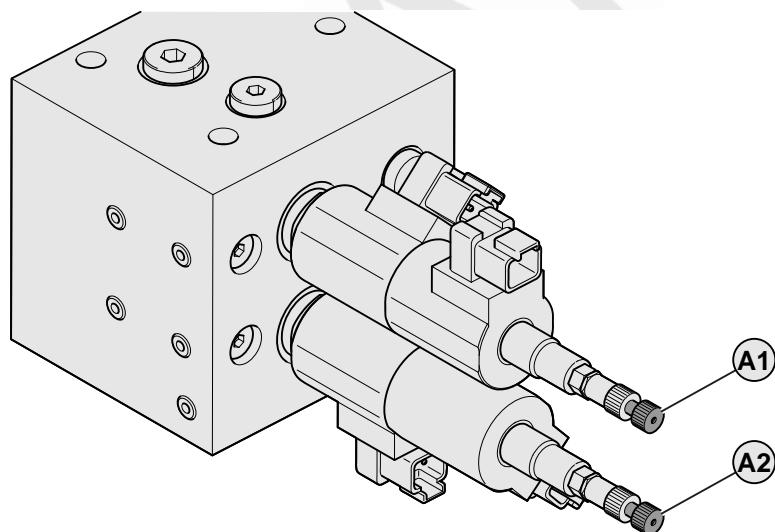
Spare parts	Quantity	Part number
X350 Spare Hose kit Electric	1	X350-1420-E-SP
Consumables	Quantity	Part number
Cloth	-	-

Reference document

3.3.10 Hydraulic System, Inspect Oil Level

3.3.19 Hydraulic System, Inspect Working Pressure

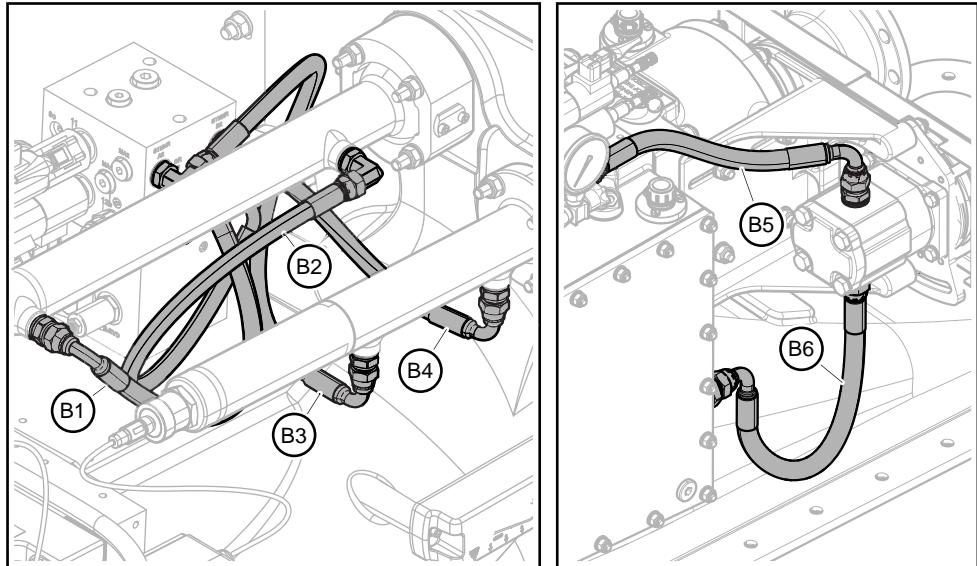
Procedure



GEN-22238-01

Figure 76

- 1 Push and turn the directional control valves (A1) and (A2) to relieve residual pressure from the system.
- 2 Wipe the surfaces clean before dismounting.



GEN-2290-01

Figure 77

- 3 Take note of connection points of the hoses (B1-B4).
- 4 Remove the hoses (B1-B4) from the cylinders and the valve block.

Note!

On installation of new hose, apply Molykote 111 Compound to the connections and tighten to torque 30 Nm.

- 5 Remove the hose (B5) from the hydraulic pump and the valve block.

Note!

On installation of new hose, apply Molykote 111 Compound to the connections and tighten to torque 21 Nm.

- 6 Remove the hose (B6) from the hydraulic pump and the hydraulic tank.

Note!

On installation of new hose, apply Molykote 111 Compound to the connections and tighten the connection to the pump to torque 45 Nm. Tighten the connection to the cylinder to torque 21 Nm.

- 7 Remove the bonded seal from the connectors.

Note!

Never leave the hydraulic connections open for a lengthy period.

- 8 Mount new bonded seal to the connectors.
- 9 Connect the new hoses according to the previously made notes.

Note!

Always use clean and plugged hoses.

- 10 Start the hydraulic system and move the cylinders back and forth to their end positions 10 times and examine for leakage. Tighten connections if necessary.
- 11 Examine the hydraulic pump for leakage. Tighten connections if necessary.
- 12 Check the oil level. See *3.3.10 Hydraulic System, Inspect Oil Level*

- 13 Ventilate the hydraulic system. See .
- 14 Check the hydraulic pressure. See 3.3.19 *Hydraulic System, Inspect Working Pressure*
- 15 Start the control system and verify that indicators are working properly and that no alarms are raised.
- 16 Task completed.

DRAFT

3.3.3 Hydraulic Reversing Cylinder, Replace

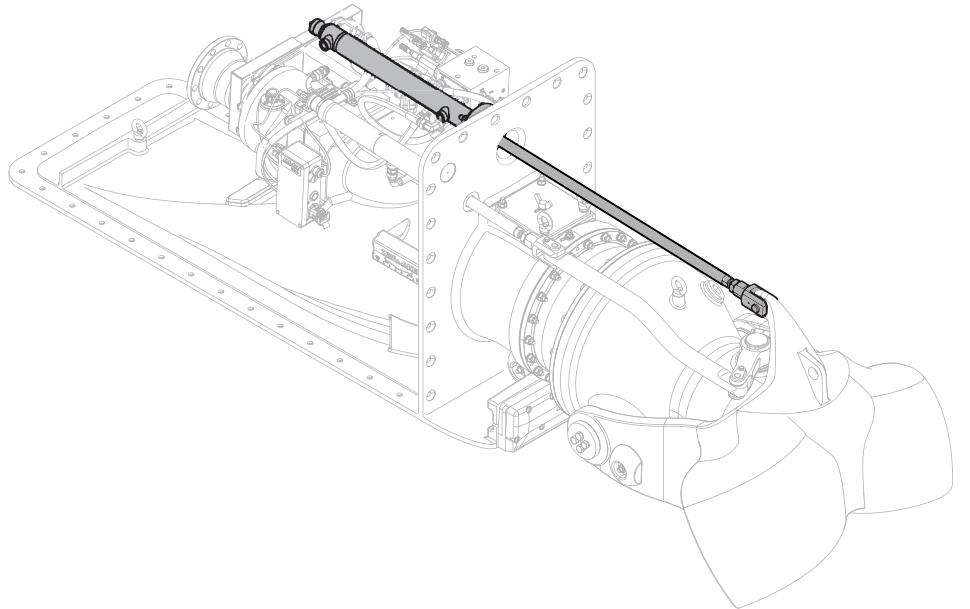


Figure 78

Task Summary

The task is to replace the hydraulic reversing cylinder.



Warning!

To make sure that the job is performed in a safe manner, dry docking of the vessel is highly recommended.



Warning!

Pressurized system! There may be residual pressure in the cylinders.



Caution!

Authorized Service Technician is required for the calibration of the position sensor.

Task Interval

Do this task during:

- Corrective maintenance, while docked.

Prerequisites

Conditions

The system is completely shut off.

Sliding hammer available.

Personnel number	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dockside / Dry docked	120 minutes

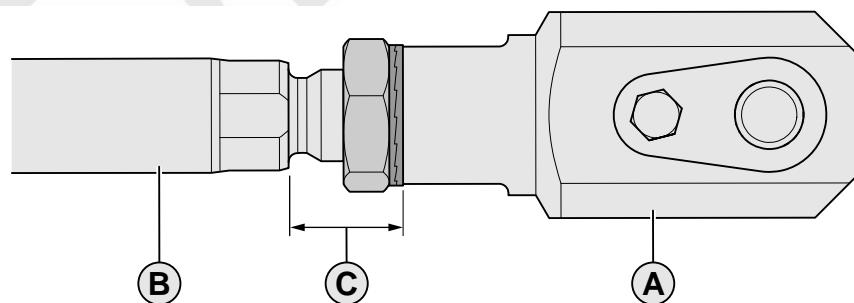
Spare parts	Quantity	Generation	Part number
Hydraulic reversing cylinder	1	MK1	41987

Consumables	Quantity	Part number
Cloth	-	-
Protection plugs	4	-
Insulating tape	-	-
Sling	1	-
Acid-free Vaseline	-	-

Reference document

- 3.3.10 Hydraulic System, Inspect Oil Level
- 3.3.19 Hydraulic System, Inspect Working Pressure

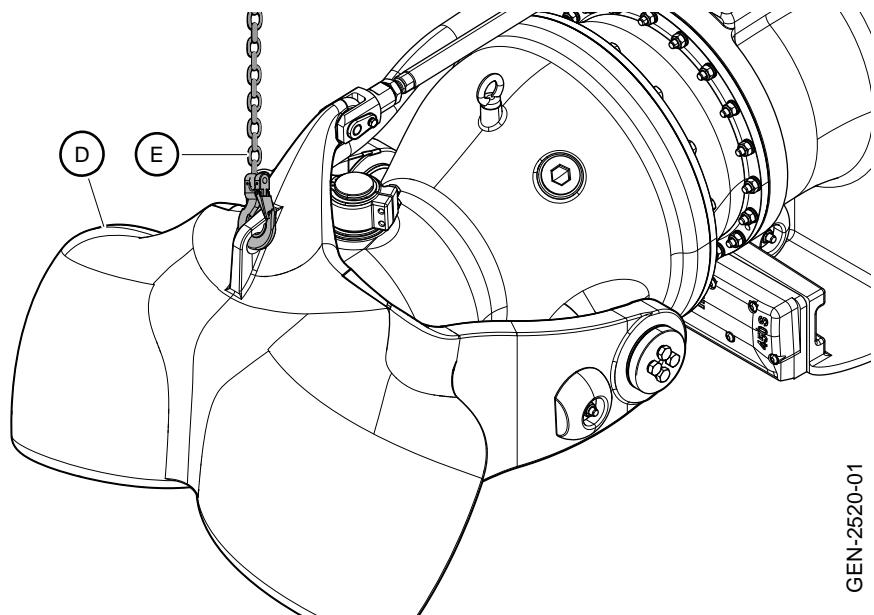
Procedure



GEN-2074-02

Figure 79

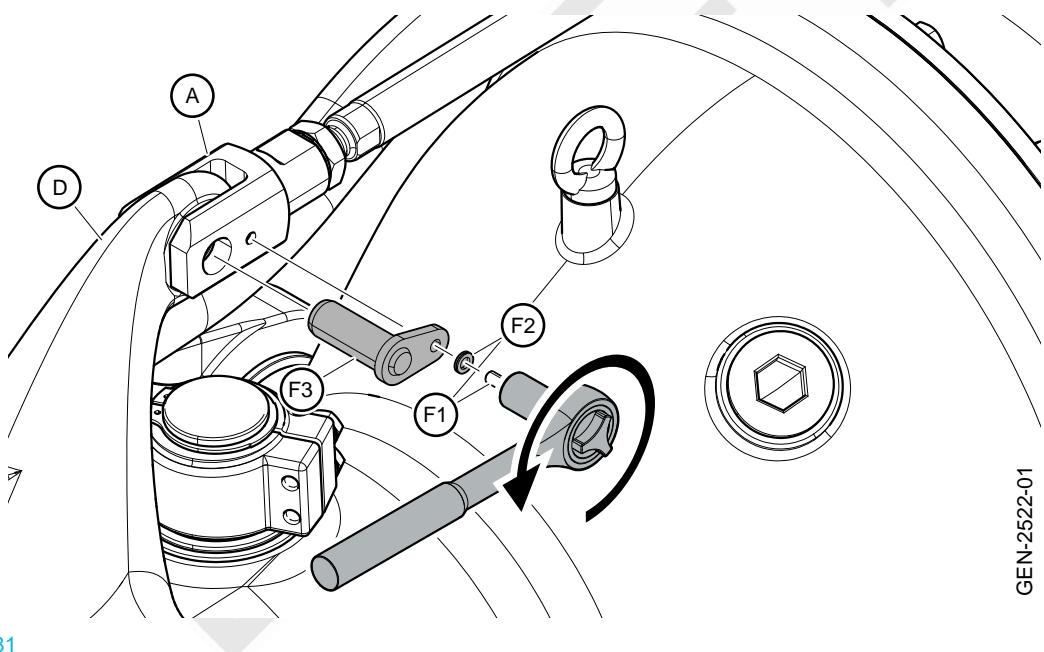
- Measure and record the distance (C) between the reversing rod clevis (A) and the reversing rod (B).



GEN-2520-01

Figure 80

- 2 Secure the bucket (D) with a lifting device (E).



GEN-2522-01

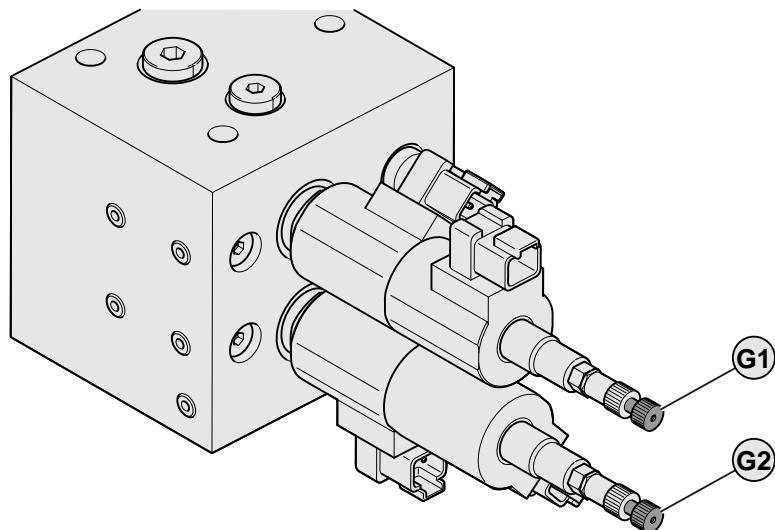
Figure 81

- 3 Remove the screw (F1) and the washer (F2) from the pin shaft (F3).

Note!

On assembly, apply Molykote DX paste to the screw (F1) and tighten to torque 8.4 Nm.

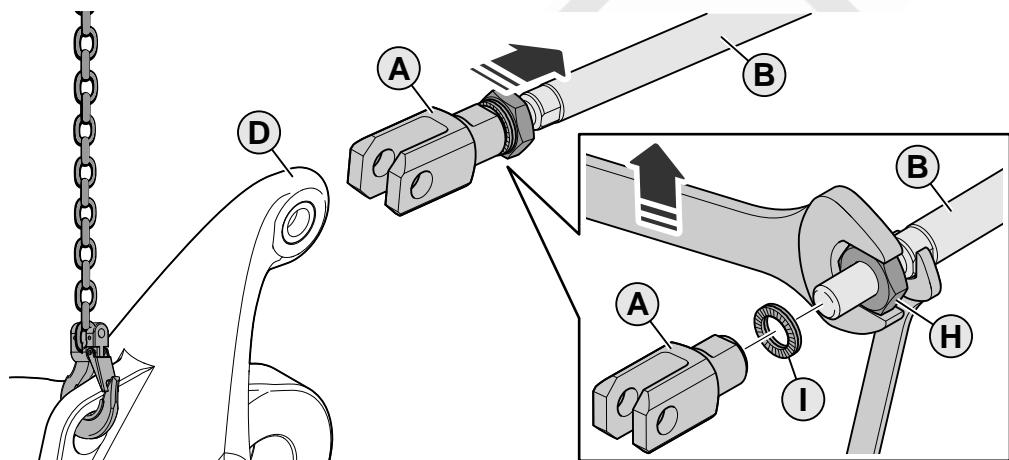
- 4 Use a hammer to remove the pin shaft (F3) from the reversing rod clevis (A) and the bucket (D).



GEN-2076-02

Figure 82

- Push and pull the directional control valves (G1) and (G2) to relieve residual pressure from the system.



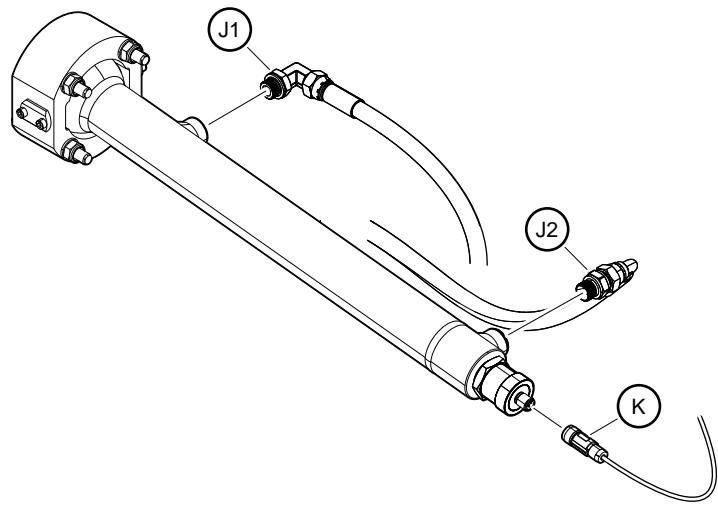
GEN-2075-02

Figure 83

- Move the reversing rod (B) and the reversing rod clevis (A) away from the bucket (D) to allow the reversing rod clevis (A) to be dismounted from the reversing rod (B). Alternatively, use adjustable chain block to lower the bucket (D).
- Use a large wrench to loosen the nut (H).
- Use a large wrench and turn the reversing rod clevis (A) to remove it from the reversing rod (B).
- Remove the lock washer (I) and the lock nut (H).

Note!

On assembly, apply Molykote DX paste to the lock nut (H) and tighten to torque 200 Nm.



GEN-2077-02

Figure 84

- 10 Wipe the surfaces clean before dismounting.
- 11 Remove the hoses (J1) and (J2) from the cylinder.

Note!

Use a tray to collect the oil spill.

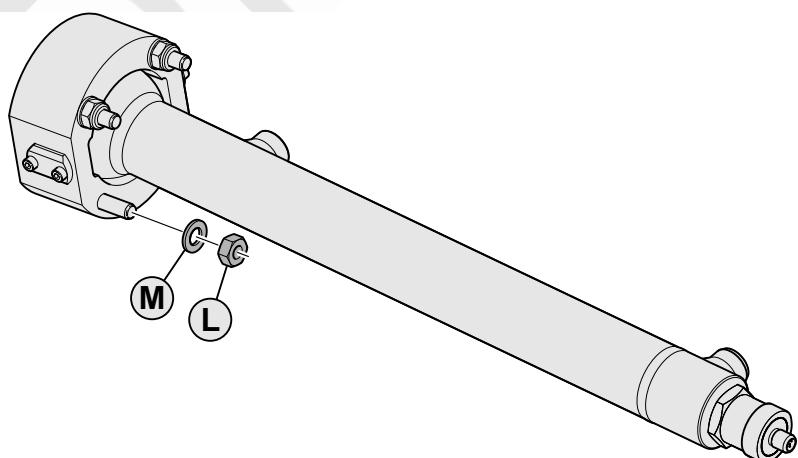
Note!

Make sure to plug the hoses.

- 12 Disconnect the sensor cable (K) from the cylinder.

Note!

Make sure to protect the connector on the cylinder.



GEN-2078-02

Figure 85

- 13 Remove the nuts (L) and washers (M).

Note!

On assembly, apply Loctite® 243 to the nuts (L) and tighten to torque 31-34 Nm.

- 14 Remove the cylinder by pulling it straight in.
- 15 If the feedback sensor is being reused, see *3.3.8 Hydraulic Reversing Cylinder, Replace Feedback Sensor*.
- 16 Install the new hydraulic cylinder in reverse order. See notes in this instruction for torque specifications.
- 17 Install the feedback sensor, see *3.3.8 Hydraulic Reversing Cylinder, Replace Feedback Sensor*.
- 18 Start the hydraulic system and move the cylinder back and forth to its end positions 10 times and examine for leakage. Tighten the connections if necessary.
- 19 Check the oil level. See *3.3.10 Hydraulic System, Inspect Oil Level*
- 20 Ventilate the hydraulic system. See .
- 21 Check the hydraulic pressure. See *3.3.19 Hydraulic System, Inspect Working Pressure*
- 22 Calibrate the jet. See *3.4.2 Jet autocalibration*
- 23 Start the control system and verify that indicators are working properly and that no alarms are raised.
- 24 Task completed.

3.3.4 Hydraulic Steering Cylinder, Replace

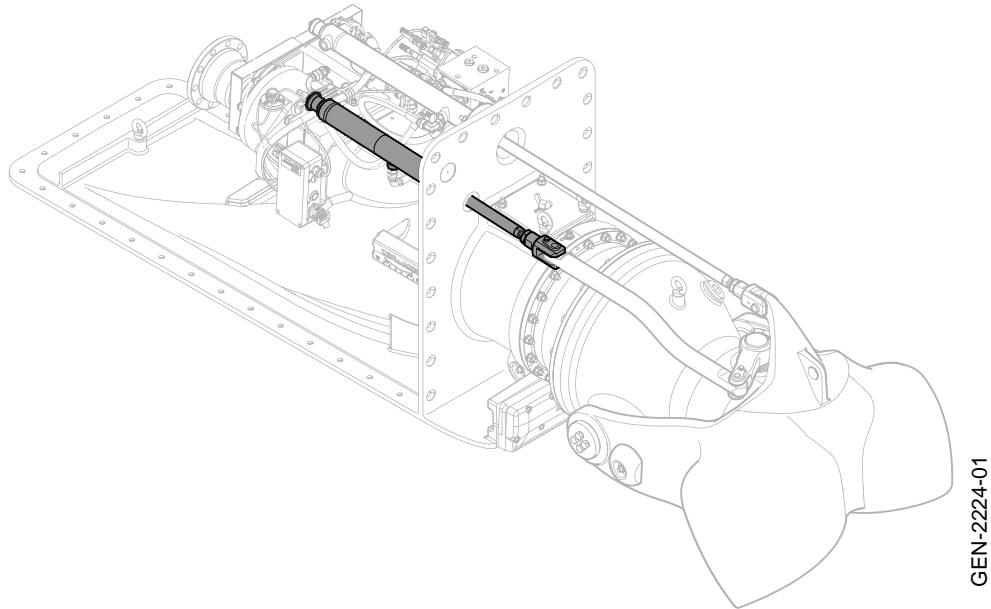


Figure 86

Task Summary

The task is to replace the hydraulic steering cylinder.



Warning!

To make sure that the job is performed in a safe manner, dry docking of the vessel is highly recommended.



Warning!

Pressurized system! There may be residual pressure in the cylinders.



Caution!

Authorized Service Technician is required for the calibration of the position sensor.

Task Interval

Do this task during:

- Corrective maintenance, while docked.

Prerequisites

Conditions

The system is completely shut off.

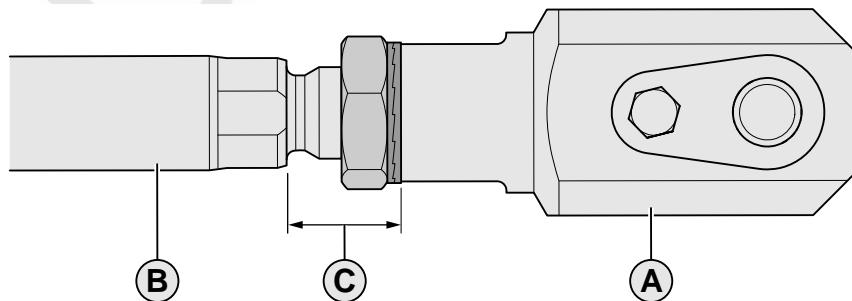
Sliding hammer available.

Personnel number	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dockside / Dry docked	120 minutes
Spare parts	Quantity	Generation	Part number
Hydraulic steering cylinder	1	MK1	41988
Hydraulic steering cylinder	1	MK2	42043
Consumables	Quantity		Part number
Cloth	-	-	-
Protection plugs	4	-	-
Insulating tape	-	-	-
Sling	1	-	-
Acid-free Vaseline	-	-	-

Reference document

- 3.3.10 Hydraulic System, Inspect Oil Level
- 3.3.19 Hydraulic System, Inspect Working Pressure

Procedure



GEN-2074-02

Figure 87

- Measure and record the distance (C) between the steering rod clevis (A) and the steering rod (B).

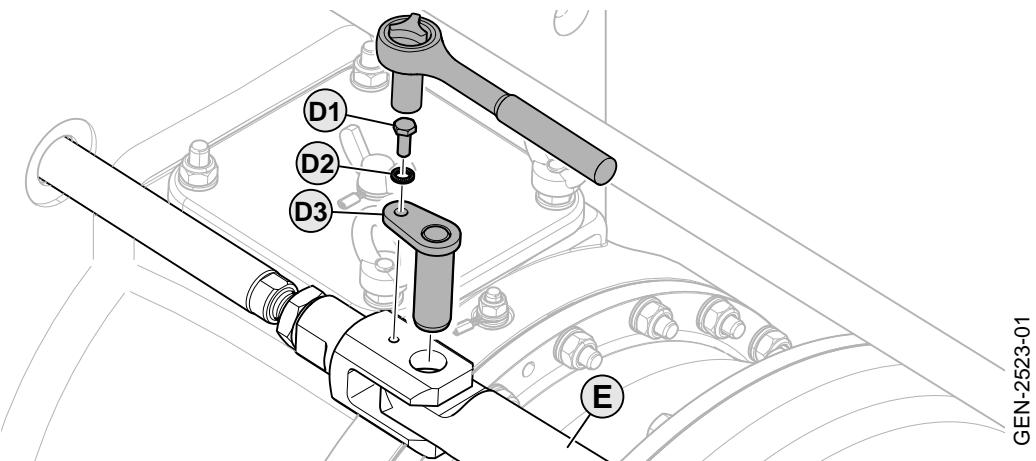


Figure 88

- 2 Remove the screw (D1) and the washer (D2) from the pin shaft (D3).

Note!

On assembly, apply Molykote DX paste to the screw (D1) and tighten to torque 8.4 Nm.

- 3 Use a sling around the link arm (E) to support it.



Caution!

The link arm (E) is heavy. To avoid damage of the pin shaft and screw at the tiller arm, make sure that the link arm is supported.

- 4 Use a hammer to remove the pin shaft (D3) from the steering rod clevis (A) and the link arm (E).

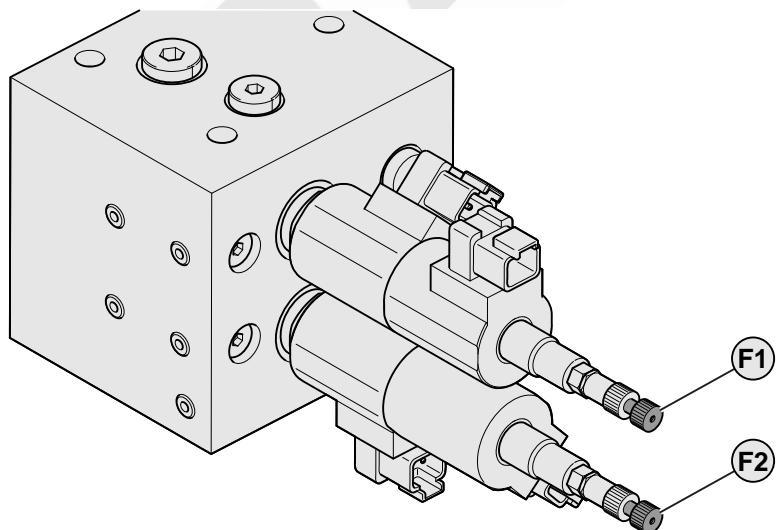


Figure 89

- 5 Push and pull the directional control valves (F1) and (F2) to relieve residual pressure from the system.

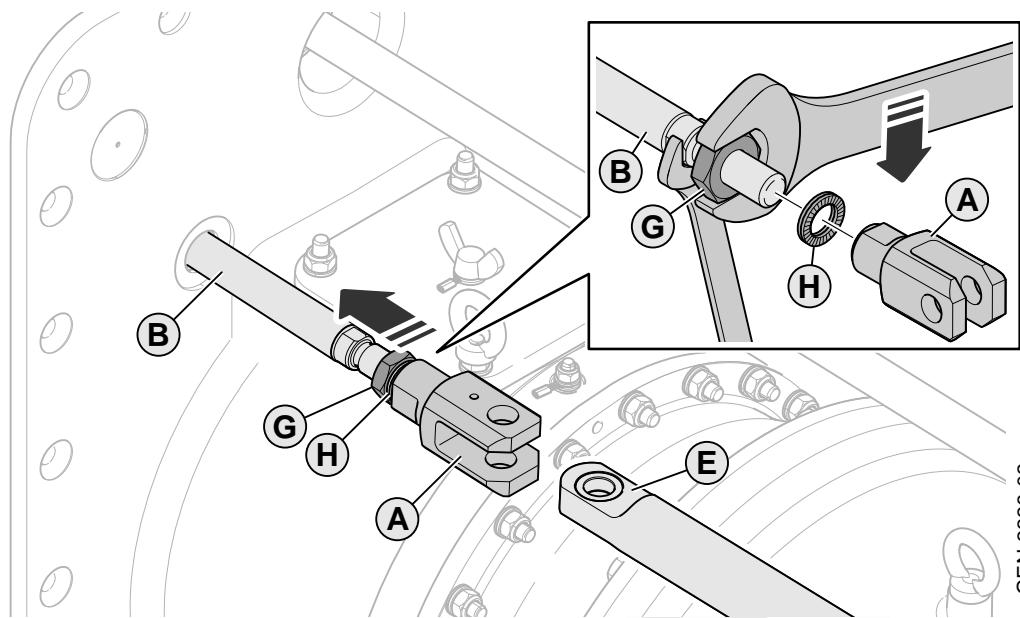


Figure 90

- 6 Move the steering rod (B) and the steering rod clevis (A) away from the link arm (E). Alternatively, move the link arm (E) to the side while supporting it.
- 7 Use a large wrench to loosen the lock nut (G).
- 8 Use a large wrench to turn the steering rod clevis (A) to remove it from the steering rod (B).
- 9 Remove the washer (H) and lock nut (G) from the steering rod.

Note!

On assembly, apply Molykote DX paste to the lock nut (G) and tighten to torque 200 Nm.

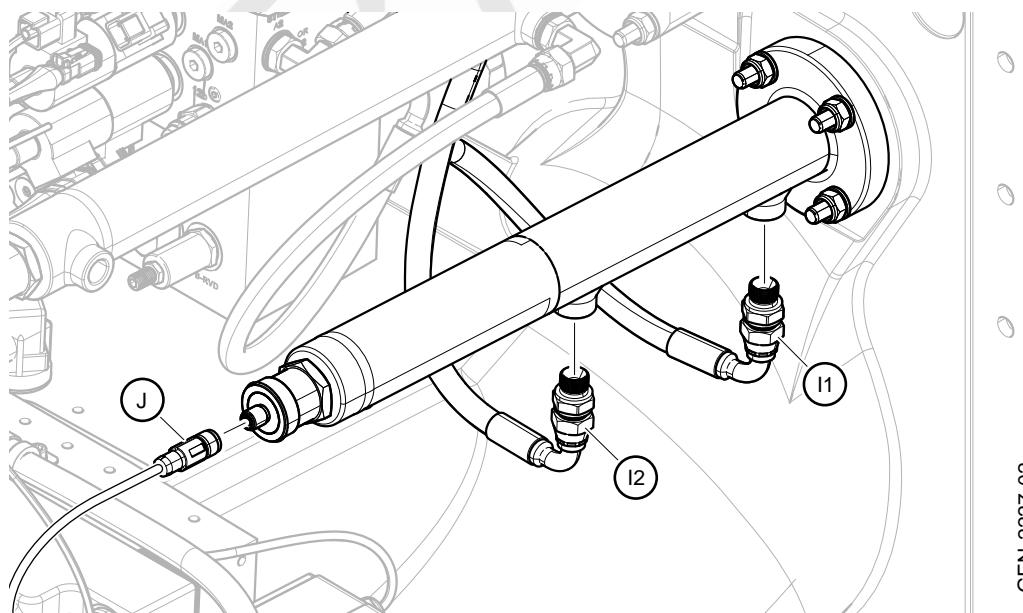


Figure 91

- 10 Wipe the surfaces clean before dismounting.
- 11 Remove the hoses (I1) and (I2) from the cylinder.

Note!

Use a tray to collect the oil spill.

Note!

Make sure to plug the hoses.

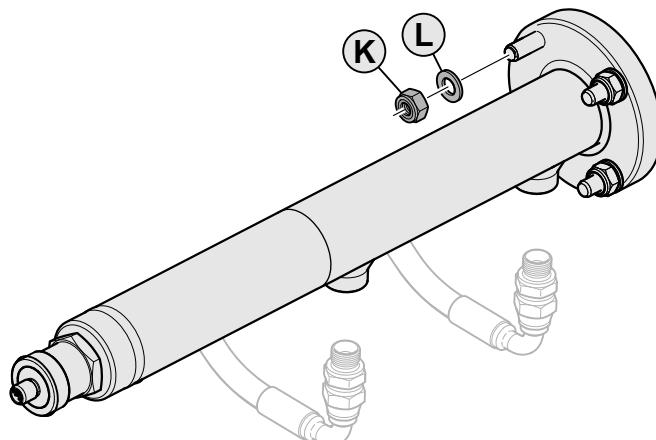
Note!

On assembly, apply Molykote 111 Compound and Loctite® 542 to the connections on the hoses (I1), (I2) and tighten to torque 30 Nm.

- 12 Disconnect the sensor cable (J) from the cylinder.

Note!

Make sure to protect the connector on the cylinder.



GEN-22228-02

Figure 92

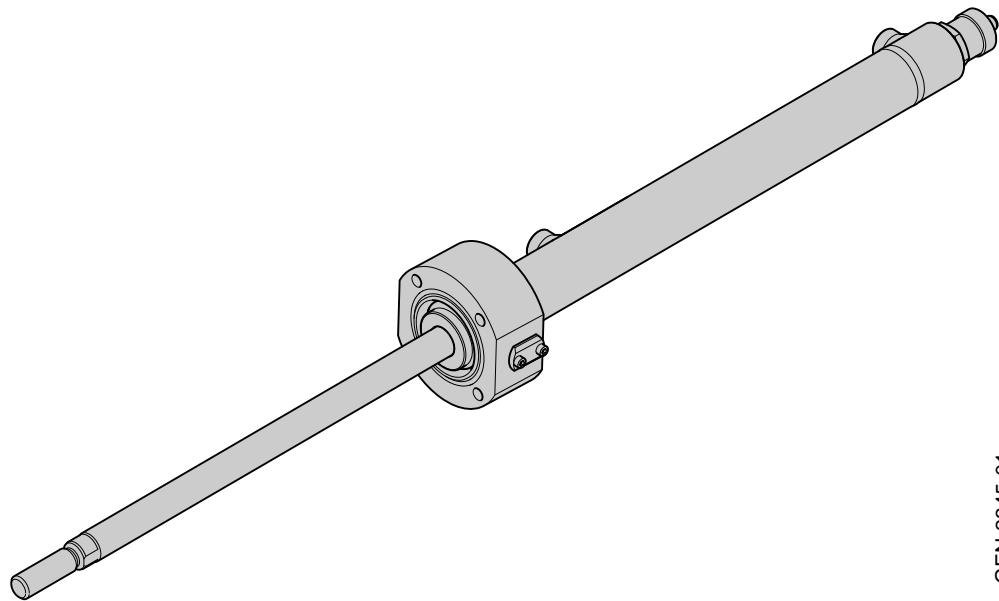
- 13 Remove the nuts (K) and washers (L).

Note!

On assembly, apply Loctite® 243 to the nuts (K) and tighten to torque 31-34 Nm.

- 14 Remove the cylinder by pulling it straight in.
- 15 If the feedback sensor is being reused, see *3.3.8 Hydraulic Reversing Cylinder, Replace Feedback Sensor*.
- 16 Install the new hydraulic cylinder in reverse order. See notes in this instruction for torque specifications.
- 17 Install the feedback sensor, see *3.3.8 Hydraulic Reversing Cylinder, Replace Feedback Sensor*.
- 18 Start the hydraulic system and move the cylinder back and forth to its end positions 10 times and examine for leakage. Tighten the connections if necessary.
- 19 Check the oil level. See *3.3.10 Hydraulic System, Inspect Oil Level*
- 20 Ventilate the hydraulic system. See .
- 21 Check the hydraulic pressure. See *3.3.19 Hydraulic System, Inspect Working Pressure*
- 22 Calibrate the jet. See *3.4.2 Jet autocalibration*
- 23 Start the control system and verify that indicators are working properly and that no alarms are raised.
- 24 Task completed.

3.3.5 Hydraulic Reversing Cylinder, Replace Seals



GEN2345-01

Figure 93

Task Summary

The task is to replace the seals on the hydraulic reversing cylinder.

Task Interval

Do this task during:

- Preventive maintenance, every 2nd year or 4 000 running hours
- Corrective maintenance, while docked*

Prerequisites

Conditions

The vessel is dry docked and supported properly.

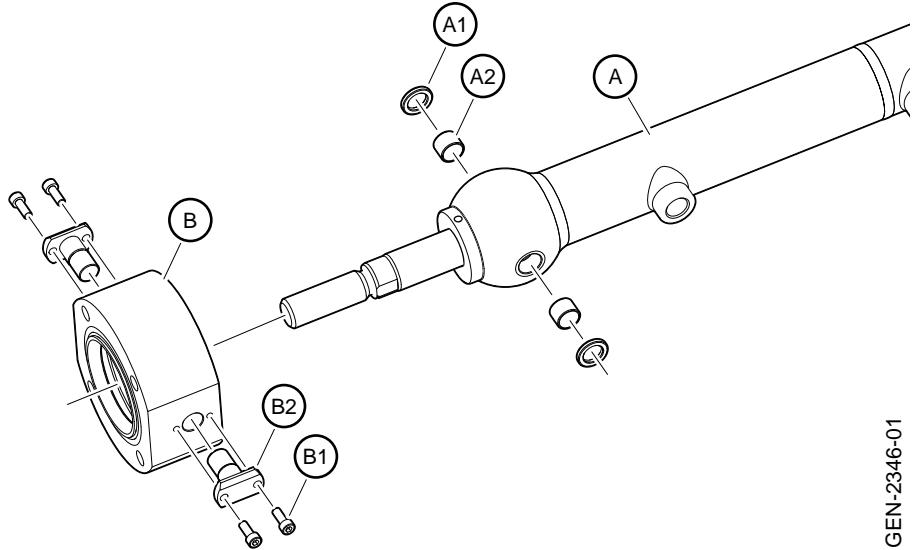
Necessary scaffolding to access unit safely.

*This task can also be done at dockside with help from divers.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dry docked	60 minutes
Spare parts	Quantity	Generation	Part number
Seal kit for Cylinder 350X	1	MK1	42013
Consumables	Quantity		Part number
Cloth	-		-
Molykote® D paste	-		-
Special tools and test equipment	Quantity		Part number
Hook spanner	1		-
Seal Installer tool	1		-
Reference document			
5.2 Torque			
3.3.10 Hydraulic System, Inspect Oil Level			
3.3.19 Hydraulic System, Inspect Working Pressure			

Procedure

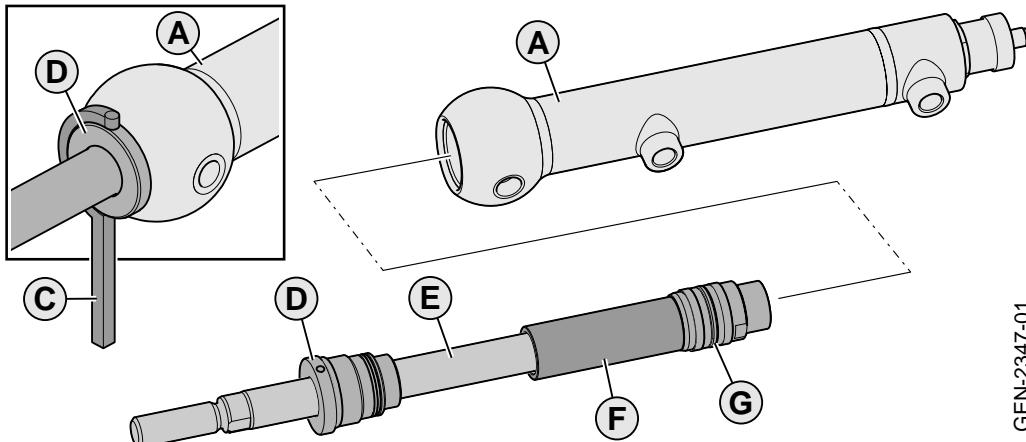
- 1 Remove the reversing cylinder. See 3.3.3 Hydraulic Reversing Cylinder, Replace



GEN-2346-01

Figure 94

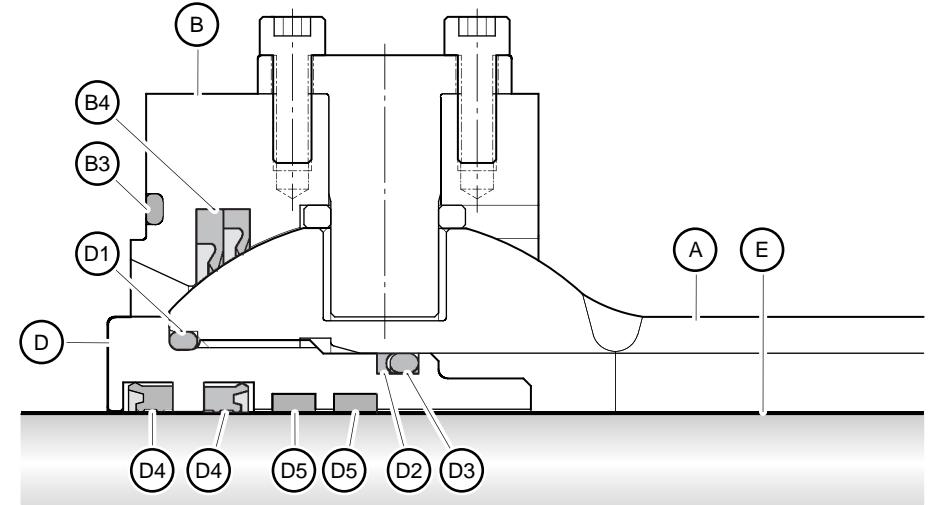
- 2 Put the cylinder tube (A) in a vice.
- 3 Remove the screws (B1) and the pin shafts (B2) from the flange (B).
- 4 Remove the flange (B) from the cylinder tube (A).
- 5 Remove the plain bearings (A1) and the bearings (A2) from the cylinder tube (A).



GEN-2347-01

Figure 95

- 6 Use a hook spanner (C) in the empty screw hole, to loosen the cylinder head (D) from the cylinder tube (A).
- 7 Pull the piston rod (E) with the cylinder head (D), the spacer (F) and the piston (G) straight out of the cylinder tube (A).

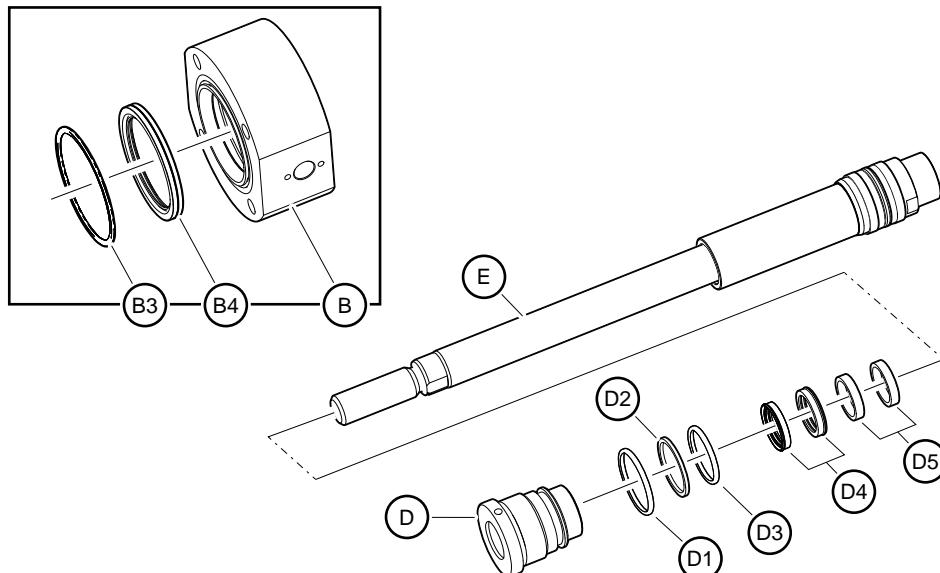


GEN-2349-01

Figure 96

**Caution!**

Make sure that the O-ring (D1), the support ring (D2), the O-ring (D3), the head seals (D4) and the guide rings (D5) are in the correct position and direction on the cylinder head (D). Make sure that the O-ring (B3) and the head seal (B4) are in the correct position and direction on the flange (B). This will help prevent damage to the equipment. See below.

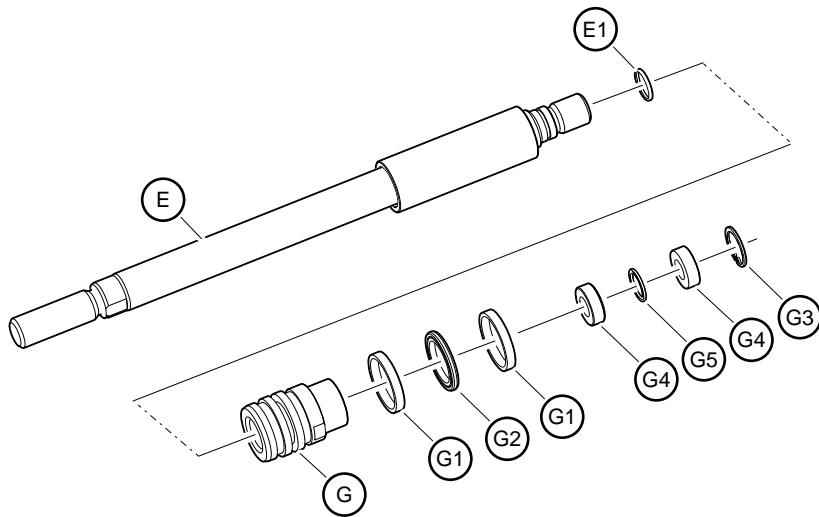


GEN-2348-01

Figure 97

- 8 Put the piston rod (E) in a vice. Make sure to protect the rod from damages and scratches.
- 9 Remove the cylinder head (D) from the piston rod (E).
- 10 Remove the O-ring (D1), the support ring (D2) and the O-ring (D3) from the cylinder head (D).
- 11 Remove the head seals (D4) and the guide rings (D5) from the cylinder head (D).
- 12 Put the new O-rings, support ring, head seals and guide rings on the cylinder head (D).

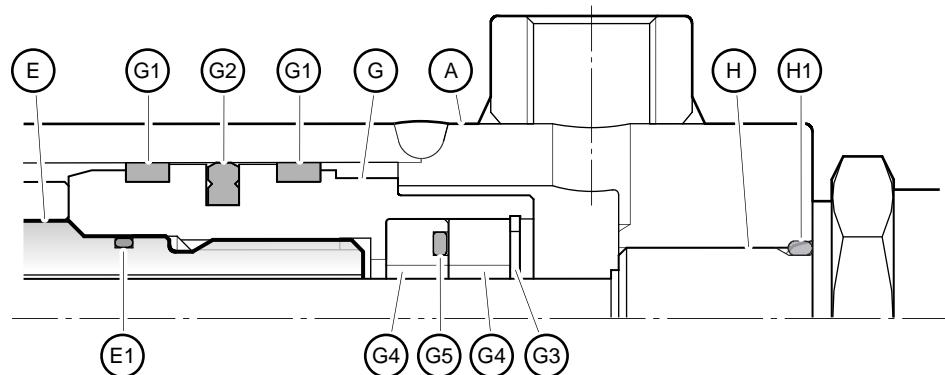
- 13 Remove the O-ring (B3) and the head seal (B4) from the flange (B).
- 14 Put the new O-ring and the new head seal on the flange (B).



GEN-2350-01

Figure 98

- 15 Remove the piston (G) from the piston rod (E) using a large wrench at the key grip.
- 16 Remove the guide rings (G1) and the piston seal (G2) from the piston (G).
- 17 Put the new guide rings and the new piston seal on the piston (G).
- 18 Remove the locking ring (G3), the spacers (G4) and the O-ring (G5) from the piston (G).
- 19 Install the spacers together with a new O-ring and the locking ring back into the piston (G).
- 20 Remove the O-ring (E1) from the piston rod (E).
- 21 Put a new O-ring on the piston rod (E).

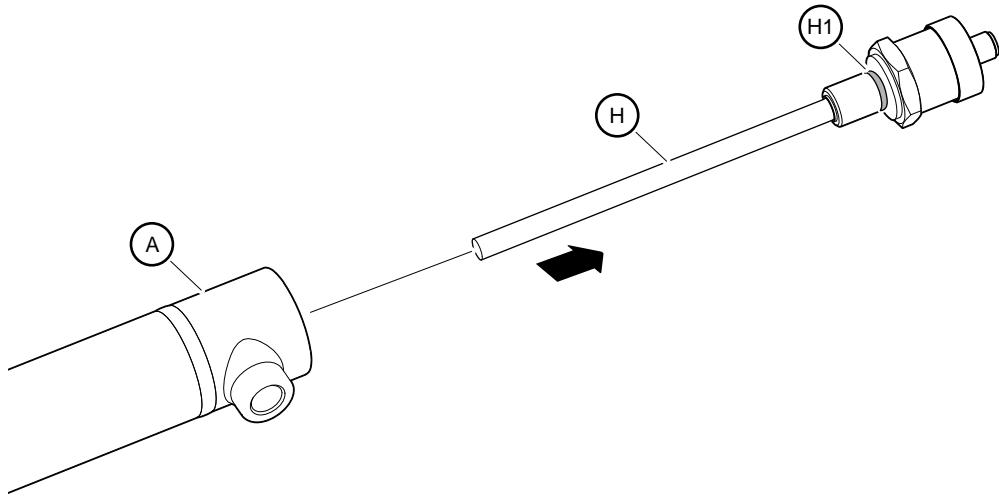


GEN-2351-01

Figure 99

**Caution!**

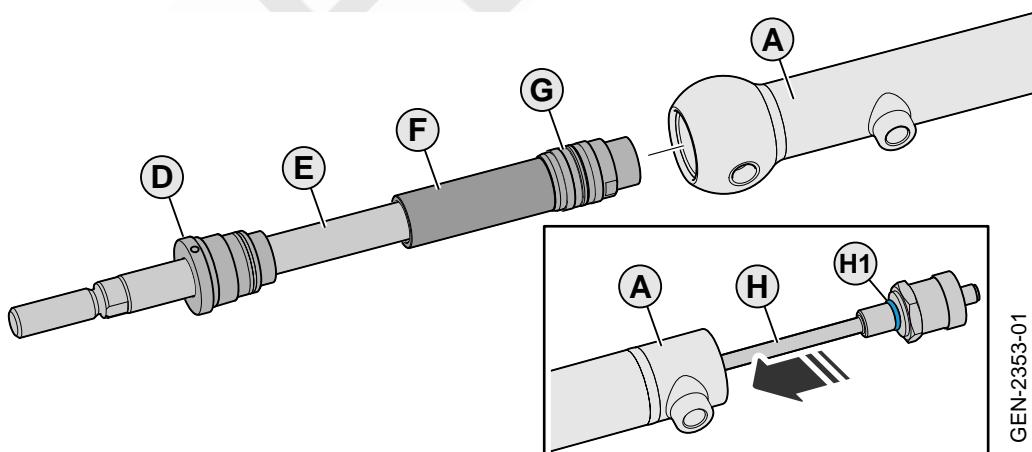
Make sure that the guide rings (G1) the piston seal (G2), the locking ring (G3), the spacers (G4), the O-ring (G5) and the O-ring (E1) are in the correct position. This will help prevent damage to the equipment. See below.



GEN-2352-01

Figure 100

- 22 Use a large wrench and turn counterclockwise to loosen the feedback sensor (H) from the cylinder tube (A).
- 23 Remove the feedback sensor (H) from the cylinder tube (A).
- 24 Remove the O-ring (H1) on the feedback sensor (H).
- 25 Install a new O-ring on the feedback sensor (H).



GEN-2353-01

Figure 101

- 26 Install the cylinder head (D) again on the piston rod (E).
- 27 Install the piston (G) again on the piston rod (E).
- 28 Make sure that the cylinder tube (A) is clean inside.

Note!

Use a cloth to wipe clean if necessary.

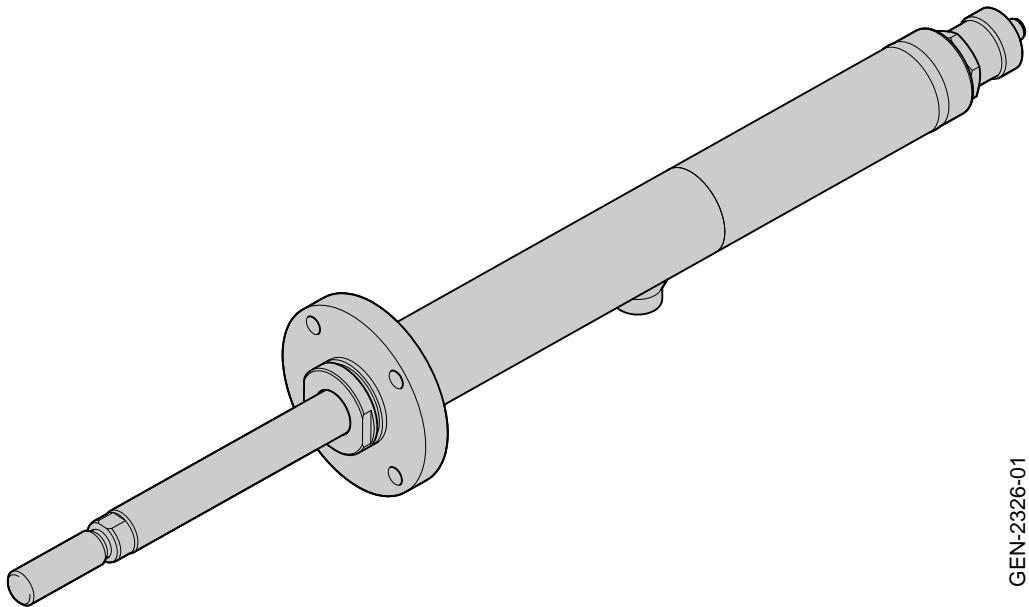
- 29 Apply grease to the piston sealing and the outer side of the cylinder head (D) to make the installation easier.
- 30 Apply Molykote® D paste or equivalent on the piston rod (G) threads.
- 31 Install the piston rod (E) into the cylinder tube (A) with the piston (G) first.
- 32 Use a hook spanner in the empty screw hole on the cylinder head (D) to tighten the cylinder head to the cylinder tube (A).
- 33 Install the feedback sensor (H) back into the cylinder tube (A). Clockwise tighten to 45 Nm of torque.

**Caution!**

Install carefully to make sure not to damage the O-ring on (H1) the feedback sensor.

- 34 Reassemble the rest of the cylinder in reverse order.
- 35 Install the hydraulic cylinder. See [3.3.3 Hydraulic Reversing Cylinder, Replace](#).
- 36 Check the oil level. See [3.3.10 Hydraulic System, Inspect Oil Level](#)
- 37 Ventilate the hydraulic system. See .
- 38 Check the hydraulic pressure. See [3.3.19 Hydraulic System, Inspect Working Pressure](#)
- 39 Calibrate the jet. See [3.4.2 Jet autocalibration](#)
- 40 Task completed.

3.3.6 Hydraulic Steering Cylinder, Replace Seals



GEN-2326-01

Figure 102

Task Summary

The task is to replace the seals on the hydraulic steering cylinder.

Task Interval

Do this task during:

- Preventive maintenance, every 2nd year or 4 000 running hours
- Corrective maintenance, while docked *

Prerequisites

Conditions

The vessel is dry docked and supported properly.

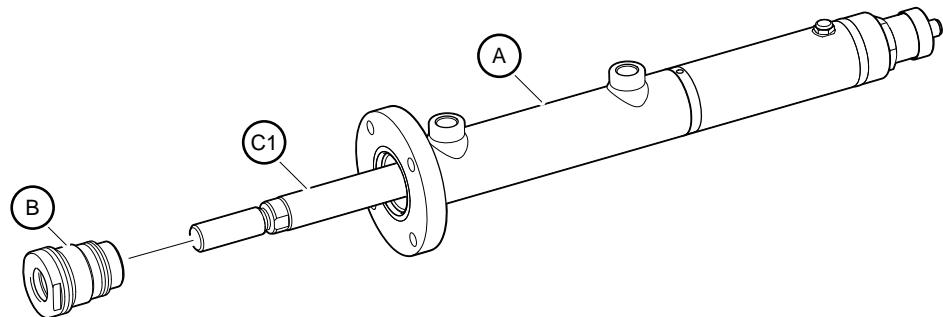
Necessary scaffolding to access unit safely.

* This task can also be done at dockside with help from divers.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dry docked	60 minutes
Spare parts	Quantity	Generation	Part number
Seal kit (for hydraulic steering cylinder MK1)	1	MK1	42014
Seal kit (for hydraulic steering cylinder MK2)	1	MK2	42046
Consumables	Quantity		Part number
Cloth	-		-
Molykote® D paste	-		-
Special tools and test equipment	Quantity		Part number
Face spanner	1		-
Reference document			
5.2 Torque			
3.3.10 Hydraulic System, Inspect Oil Level			
3.3.19 Hydraulic System, Inspect Working Pressure			

Procedure

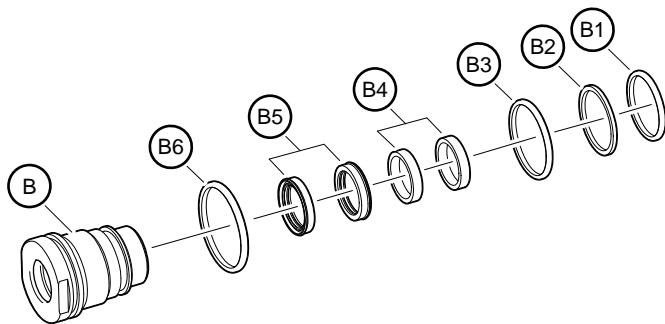
- 1 Remove the steering cylinder. See 3.3.4 Hydraulic Steering Cylinder, Replace.



GEN-2467-02

Figure 103

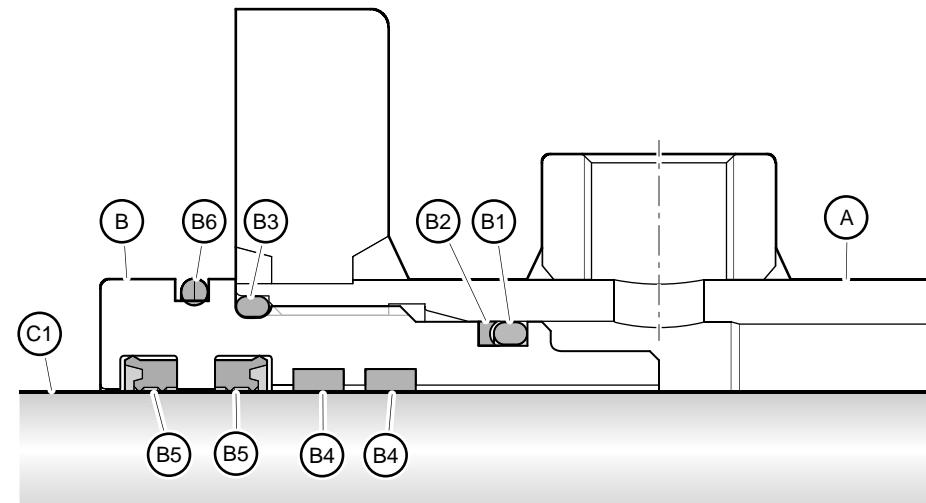
- 2 Put the cylinder tube (A) in a vice.
- 3 Use a large wrench at the key grip and turn the cylinder head (B) counter clockwise to loosen it from the cylinder tube (A).
- 4 Remove the cylinder head (B) from the cylinder tube (A) and the piston rod (C1).



GEN-2468-02

Figure 104

- 5 Remove the O-rings (B1), (B3), (B6) and the support ring (B2) from the cylinder head (B).
- 6 Remove the guide rings (B4) and the head seals (B5) from the cylinder head (B).
- 7 Put the new head seals, guide rings, O-rings and support ring on the cylinder head (B).

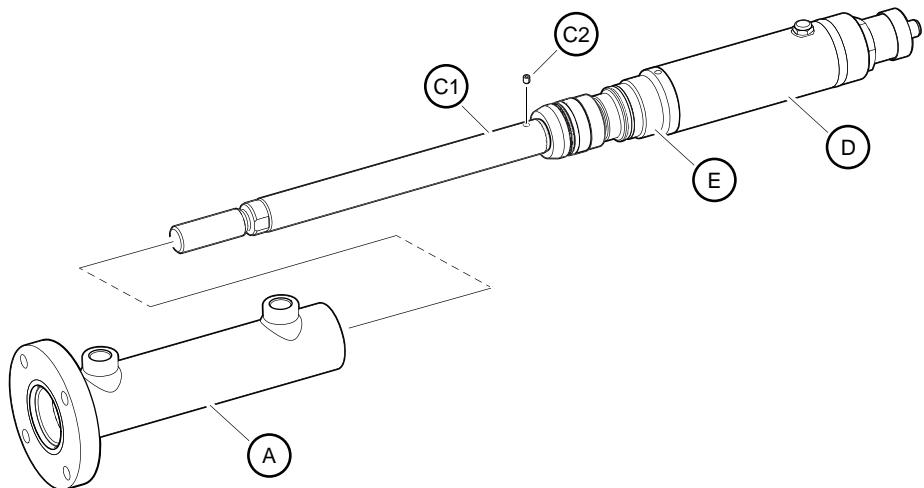


GEN-2343-02

Figure 105

**Caution!**

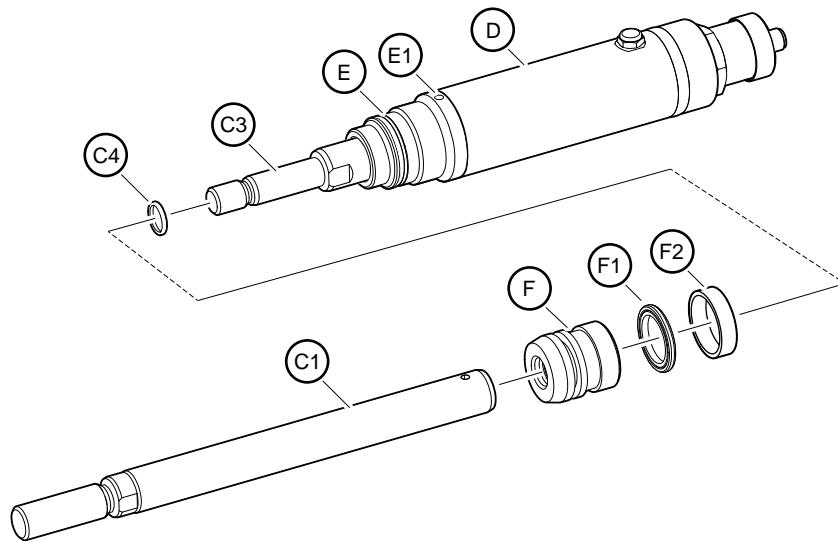
Make sure that the O-ring (B1), the support ring (B2), the O-ring (B3), the guide rings (B4), the head seals (B5) and the O-ring (B6) are in the correct position and direction. This will help prevent damage to the equipment.



GEN-2469-02

Figure 106

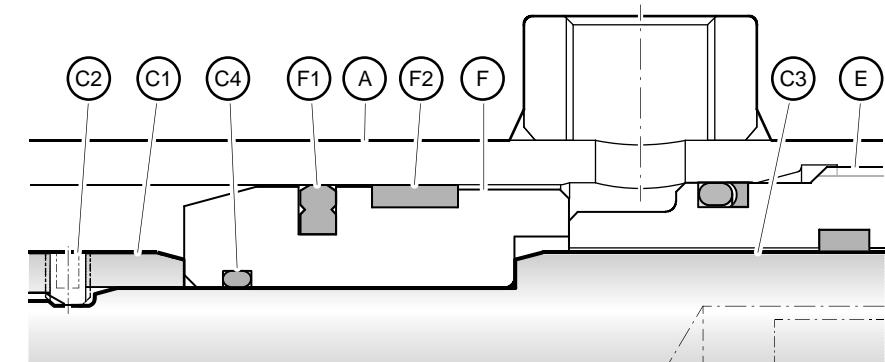
- 8 Put the cylinder tube (A) in a vice.
- 9 Use a hook spanner (E1) in the hole on the intermediate gable (E) and turn counterclockwise to loosen and remove the rest of the cylinder from the cylinder tube (A).
- 10 Remove the lock screw (C2) from the piston rod (C1).



GEN-2470-02

Figure 107

- 11 Remove the piston rod (C1) from the piston rod (C3).
- 12 Remove the piston (F) from the piston rod (C3).
- 13 Remove the piston seal (F1) and the guide ring (F2) from the piston (F).
- 14 Put the new piston seal and the new guide ring on the piston (F).
- 15 Remove the O-ring (C4) from the piston rod (C3).
- 16 Put the new O-ring on the piston rod (C3).

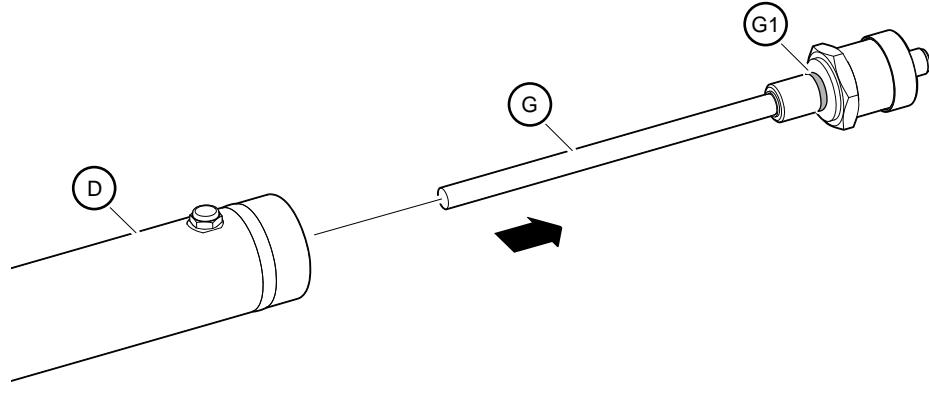


GEN-2342-02

Figure 108

**Caution!**

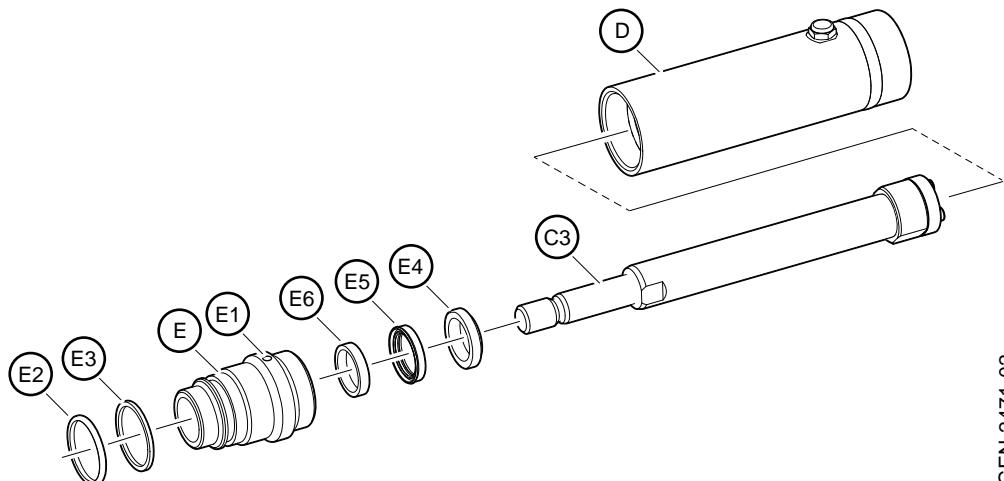
Make sure the O-ring (C4), the piston seal (F1) and the guide ring (F2) are in the correct position and direction. This will help prevent damage to the equipment.



GEN-2332-02

Figure 109

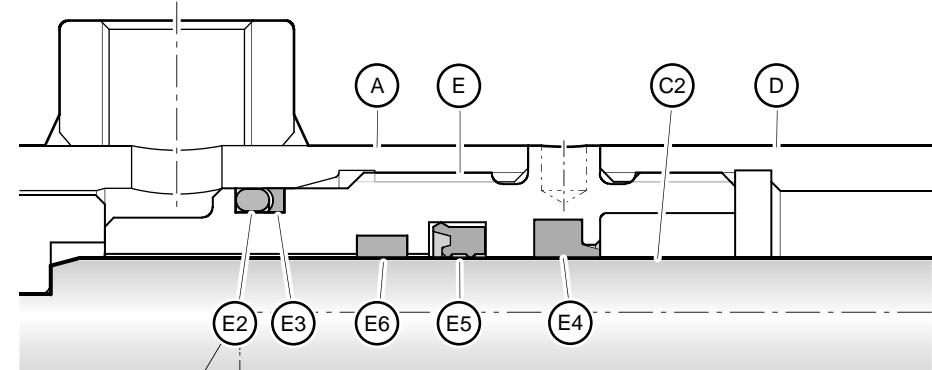
- 17 Use a large wrench and turn counterclockwise to loosen and remove the feedback sensor (G) from the protection tube (D).
- 18 Remove the O-ring (G1) on the feedback sensor (G).
- 19 Install a new O-ring on the feedback sensor (G).



GEN-2471-02

Figure 110

- 20 Put the protection tube (D) in a vice.
- 21 Use a hook spanner in the hole (E1) and turn counterclockwise to loosen and remove the intermediate gable (E) and the piston rod (C) from the protection tube (D).
- 22 Remove the O-ring (E2) and the guide ring (E3) from the intermediate gable (E).
- 23 Remove the wiper seal (E4), the head seal (E5) and the guide ring (E6) from the intermediate gable (E).
- 24 Install the new wiper seal, head seal, guide rings and O-ring on the intermediate gable (E).



GEN-2344-02

Figure 111

**Caution!**

Make sure that the O-ring (E2), the guide ring (E3), the wiper seal (E4), the head seal (E5) and the guide ring (E6) are in the correct position and direction. This will help prevent damage to the equipment.

25 Reassemble the steering cylinder:

- 25.1 Make sure that the protection tube (D) is clean inside.

Note!

Use a cloth to wipe clean if necessary.

- 25.2 Install the intermediate gable (E) and the piston rod (C3) into the protection tube (D).
- 25.3 Install the piston (F) to the piston rod (C3).
- 25.4 Apply Molykote® D paste or equivalent on the piston rods (C1)+(C3) threads.
- 25.5 Install the lock screw (C2) to attach the piston rod (C1) to the piston rod (C3).
- 25.6 Apply grease to the piston sealing to make the installation of the cylinder tube (A) easier.
- 25.7 Make sure that the cylinder tube (A) is clean inside.

Note!

Use a cloth to wipe clean if necessary.

- 25.8 Slide the cylinder tube (A) over the piston (D).
- 25.9 Turn the cylinder tube (A) clockwise to install it to the intermediate gable (E).
- 25.10 Install the feedback sensor (G) back into the protection tube (D). Clockwise tighten to 45 Nm of torque.

**Caution!**

Install carefully to make sure not to damage the inner part of the feedback sensor.

- 25.11 Use a large wrench to tighten the front end of the cylinder head (B) to the cylinder tube (A).

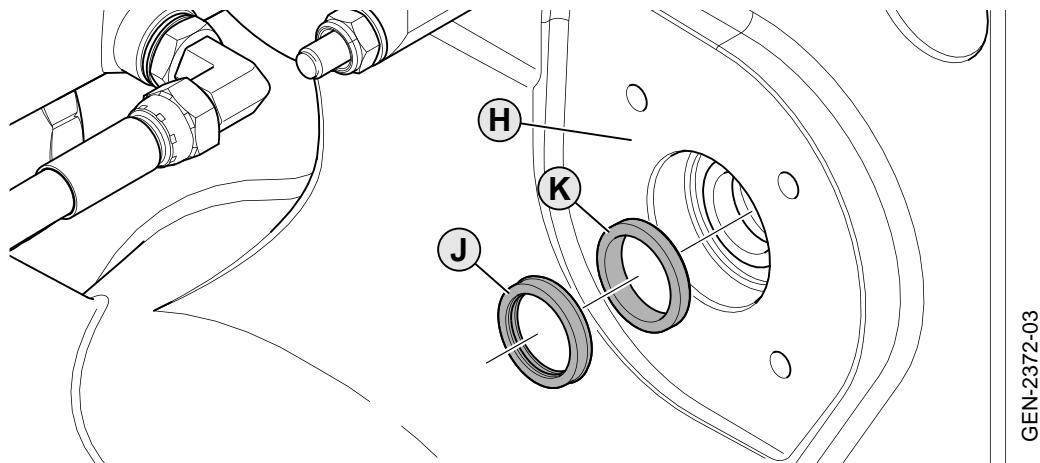


Figure 112

- 26 Remove the transom seal (J) and wiper seal (K) from the transom (H) on the intake.
- 27 Install the new transom seal and wiper seal in the transom (H).

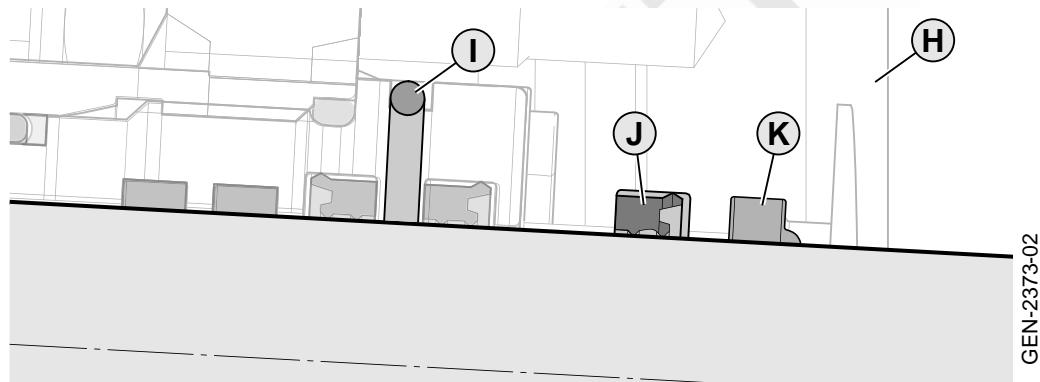


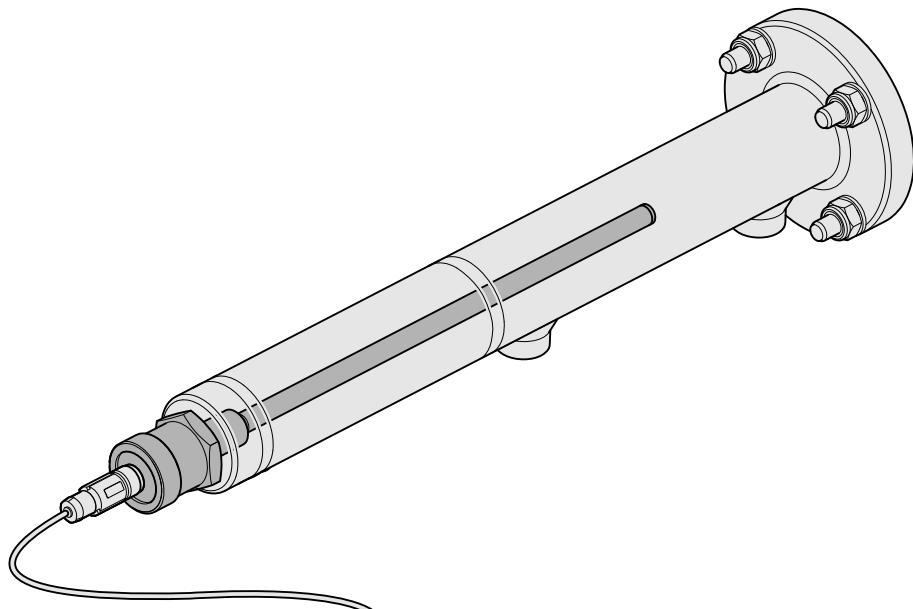
Figure 113

**Caution!**

Make sure the transom seal (J) in the correct position and direction. This will help prevent damage to the equipment.

- 28 Install the rest of the hydraulic cylinder in the reverse order. See [3.3.4 Hydraulic Steering Cylinder, Replace](#).
- 29 Check the oil level. See [3.3.10 Hydraulic System, Inspect Oil Level](#)
- 30 Ventilate the hydraulic system. See .
- 31 Check the hydraulic pressure. See [3.3.19 Hydraulic System, Inspect Working Pressure](#)
- 32 Calibrate the jet. See [3.4.2 Jet autocalibration](#)
- 33 Task completed.

3.3.7 Hydraulic Steering Cylinder, Replace Feedback Sensor



GEN-2479-02

Figure 114

Task Summary

The task is to replace the feedback sensor on the hydraulic steering cylinder.

Task Interval

Do this task during:

- Corrective maintenance, while docked

Prerequisites

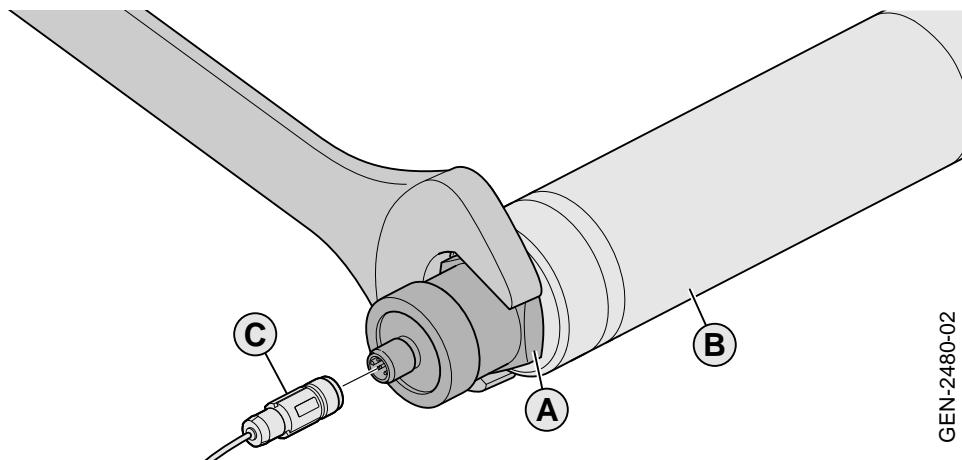
Conditions

Necessary scaffolding to access unit safely.

The feedback sensor cable is disconnected from the MBU.

Number of personnel	Skill level	Maintenance facility level	Estimated time		
1	Authorized Service Technician	Dry docked or dockside	60 minutes		
Spare parts	Quantity	Part number			
Feedback sensor (for hydraulic steering cylinder)	1	41912			
Consumables	Quantity	Part number			
Cloth	-	-			
Molykote® D paste	-	-			
Reference document					
5.2 Torque					

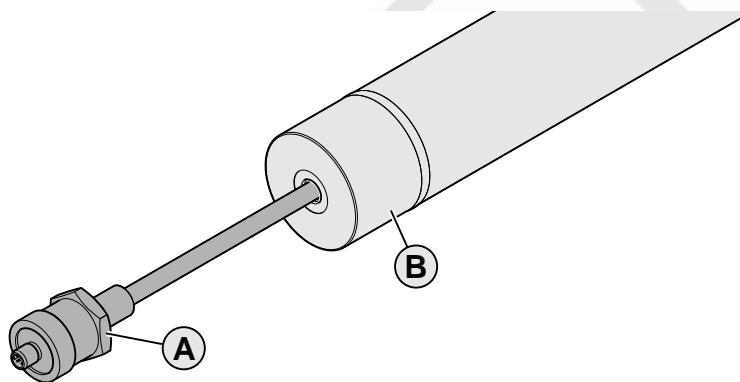
Procedure



GEN-2480-02

Figure 115

- 1 Disconnect the sensor cable (C).
- 2 Use a large wrench to loosen the feedback sensor (A) from the cylinder tube (B).

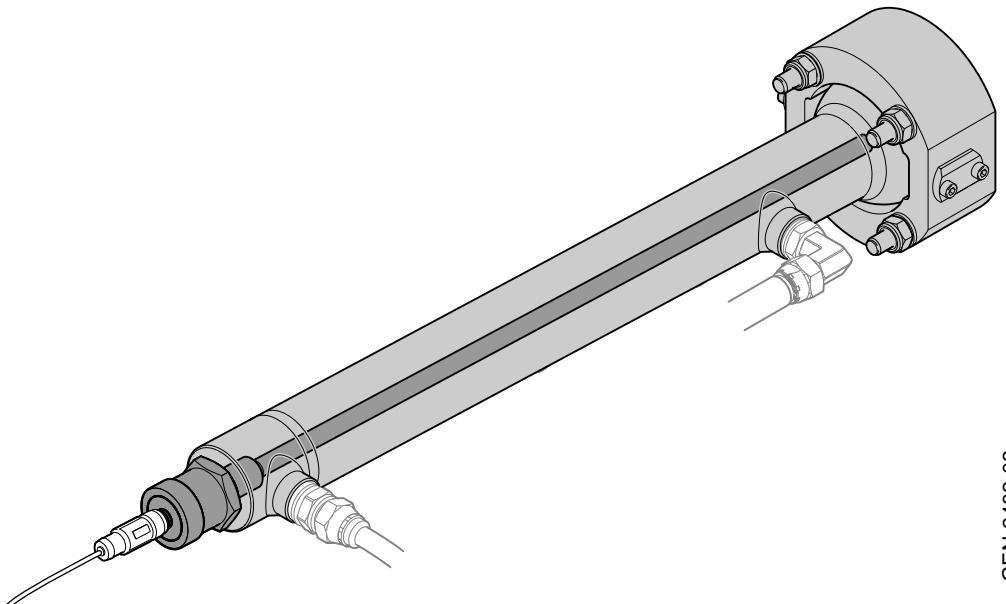


GEN-2481-01

Figure 116

- 3 Pull and remove the feedback sensor (A) from the cylinder tube (B).
- 4 Put the new O-rings and plastic support washers on the new feedback sensor head.
- 5 Carefully push the new feedback sensor into the cylinder tube (B).
- 6 Use a large wrench to install the feedback sensor (A) on the cylinder tube (B). Tighten to torque, 45 Nm.
- 7 Connect the sensor cable (C).
- 8 Calibrate the jet. See *3.4.2 Jet autocalibration*
- 9 Task completed.

3.3.8 Hydraulic Reversing Cylinder, Replace Feedback Sensor



GEN-2482-02

Figure 117

Task Summary

The task is to replace the feedback sensor on the hydraulic reversing cylinder.

Task Interval

Do this task during:

- Corrective maintenance, while docked

Prerequisites

Conditions

Necessary scaffolding to access unit safely.

The feedback sensor cables are disconnected from the MBU.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dry docked	60 minutes

Spare parts	Quantity	Part number
Feedback sensor (for hydraulic reversing cylinder)	1	41909

Consumables	Quantity	Part number
Cloth	-	-
Molykote® D paste	-	-

Reference document

5.2 Torque

Procedure

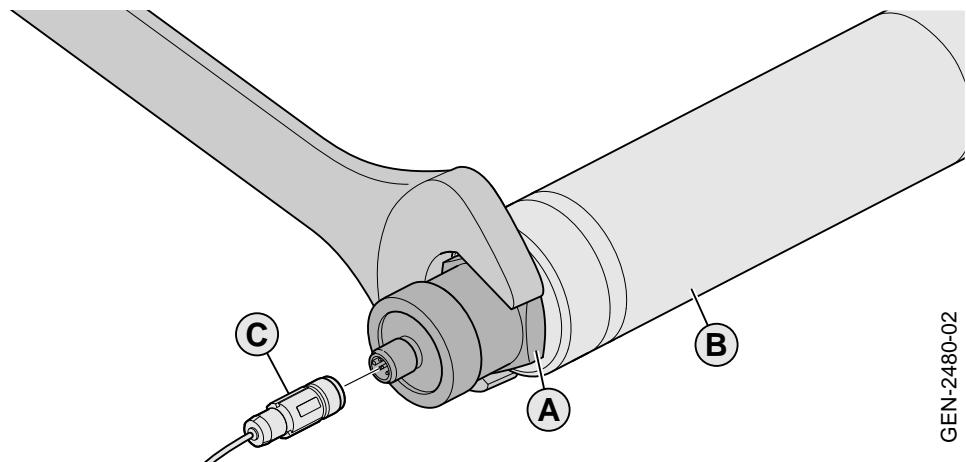


Figure 118

- 1 Disconnect the sensor cable (C).
- 2 Use a large wrench to loosen the feedback sensor (A) from the cylinder tube (B).

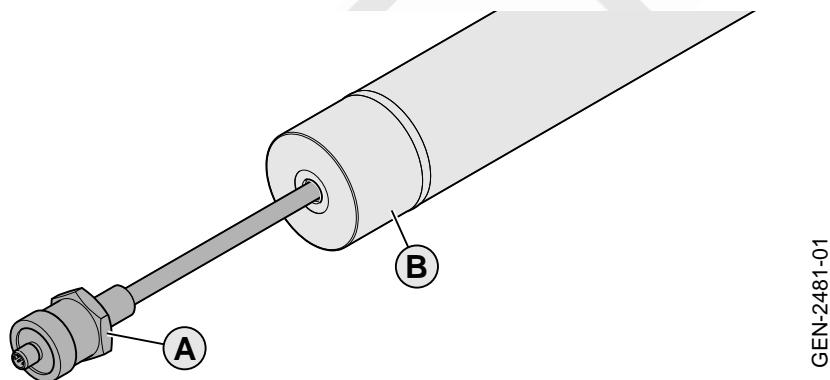


Figure 119

- 3 Pull and remove the feedback sensor (A) from the cylinder tube (B).
- 4 Put the new O-rings and plastic support washers on the new feedback sensor head.
- 5 Carefully push the new feedback sensor into the cylinder tube (B).
- 6 Use a large wrench to install the feedback sensor (A) on the cylinder tube (B). Tighten to torque 45 Nm.
- 7 Connect the sensor cable (C).
- 8 Calibrate the jet. See *3.4.2 Jet autocalibration*
- 9 Task completed.

3.3.9 Hydraulic and Lubrication System, Replace Filler Breather Filter

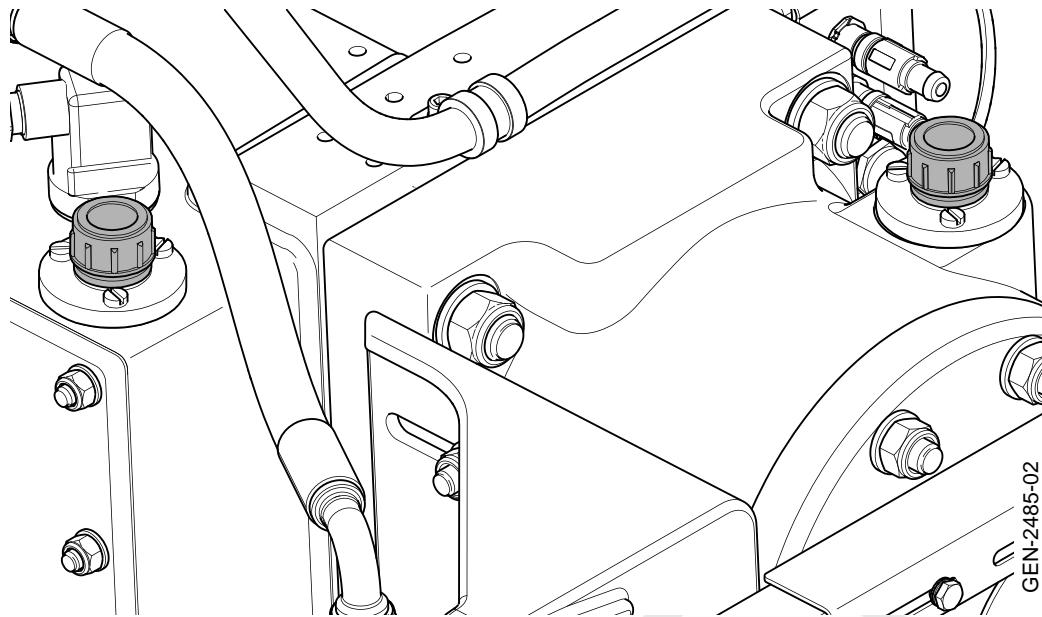


Figure 120

Task Summary

The task is to replace the filler breather filters on the hydraulic and lubrication system (hydraulic tank and shaft bearing assembly).

Task Interval

Do this task during:

- Preventive maintenance, annually
- Corrective maintenance

Prerequisites

Conditions

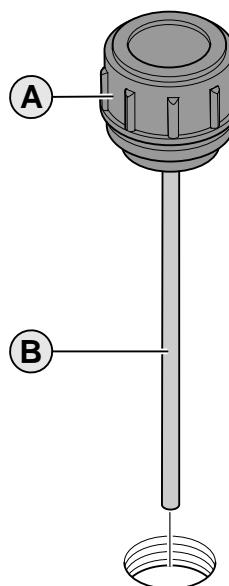
The jet propulsion system must be shut down.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Chief Engineer	Dockside	5 minutes

Spare parts	Quantity	Part number
Filler breather filter	2	X310-1410-2

Consumables	Quantity	Part number
Cloth	1	-
Protection plug	1	-

Procedure

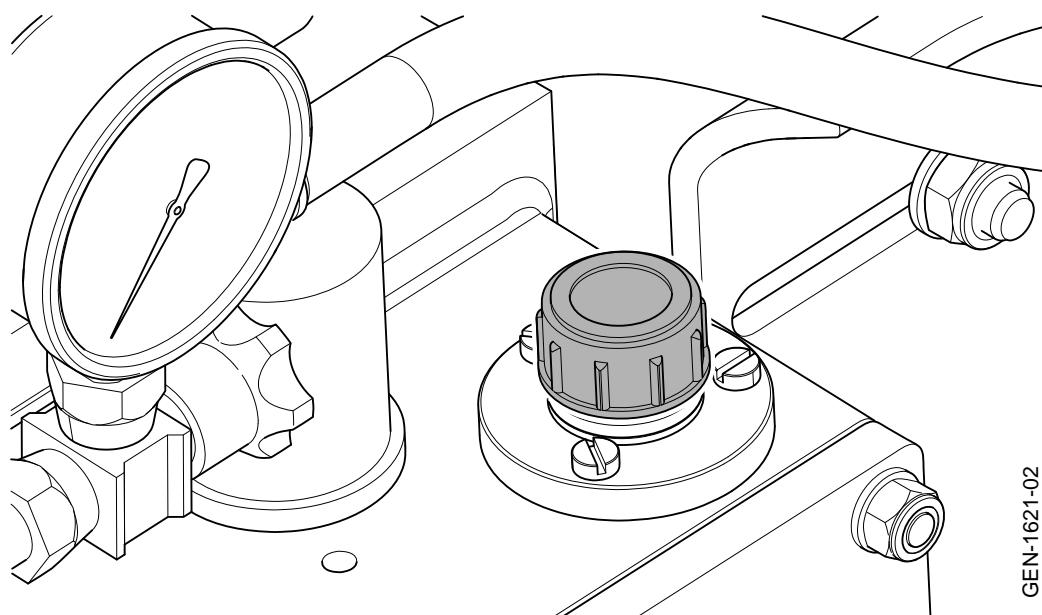


GEN-2487-02

Figure 121

- 1 Clean the filter connection.
- 2 Turn the filter (A) to remove it. Use a protection plug to plug the filter connection if leaving the tank.
- 3 Remove the dipstick (B) from the filter (A).
- 4 Put the new filter on the dipstick (B) and install again.
- 5 Task completed.

3.3.10 Hydraulic System, Inspect Oil Level



GEN-1621-02

Figure 122

Task Summary

The task is to inspect the oil level on the hydraulic system (hydraulic tank).

Task Interval

Do this task during:

- Preventive maintenance, during operation daily
- Corrective maintenance

Prerequisites

Conditions

None

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Crew	On equipment / at sea	1 minute

Procedure

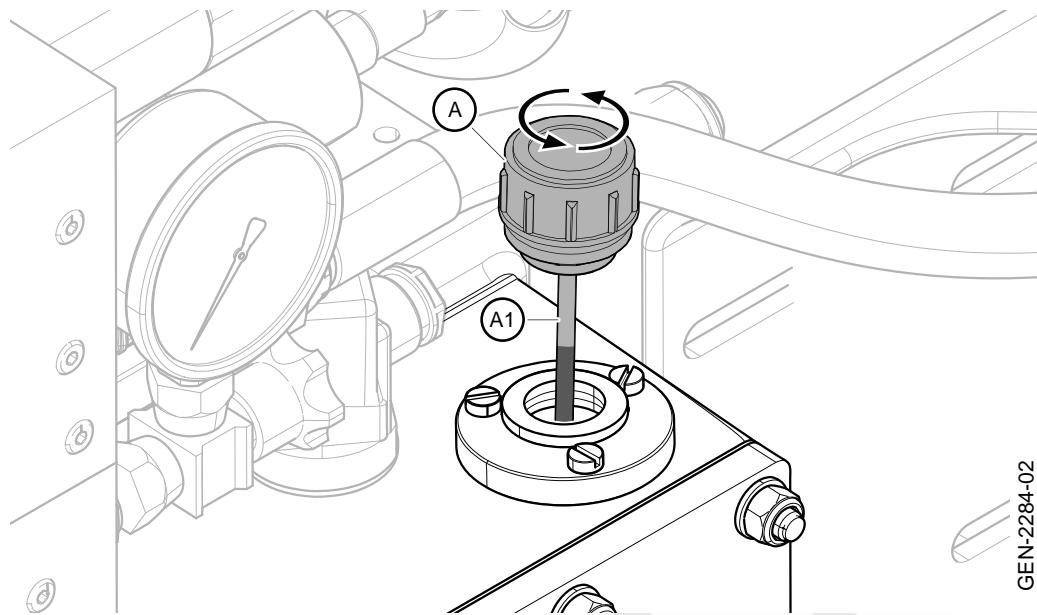


Figure 123

- 1 Remove the air filter (A) with the attached dipstick (A1).
- 2 Wipe the dipstick clean.
- 3 Install the air filter (A) with the dipstick until it is fully seated.
- 4 View the oil level on the dipstick (A1) to confirm that the oil level is within the safe operating range.
- 5 Add oil if required. For more information
- 6 Task completed.

3.3.11 Hydraulic System, Inspect Oil Temperature

Task Summary

The task is to inspect the oil temperature on the hydraulic system (hydraulic tank).

Task Interval

Do this task during:

- During operation.

Prerequisites

Conditions

System has reached working temperature.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Crew	On equipment / at sea	5 minutes

Procedure

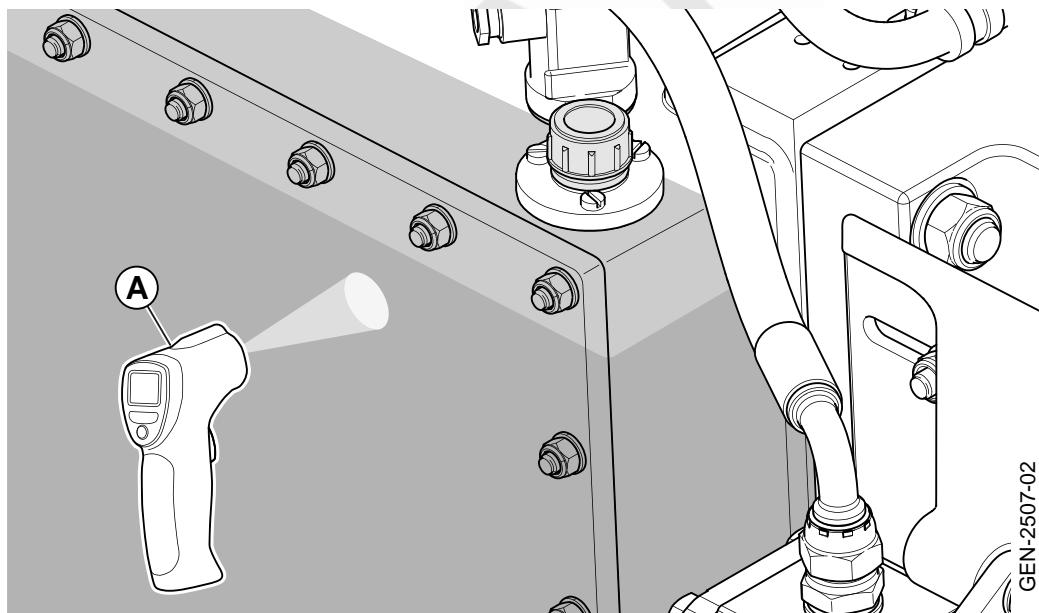


Figure 124

- 1 Use an IR-thermometer (A) to measure the oil temperature on the hydraulic tank, somewhere below the oil level.
- 2 Task completed.

3.3.12 Hydraulic System, Inspect Oil Quality

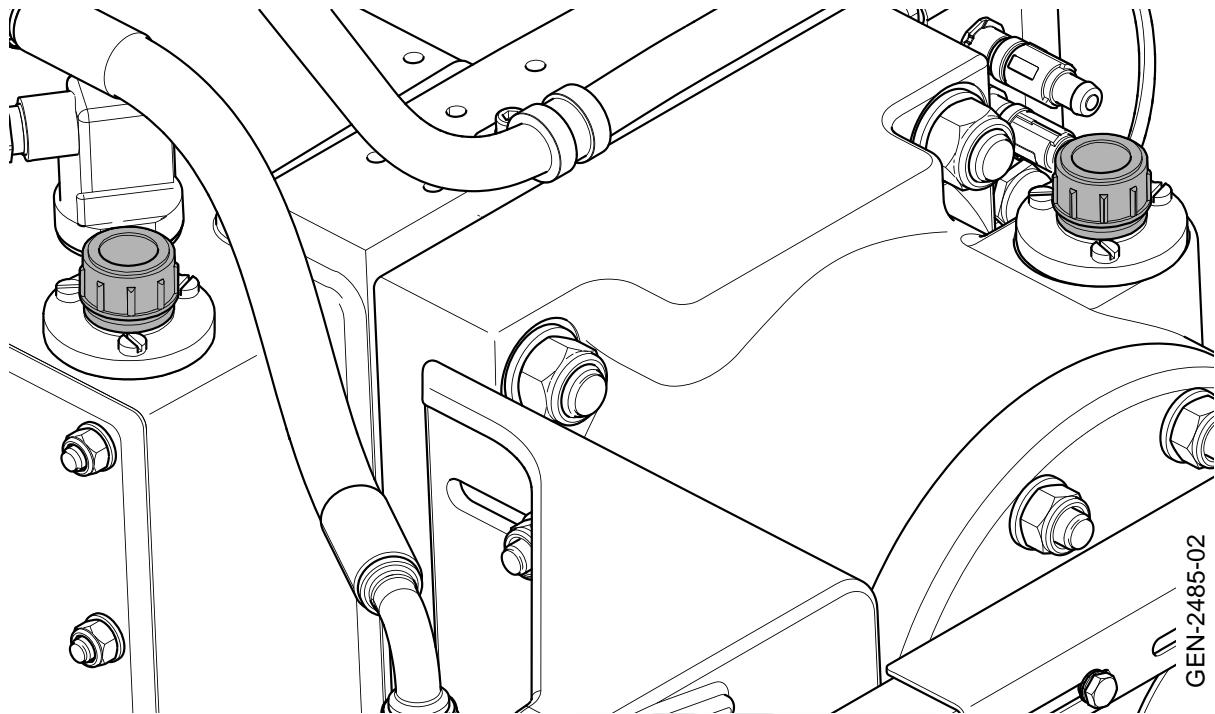


Figure 125

Task Summary

The task is to inspect the hydraulic oil quality on the hydraulic system (hydraulic tank and shaft bearing assembly).



Warning!

Burn risk! The oil may be hot.

Task Interval

Do this task during:

- Preventive maintenance, annually

Prerequisites

Conditions

Vacuum pump for oil sampling available.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Crew	On equipment / at sea	5 minutes

Consumables	Quantity	Part number
Bottle for the oil sample	1(2)	-

Reference document

5.4 Oil Contamination Limits

Procedure

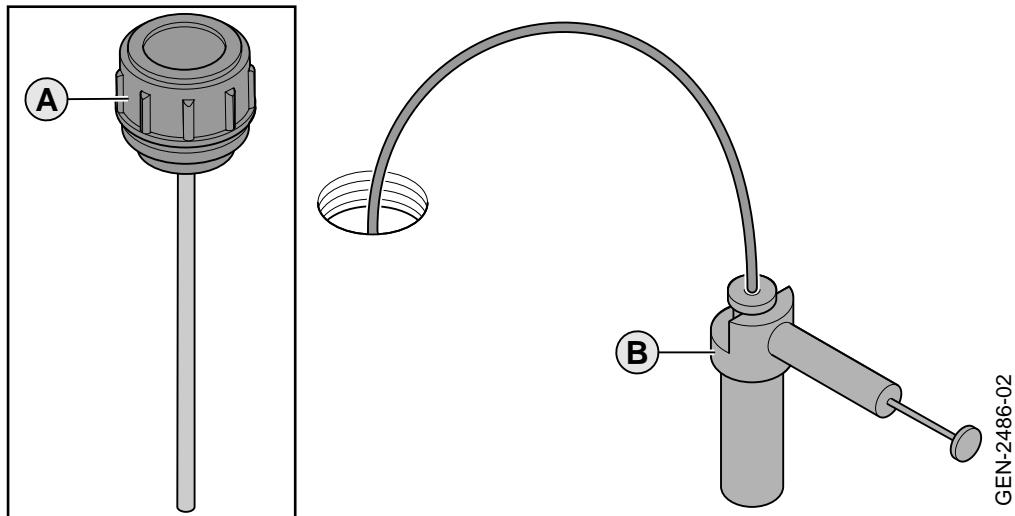
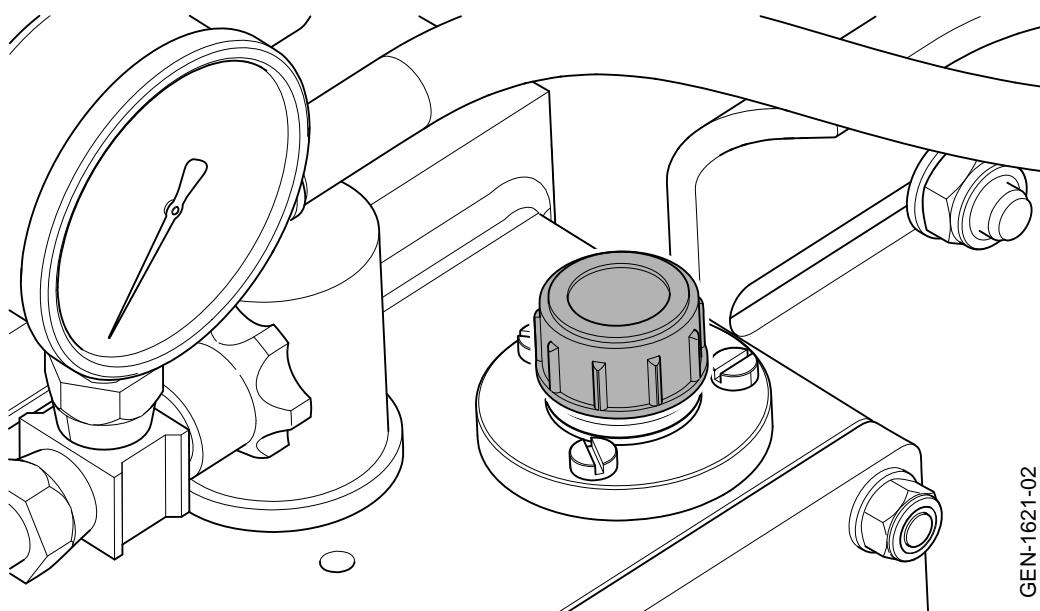


Figure 126

- 1 Remove the hydraulic air filter (A).
- 2 Insert the tube from vacuum pump (B) through the air filter mounting hole, down to the middle of the tank and take the oil sample.
- 3 Fill the bottle to 3/4.
- 4 Label the bottle and send it for analysis.
For acceptance criteria, see .
If the contamination is outside the acceptance criteria, the oil must be changed. See 3.3.14 Hydraulic Tank, Replace Oil.
- 5 Install the hydraulic air filter (A).
- 6 Task completed.

3.3.13 Hydraulic System, Add Oil



GEN-1621-02

Figure 127

Task Summary

The task is to add oil to the hydraulic system (hydraulic tank).



Warning!

Burn risk! Oil may be hot after operation.

Task Interval

Do this task during:

- Corrective maintenance, while docked

Prerequisites

Conditions

System completely shut off.

Oil container available.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Chief Engineer	On equipment / at sea	30 minutes

Consumables	Quantity	Part number
Hydraulic oil	-	-
Cloth	1	-

Special tools and test equipment	Quantity	Part number
----------------------------------	----------	-------------

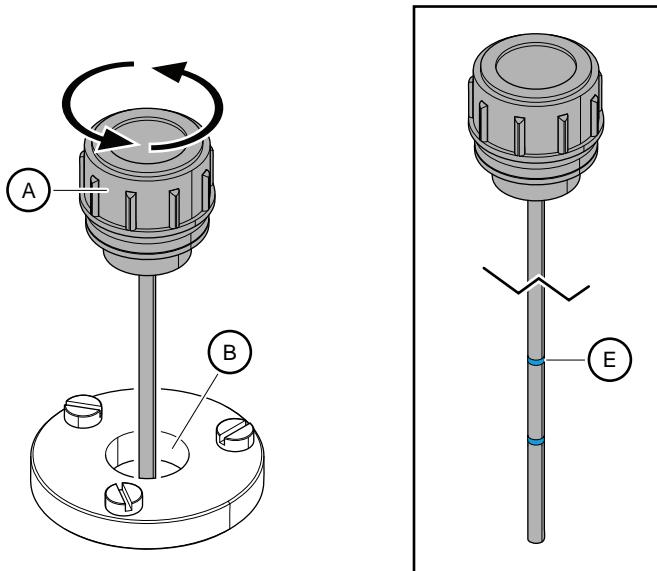
Filler unit

1

-

Reference document

3.3.19 Hydraulic System, Inspect Working Pressure

Procedure

GEN-1681-01

Figure 128

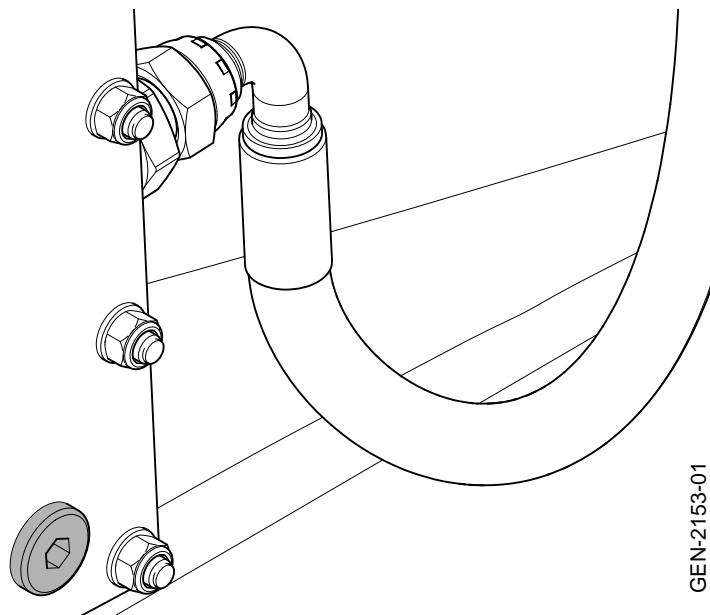
- 1 Make sure you have the right oil. See 5.6 Fluids and Lubricants.
- 2 Remove the air filter (A) with the attached dipstick.
- 3 Fill with new oil through the air filter connection (B).

Note!

It is recommended to filter the oil before or upon filling. New oil may contain quite high particle counts.

- 4 Wipe the dipstick clean.
- 5 Install the air filter with the dipstick until it is fully seated.
- 6 View the oil level on the dipstick (E) to confirm that the oil level is within the safe operating range.
- 7 Repeat steps 1-5 until the oil level is within the safe operating range.
- 8 Install the air filter (A) with the dipstick again.
- 9 Start the hydraulic system and make a function test to make sure that the system is working.
- 10 Ventilate the hydraulic system. See .
- 11 Check the hydraulic pressure. See 3.3.19 Hydraulic System, Inspect Working Pressure
- 12 Task completed.

3.3.14 Hydraulic Tank, Replace Oil



GEN-2153-01

Figure 129

Task Summary

The task is to replace the hydraulic oil.



Warning!

The system must be completely shut off so that the hydraulic system is not pressurized. Use safety glasses.



Warning!

Burn risk! Oil may be hot.

Task Interval

Do this task during:

- Preventive maintenance, every 24 months
- Corrective maintenance, while docked

Prerequisites

Conditions

System completely shut off.

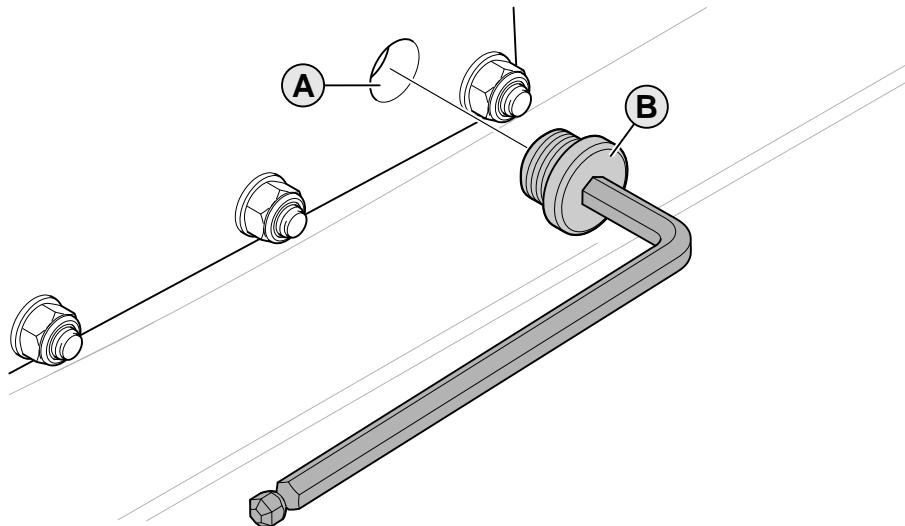
Oil container available.

Number of personnel	Skill level	Maintenance facility level	Estimated time		
1	Chief Engineer	Dockside	180 minutes + oil flushing		
Spare parts	Quantity	Part number			
Pressure oil filter cartridge	1				
Air filter	1				
Consumables	Quantity	Part number			
Hydraulic oil	See hydraulic oil specification for oil volume.	-			
Cloth	1	-			
Special tools and test equipment	Quantity	Part number			
Filler unit	1	-			
Reference document					
3.3.25 Hydraulic System, Replace Oil Filter					

Reference document

3.3.9 Hydraulic and Lubrication System, Replace Filler Breather Filter

3.3.19 Hydraulic System, Inspect Working Pressure

Procedure

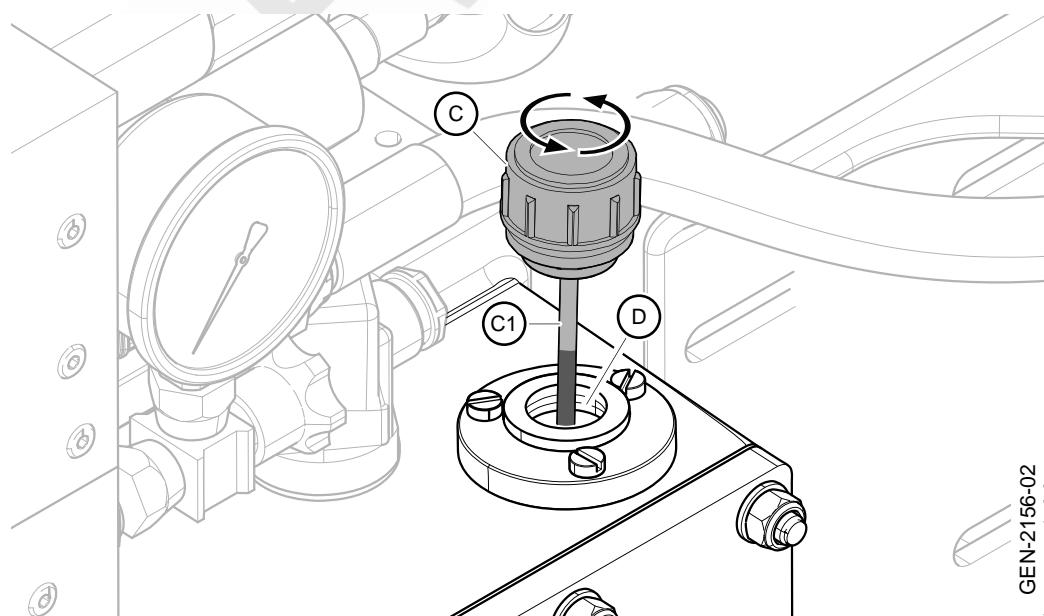
GEN-2154-01

Figure 130

- 1 Place an oil container under the drain hole (A) and remove the oil plug (B).
- 2 When all oil is drained, install the oil plug (B) to torque 30 Nm.

Note!

If draining the tank by this method is not possible, use the hydraulic pump to empty the hydraulic tank.



GEN-2156-02

Figure 131

- 3 Remove the air filter (C) with the attached dipstick (C1).

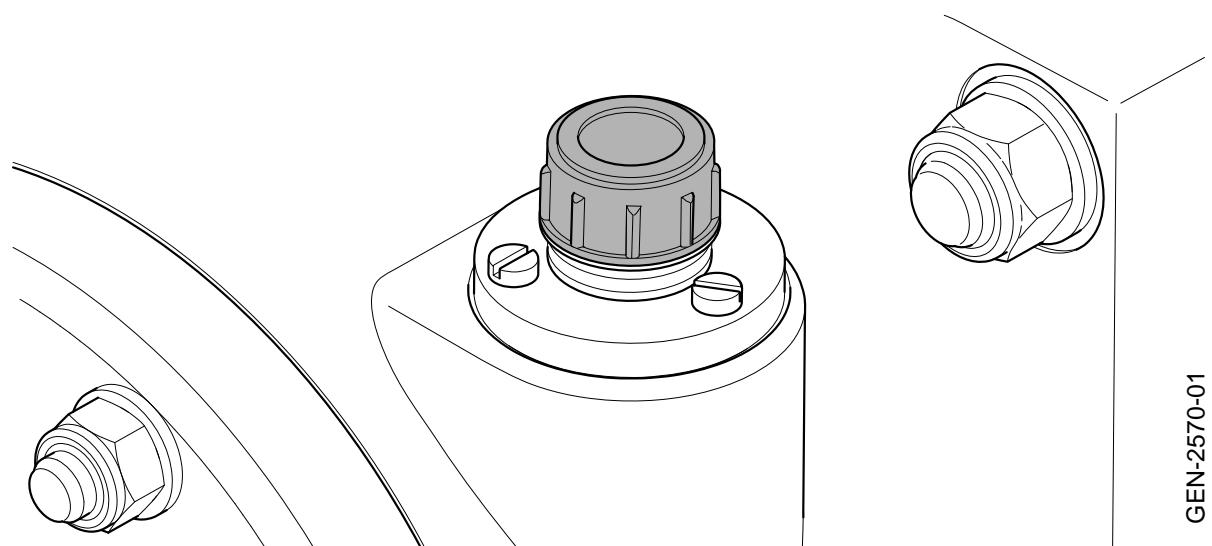
- 4 Fill with new oil through the air filter connection (D).

Note!

It is recommended to filter the oil before or upon filling. New oil may contain quite high particle counts.

- 5 Wipe the dipstick (C1) clean.
- 6 Install the air filter with the dipstick until it is fully seated.
- 7 View the oil level on the dipstick (C1) to confirm that the oil level is within the safe operating range.
- 8 Repeat steps 3-7 until the oil level is within the safe operating range.
- 9 Install and firmly tighten the air filter (C) with the dipstick (C1) again.
- 10 Replace the pressure oil filter. See *3.3.25 Hydraulic System, Replace Oil Filter*.
- 11 Ventilate the hydraulic system. See .
- 12 Check the hydraulic pressure. See *3.3.19 Hydraulic System, Inspect Working Pressure*
- 13 Start the hydraulic system and make a function test to make sure that the system is working.
- 14 Task completed.

3.3.15 Lubrication System, Add Oil



GEN-2570-01

Figure 132

Task Summary

The task is to add oil to the lubrication system.

Task Interval

Do this task during:

Prerequisites

Conditions

System completely shut off.

Oil container available.

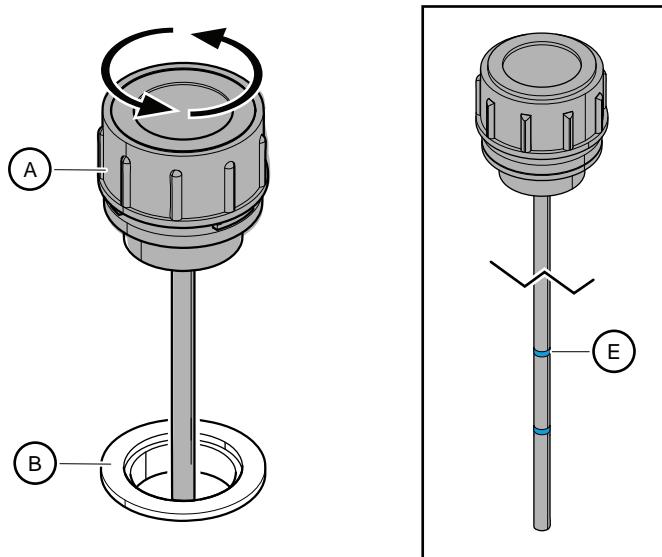
Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Chief engineer, basic	Dockside	30 minutes

Consumables	Quantity	Part number
Lubrication oil	See lubrication oil specification for oil volume.	-
Cloth	1	-

Special tools and test equipment	Quantity	Part number
Filler unit	1	-

Reference document

Procedure

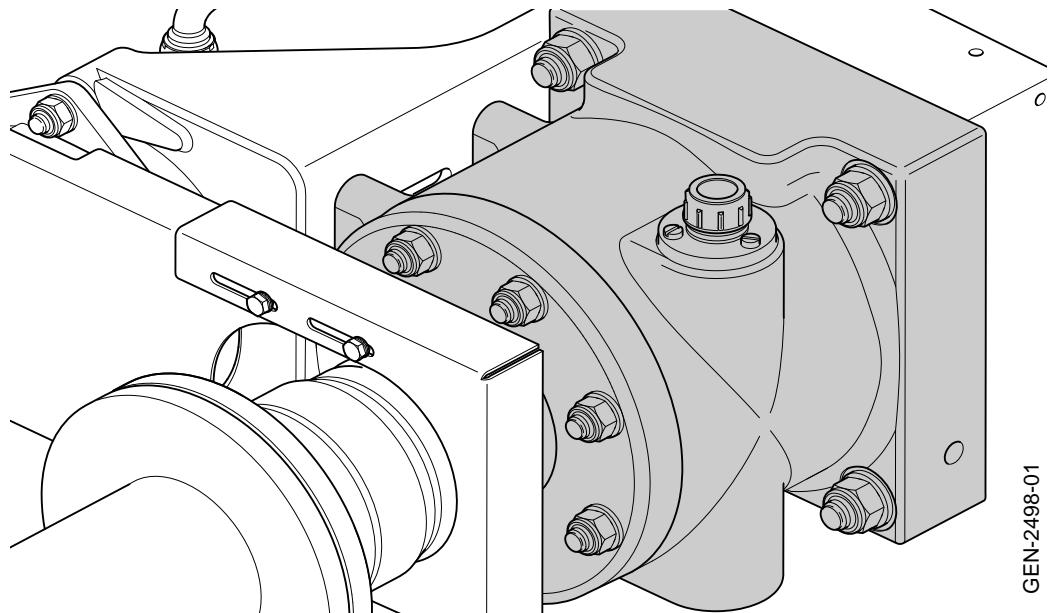


GEN-2943-02

Figure 133

- 1 Make sure you have the right oil. See *5.6 Fluids and Lubricants*.
 - 2 Remove the air filter (A) with the attached dipstick (E).
 - 3 Fill with new oil through the air filter connection (B).
- Note!**
It is recommended to filter the oil before or upon filling. New oil may contain quite high particle counts.
- 4 Wipe the dipstick (E) clean.
 - 5 Install the air filter with the dipstick until it is fully seated.
 - 6 View the oil level on the dipstick (E) to confirm that the oil level is within the safe operating range.
 - 7 Repeat steps 1-5 until the oil level is within the safe operating range.
 - 8 Install and firmly tighten the air filter (A) with the dipstick (E) again.
 - 9 Task completed.

3.3.16 Thrust Bearing, Replace Oil



GEN-2498-01

Figure 134

Task Summary

The task is to replace the lubrication oil.



Warning!

The system must be completely shut off so that the lubrication system is not pressurized. Use safety glasses.



Warning!

Burn risk! Oil may be hot.

Task Interval

Do this task during:

- Preventive maintenance, every 500 operating hours
- Corrective maintenance, while docked

Prerequisites

Conditions

System completely shut off.

Oil container available.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Chief Engineer	Dockside	180 minutes + oil flushing
Spare parts	Quantity	Part number	
Air filter	1		
Consumables	Quantity	Part number	
Lubrication oil	See lubrication oil specification for oil volume.	-	
Cloth	1	-	
Special tools and test equipment	Quantity	Part number	
Filler unit	1	-	

Reference document

5.4 Oil Contamination Limits

Procedure

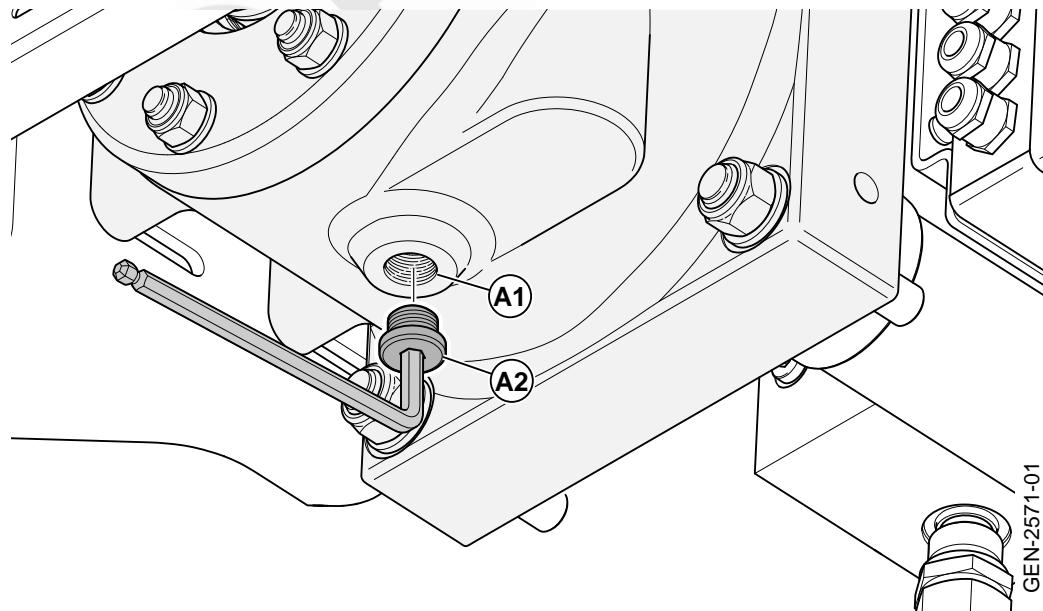


Figure 135

- 1 Place an oil container under the drain hole (A1) and remove the oil plug (A2).

- 2 When all oil is drained, install the oil plug (A2) to torque 30 Nm.

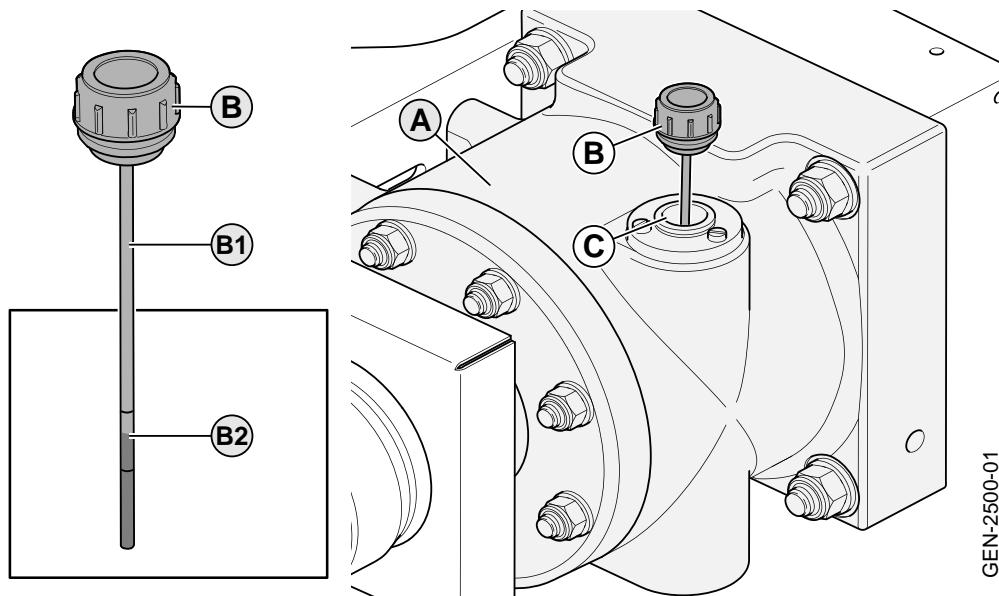


Figure 136

- 3 Remove the air filter (B) with the attached dipstick (B1).
- 4 Fill with new oil through the air filter connection (C).

Note!

It is recommended to filter the oil before or upon filling. New oil may contain quite high particle counts.

- 5 Wipe the dipstick (B1) clean.
- 6 Install the air filter with the dipstick until it is fully seated.
- 7 View the oil level on the dipstick (B1) to confirm that the oil level is within the safe operating range.
- 8 Repeat steps 3-7 until the oil level is within the safe operating range.
- 9 Install and firmly tighten the air filter (B) with the dipstick (B1) again.
- 10 Task completed.

3.3.17 Hydraulic Tank, Inspect Oil Level Switch

Task Summary

The task is to inspect the oil level switch.

Task Interval

Do this task during:

- Preventive maintenance, annually

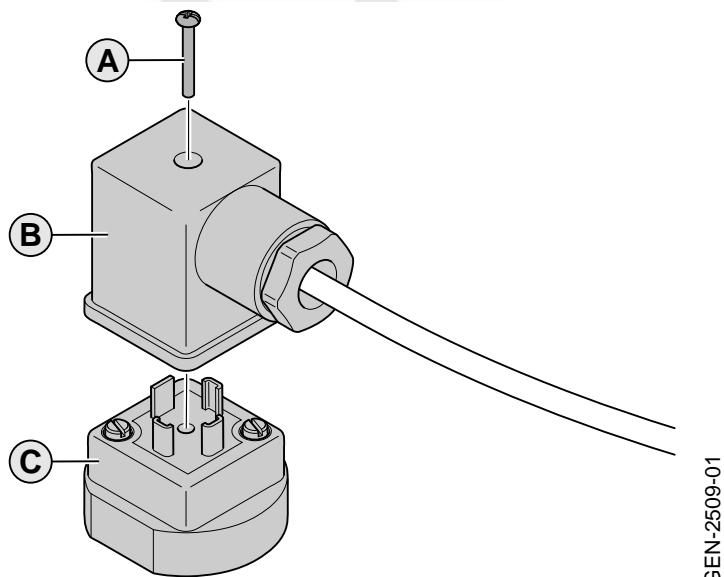
Prerequisites

Conditions

Control system power on.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Chief Engineer	Dockside	10 minutes

Procedure



GEN-2509-01

Figure 137

- 1 Remove the screw (A) from the cable connector (B).
- 2 Disconnect the cable connector (B) from the contacts on the oil level switch (C). If an alarm is raised the alarm pathway is functional.
- 3 Install the cable connector.
- 4 Task completed.

3.3.18 Hydraulic Tank, Replace Oil Level Switch

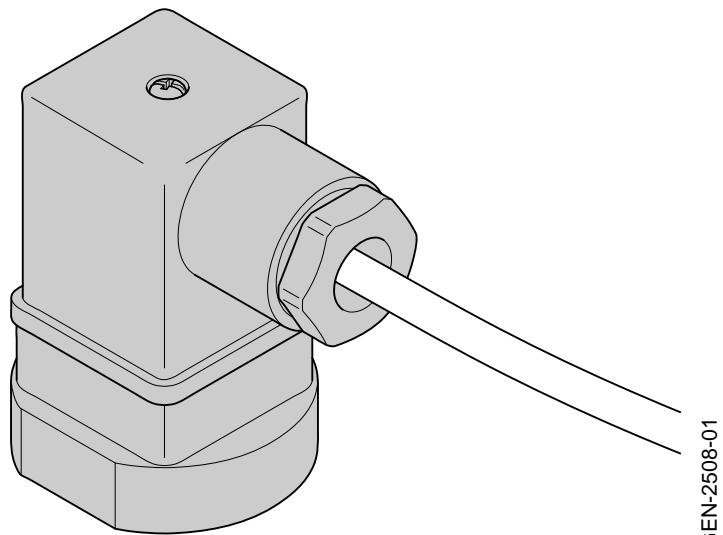


Figure 138

Task Summary

The task is to replace the oil level switch.

Task Interval

Do this task during:

- Corrective maintenance

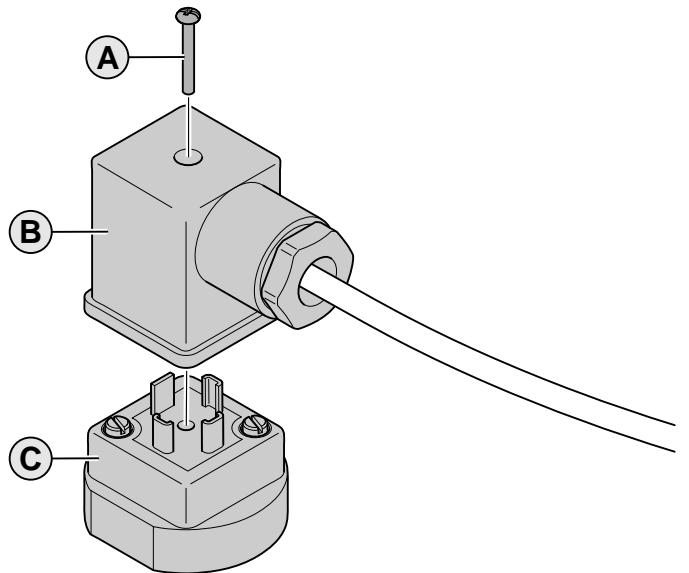
Prerequisites

Conditions

System completely shut off.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dockside	20 minutes
Spare parts	Quantity	Part number	
Hydraulic oil level alarm switch	1	HS-25540-01	

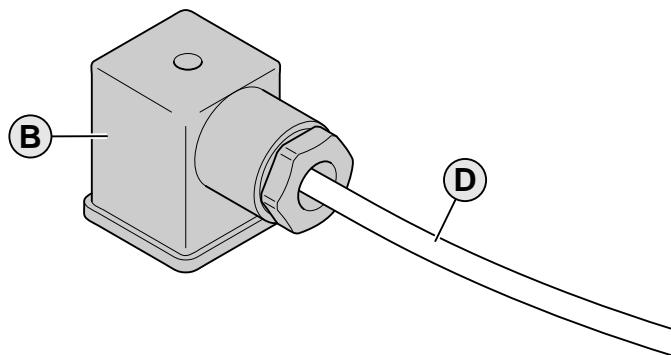
Procedure



GEN-2509-01

Figure 139

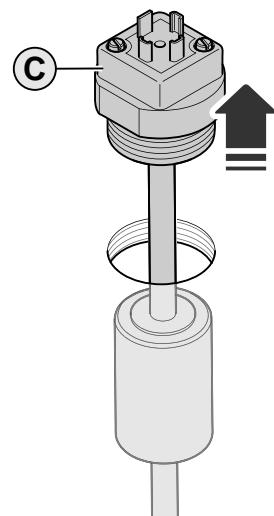
- 1 Remove the screw (A) from the top of the cable connector (B).
- 2 Disconnect the cable connector (B) from the contact on the oil level switch (C).



GEN-2510-01

Figure 140

- 3 Remove the cable connector (B) from the alarm cable (D).
- 4 Install the new cable connector (B) on the alarm cable (D).



GEN-2511-01

Figure 141

- 5 Unscrew the oil level switch (C) to remove it from the hydraulic tank.
- 6 Install the new oil level switch on the hydraulic tank.
- 7 Connect the cable connector (B) to the oil level switch (C).
- 8 Install the screw (A) to attach the cable connector (B) to the oil level switch (C).
- 9 Task completed.

3.3.19 Hydraulic System, Inspect Working Pressure

Task Summary

The task is to inspect the hydraulic working pressure.

Task Interval

Do this task during:

- Preventive maintenance, daily.

Prerequisites

Conditions

Main engine running.

System has reached working temperature.

Personnel number	Skill level	Maintenance facility level	Estimated time
1	Crew	On equipment / at sea	5 minutes

Procedure

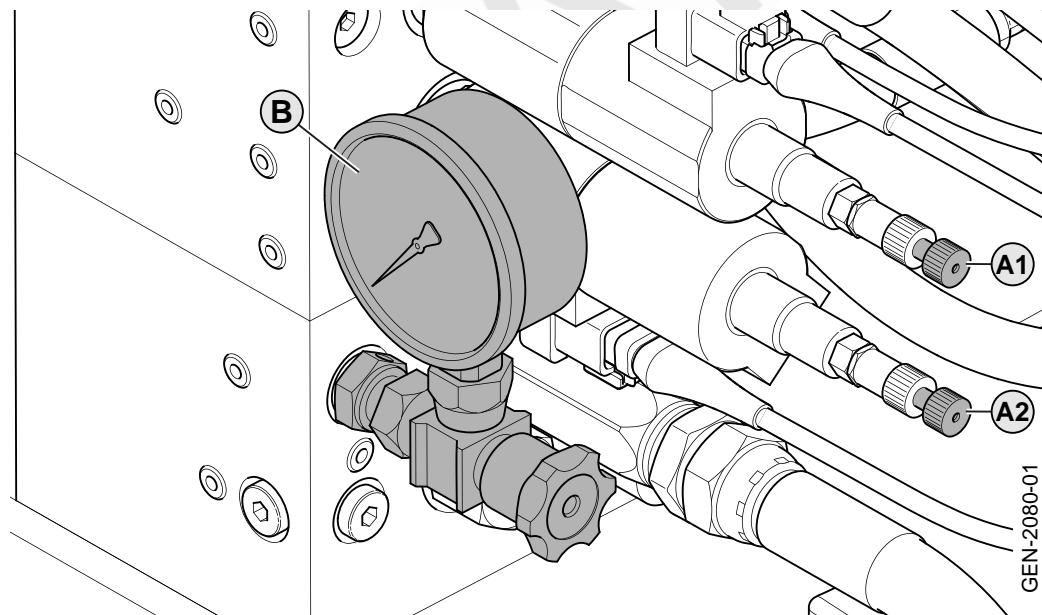


Figure 142

- Activate one of the directional control valves (A1) or (A2) using the manual override. The hydraulic cylinder must be extended to full stroke (at end position).
- The working pressure for the pump is indicated on the pressure gauge (B). Recommended pressure is 140 ± 5 bar. If the measured pressure deviates,
- Task completed.

3.3.20 Hydraulic System, Adjust Working Pressure

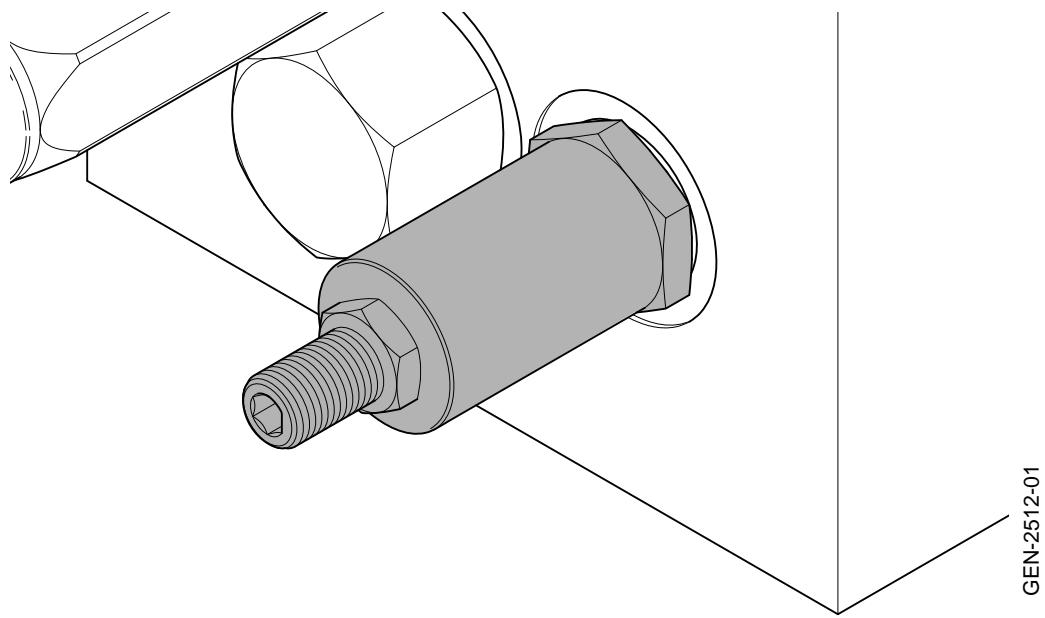


Figure 143

Task Summary

The task is to adjust the working pressure.

Task Interval

Do this task during:

- Corrective maintenance

Prerequisites

Conditions

Main engine running.

Personnel number	Skill level	Maintenance facility level	Estimated time
1	Chief Engineer	Dockside	20 minutes

Procedure

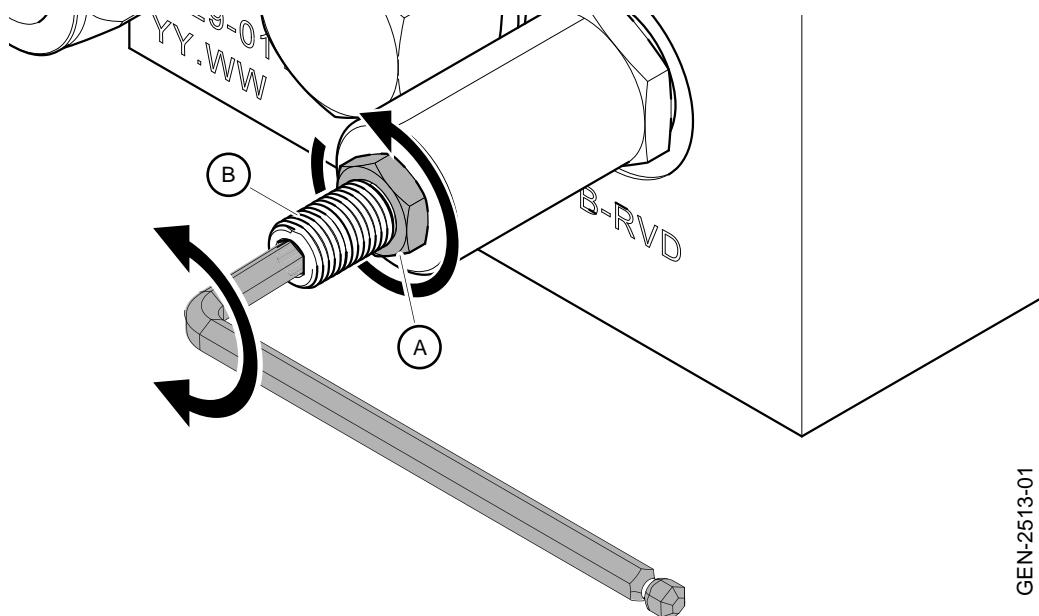


Figure 144

- 1 Loosen the main pressure regulator locknut (A). Do not remove it.

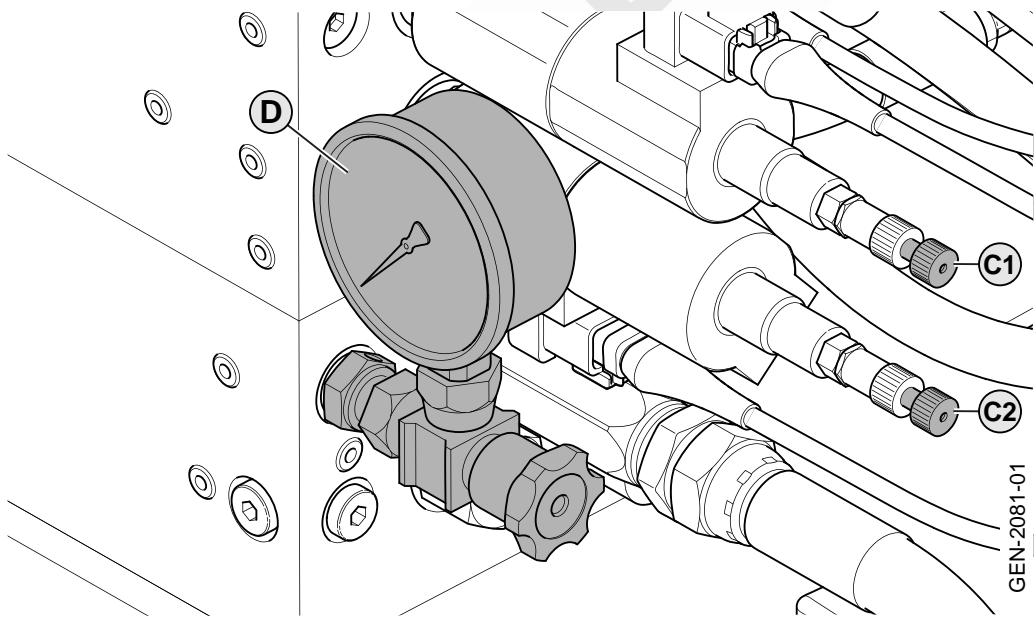


Figure 145

- 2 Activate one of the directional control valves (C1) or (C2) using the manual override.
- 3 Keep the directional control valve at full stroke position while checking the working pressure on the pressure gauge (D).
- 4 Turn the adjustment screw to adjust the pressure (B). Set the pressure to 140 bar.
 - To increase the pressure, turn the adjustment screw clockwise.
 - To decrease the pressure, turn the adjustment screw counter clockwise.
- 5 Tighten the main pressure regulator lock nut (A).
- 6 Task completed.

3.3.21 Hydraulic System, Inspect Pressure Limit

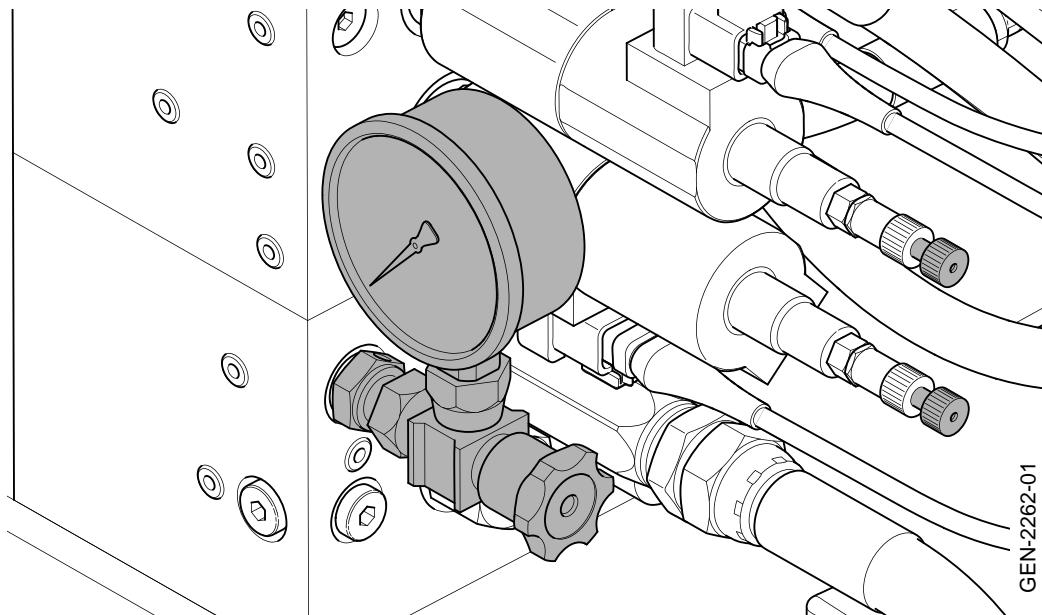


Figure 146

Task Summary

The task is to inspect the hydraulic pressure limit.

There is a pressure limit valve in the system that is activated at 180 bar if the normal pressure regulator fails.

Task Interval

Do this task during:

- Preventive maintenance, annually
- Corrective maintenance

Prerequisites

Conditions

Main engine running.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dockside	20 minutes

Procedure

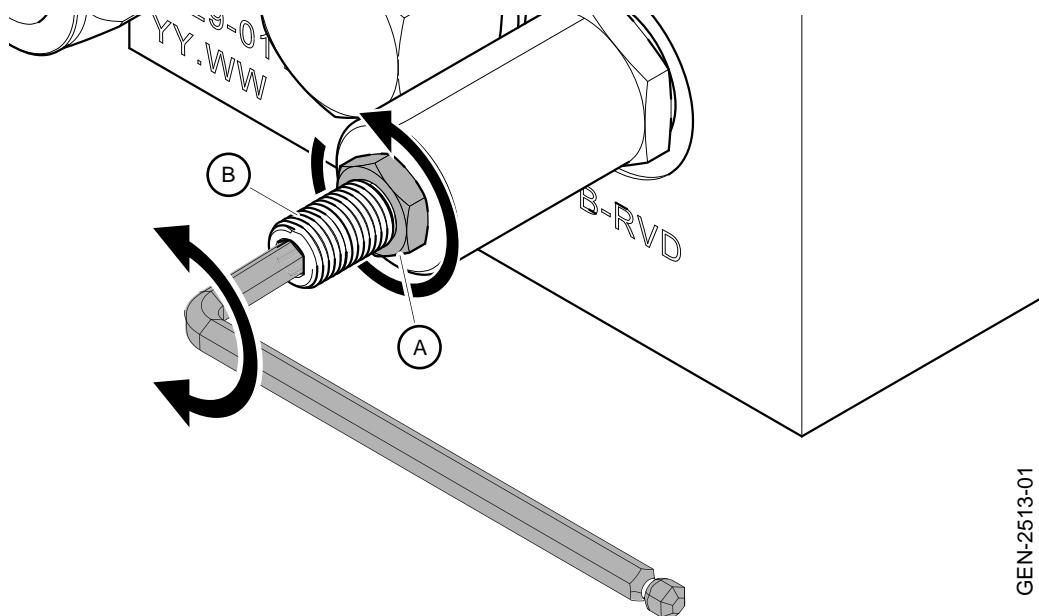


Figure 147

- 1 Loosen the main pressure regulator lock nut (A) without removing it.

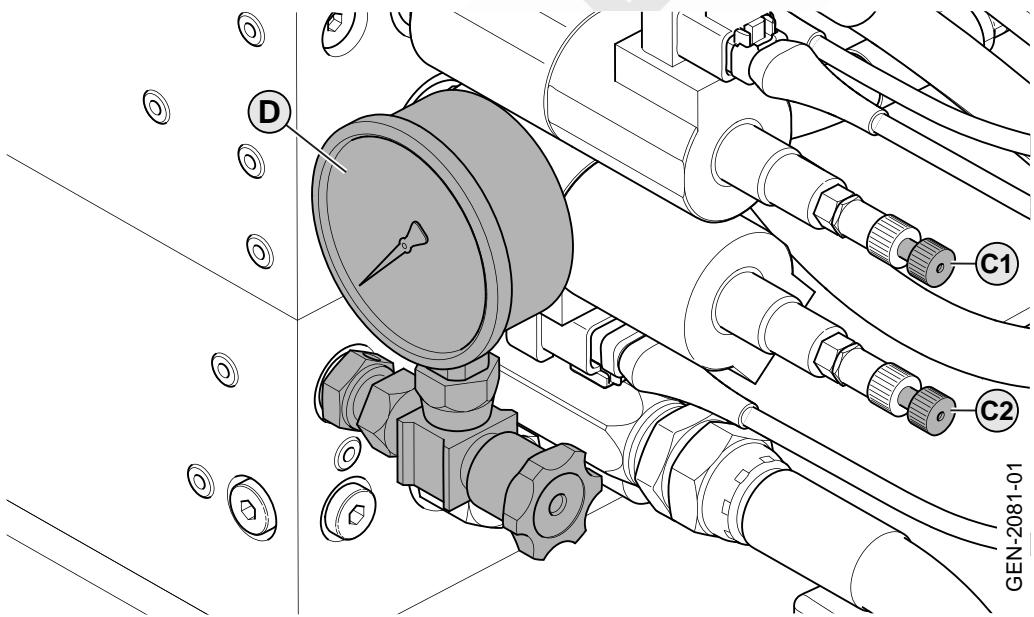


Figure 148

- 2 Activate one of the directional control valves (C1) or (C2) to set the hydraulic cylinders to full stroke position.
- 3 Examine the working pressure on the pressure gauge (D).
The recommended working pressure is 140 ± 5 bar.
- 4 Turn the adjustment screw (B) clockwise to increase the pressure.
Increase the pressure until the limit is reached.
- 5 Examine the working pressure on the pressure gauge (D).
The recommended pressure limit is 180 ± 5 bar. If the pressure limit is out of range, see 3.3.22 *Hydraulic System, Adjust Pressure Limit*. Otherwise proceed to step 6.
- 6 Reset the working pressure to 140 ± 5 bar by adjusting the adjustment screw (B).

- 7 Tighten the main pressure regulator lock nut (A).
- 8 Install the cap (A) on the main pressure regulator lock nut (B) again.
- 9 Task completed.

DRAFT

3.3.22 Hydraulic System, Adjust Pressure Limit

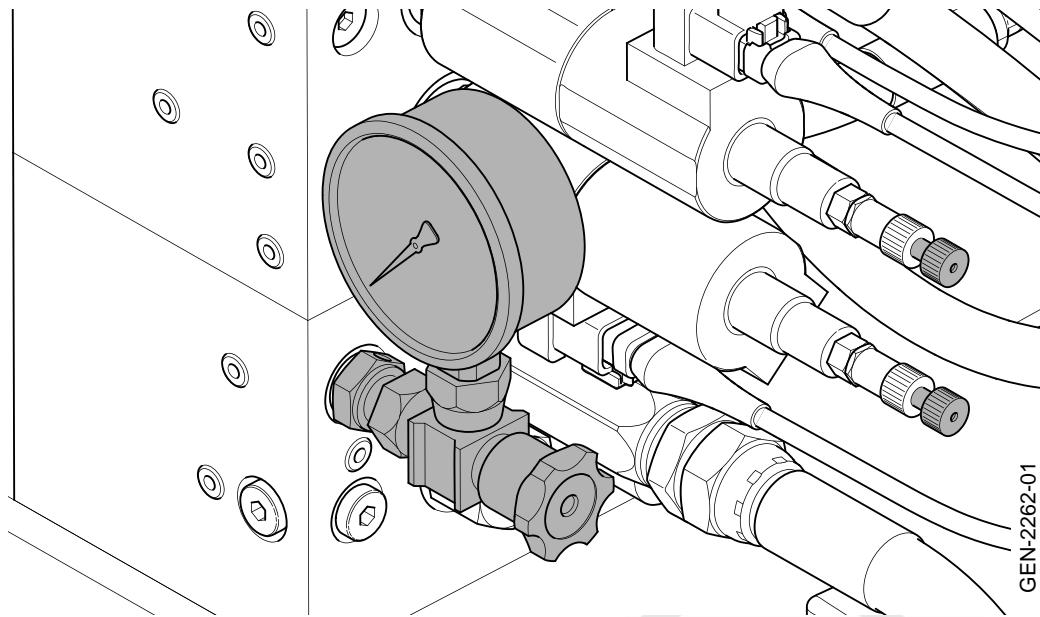


Figure 149

Task Summary

The task is to adjust the hydraulic pressure limit.

There is a pressure limit valve in the system that is activated at 180 bar if the normal pressure regulator fails.

Task Interval

Do this task during:

- Preventive maintenance, annually
- Corrective maintenance

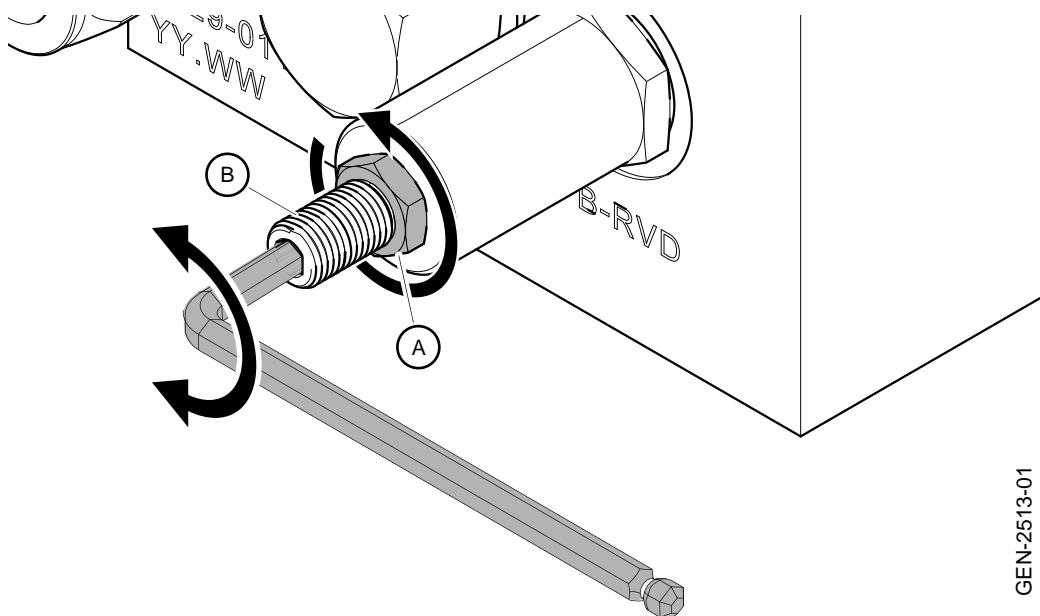
Prerequisites

Conditions

Main engine running.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dockside	20 minutes

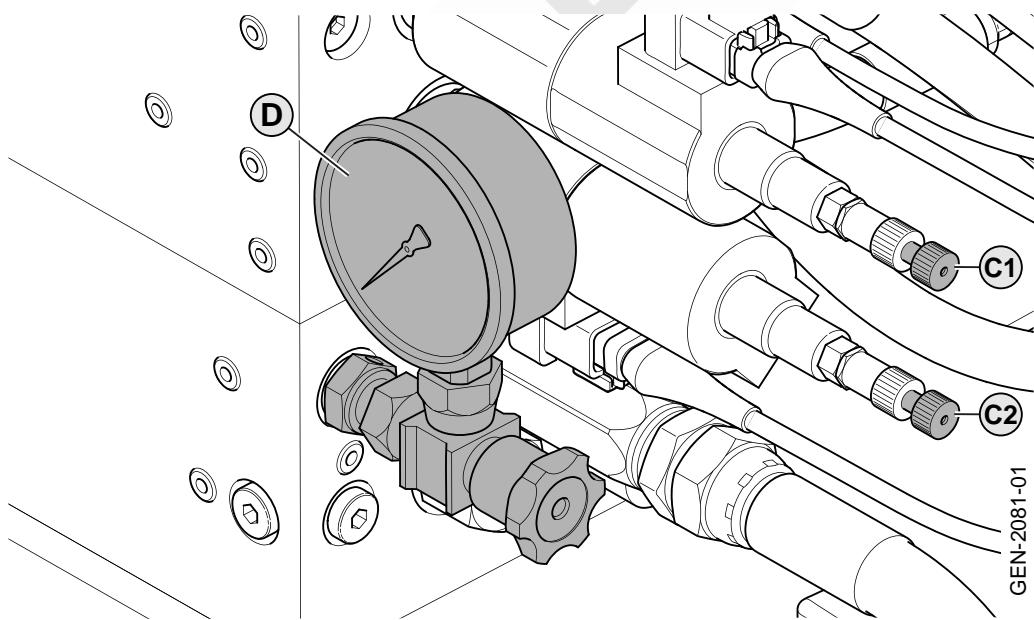
Procedure



GEN-2513-01

Figure 150

- 1 Loosen the main pressure regulator lock nut (A) without removing it.



GEN-2081-01

Figure 151

- 2 Activate one of the directional control valves (C1) or (C2) to set the hydraulic cylinders to full stroke position.
- 3 Monitor the working pressure on the pressure gauge (D).
- 4 Turn the adjustment screw (B) clockwise to increase the pressure.
Increase the pressure until the limit is reached.

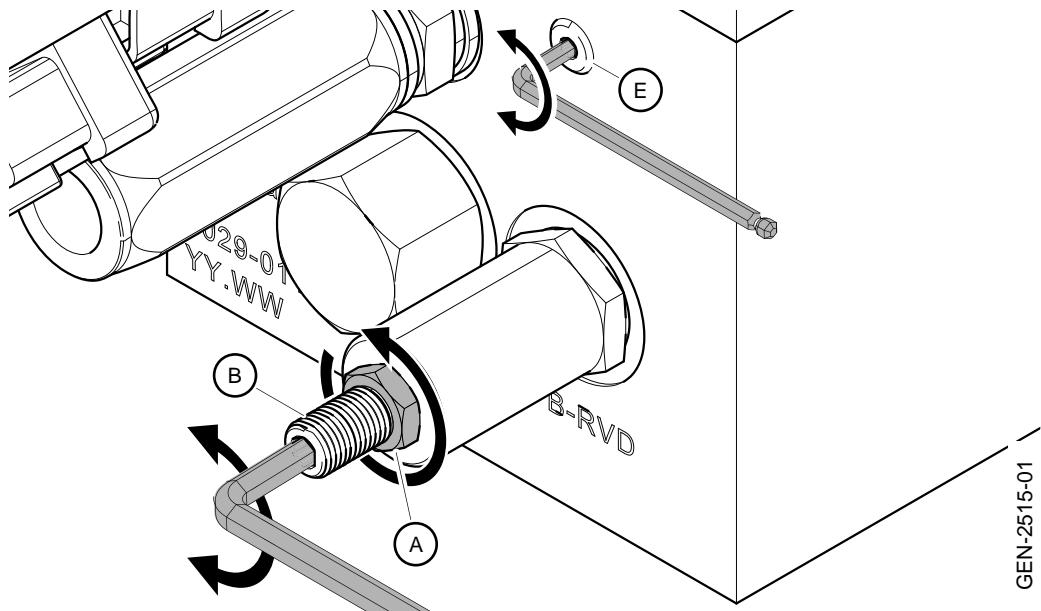


Figure 152

- 5 Adjust the pressure limit with the adjustment screw (E). Set the pressure limit to 180 ± 5 bar.
 - To increase the pressure limit, turn the adjustment screw (E) clockwise.
 - To decrease the pressure limit, turn the adjustment screw (E) counter clockwise.
- 6 Reset the working pressure to 140 ± 5 bar by adjusting the adjustment screw (B).
- 7 Tighten main pressure regulator lock nut (A).
- 8 Task completed.

3.3.23 Hydraulic System, Inspect Pressure Gauge

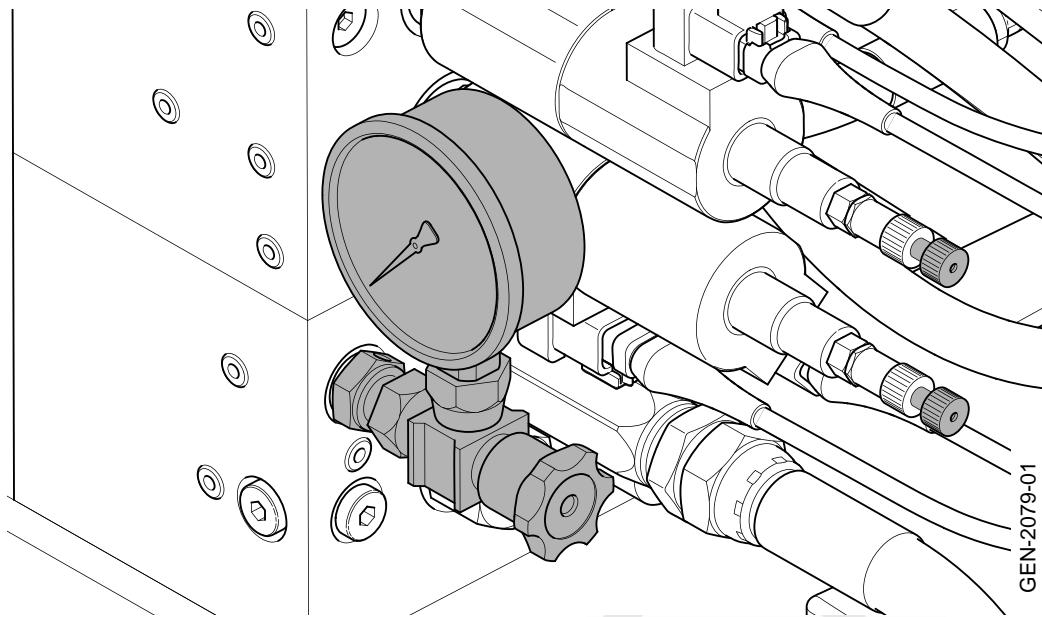


Figure 153

Task Summary

The task is to test the pressure gauge with a gauge test equipment.

Task Interval

Do this task during:

- Preventive maintenance, every 5th year
- Corrective maintenance

Prerequisites

Conditions

Hydraulic system off.

Personnel number	Skill level	Maintenance facility level (choose one)	Estimated time
1	Chief Engineer	On equipment / at sea	30 minutes

Consumables	Quantity	Part number
Protection plug	1	-

Special tools and test equipment	Quantity	Part number
Gauge test equipment	1	-

Procedure

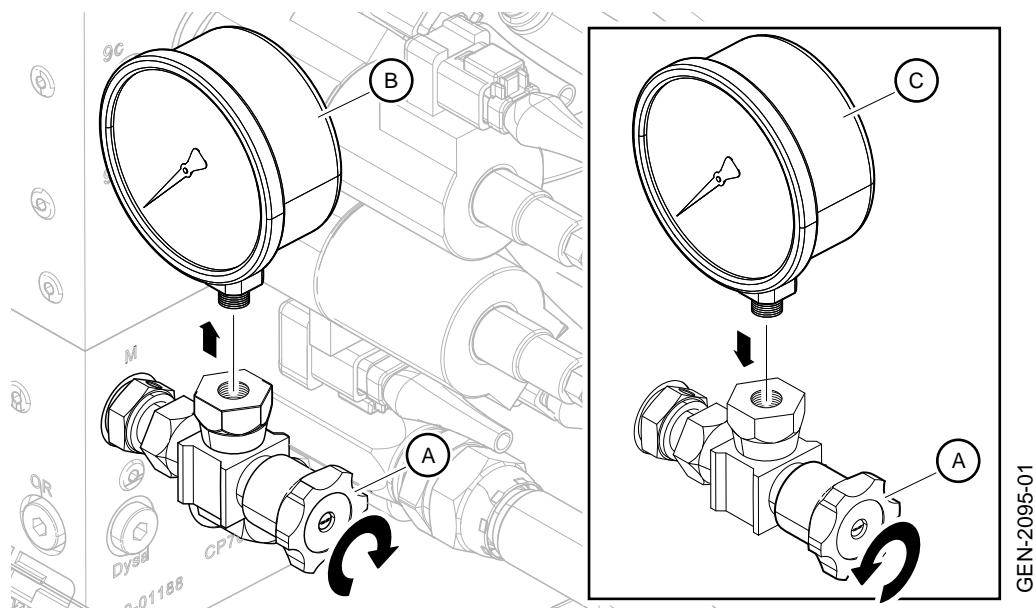


Figure 154

GEN-2095-01



Warning!
Pressurized system!

- 1 Remove the pressure gauge (B):
 - 1.1 Turn the needle valve (A) clockwise to close it.
 - 1.2 Use a wrench to remove the pressure gauge (B).
 - 1.3 Put a protection plug in the gauge connection.
- 2 Do a functional test of the pressure gauge:
 - 2.1 Connect the pressure gauge (B) to the gauge test equipment.
 - 2.2 Use the gauge test equipment.

Note!
To use the gauge test equipment, refer to manufacturer's instructions.

 - 2.3 Remove the pressure gauge from the gauge test equipment.
 - 2.4 If the test shows that the pressure gauge (B) values are different more than 10%, replace the pressure gauge. See *3.3.24 Hydraulic System, Replace Pressure Gauge*. If not, see step 3.
- 3 Install the pressure gauge again:
 - 3.1 Remove the protection plug from the gauge connection.
 - 3.2 Use a wrench to install the pressure gauge (C).
 - 3.3 Turn the valve (A) counterclockwise to open it.
- 4 Task completed.

3.3.24 Hydraulic System, Replace Pressure Gauge

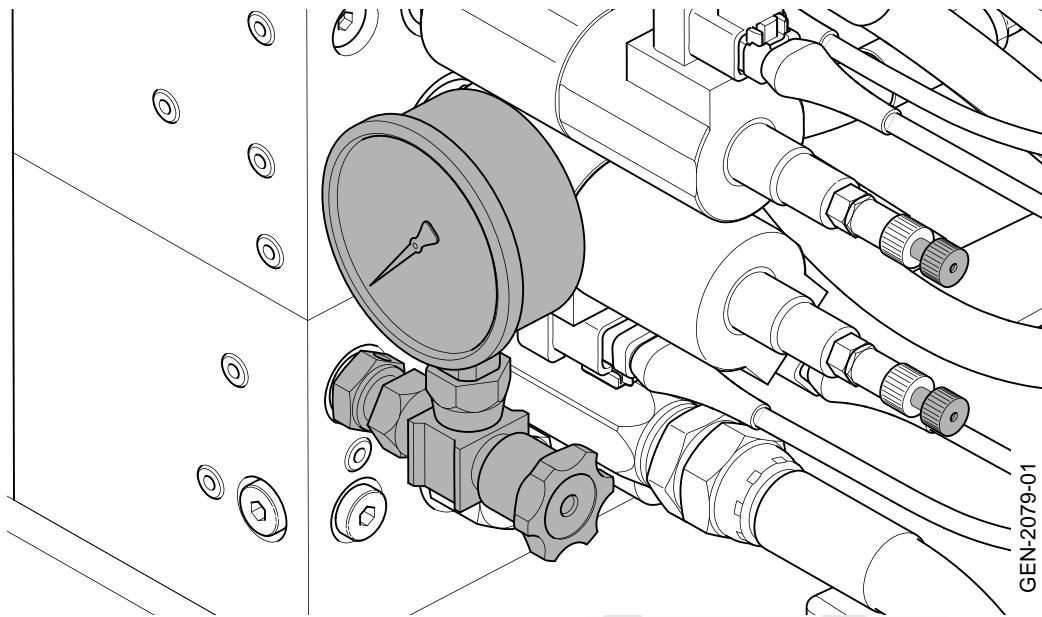


Figure 155

Task Summary

The task is to replace the hydraulic pressure gauge.

Task Interval

Do this task during:

- Corrective maintenance

Prerequisites

Conditions

Hydraulic system off.

Personnel number	Skill level	Maintenance facility level	Estimated time
1	Chief Engineer	Dockside	20 minutes

Spare parts	Quantity	Part number
Hydraulic pressure gauge	1	

Consumables	Quantity	Part number
Wipes and cloths	-	-
Protection plug	1	-

Procedure

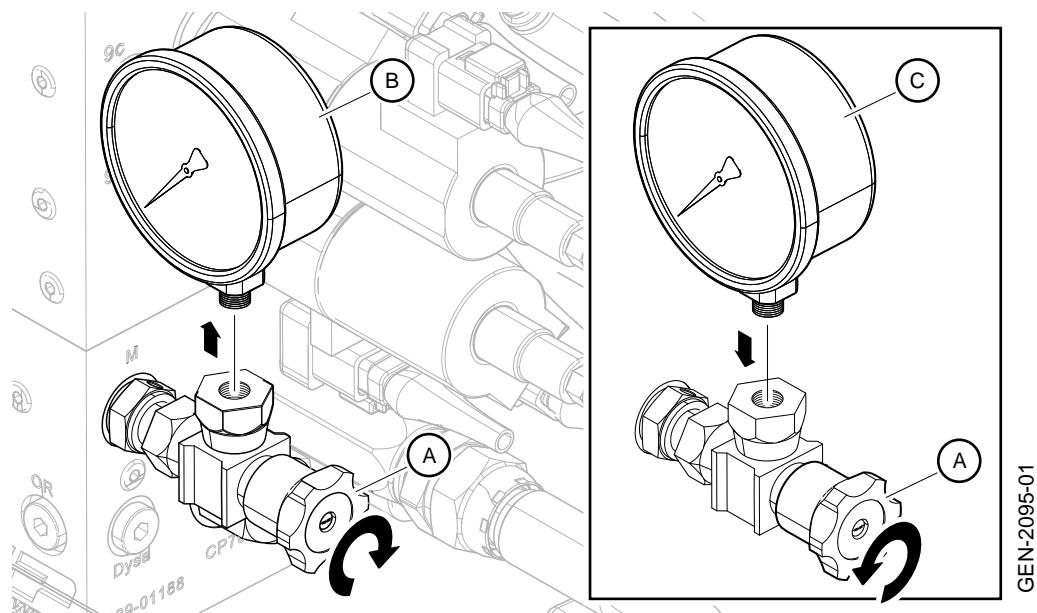


Figure 156

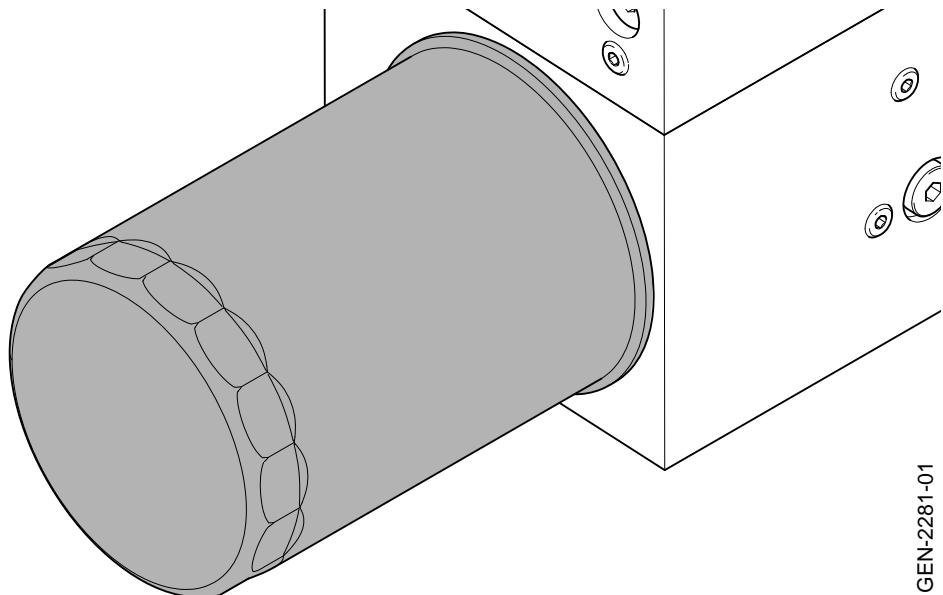
GEN-2095-01



Warning!
Pressurized system!

- 1 Turn the needle valve (A) clockwise to close it.
- 2 Remove the pressure gauge (B).
- 3 Replace all O-rings.
- 4 Install the new pressure gauge (C) in the needle valve (A).
- 5 Turn the needle valve (A) counterclockwise to open it.
- 6 Task completed.

3.3.25 Hydraulic System, Replace Oil Filter



GEN22281-01

Figure 157

Task Summary

The task is to replace the oil filter.



Warning!

Pressurized system! The system must be completely shut off so that the hydraulic system is not pressurized. Use safety glasses.

Task Interval

Do this task during:

- Preventive maintenance, annually
- Corrective maintenance

Prerequisites

Conditions

The system is completely shut off.

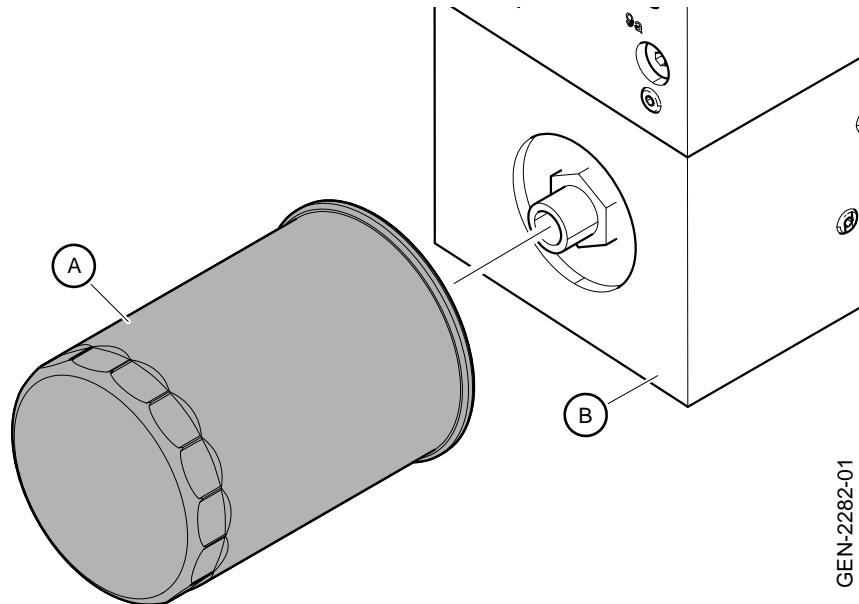
Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Chief Engineer	Dockside	10 minutes
Spare parts	Quantity	Part number	
Oil filter cartridge	1	HS-25300-01	

Consumables	Quantity	Part number
Cloth	1	-
Bucket	1	-

Reference document

3.3.10 Hydraulic System, Inspect Oil Level

Procedure



GEN-2282-01

Figure 158

- 1 Put a tray or an absorbing cloth under the oil filter (A) to collect any oil spill.
- 2 Turn the oil filter (A) counterclockwise to remove it from the valve block (B).
- 3 Install a new oil filter on the valve block (B). Tighten by hand.
- 4 Start the system.
- 5 Examine for leaks. Tighten connections.
- 6 Ventilate the hydraulic system. See .
- 7 Examine the oil level. See 3.3.10 Hydraulic System, Inspect Oil Level.
- 8 Task completed.

3.3.26 Hydraulic System, Replace Directional Control Valves

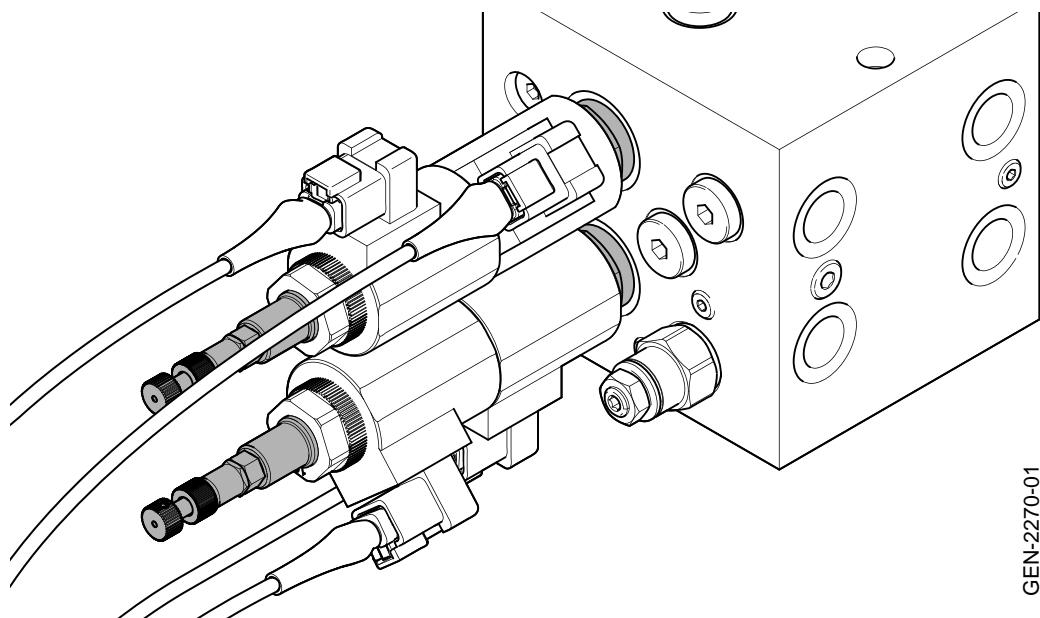


Figure 159

Task Summary

The task is to replace the directional control valves.



Warning!
Pressurized system!

Task Interval

Do this task during:

- Corrective maintenance

Prerequisites

Conditions

The system is completely shut off.

Number of personnel	Skill level	Maintenance facility level	Estimated time
---------------------	-------------	----------------------------	----------------

1	Authorized Service Technician	Dockside	10 minutes
---	-------------------------------	----------	------------

Spare parts	Quantity	Part number
Directional Control Valve	1	

Procedure

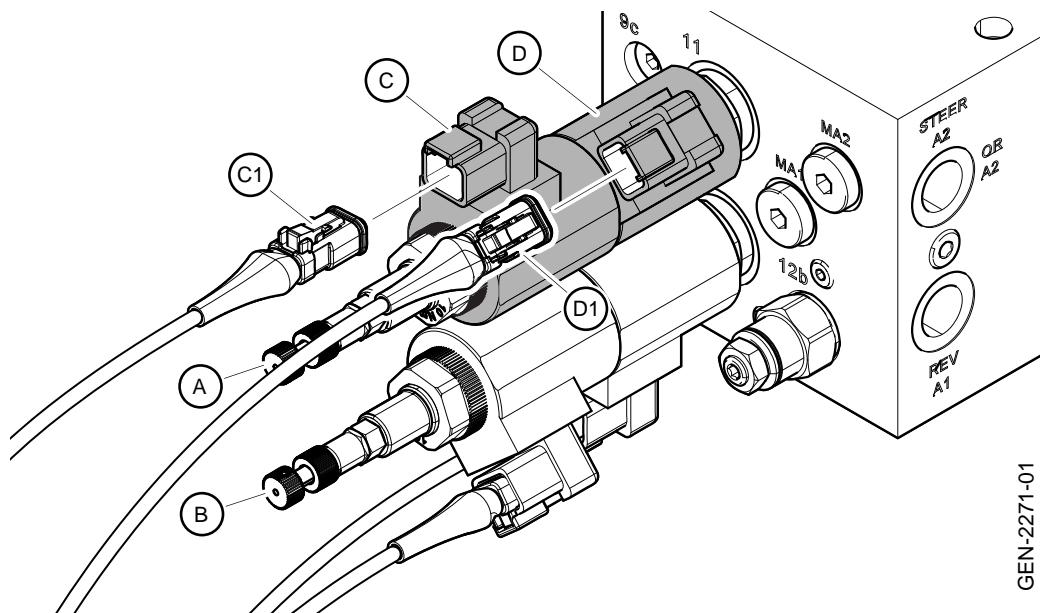


Figure 160

- 1 Push and turn the directional control valves (A) and (B) to release any residual pressure.
- 2 Remove the cable connections (C1) and (D1) from the coils (C) and (D) on the directional control valve (A).

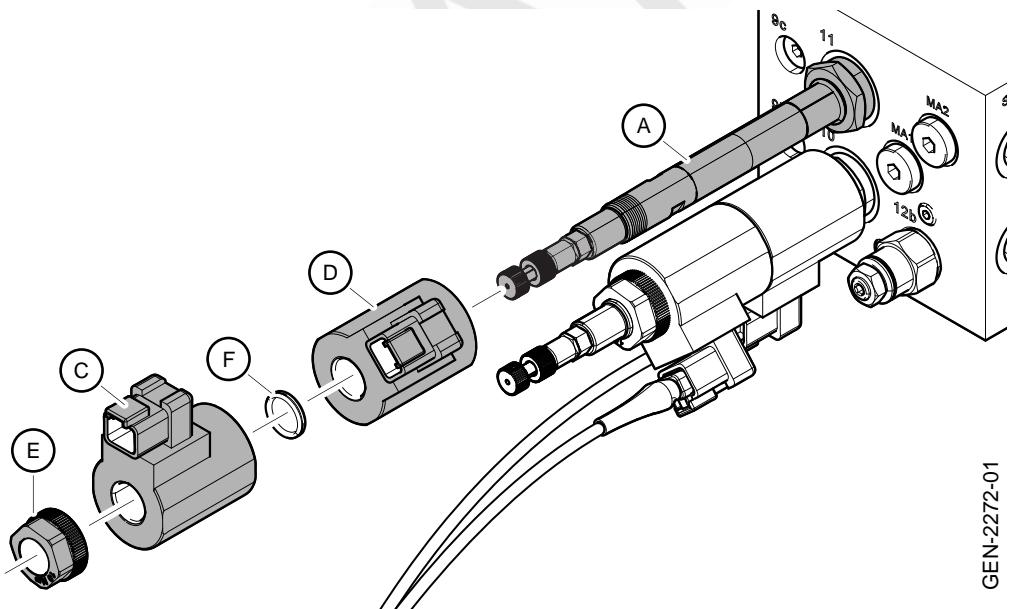


Figure 161

- 3 Remove the nut (E) from the control valve (A).
- 4 Remove the coil (C).
- 5 Remove the O-ring (F).
- 6 Remove the coil (D).

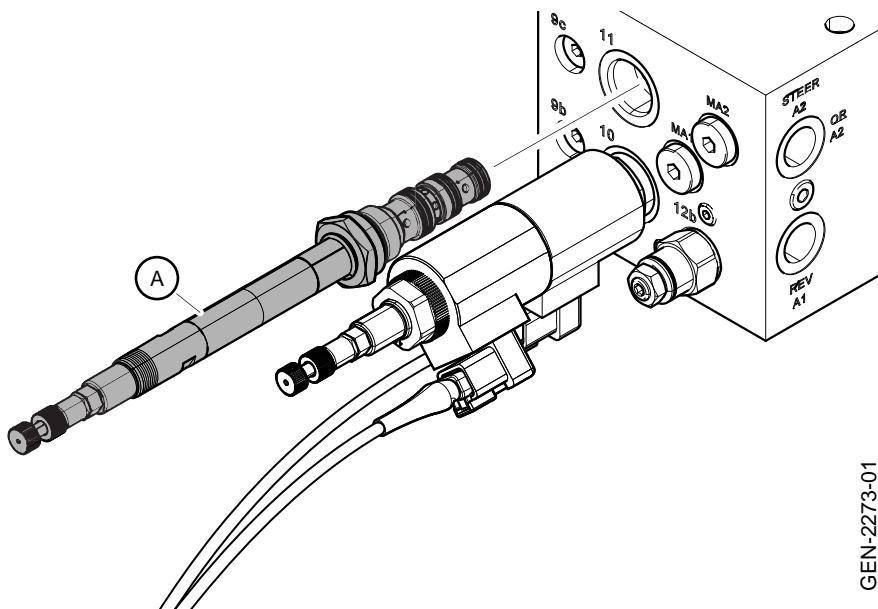


Figure 162

- 7 Remove the directional control valve (A) from the valve block.
- 8 Install the new directional control valve on the valve block.
- 9 Install the coils and the O-ring on the control valve (A) again.
- 10 Install the nut (E) again.



Caution!
Torque to 9–11 Nm.

- 11 Install the cable connections (C1) and (D1) in the coils again.
- 12 Task completed.

3.3.27 Hydraulic System, Replace Load Control Valves

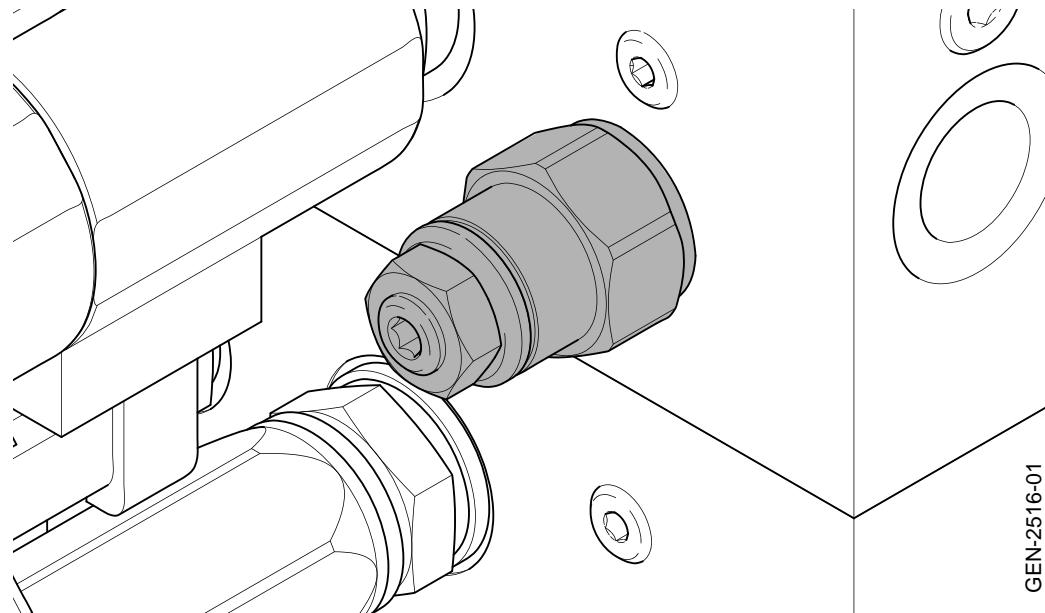


Figure 163

Task Summary

The task is to replace the load control valves.



Warning!
Pressurized system!

Task Interval

Do this task during:

- Corrective maintenance

Prerequisites

Conditions

The system is completely shut off.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dockside	10 minutes
Spare parts	Quantity	Part number	
Over Centre Valve	2	MJP-4200-WM-A1	

Procedure

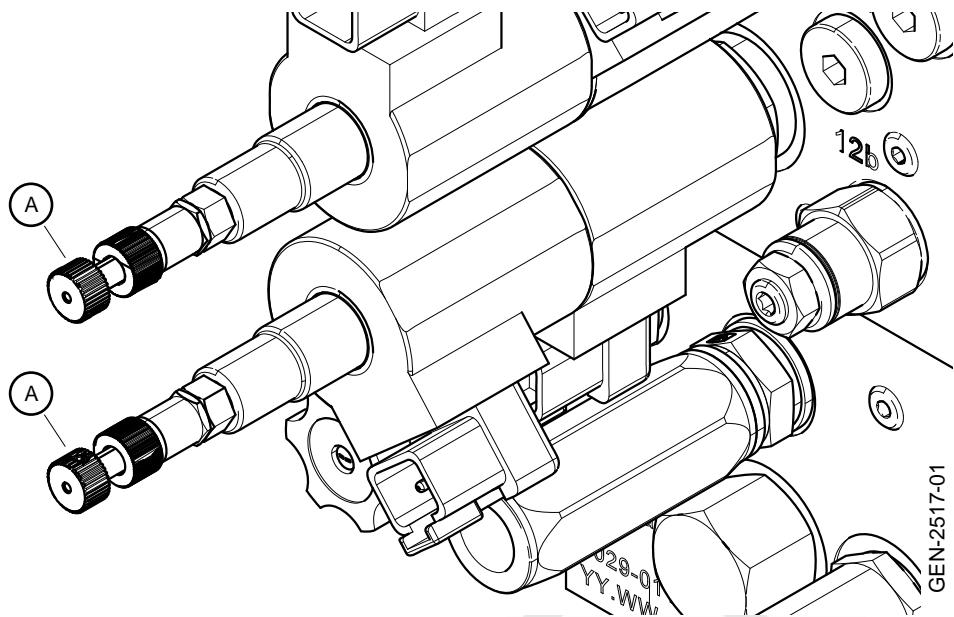


Figure 164

- 1 Push and turn the directional control valves (A) to release any residual pressure.

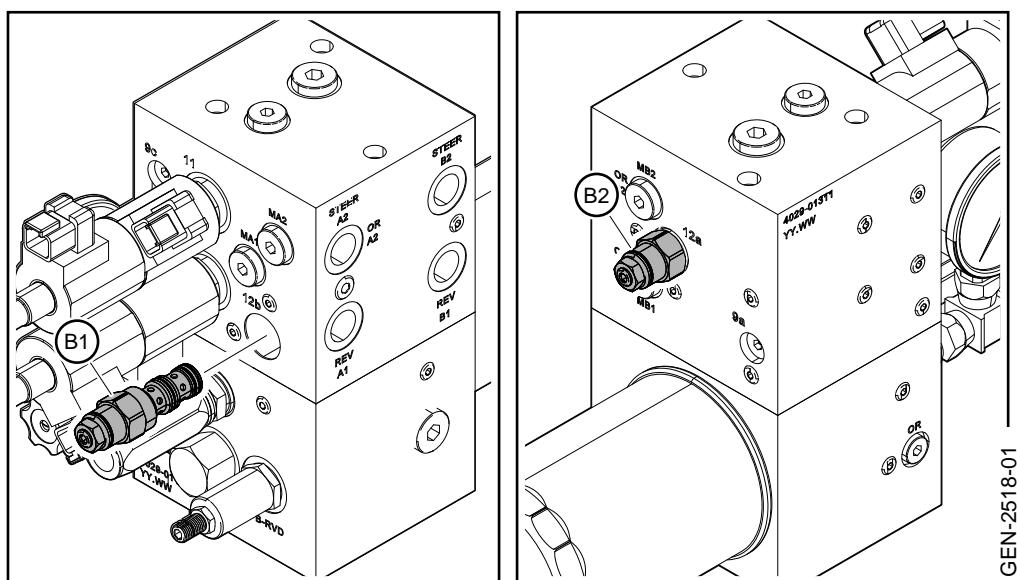
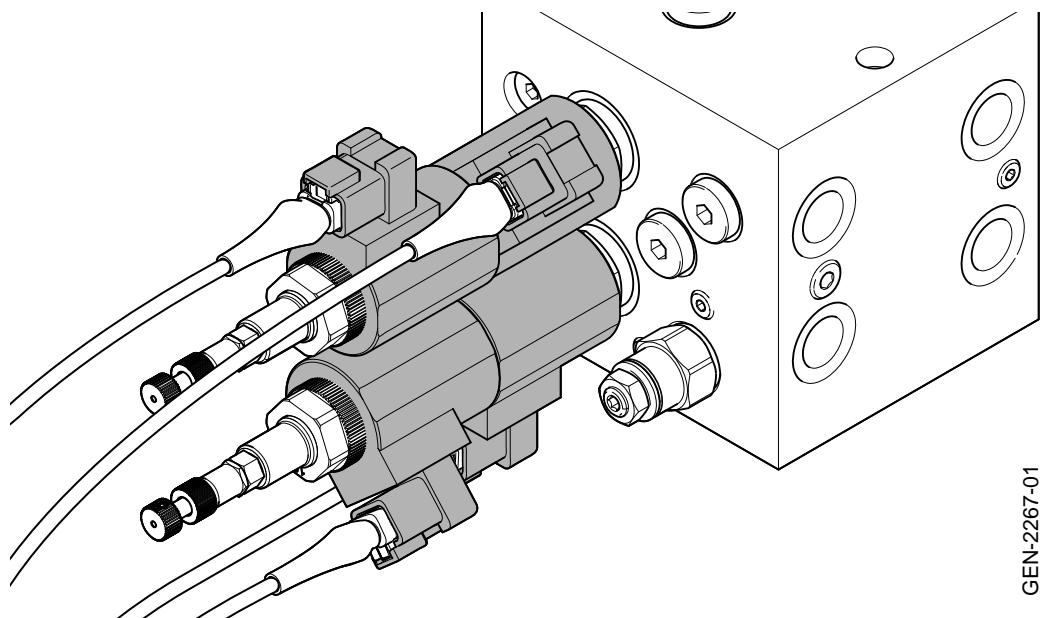


Figure 165

- 2 Remove the load control valves (B1) and (B2) from the valve block.
- 3 Install the new load control valves on the valve block.
- 4 Task completed.

3.3.28 Hydraulic System, Replace Solenoid Coils



GEN-2267-01

Figure 166

Task Summary

The task is to replace the solenoid coils.



Warning!
Pressurized system!

Task Interval

Do this task during:

- Corrective maintenance

Prerequisites

Conditions

The system is completely shut off.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dockside	10 minutes
Spare parts	Quantity	Part number	
Solenoid coil	4	HS-25410-05	

Procedure

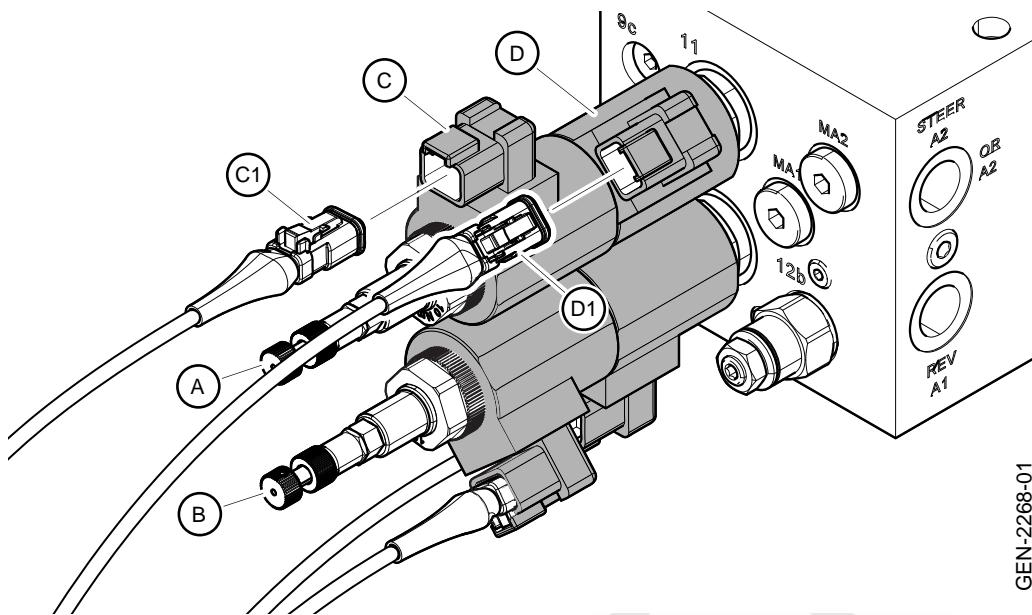


Figure 167

- 1 Push and turn the directional control valves (A) and (B) to release any residual pressure.
- 2 Remove the cable connections (C1) and (D1) from the coils (C) and (D) on the directional control valve (A).

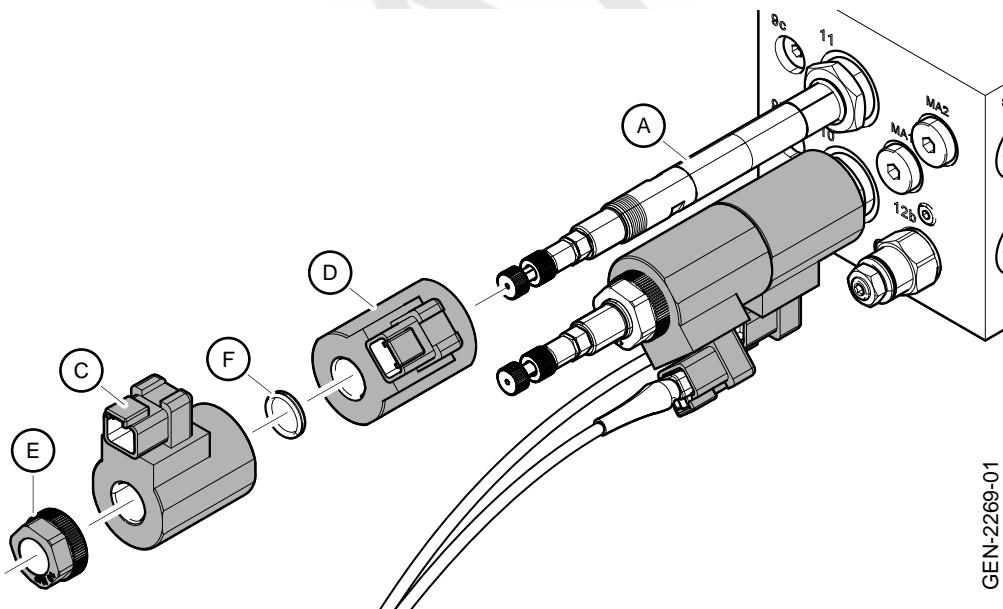


Figure 168

- 3 Remove the nut (E) from the control valve (A).
- 4 Remove the coil (C).
- 5 Remove the O-ring (F).
- 6 Remove the coil (D).
- 7 Install the new coils and the O-ring on the control valve (A).
- 8 Install the nut (E) again.



Caution!
Torque to 9–11 Nm.

- 9 Install the cable connections (C1) and (D1) in the coils again.
- 10 Task completed.

DRAFT

3.3.29 Hydraulic Pump, Inspect

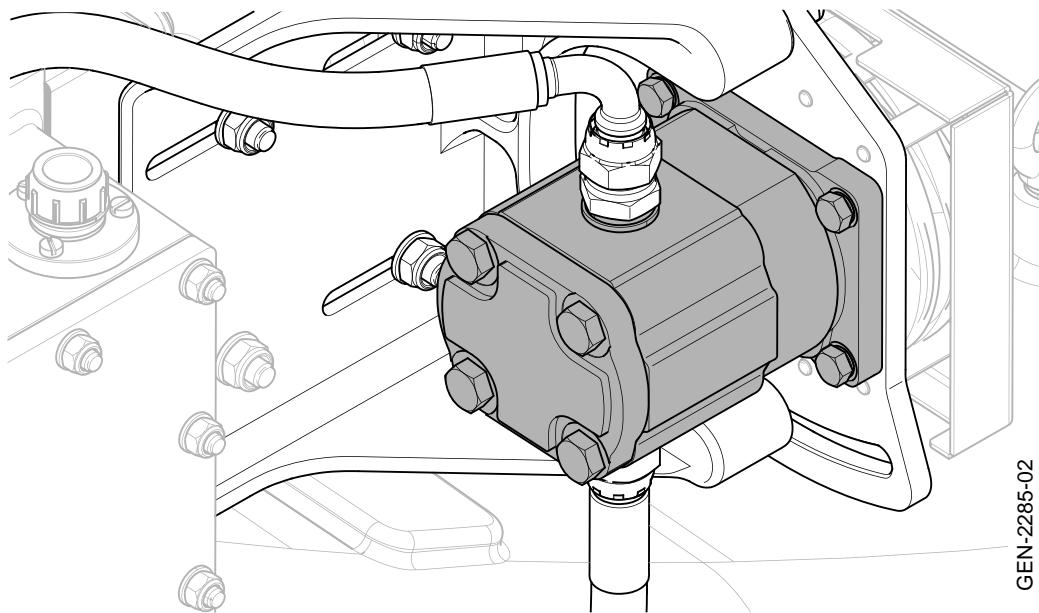


Figure 169

Task Summary

The task is to do a general inspection of the hydraulic pump.



Warning!

Pressurized system! There may be residual pressure in the cylinders.

Task Interval

Do this task during:

- Preventive maintenance, yearly.
- Corrective maintenance, while docked

Prerequisites

Conditions

The system is completely shut off.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Chief Engineer	Dockside	40 minutes

Consumables	Quantity	Part number
Cloth	-	-

Reference document

Procedure

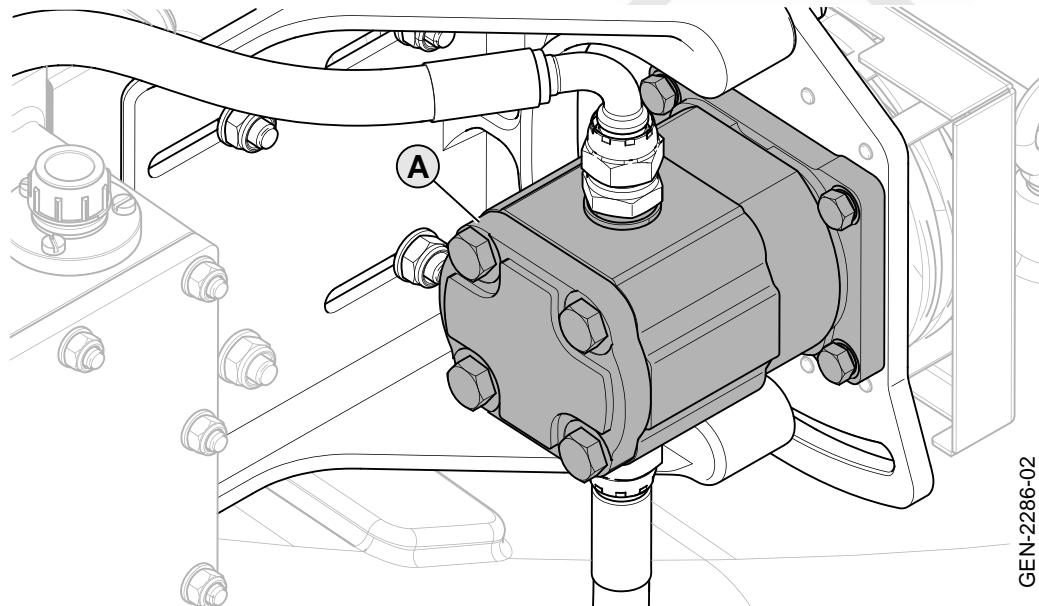


Figure 170

- 1 Inspect the pump and the connections for oil leaks. Repair any leakage immediately or replace the pump. See *3.3.30 Hydraulic System, Replace the Pump*
- 2 Task completed.

3.3.30 Hydraulic System, Replace the Pump

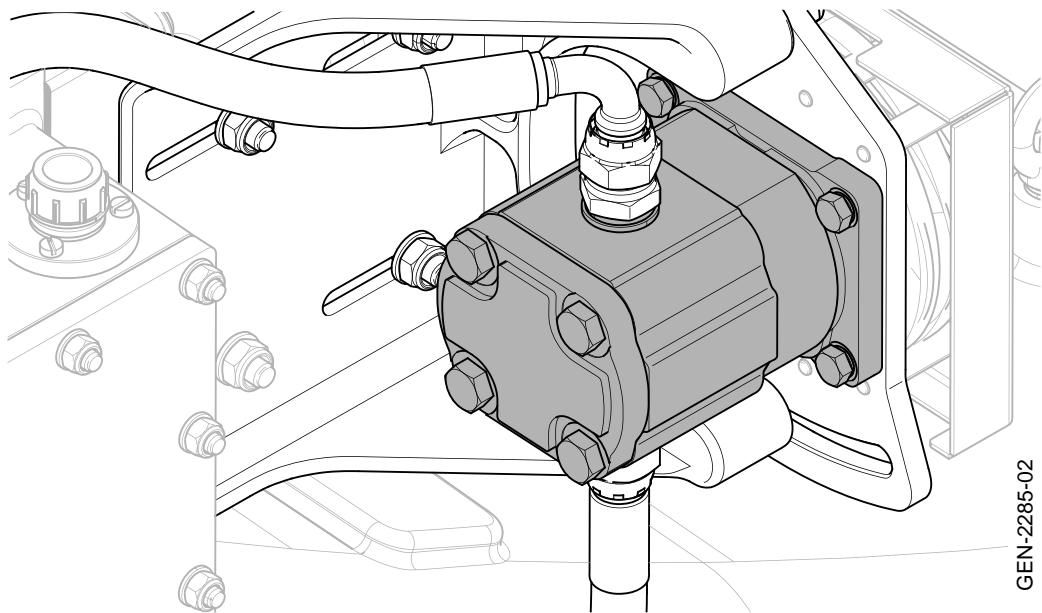


Figure 171

Task Summary

The task is to replace the hydraulic pump.



Warning!
Pressurized system!



Warning!
Hot hydraulic fluid!



Warning!
Flammable!

Task Interval

Do this task during:

- Corrective maintenance

Prerequisites

Conditions

The system is completely shut off.

Bucket available.

Personnel number	Skill level	Maintenance facility level (choose one)	Estimated time
1	Authorized Service Technician	Dock, workshop / dry dock	60 min

Spare parts	Quantity	Part number
Hydraulic Pump	1	HS-25220-02

Consumables	Quantity	Part number
Wipes and cloths	-	-
Protection plugs for hoses and tubes	-	-

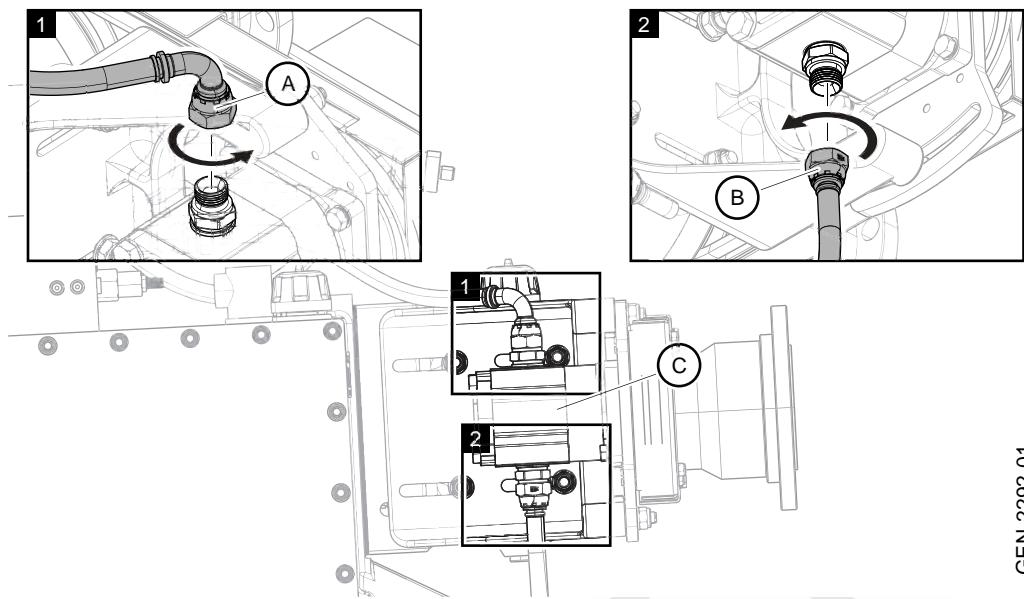
Reference document

3.3.10 Hydraulic System, Inspect Oil Level

3.3.20 Hydraulic System, Adjust Working Pressure

3.3.22 Hydraulic System, Adjust Pressure Limit

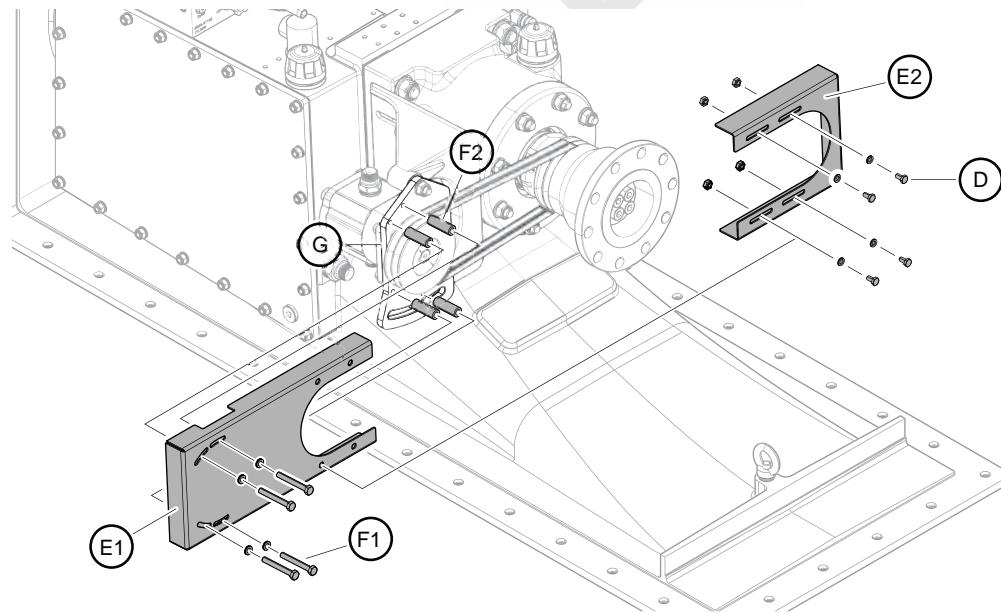
Procedure



GEN-2292-01

Figure 172

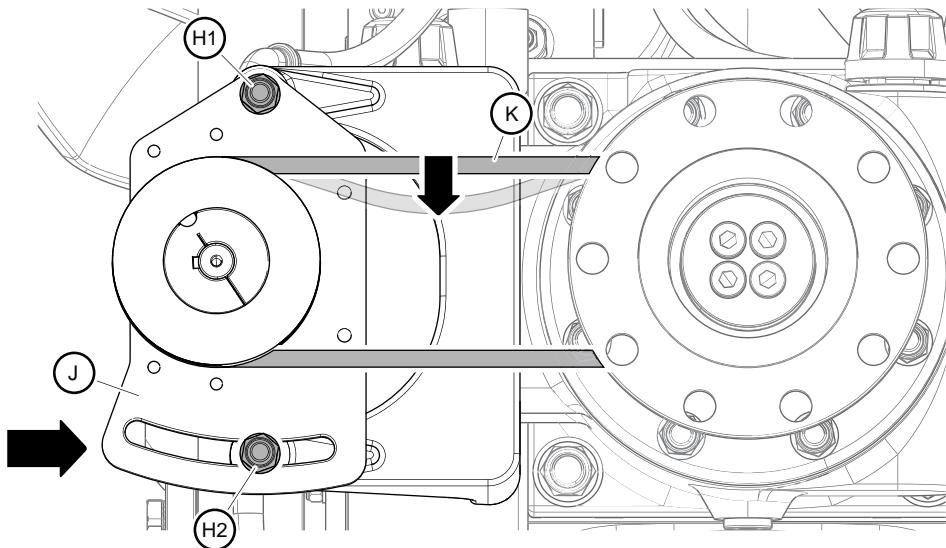
- 1 Remove the hydraulic hose connectors (A) and (B) from the hydraulic pump (C).



GEN-2293-02

Figure 173

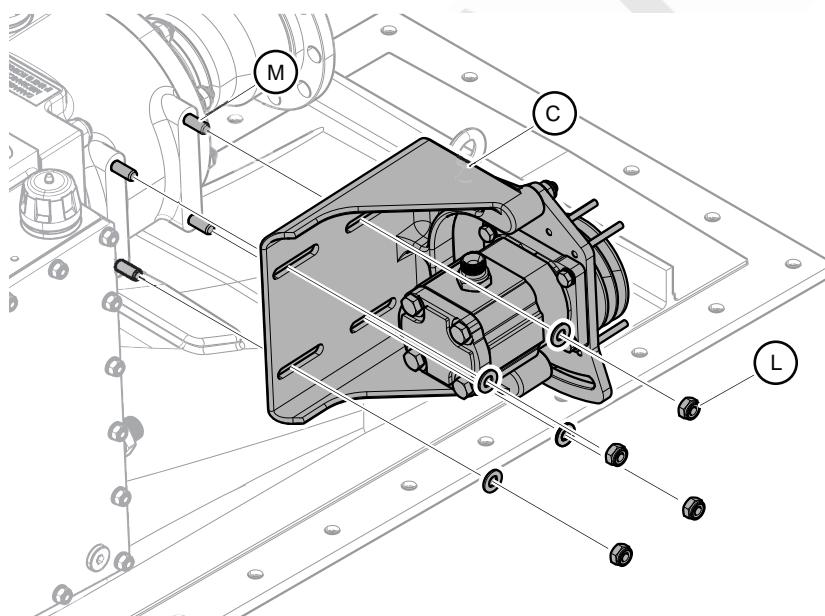
- 2 Remove the screws, nuts and washers (D) from the belt guard sections (E1) and (E2).
- 3 Remove the belt guard section (E2) from the belt guard section (E1).
- 4 Remove the screws, washers (F1), spacers (F2) and belt guard section (E1) from the pump plate (G).



GEN-2294-02

Figure 174

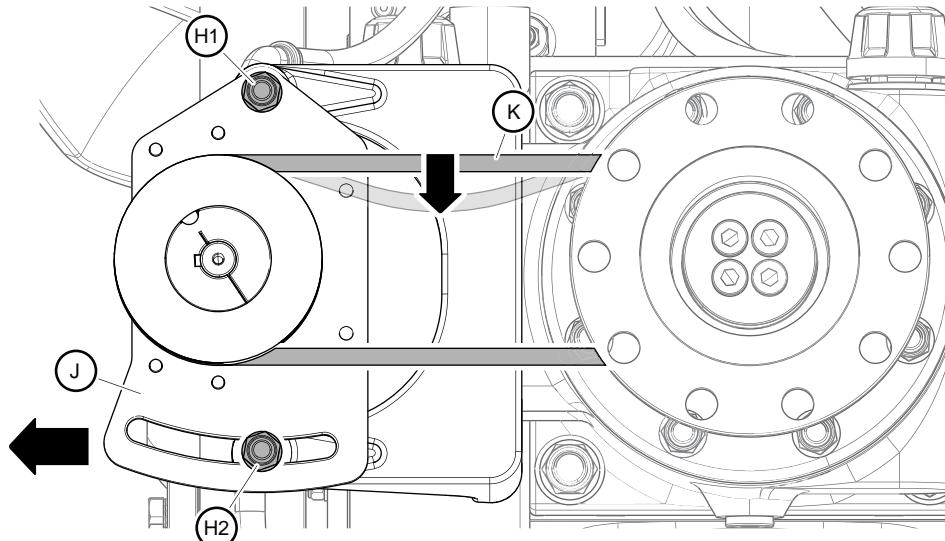
- 5 Loosen the nuts (H1) and (H2) on the pump plate (J).
- 6 Move the pump plate (J) and the pump to the right until the V-belts (K) are lose.
- 7 Remove the V-belts (K).



GEN-2295-01

Figure 175

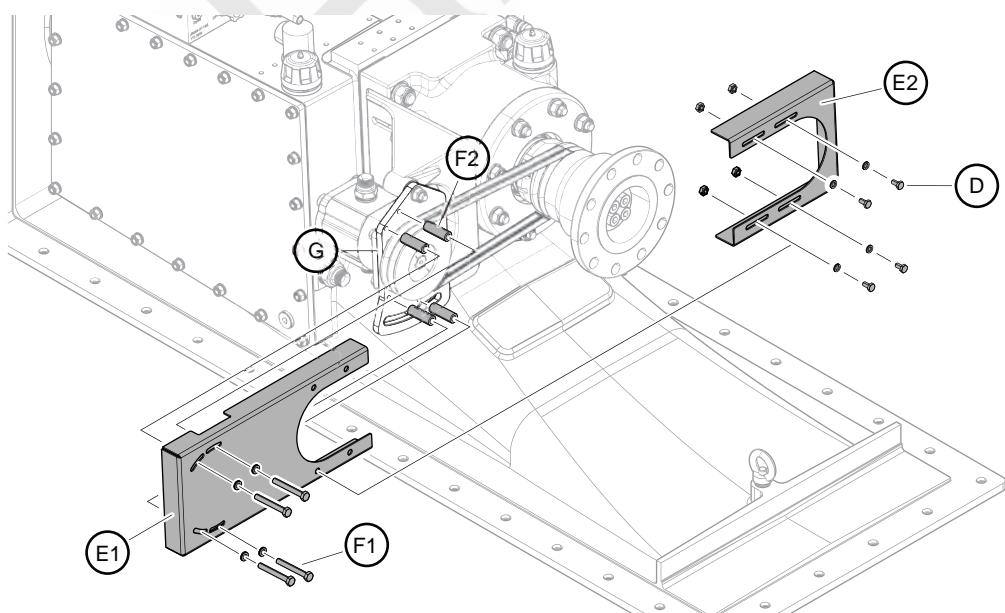
- 8 Remove the nuts and washers (L).
- 9 Remove the pump bracket and hydraulic pump (C) from the threaded pins (M)
- 10 Install the new pump bracket and hydraulic pump on the threaded pins (M).
- 11 Apply Loctite® 243 to the nuts (L).
- 12 Install the nuts and washers (L) again. Torque to 34 Nm.



GEN-2296-02

Figure 176

- 13 Loosen the nuts (H1) and (H2) from the pump plate (J).
- 14 Install the V-belts (K).
- 15 Move the pump plate (J) and the pump to the left until the V-belts (K) are tightened.
- 16 Tighten the nut (H1).
- 17 Push down on the V-belts (K) to measure the deflection and adjust the pump plate (J) and pump until the deflection of the V-belts (K) is 4–8 mm.
- 18 Tighten the nut (H2).
- 19 Make sure that the deflection is correct. If not, loosen the nut (H2) and repeat step 17 to 19.
- 20 Tighten the nuts (H1) and (H2) to 31–34 Nm.



GEN-2293-02

Figure 177

- 21 Install the screws, washers (F1) and spacers (F2) on the threaded pins of the pump plate (G) to attach the belt guard section (E1).

- 22 Align the belt guard section (E2) to the belt guard section (E1).
- 23 Install the screws, nuts and washers (D) to the belt guard sections (E1) and (E2).

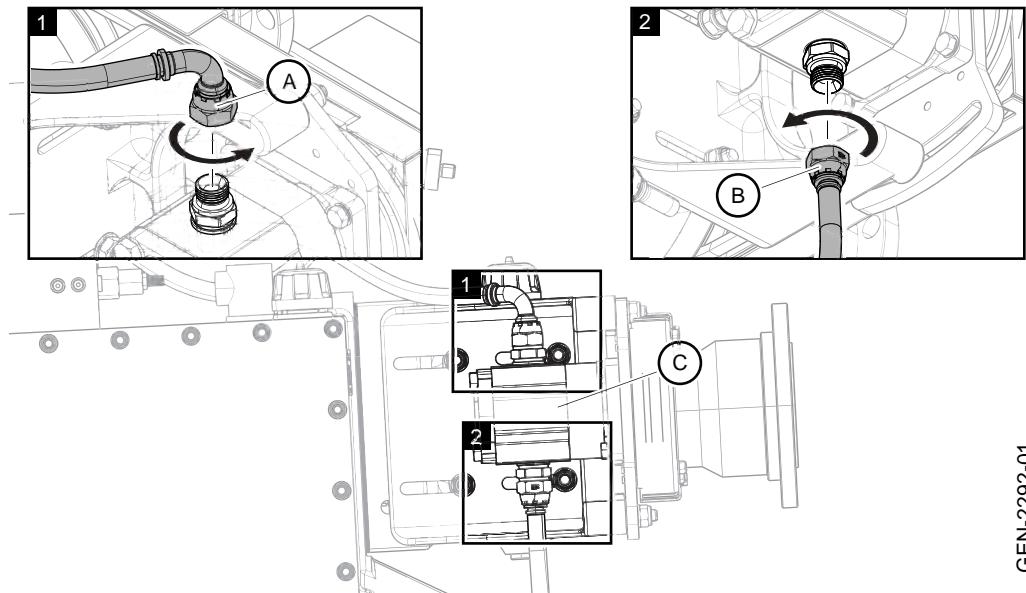


Figure 178

GEN-2292-01

- 24 Apply Molykote 111 compound to the hose connectors (A) and (B).
- 25 Install the hydraulic hose connectors (A) and (B) to the new hydraulic pump (C). Torque the hose connectors to 21 Nm.
- 26 Task completed.

3.3.31 V-Belts, Inspect and Adjust

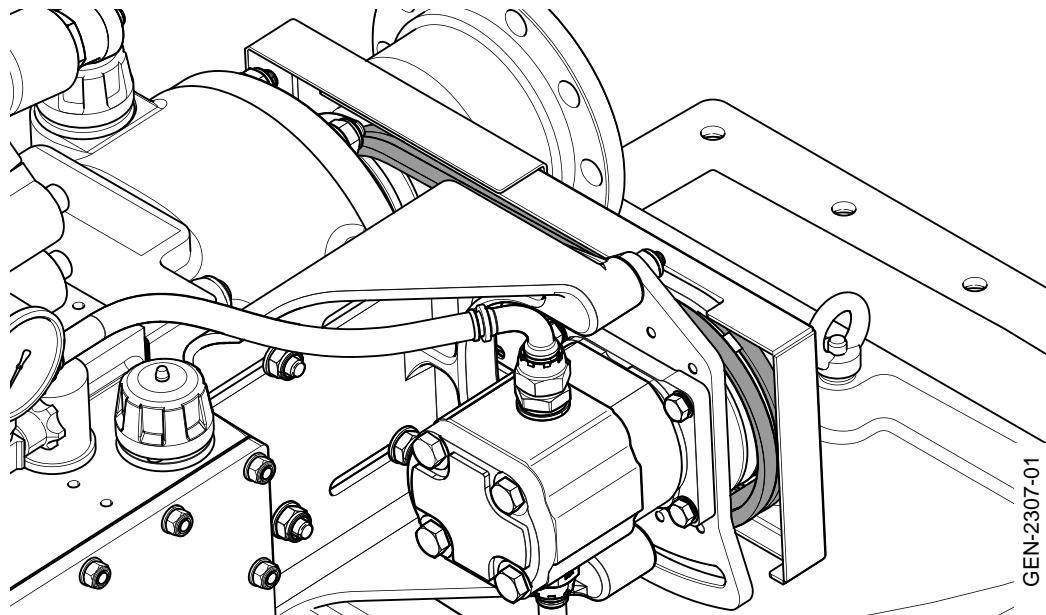


Figure 179

Task Summary

The task is to inspect and if needed, to adjust the V-belts.

Task Interval

Do this task during:

- Preventive maintenance, annually
- Corrective maintenance

Prerequisites

Conditions

The system is completely shut off.

Personnel number	Skill level (choose one)	Maintenance facility level (choose one)	Estimated time
1	Chief Engineer	Dock, workshop / dry dock	60 min

Procedure

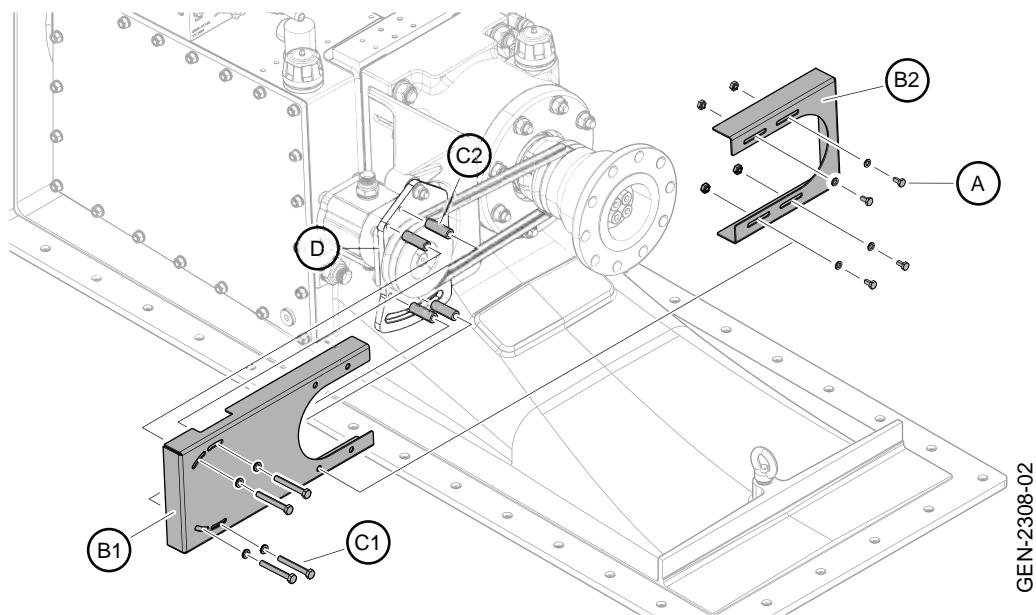


Figure 180

- 1 Remove the screws, nuts and washers (A) from the belt guard sections (B1) and (B2).
- 2 Remove the belt guard section (B2) from the belt guard section (B1).
- 3 Remove the nuts, washers (C1), spacers (C2) and belt guard section (B1) from the pump plate (D).

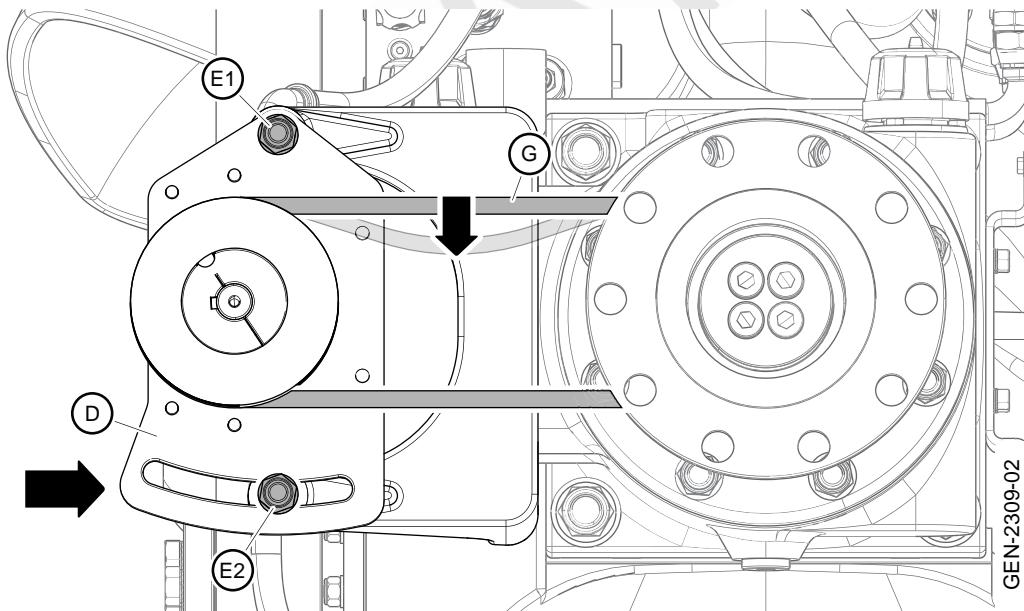


Figure 181

- 4 Push down on the V-belts (G) to measure the deflection.
- 5 If the measured deflection on the V-belts is not within 4-8 mm, loosen the nuts (E1) and (E2) on the pump plate (D).
- 6 Push down on the V-belts (G) to measure the deflection and adjust the pump plate (D) and the pump until the deflection of the V-belts is 4-8 mm.
- 7 Tighten the nut (E2).
- 8 Make sure that the deflection is correct. If not, loosen the nut (E2) and repeat steps 6 to 8.

- 9 Tighten the nuts (E1) and (E2) to torque 31-34 Nm.

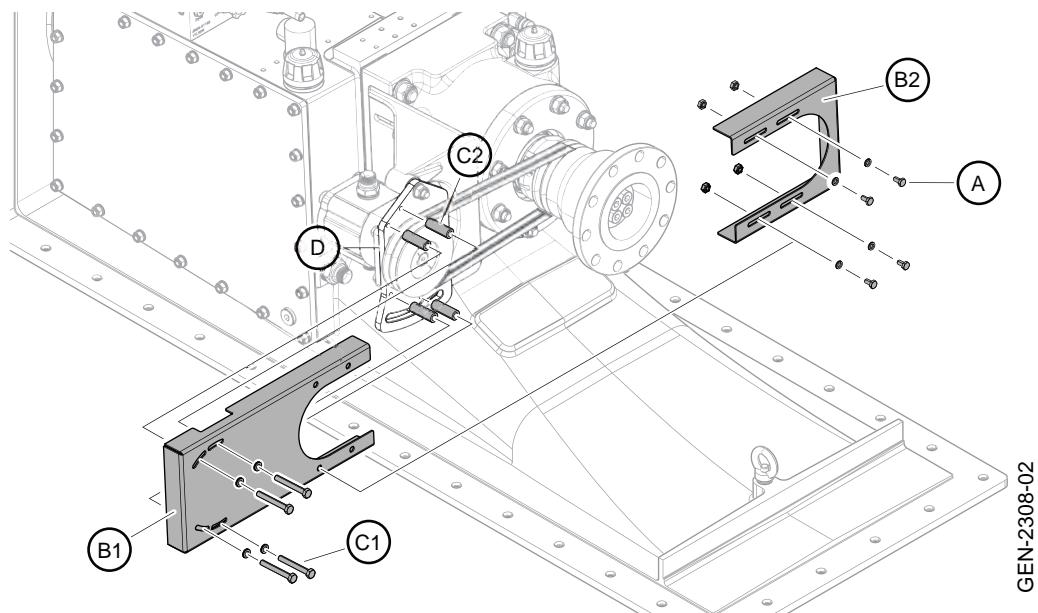


Figure 182

- 10 Install the nuts, washers (C1) and the spacers (C2) to attach the belt guard section (B1) to the pump plate (D).
- 11 Align the belt guard section (B2) to the belt guard section (B1).
- 12 Install the screws, nuts and washers (A) to the belt guard sections (B1) and (B2).
- 13 Task completed.

3.3.32 V-Belts, Replace

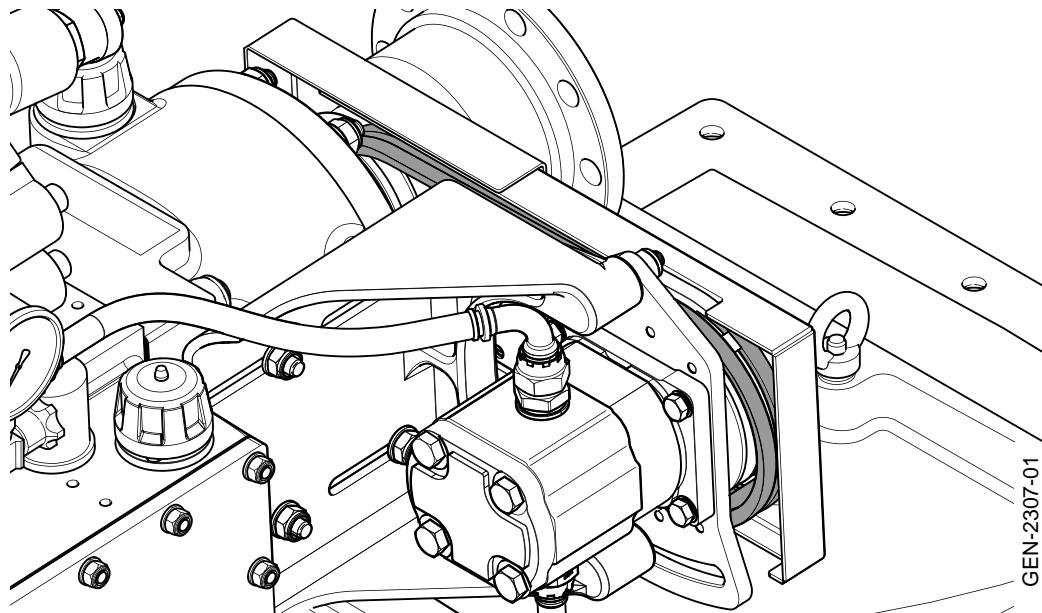


Figure 183

Task Summary

The task is to replace the V-belts.

Task Interval

Do this task during:

- Preventive maintenance, every 5th year. Also replace of spare belts, that is put around the shaft and fastened to the belt guard.
- Corrective maintenance. Change of belts to spare belts.

Prerequisites

Conditions

Intermediate shaft removed to allow replace belts to be installed around drive shaft when changing all belts every 5th year.

System completely shut down for changing to spare belts.

Personnel number	Skill level	Maintenance facility level (choose one)	Estimated time
1	Change of V-belts to spare belts: Chief Engineer	Dock, workshop / dry dock	60 min
1	V-belts, replace: Authorized Service Technician	Dock, workshop / dry dock	60 min

Spare parts	Quantity	Part number
V-Belt	4, including spare belts	9611-625-00T

Procedure

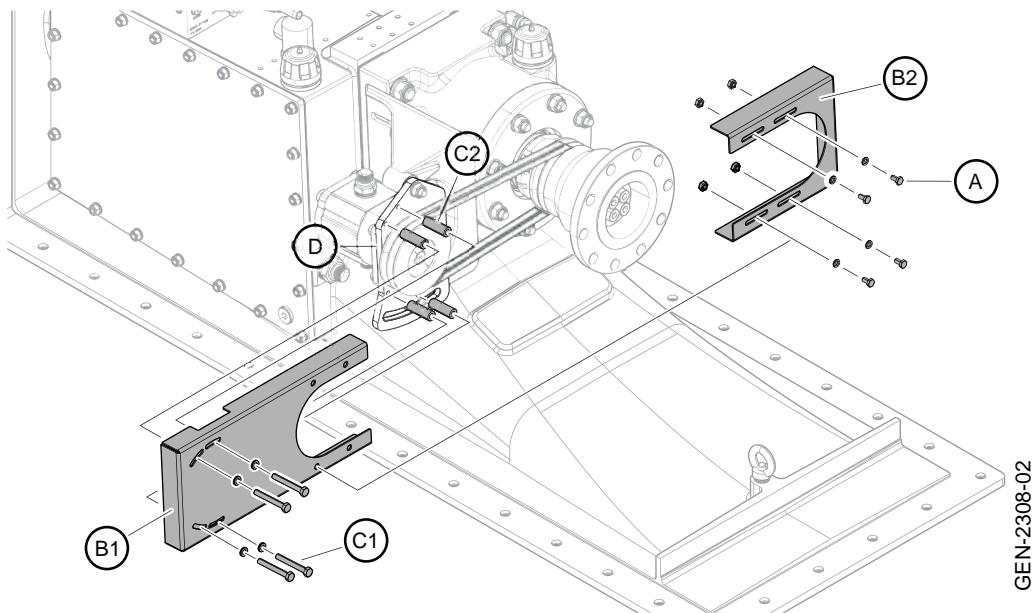


Figure 184

- 1 Remove the V-belts.
 - 1.1 Remove the screws, nuts and washers (A) from the belt guard sections (B1) and (B2).
 - 1.2 Remove the belt guard section (B2) from the belt guard section (B1).
 - 1.3 Remove the bolts, washers (C1), spacers (C2) and belt guard section (B1) from the pump plate (D).

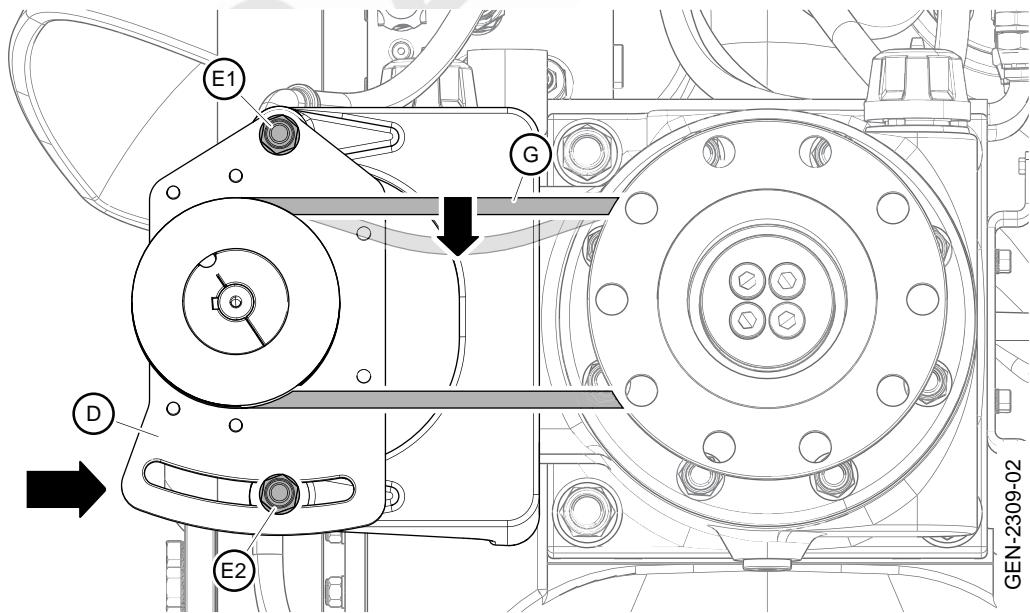


Figure 185

- 1.4 Loosen the nuts (E1) and (E2) on the pump plate (D).
- 1.5 Move the pump plate (D) and the pump to the right until the V-belts (G) are loose.
- 1.6 Remove the V-belts (G) including the spare belts if they are unused.
- 2 Install the new V-belts.
 - 2.1 Move the pump plate (D) and the pump to the left until the V-belts (G) are tightened.

- 2.2 Tighten the nut (E1).
- 2.3 Push down on the V-belts (G) to measure the deflection and adjust the pump plate (D) and pump until the deflection of the V-belts is 4–8 mm.
- 2.4 Tighten the nut (E2).
- 2.5 Make sure that the deflection is correct. If not, loosen the nut (E2) and repeat step 2.3 to 19.
- 2.6 Tighten the nuts (E1) and (E2) to 31–34 Nm.

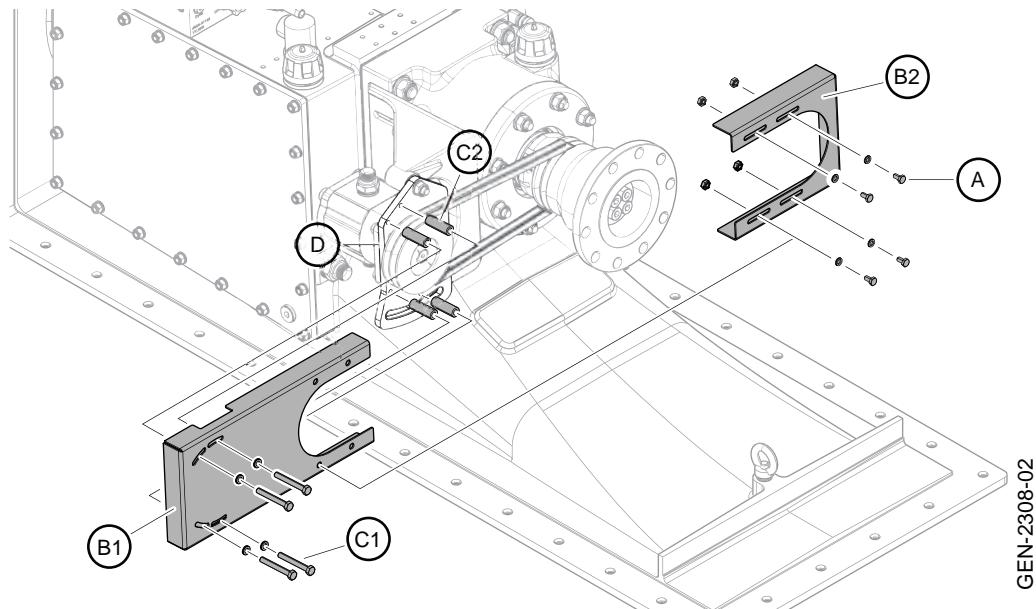


Figure 186

- 2.7 Install the bolts, washers (C1) and the spacers (C2) to attach the belt guard section (B1) to the pump plate (D).
- 2.8 Align the belt guard section (B2) to the belt guard section (B1).
- 2.9 Install the screws, nuts and washers (A) to the belt guard sections (B1) and (B2).
- 2.10 Fasten spare belts.
- 2.11 Task completed.

3.4 Control System

Warning!



When working with electrical components inside Control System Units, make sure that you follow routines regarding ESD. Semiconductors and circuit boards can be damaged by electrostatic discharge (ESD). When handling, care must be taken so that the devices are not damaged. Use an ESD bracelet or similar ESD rated protection. Otherwise always discharge yourself and your tools by touching a grounded bare metal surface before touching an ESD-sensitive electronic component. Damage due to inappropriate handling is not covered by the warranty.

3.4.1 Control System Components, inspect for wear and damages

Task Summary

The task is to inspect for damaged control system components.

Task Interval

Do this task during:

- Yearly inspection

Prerequisites

Conditions

The control system is completely shut off.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Chief Engineer	Dockside	4 hours

Procedure

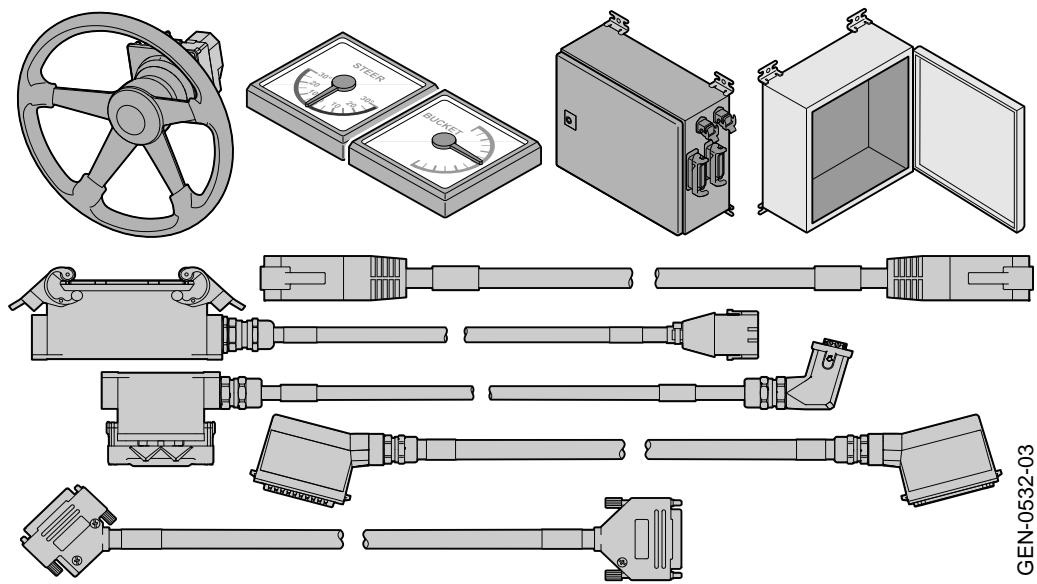


Figure 187

1 In the Engine room:

- 1.1 Inspect the outside of the control cabinets.
 - A. Visually inspect all cabinets, look for signs of corrosion and damage. Most often noted around the top surface.
If corrosion is seen, this should be photographed and then cleaned and repainted.
- 1.2 Inspect the inside of the control cabinets.
 - B. Ensure cabinets are clean and fresh internally, no sign of dust or water ingress.
Clean cabinet if dirty and search for the source. If intrusion of dirt or water occurs, check all seals and repair broken seals or replace cabinet.
 - C. Check for signs of modification, check that all items are secure on the DIN rail.
Fasten all loose objects.
- 1.3 Check all connectors for tightness and integrity.
 - D. Ensure all connectors and glands are tight, secure and not damaged.
Fasten all loose connectors and secure loose cables.
 - E. Check for signs of wear or fatigue on the cable around the connector.
Replace damaged cables, see *3.4.7 Control System, Inspect and Replace Cables*
 - F. Ensure there are no excessive bending or pressure on the cable and connector.
Re-route cables if they have excessive bending.
 - G. Check that no connections are cross threaded. Where cables pass through glands the outer sheath should be clamped such that the strain is taken by the gland.

2 In the Jet room:

- 2.1 Inspect the outside of the control cabinets and connection boxes.
 - H. Visually inspect all cabinets, look for signs of corrosion and damage. Most often noted around the top surface.
If corrosion is seen, this should be photographed and then cleaned and repainted.
- 2.2 Inspect the inside of the control cabinets.
 - I. Ensure cabinets are clean and fresh internally, no sign of dust or water ingress.
Clean cabinet if dirty and search for the source. If intrusion of dirt or water occurs, check all seals and repair broken seals or replace cabinet.

- J. Check for signs of modification, check that all items are secure on the DIN rail.
Fasten all loose objects.
 - 2.3 Inspect cables.
 - K. Inspect the cabling around the Jet space, take special note of connectors, as well as areas where cables bends.
Replace damaged cables, see *3.4.7 Control System, Inspect and Replace Cables*
 - L. Ensure cables are above the bilge level and is not secured to a object or location where vibration occurs.
Re-route cables if they have excessive bending, if they are below the bilge level or is secured to a object or location where vibration occurs.
 - 2.4 Inspect feedback connections.
 - M. Ensure all connectors are tight, secure and not damaged.
Fasten all loose connectors and secure loose cables.
 - N. Check for signs of wear or fatigue on the cable around the connector.
Replace damaged feedback sensors or cables, see *3.3.7 Hydraulic Steering Cylinder, Replace Feedback Sensor* and *3.3.8 Hydraulic Reversing Cylinder, Replace Feedback Sensor*
 - O. Ensure there are no excessive bending or pressure on the cable and connector.
Re-route cables if they have excessive bending.
- 3 On the Bridge:
- 3.1 Inspect Controls.
 - P. Visually inspect all items on the bridge for corrosion or damage. Most often noted on open bridges. If corrosion is seen, this should be photographed
Remove corrosion if visible and replace damaged Controls.
 - Q. Ensure all buttons are readable. If sealing covers are fitted ensure they are intact.
Replace lenses on buttons if they are damaged or unreadable. See *3.4.11 Indoor Panels, Lenses and LEDs, Replace*
If sealing covers are damaged, change the covers if personnel is adequately trained and certified or send item to MJP for repair.
 - R. Move all control heads through the full range of motion, note any play and / or friction which may indicate the control is not fully functional.
Replace damaged Controls.
 - 3.2 Inspect cables.
 - S. Inspect all cables, ensuring connectors are correctly fastened, there is no excessive bending or pressure on connectors. Take particular note of any pivot points, for example where cables travel to a seat arm rest. Ensure that cables are not stressed in any arm rest position.
Fasten all loose connectors, secure loose cables and re-route cables if they have excessive bending.
- 4 Task completed.

3.4.2 Jet autocalibration



GEN-2986-01

Figure 188

Task Summary

The task is to auto calibrate the Jet.

Note!

Adequately trained and certified personnel are required for this task.

Task Interval

Do this task during:

- First start-up
- Corrective maintenance



Warning!

Jet calibration moves both the bucket and nozzle which requires hydraulic pressure. Certain vessel configurations require the gearbox to be clutched in for this. In all case ensure that the vessel is securely moored such that no damage or hazard will occur.

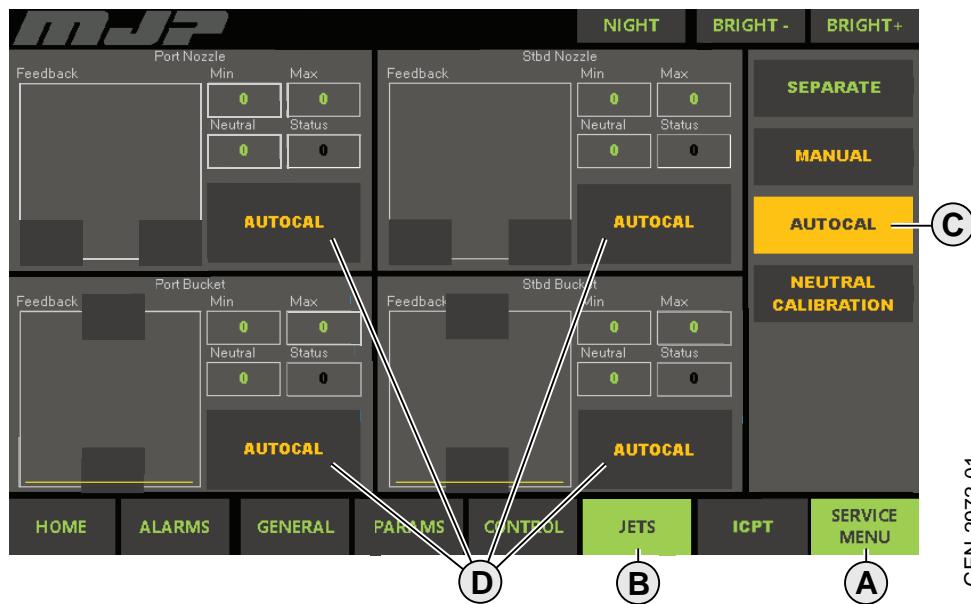
Prerequisites

Conditions

Main engine running

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician or Chief Engineer with remote support	Dockside	15 minutes

Procedure



GEN-2972-01

Figure 189

- 1 Manually operate the bucket and nozzle away from the mechanical end position.
- 2 Tap the SERVICE MENU (A) on the display panel, to access the service screen for maintenance and setup.
- 3 Tap the JETS (B) to open the Water Jet information and setup page.
- 4 Tap the AUTOCAL (C) to enter the Autocalibration MSA. This does not start the actual autocalibration procedure, only enters the mode in which it can be started.
- 5 Tap the AUTOCAL (D) for all available jets. When in autocal mode, Autocal button starts autocalibration procedure.
- 6 When the autocalibration is done, it is also saved.
- 7 Task completed.

3.4.3 Control Levers, Calibrate



GEN-2986-01

Figure 190

Task Summary

The task is to calibrate the controls in the system.

This example shows how to calibrate the thrust handle located on the Port side.

Task Interval

Do this task during:

- Corrective maintenance

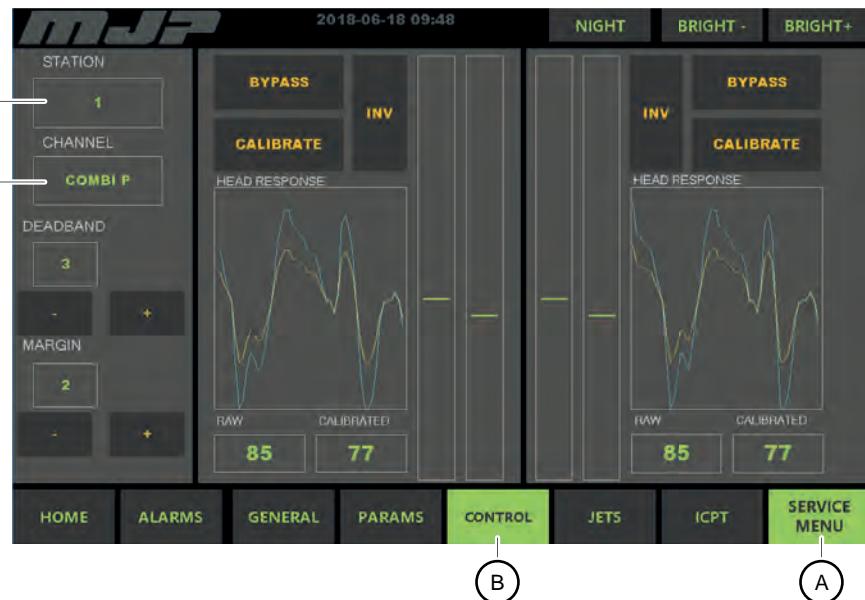
Prerequisites

Conditions

None

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician or Chief Engineer with remote support	Dock, workshop / Dry dock	15 minutes

Procedure



GEN-1715-01

Figure 191

- 1 Enter service mode (A).
- 2 Select “CONTROL” (B).
- 3 To the left the currently selected station (C) and control head channel (D) is displayed.
- 4 Press “STATION” (C) or “CHANNEL” (D) to present a list of available stations and control head channels to select.

Note!

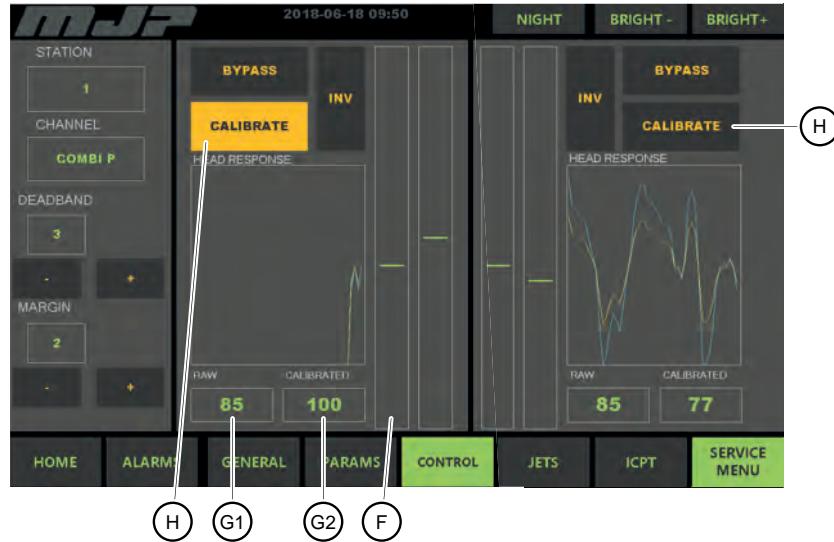
If “STATION” is selected, press “STATION/CHANNEL” again to access the list of available stations and control heads.



GEN-1716-01

Figure 192

- 5 Select station (E1).
- 6 Select the control head to be calibrated (E2) from the list.



GEN-1717-01

Figure 193

- 7 Once a channel has been selected, the SCALE indication (F) will show the raw input value (G1) and the calibrated value (G2) of the selected controller in real-time.

Note!

If the control head has not yet been calibrated, only the raw value will move.

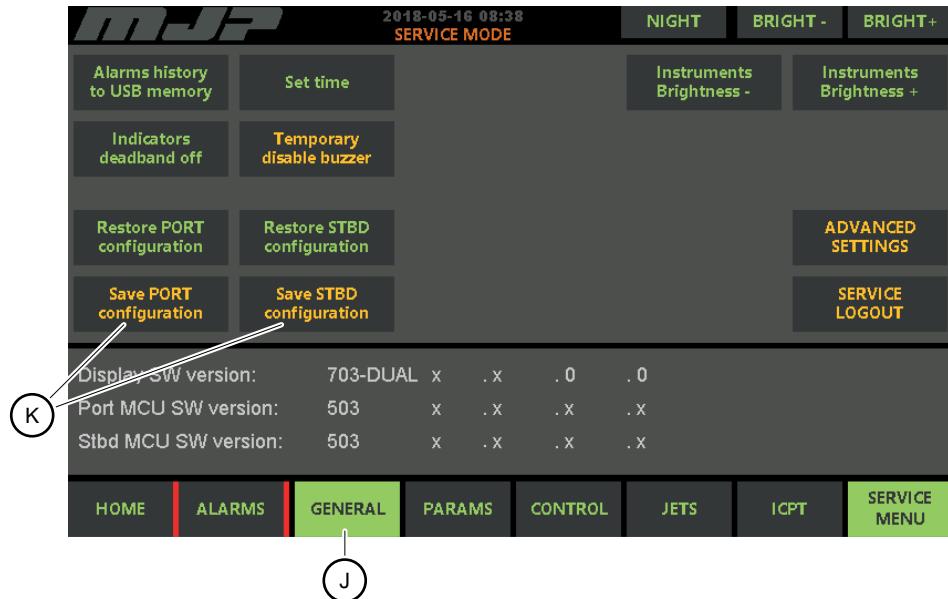
- 8 Channels are calibrated one at a time. To calibrate:

- 8.1 Press the “CALIBRATE” button (H). The button will be highlighted to indicate calibration mode is active.

Note!

In a system with 2 MCU's this needs to be done on “both” sides. They can (and are recommended to) be calibrated at the same time, but the buttons on each side must be pressed separately.

- 8.2 Slowly move the control head to both end stops, for example hard to port, then hard to starboard or full ahead then full astern.
- 8.3 Return the control head to its neutral position.
- 8.4 Press the “CALIBRATE” button (H) again. The button will be deselected indicating calibration has finished.
- 8.5 Confirm that the calibration has been successful by moving the control head and confirming that the “CAL” indication marker (G2) follow your movement as expected.



GEN-1718-01

Figure 194

- 8.6 When the calibration is complete, the parameters must be saved to memory to remain after a system restart.
 - 8.7 To save enter the “GENERAL” menu (J) and press “Save configuration” (K). This action will store all the parameters including the calibration.
- 9 Task completed.

3.4.4 Display Panel, Service Menu

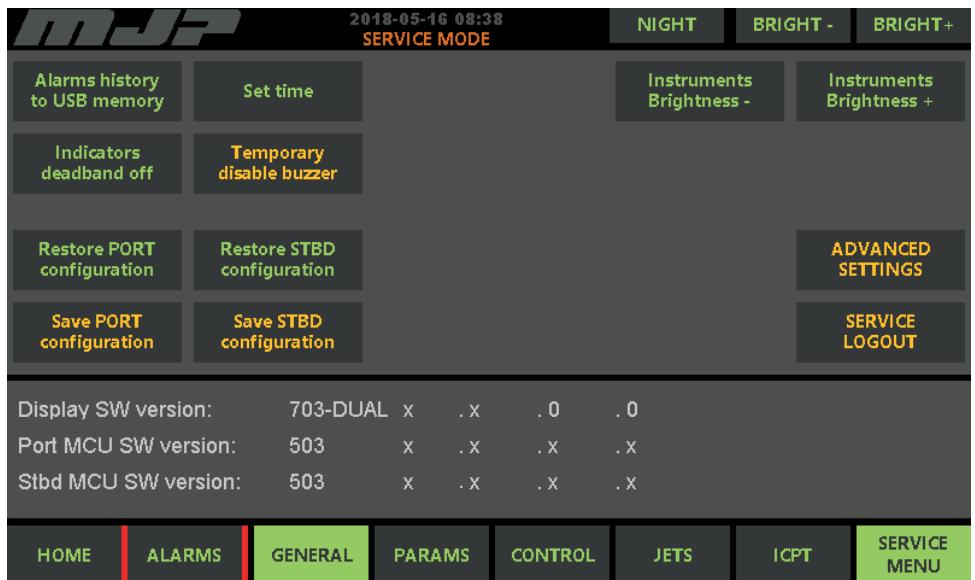


Figure 195

Task Summary

The task is to enter the control systems Service Menu.

Some changes can be done without Service Login, such as instrument brightness.

The service menu Service Login gives access to changes of the system parameters.



Warning!

Changes to the system parameters may adversely affect the control system or make it unsafe to operate.

Task Interval

Do this task during:

- Corrective maintenance

Prerequisites

Conditions

The system power is on.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician or Chief Engineer with remote support	Dockside	10-60 minutes

Service Menu, General

Entering the service menu opens the Service Menu > General page. The items 4-8 are added to the toolbar at the bottom of the screen. These buttons are used to navigate between different service pages. At any time, press HOME button to return to the home screen.

User Mode

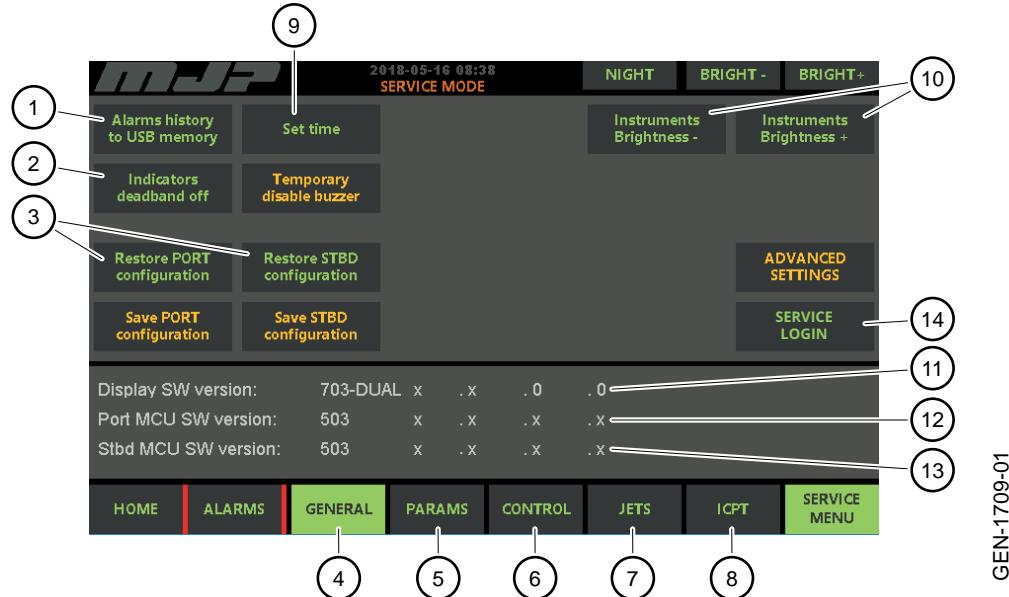


Figure 196

The display defaults to 'user mode' which prevents changing to the system parameters which may adversely affect the control system or make it unsafe to operate. The following options are available in 'user mode'.

Pos	Part	Description
1	Alarm history to USB memory	Tap this button to download the alarm history to an attached USB memory stick.
2	Feedback indicators deadband off	Tap this button if an exact position of bucket and feedback is required. In this case, the indicators in the display may not appear centred when the port controls are in neutral.
3	Restore PORT Configuration	Allows the operator to restore the display configuration to the values stored in the control system PLC.
4	GENERAL	Tap to open the general information and setup page.
5	PARAMS	Tap to open the system parameter page.
6	CONTROL	Tap to open the control head information and setup page.
7	JETS	Tap to open the waterjet information and setup page.
8	ICPT	Tap to open the interceptor information and setup page.
9	Set Time	Tap to set the time and date in the display.
10	Instrument brightness	Adjusts the backlight brightness of control heads and instruments connected to the Jetmaster 3 control system.
11	Display SW version	The current software version running in the display unit software version, has five fields: <ul style="list-style-type: none">• HW version supported

Pos	Part	Description
		<ul style="list-style-type: none"> • SW major version • SW minor version • SW project specific major version • SW project specific minor version.
12	Port MCU SW version	<p>The current SW version running in the port MCU software version, has five fields:</p> <ul style="list-style-type: none"> • HW version supported • SW major version • SW minor version • SW project specific major version • SW project specific minor version
13	Stbd MCU SW version	<p>The current SW version running in the starboard MCU software version, has five fields:</p> <ul style="list-style-type: none"> • HW version supported • SW major version • SW minor version • SW project specific major version • SW project specific minor version.
14	Service login / logout	Tap to login / logout of service mode.

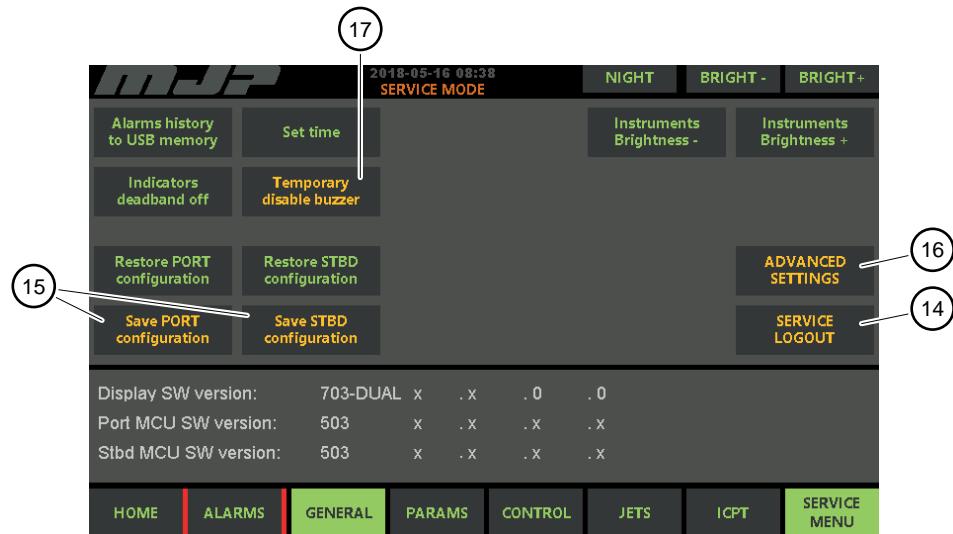
Login Service mode

Trained service engineers are permitted to enter the service mode using the service login button and a passcode.



Warning!

Making changes to settings in service mode may cause unexpected and dangerous operation of the vessel. Only trained and authorised personnel are to use service mode.



GEN-1713-01

Figure 197

Once logged in, the following additional options become available.

Pos	Part	Description
14	Service login/logout	Tap to login/logout of service mode.
15	Save configuration	Save the configuration parameter values to control systems MCU PLC's nonvolatile memory. This will only affect configuration connected to one MCU.
16	Advanced settings	Opens a page with advanced service settings.
17	Temporary disable buzzer	Disables the buzzer temporarily. For use only during commissioning. When logging out from the service mode, the buzzer is always enabled.

Display Panel, Service Login

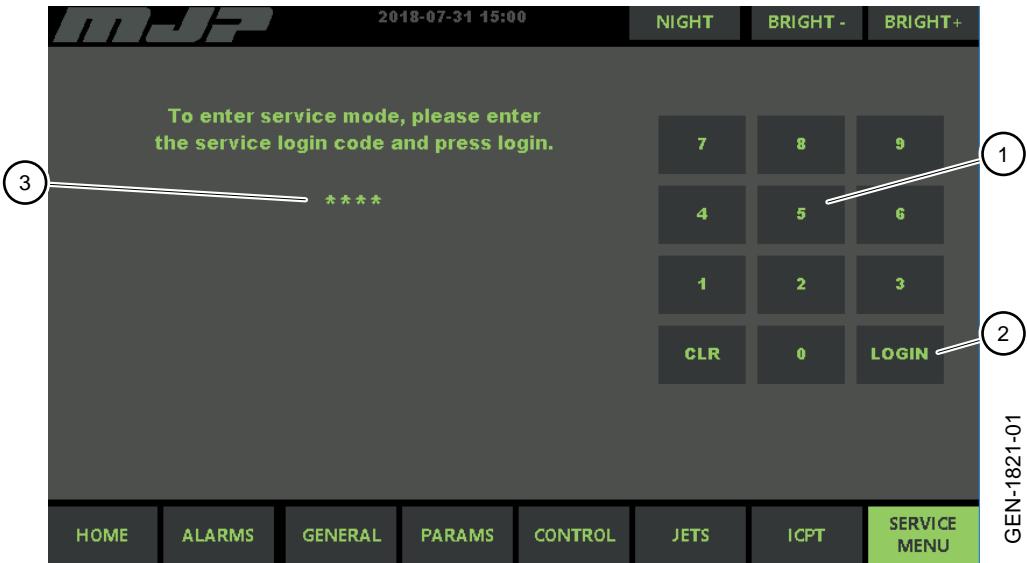


Figure 198

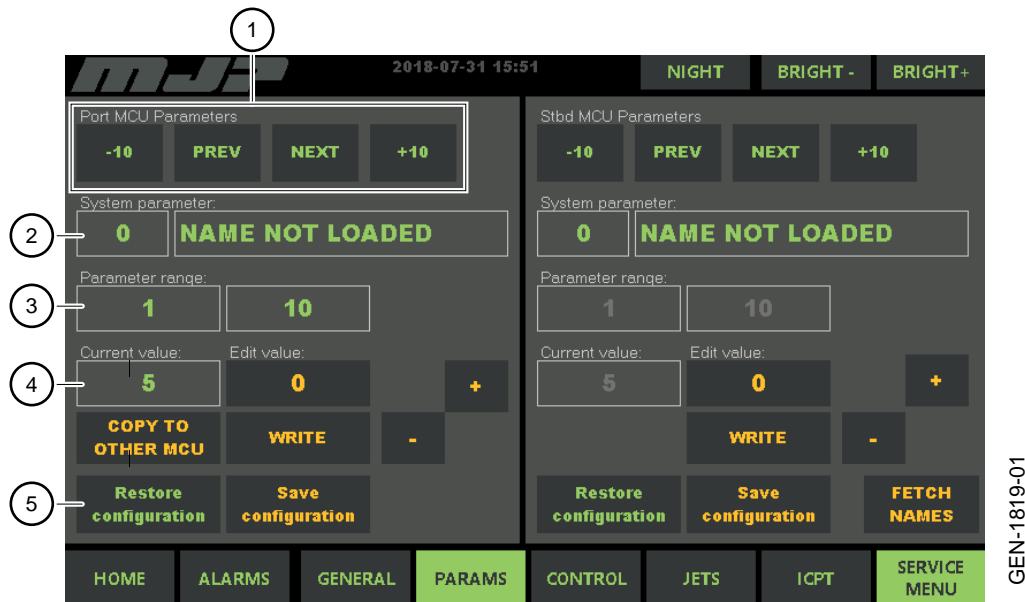
The service menu Service Login gives access to changes of the system parameters.

Pos	Part	Description
1	Numeric keypad	Numeric keypad for entering service code.
2	Login	When the pin code is entered, tap this button to login. After a successful login, a warning screen will be displayed.
3	PIN indication	Indication of how many digits entered in the code.

Service Menu, Parameters

User Mode (Read Only)

The Jetmaster 3 control system can be configured to operate across a wide range of vessels.



GEN-1819-01

Figure 199

When not logged in to service mode, the parameter page only allows viewing of the parameters values. No values can be changed. If a fault occurs, it is possible that the service engineer may ask the operator to inspect parameter values. The following details the available items.

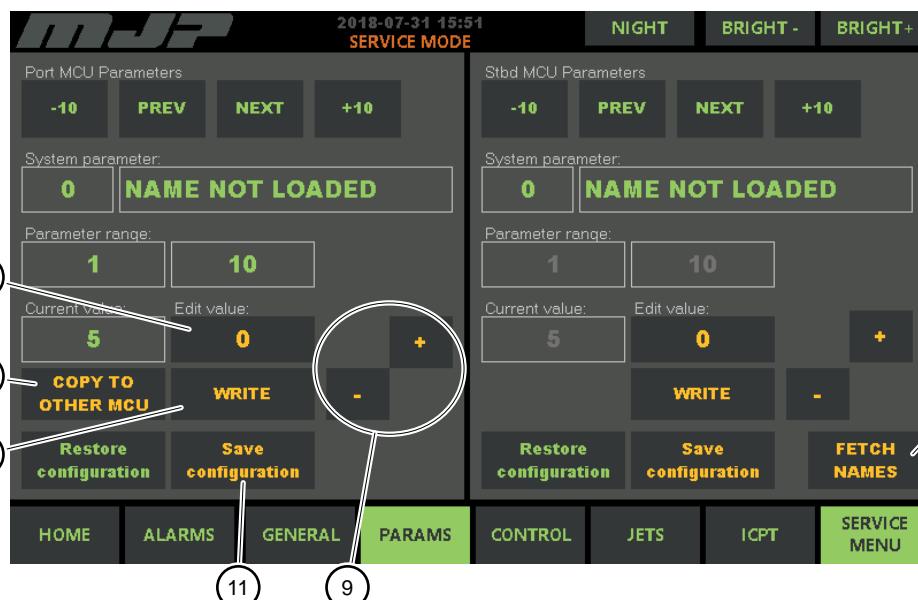
Pos	Part	Description
1	MCU parameter	The four buttons allow the operator to change to a different parameter. The NEXT and PREV buttons move forwards and backwards one parameter at a time. +10 and -10 moves 10 parameters at a time.
2	System parameter	Parameter number and text label. Shows which parameter currently being displayed.
3	Parameter range	Minimum and maximum values of the selected parameter.
4	Current value	The current value of the selected parameter.
5	Restore configuration	Resets all parameters from the nonvolatile memory. Unless the changes have been saved, pressing this button will discard all.

Login Service mode

Once logged in the service engineer can use the parameters page to make changes to parameter values and save these in the PLC memory.

**Warning!**

Making changes to settings in service mode may cause unexpected and dangerous operation of the vessel. Only trained and authorised personnel are to use service mode.



GEN-1820-01

Figure 200

Once logged in, the following additional options become available.

Pos	Part	Description
8	Edit value	Tap this button to open a numeric keypad allowing the engineer to enter specific parameter values.
9	- +	An alternative option to using the numeric keypad. The + and – buttons allow the engineer to increment and decrement the selected parameters value.
10	Write	<p>Writes the new value to the parameter. This value will now be used by the control system.</p> <p>Note! This is only stored in volatile memory and the new value will be lost if the control system is switched off.</p> <p>To preserve the new parameter values, the save configuration button must be used.</p>
11	Save configuration	Saves all parameter values to the control system PLC. Once saved these new values will remain, even after restart.

Pos	Part	Description
12	Copy to other MCU	Copies the current value of the parameter to the other MCU. This is supposed to be used as an aid to set parameters that should be identical on both MCU's. Note! The parameters must still be saved to nonvolatile memory by pressing Save configuration for both MCU's individually to ensure they are preserved after power cycling the system.
13	Fetch names	Fetch names for all the parameters from the MCU. This may take a couple of minutes but only needs to be done once. When all names have been loaded they are stored in the nonvolatile memory of the display and is then loaded on start up.

Service Menu, Controls

User Mode

The controls page allows the operator to see the input for each control. This allows the operator to confirm that a control is working correctly.



Figure 201

The active control still remains in command of the vessel. Moving the control will move the vessel.

Pos	Part	Description
1	Station	Indicates the currently selected station. Tap it to open a popup to select station.
2	Channel	Indicates the currently selected control head channel. Tap it to open a popup to select channel.

Pos	Part	Description
3	Deadband	Indicates the deadband (around the neutral point) on the selected control channel.
4	Margin	Indicates the margin for out of span detection on the selected control channel.
5	Raw	Raw signal value.
6	Calibrated	Calibrated signal value.
		Indication of the selected control heads raw input and calibrated signals. The raw value acquired from the control head are shown in the left graph, the calibration is in the right graph. If the control head is not calibrated, or the head is under calibration, this indication is fixed in zero position.
7	Scale indication	A correctly calibrated signal should reach the top and bottom at full throw.
8	Control head response time graph	Shows a graph of the acquired signal. A new point is taken when a different value from the last is received, that is the graph shall only update when the control head is being moved.

Login Service Mode

In service mode, the service engineer is able to calibrate each channel. Calibrations or other settings are not automatically saved to nonvolatile memory and must be saved using Save Configuration on the General Service page, for each MCU.

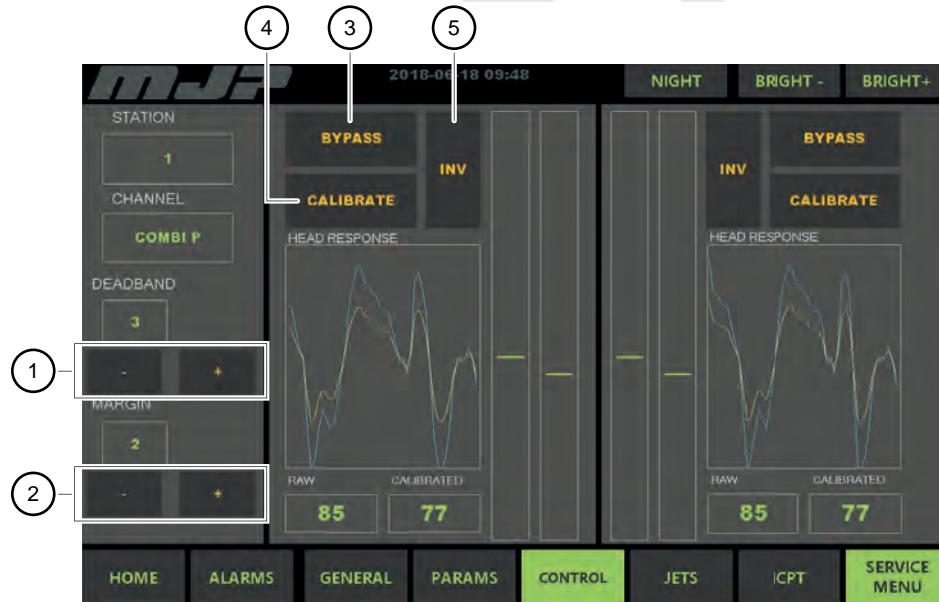


Figure 202

Once logged in, the following additional options become available.

Pos	Part	Description
1	Deadband +/-	Indicates the currently selected station. Tap it to open a popup to select station and channel.
2	Margin +/-	Indicates the currently selected control head channel. Tap it to open a popup to select station and channel.

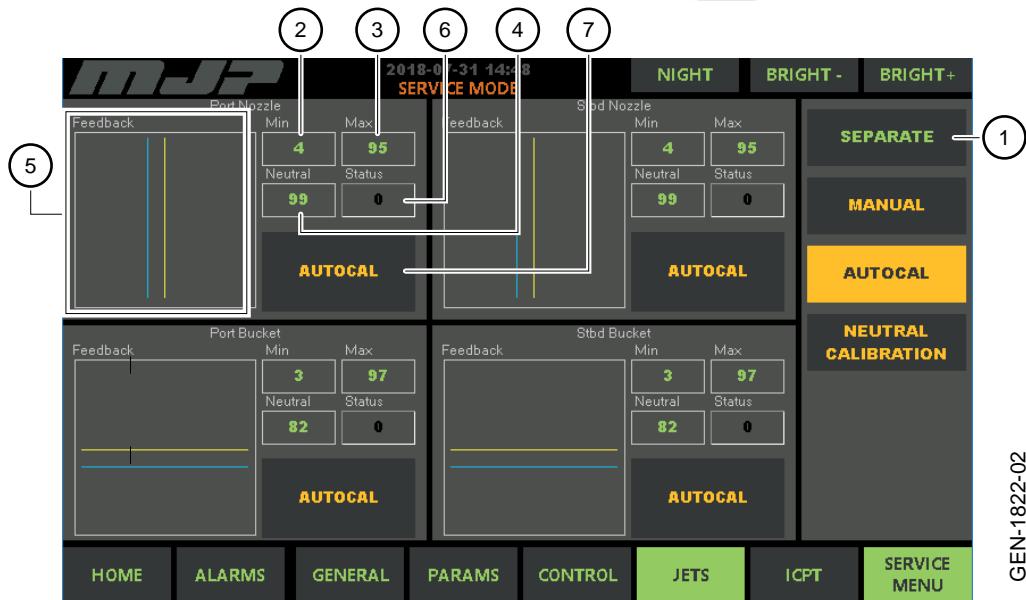
Pos	Part	Description
3	Bypass	Indicates the deadband (around the neutral point) on the selected control channel.
4	Calibrate	Indicates the margin for out of span detection on the selected control channel.
5	Inv	The grey box area holds the calibration instrumentation for the port MCU.

Service Menu, Jets

User Mode (read only)

Note!

The display shows port and starboard jet.



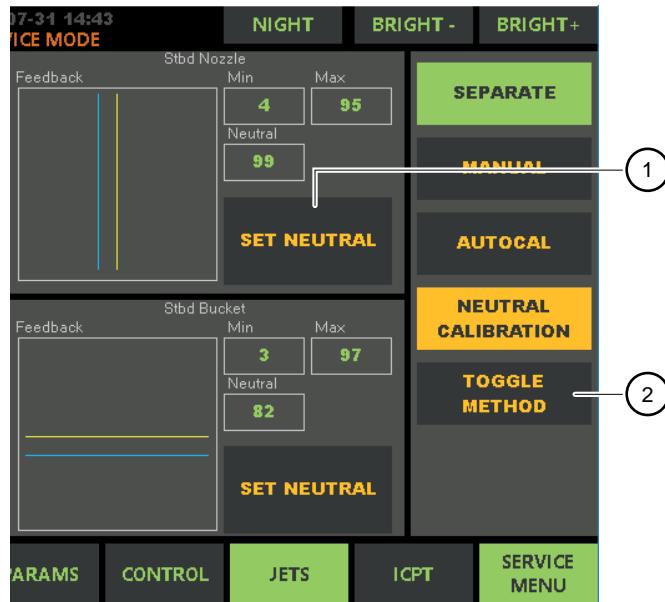
GEN-1822-02

Figure 203

The jet page provides information on the bucket and nozzle positions for the jets linked to a particular screen.

Pos	Part	Description
1	Default mode button	Enter the default manoeuvring mode. Normally SEPARATE, CSW.
2	Min	Lowest recorded feedback value.
3	Max	Highest recorded feedback value.
4	Neutral	Neutral point. Given in the calibrated signal scaling.
5	Actuator position, rolling time graph	A rolling graph of the current position of the actuator (nozzle/bucket). Useful to get a visualization of the actuator response.

Pos	Part	Description
6	Autocalibration status code See figure Figure 203	When in autocal mode, status code for the automatic calibration process. See <i>Service Menu</i> , <i>Parameters</i> , <i>Login Service Mode</i> for more info.
7	AUTOCAL See figure Figure 203	When in autocal mode, AUTOCAL button starts automatic calibration procedure. These are only visible if an azimuth control is not present in the configuration.

Jet Calibration, Login Service Mode

GEN-1824-01

Figure 204

When logged in as a service engineer it is possible to perform automatic calibration of the bucket and nozzle or manually adjust the calibration endpoints or neutral position.

Pos	Part	Description
1	SET NEUTRAL	When neutral calibration is enabled and toggle method is disabled, this set neutral button appears. When this button is tapped, the nozzle or bucket takes the current position it is in and use as neutral point.
2	TOGGLE METHOD	Only visible when Neutral calibration is active. Toggle between the methods of setting neutral position. One method being "set current value as neutral" and the other being "increment or decrement steps".

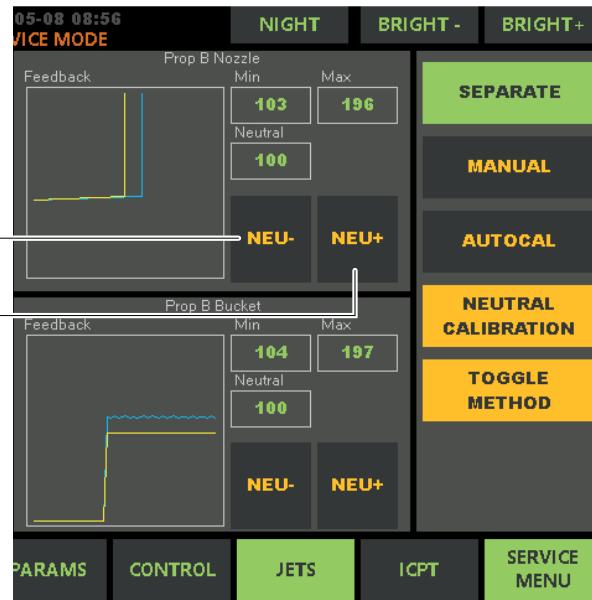


Figure 205

Pos	Part	Description
1	NEU-	Decrement neutral position by one step.
2	NEU+	Increment neutral position by one step.

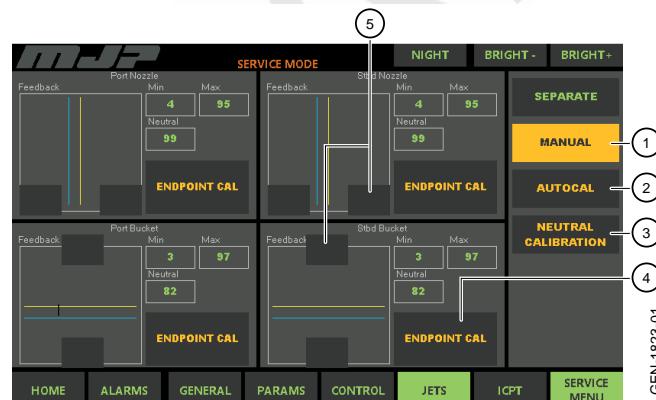


Figure 206

Pos	Part	Description
1	MANUAL mode button	Enter the Manual MSA.
2	AUTOCAL mode button	Enter the Autocalibration MSA. This does not start the actual automatic calibration procedure. This only enters the mode in which it can be started.
3	NEUTRAL CALIBRATION	This button enables the neutral calibration. When activated, more instruments will show to support this feature.

Pos	Part	Description
4	ENDPOINT CAL	Only visible if in manual mode. When endpoint calibration is enabled a popup will appear to confirm that the previous endpoint calibration will be lost if proceeded. If the calibration procedure is not completed the concerned nozzle or bucket may not be operational.
5	Manual controls	Only visible if in manual mode. Manual controls for moving the nozzles to port or starboard and for moving buckets up or down.

Service Menu, Interceptors (ICPT)

Interceptor steering is an optional feature. When using interceptor steering it is possible to adjust the steering control input to nozzle output scaling for different RPM demands to tune the total steering effect. There is one setpoint for each 10% RPM demand.

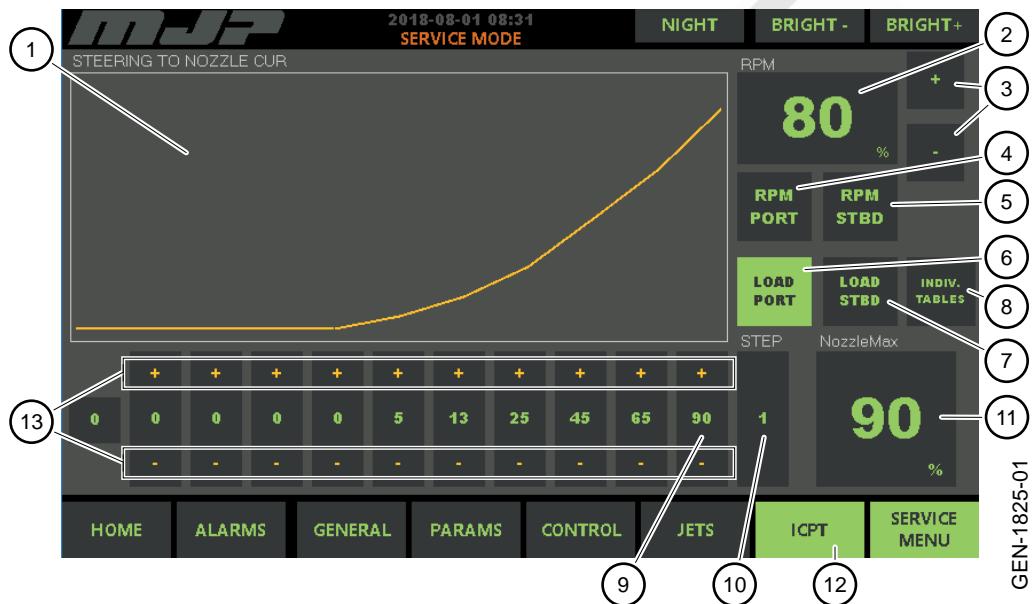


Figure 207

The interceptor menu allows the operator to view the interceptor steering parameters

Pos	Part	Description
1	Steering to nozzle graph	Displays the percentage ratio from steering demand to nozzle position for the currently selected RPM. If the RPM is set to follow port or starboard RPM demand the values is interpolated between the closest curve entries.
2	RPM indicator	Shows the selected RPM.
3	RPM +/-	Increment or decrement the selected RPM by 10%.
4	RPM PORT	Connects the selected RPM to port RPM demand Note: In a quad system this is: <ul style="list-style-type: none">• Port outer jet on the port display (QP)• Stbd inner jet on the stbd display (QS).
5	RPM STBD	Connects the selected RPM to stbd RPM demand Note: In a quad system this is:

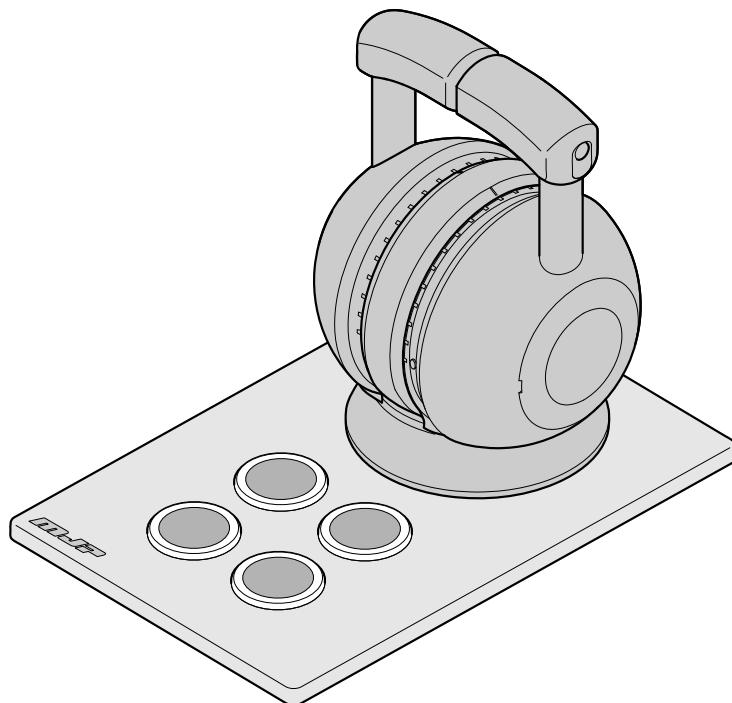
Pos	Part	Description
		<ul style="list-style-type: none"> • Port inner jet on the port display (QP) • Stbd outer jet on the stbd display (QS).
6	LOAD PORT	Indicates if the currently loaded set of curves is from port MCU. If tapped the curves are loaded from port MCU.
7	LOAD STBD	Indicates if the currently loaded set of curves is from stbd MCU. If tapped the curves are loaded from stbd MCU.
8	Indiv. Tables	This is a toggle button, selecting if the port and stbd MCU should use individual or copies of the same set of curves.
9	Curve values	The closest curve entry for the selected RPM. The values are for 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100% steer respectively.
10	STEP	Indicates the STEP to increment or decrement each curve entry. Tap it to toggle between 1 and 10.
11	NozzleMax	The maximum nozzle output at the selected RPM.
12	ICPT	On this page the button will toggle a pop up with a 3D graph of all the curves for different RPM.

Login Service Mode

When logged in as a service engineer the parameters can be adjusted as required.

Pos	Part	Description
13	Edit curve values +/-	<p>+/- will increment/decrement that value by the STEP-value. The value for 0% steer cannot be edited. It is not possible to edit values while any selected RPM is set to follow RPM demand of port or stbd.</p> <p>For any changes to be persistent "Save configuration" must be pressed on the general service page.</p>

3.4.5 Combinator Controller, Replace



GEN-1917-01

Figure 208

Task Summary

The task is to replace the combinator controller.

Task Interval

Do this task during:

- Corrective maintenance

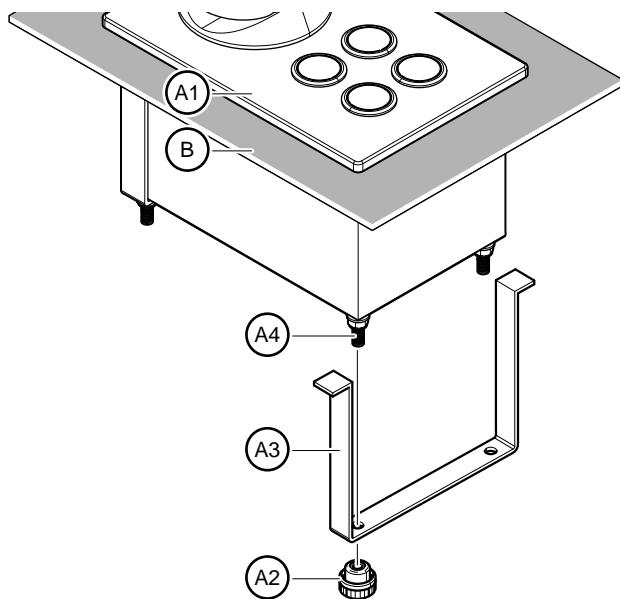
Prerequisites

Conditions

The control system is completely shut off.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dockside	20 minutes
Spare parts	Quantity	Part number	
Combinator controller	1	Contact MJP	

Procedure

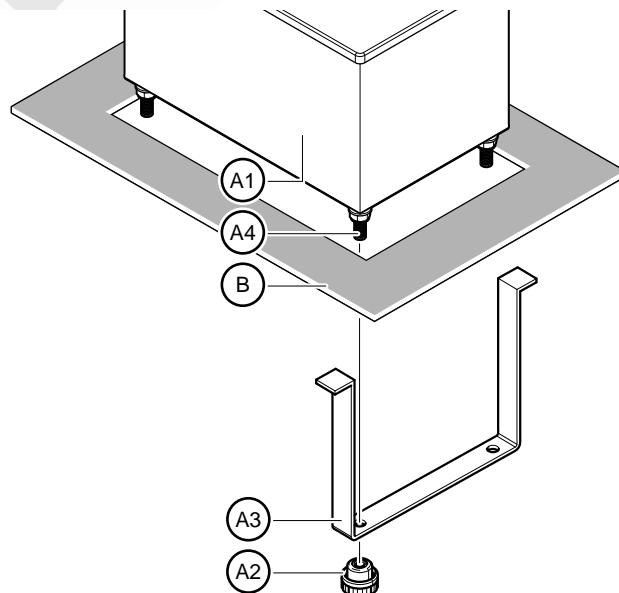


GEN-1918-01

Figure 209

1 Remove the combinator controller:

- 1.1 Examine the labels on each cable to make sure that all cables are correctly connected to the combinator controller (A1).
- 1.2 Disconnect each cable connected to the combinator controller (A1).
- 1.3 Examine each cable to make sure there is no damage on the cables. If the cables are damaged, contact MJP.
- 1.4 Remove the nuts (A2).
- 1.5 Remove the brackets (A3).
- 1.6 Remove the combinator controller (A1) from the bridge panel (B).



GEN-1919-01

Figure 210

2 Install the new combinator controller:

- 2.1 Remove the nuts (A2) and the brackets (A3) from the threaded pins (A4) on the new combinator controller (A1).
- 2.2 Insert the new combinator controller (A1) into the cut out hole on the control panel (B).
- 2.3 Install the nuts (A2) to attach the bracket (A3) to the threaded pins (A4) under the combinator controller (A1).
- 2.4 Tighten the nuts (A2) to fasten the brackets (A3) and combinator controller (A1) to the bridge panel (B).
- 2.5 Connect the cables to the combinator controller (A1).



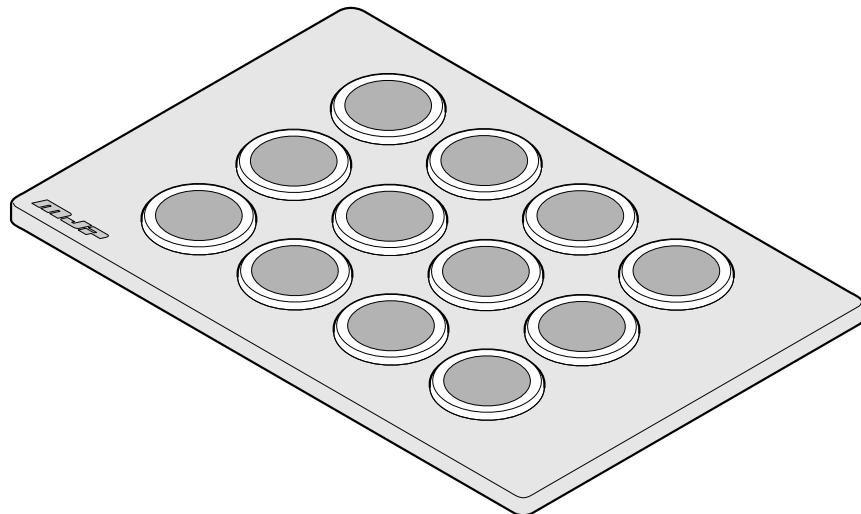
Caution!

Before you connect the cables, examine each cable to make sure there is no damage on the cables and that all labels are correct.

- 2.6 Power on and start the system.
- 2.7 Calibrate the control levers, see *3.4.3 Control Levers, Calibrate*.
- 2.8 Make sure that the combinator controller (A1) operates correctly.

3 Task completed.

3.4.6 Command Panel BUS, Replace



GEN-2814-01

Figure 211

Task Summary

The task is to replace the command panel.

Task Interval

Do this task during:

- Corrective maintenance

Prerequisites

Conditions

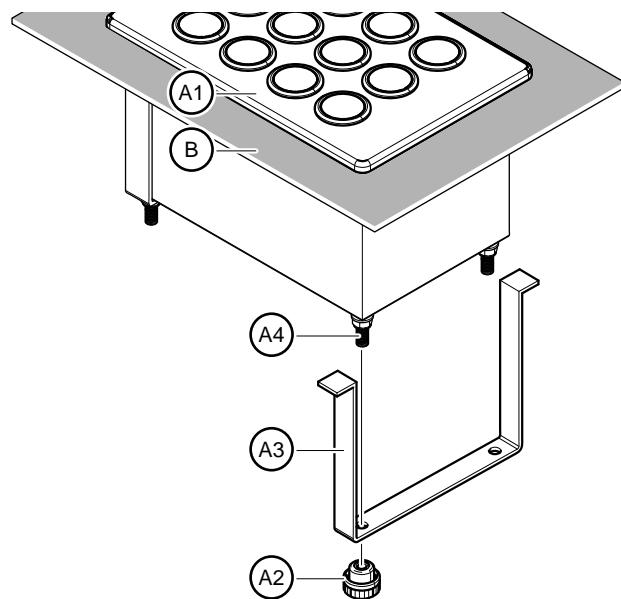
The system is completely shut off.

All levers in neutral position.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dockside	20 minutes

Spare parts	Quantity	Part number
Command panel	1	Contact MJP

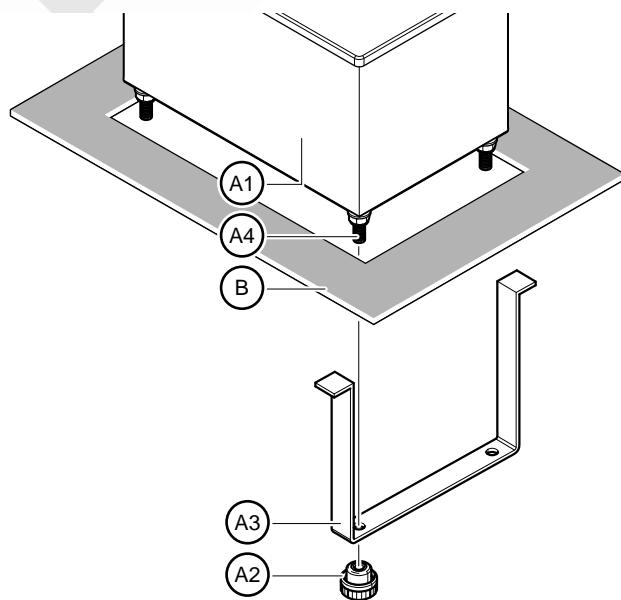
Procedure



GEN-2819-01

Figure 212

- 1 Remove the command panel:
 - 1.1 Examine the labels on each cable to make sure that all cables are correctly connected to the command panel (A1).
 - 1.2 Disconnect each cable connected to the command panel (A1).
 - 1.3 Examine each cable to make sure there is no damage on the cables. If the cables are damaged, contact MJP.
 - 1.4 Remove the nuts (A2).
 - 1.5 Remove the brackets (A3).
 - 1.6 Remove the command panel (A1) from the bridge panel (B).



GEN-1919-01

Figure 213

- 2 Install the new command panel:

- 2.1 Remove the nuts (A2) and the brackets (A3) from the threaded pins (A4) on the new command panel (A1).
- 2.2 Put the new command panel (A1) into the cut out hole on the control panel (B).
- 2.3 Install the nuts (A2) to attach the bracket (A3) to the threaded pins (A4) under the command panel (A1).
- 2.4 Tighten the nuts (A2) to fasten the brackets (A3) and the command panel (A1) to the bridge panel (B).
- 2.5 Connect the cables to the command panel (A1).

**Caution!**

Before you connect the cables, examine each cable to make sure there is no damage on the cables and that all labels are correct.

- 2.6 Power on and start the system.
 - 2.7 At the power central, switch the power on for Main and Backup system.
 - 2.8 Verify that lamps and LEDs are OK. If not OK, see *3.4.10 Indoor Panels, Lenses and LEDs, Inspect*.
 - 2.9 Go through all the available modes / functions in the command panel (A1) to make sure that both commands and indications work properly.
- 3 Task completed.

3.4.7 Control System, Inspect and Replace Cables

Task Summary

The task is to inspect and replace damaged control system cables.

Task Interval

Do this task during:

- Corrective maintenance

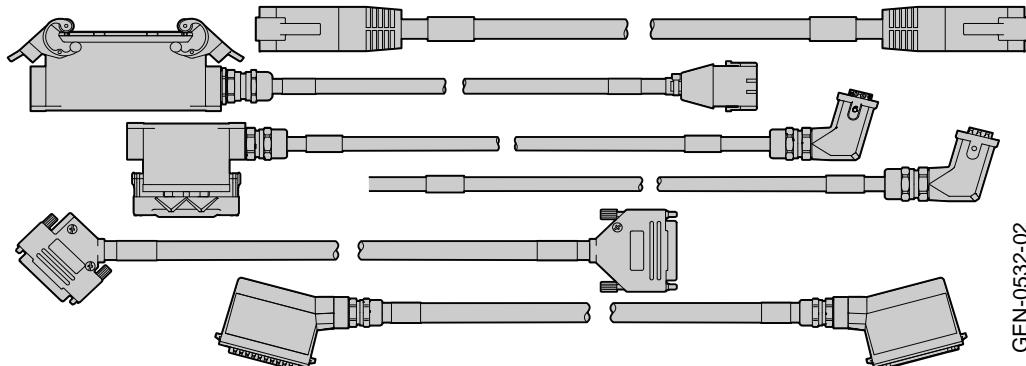
Prerequisites

Conditions

The control system is completely shut off.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Chief Engineer	Dockside	45 minutes
Spare parts		Quantity	Part number
Control system cables		—	See separate drawing

Procedure



GEN-0532-02

Figure 214

- 1 Identify which cable to inspect for damage. See Control System.
- 2 Examine that the cable is working correctly.
- 3 If there are damages, change cable.
- 4 Power on and start the system.
- 5 Verify that the system works correctly.

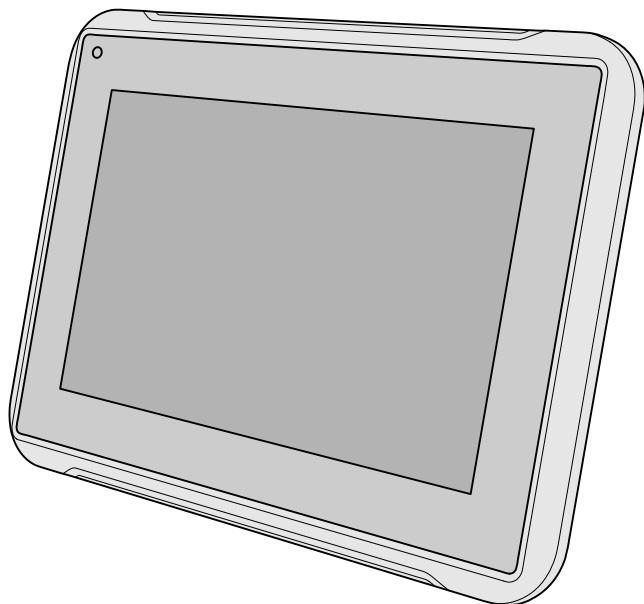


Caution!

If the system does not work correctly, make sure that all the cables are adequately installed. Cables that appear to be correctly installed may need to be adjusted to achieve a correct installation.

- 6 Task completed.

3.4.8 Display Panel, Replace



GEN-1654-01

Figure 215

Task Summary

The task is to replace the display panel.

The same procedure applies to the DP system display panel.

Task Interval

Do this task during:

- Corrective maintenance

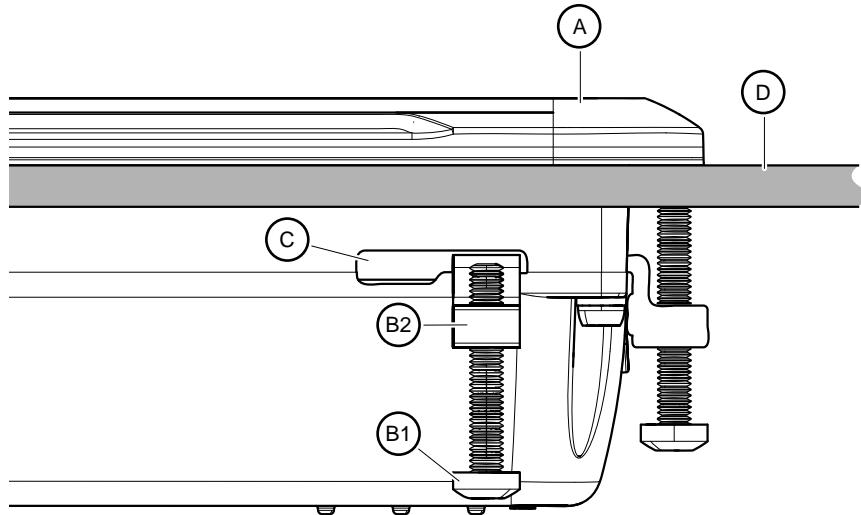
Prerequisites

Conditions

The control system is completely shut off.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dockside	20 minutes
Spare parts	Quantity	Part number	
Display Panel	1	C-50005	

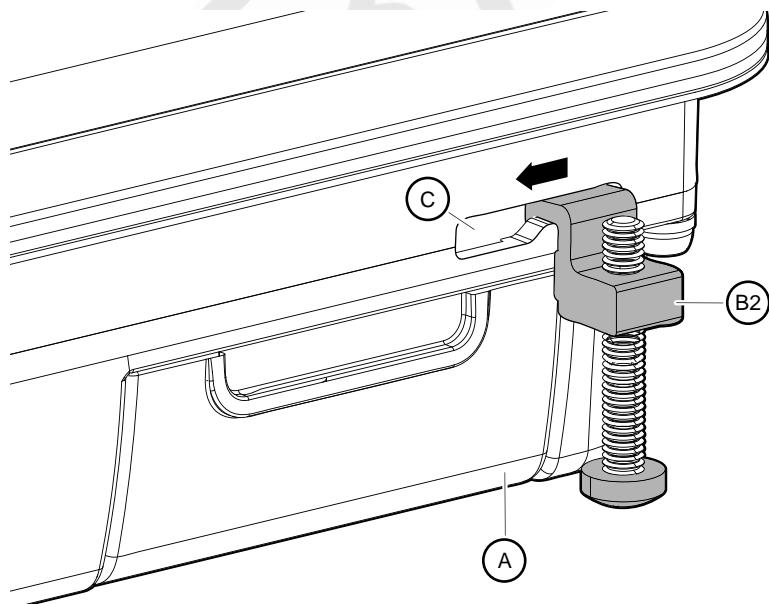
Procedure



GEN-1690-01

Figure 216

- 1 Remove the display panel (A):
 - 1.1 Examine each cable connected to the display panel (A) to make sure all labels are correct.
 - 1.2 Disconnect each cable connected to the display panel (A).
 - 1.3 Examine each cable to make sure that there is no damage on the cables. If the cables are damaged, contact MJP.
 - 1.4 Loosen the screws (B1) on the installation fasteners (B2) installed in the insertion slots (C) on the display panel (A).



GEN-1691-01

Figure 217

- 1.5 Remove the installation fasteners (B2) from the insertion slots (C).

GEN-1692-01

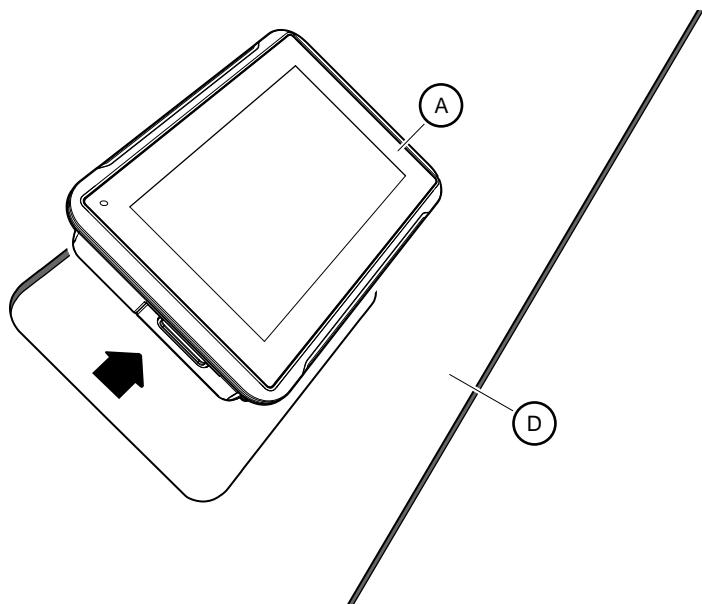


Figure 218

- 1.6 Remove the display panel (A) from the control panel (D).
- 2 Install the new display panel:
 - 2.1 Insert the new display panel into the cut out hole on the control panel (D).

Note!

The display must be oriented with the round LED (A2) in the top left corner.

- 2.2 Insert the installation fasteners (B2) in the insertion slots (C).
- 2.3 Tighten the fastener screws (B1). See .

**Caution!**

Do not tighten the fastener screws with too much force. This can cause damage to the plastic case of the display panel.

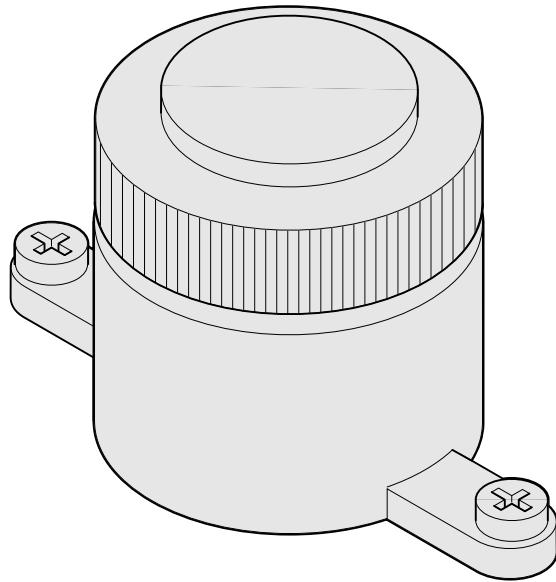
- 2.4 Connect the cables to the new display panel.

**Caution!**

Before you connect the cables, examine each cable to make sure there is no damage on the cables and that all labels are correct.

- 3 Start the system:
 - 3.1 Make sure that the display panel starts correctly.
 - 3.2 Do a check of all menus, modes, functions and alarms of the display panel.
- 4 Task completed.

3.4.9 External Alarm Buzzer, Replace



GEN-0485-01

Figure 219

Task Summary

The task is to replace the external alarm buzzer.

Task Interval

Do this task during:

- Corrective maintenance

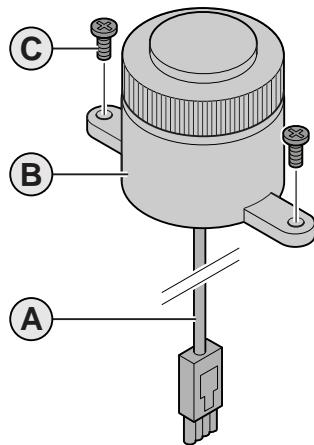
Prerequisites

Conditions

The control system is completely shut off.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dockside	20 minutes
Spare parts	Quantity	Part number	
External alarm buzzer	1	Contact MJP	

Procedure

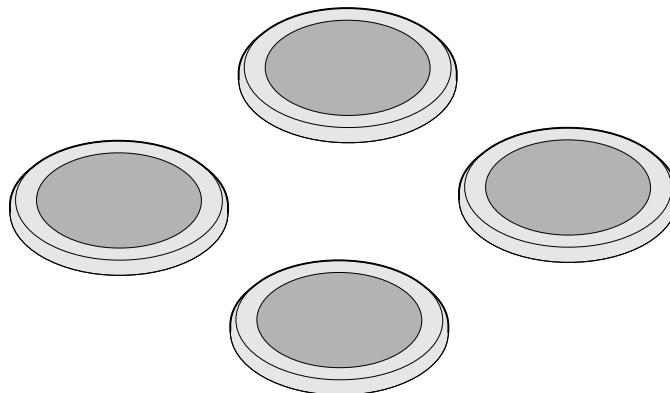


GEN-0478-01

Figure 220

- 1 Remove the external alarm buzzer:
 - 1.1 Examine the cable (A) to make sure that all labels are correct.
 - 1.2 Disconnect the cable (A) from the display cable.
 - 1.3 Remove the screws (C) from the alarm buzzer.
 - 1.4 Remove the alarm buzzer (B) from the control panel.
 - 1.5 Examine the cable (A) to make sure that there is no damage. If the cable is damaged, contact MJP.
 - 2 Install the new alarm buzzer:
 - 2.1 Install the screws (C) to attach the new alarm buzzer to the control panel.
 - 2.2 Connect the cable (A) to the display cable.
- Caution!**
Before you connect the cable, examine the cable to make sure there is no damage on the cable and that all labels are correct.
- 2.3 Start the system.
 - 2.4 Make sure that the alarm buzzer operates correctly.
- 3 Task completed.

3.4.10 Indoor Panels, Lenses and LEDs, Inspect



GEN-0497-03

Figure 221

Task Summary

The task is to inspect lenses and LEDs on indoor panels.

Task Interval

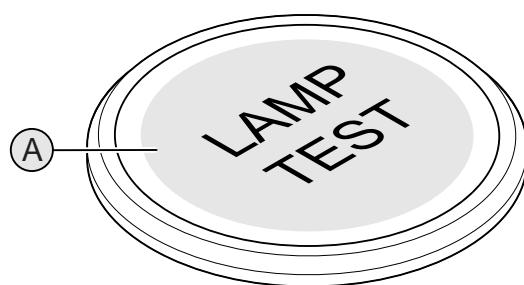
Do this task during:

- Corrective maintenance

Prerequisites

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Crew	On equipment / at sea	20 minutes

Procedure

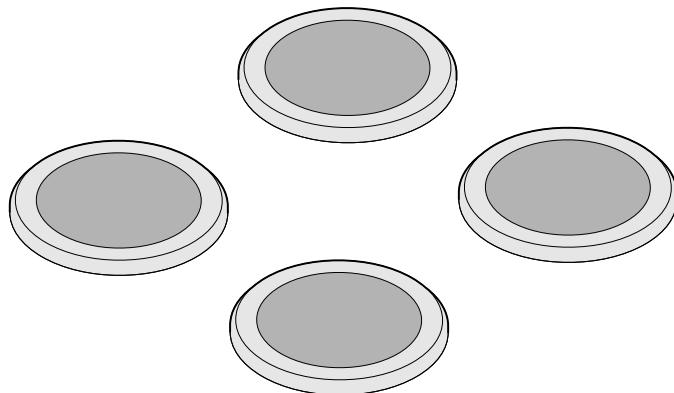


GEN-0500-03

Figure 222

- 1 Check that all lenses are not broken and fully readable.
- 2 Press the LAMP TEST button (A) to see if there is any broken LEDs.
- 3 Replace broken LEDs. See 3.4.11 Indoor Panels, Lenses and LEDs, Replace.
- 4 Replace broken or unreadable lenses. See 3.4.11 Indoor Panels, Lenses and LEDs, Replace
- 5 Task completed.

3.4.11 Indoor Panels, Lenses and LEDs, Replace



GEN-0497-03

Figure 223

Task Summary

The task is to replace broken LEDs on indoor panels.

The same procedure to replace broken or worn lenses on indoor panels.

Task Interval

Do this task during:

- Corrective maintenance

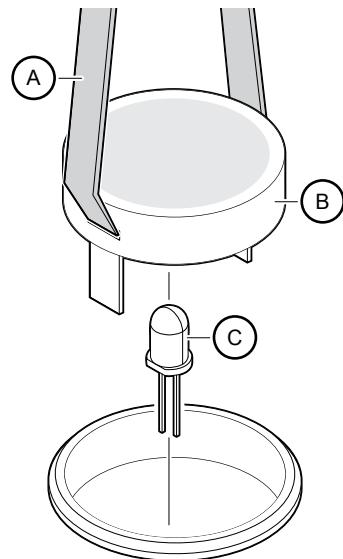
Prerequisites

Conditions

None

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Crew	On equipment / at sea	20 minutes
Spare parts		Quantity	Part number
LED yellow		1	J10-2J12-1064
LED red		1	J10-2J12-1062
Lenses		-	Contact MJP
Special tools and test equipment		Quantity	Part number
LED Tool kit (for backup unit and command panel)		1	Contact MJP

Procedure



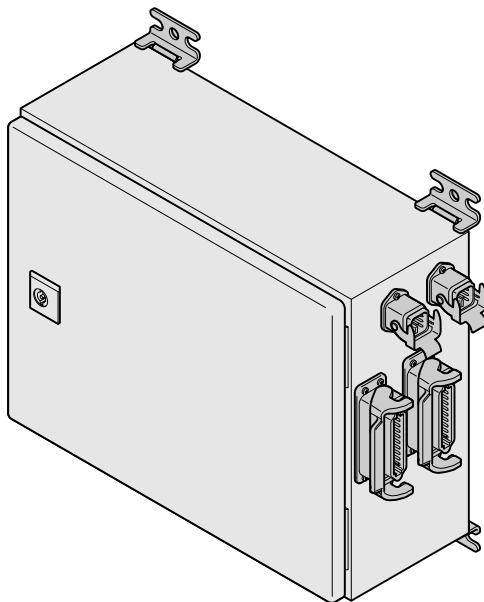
GEN-0687-01

Figure 224

For changing lenses (B), skip step 2 and 3.

- 1 Use the lens remover tool (A) to gently remove the cap / lens (B).
- 2 Use the LED remover to remove the broken LED (C).
- 3 Install a new LED.
- 4 Press the cap / lens (B) gently back into place.
- 5 Task completed.

3.4.12 Main Control Unit, Replace



GEN1646-01

Figure 225

Task Summary

The task is to replace the Main control unit.

Task Interval

Do this task during:

- Corrective maintenance

Prerequisites

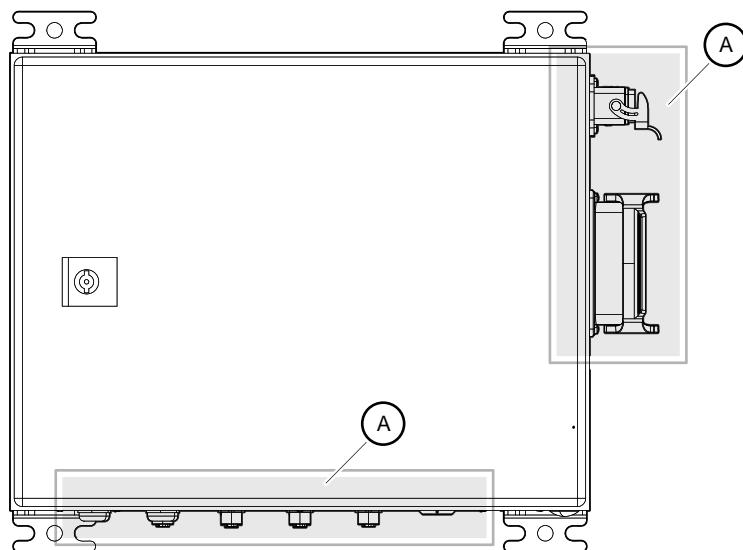
Conditions

The control system is completely shut off.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dockside	90 minutes

Spare parts	Quantity	Part number
Main control unit	1	

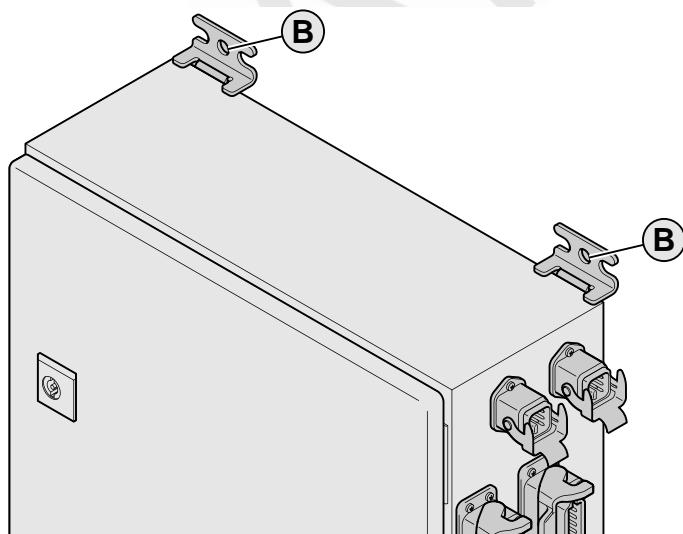
Procedure



GEN-1697-01

Figure 226

- 1 Make sure that all cables (A) going to the control unit are documented or labelled properly.
- 2 Disconnect and remove all cables (A) going into the control unit.
- 3 Examine all cables (A) for visible damages. If there are damages, contact MJP.

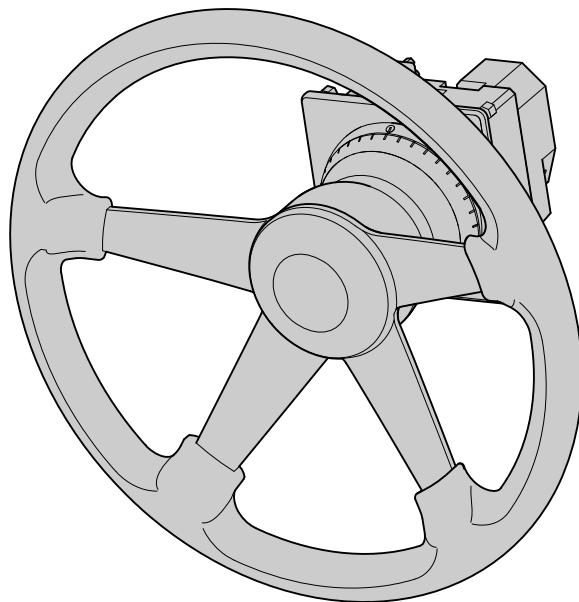


GEN-1698-01

Figure 227

- 4 Remove all screws and washers (B) holding the control unit into place.
- 5 Remove the control unit.
- 6 Install the new control unit.
- 7 Install all screws and washers (B) to the control unit.
- 8 Connect the cables (A) into the control unit.
- 9 Power on and start the system.
- 10 Make sure that the control unit is working properly.
- 11 Task completed.

3.4.13 Steer Wheel, Replace Steer Controller



GEN-1333-01

Figure 228

Task Summary

The task is to replace the steer controller under the steer wheel.

Task Interval

Do this task during:

- Corrective maintenance

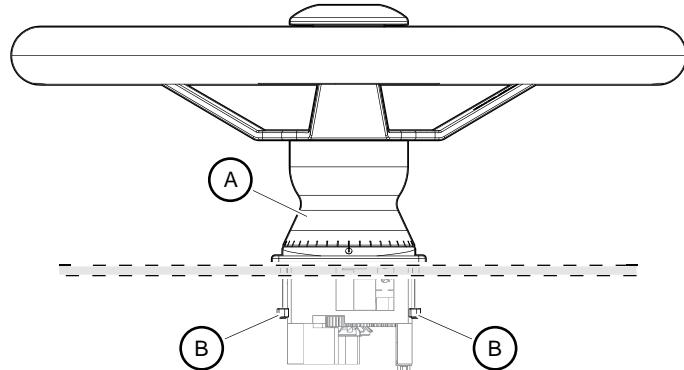
Prerequisites

Conditions

The control system is completely shut off.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician or Chief Engineer with remote support	Dockside	20 minutes
Spare parts	Quantity	Part number	
Steer controller	1	Contact MJP	

Procedure

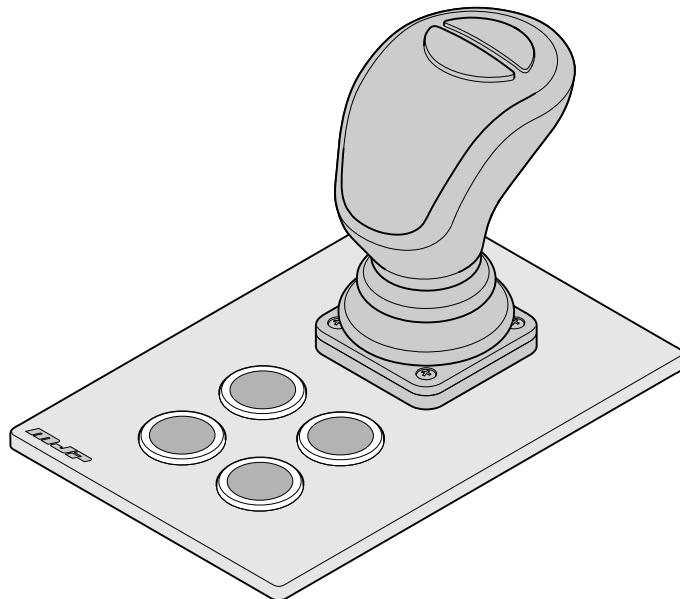


GEN-2808-01

Figure 229

- 1 Make sure that all cables connected to the steer controller (A) are correctly labelled.
- 2 Remove all cables connected to the steer controller (A).
- 3 Examine all cables for visible damage. If there are damages, contact MJP.
- 4 Remove the nuts and spacers (B).
- 5 Remove the steer controller (A) from the panel.
- 6 Put the new steer controller into the cut-out in the panel.
- 7 Install the nuts and spacers (B) to attach the new steer controller to the panel.
- 8 Connect the cables to the new steer controller.
- 9 Power on and start the system.
- 10 Calibrate control levers. See *3.4.3 Control Levers, Calibrate*.
- 11 Make sure that the new steer controller is working correctly.
- 12 Task completed.

3.4.14 VCS Panel (BUS), Replace



GEN-1893-02

Figure 230

Task Summary

The task is to replace the VCS panel.

Task Interval

Do this task during:

- Corrective maintenance

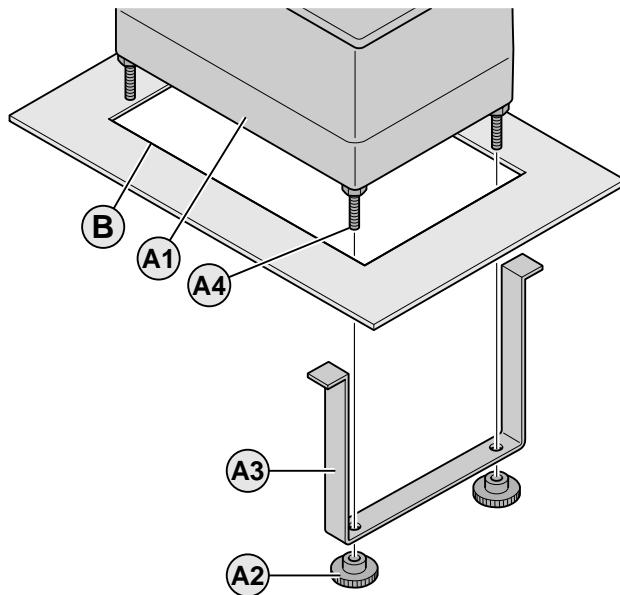
Prerequisites

Conditions

The control system is completely shut off.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician or Chief Engineer with remote support	Dockside	20 minutes
Spare parts		Quantity	Part number
VCS panel		1	Contact MJP

Procedure



GEN-1862-01

Figure 231

- 1 Remove the VCS panel:
 - 1.1 Examine the labels on each cable to make sure that all cables are correctly connected to the VCS panel (A1).
 - 1.2 Disconnect each cable connected to the VCS panel.
 - 1.3 Examine each cable to make sure there is no damage on the cables. If the cables are damaged, contact MJP.
 - 1.4 Remove the nuts (A2).
 - 1.5 Remove the brackets (A3).
 - 1.6 Remove the VCS panel from the bridge panel (B).
- 2 Install the new VCS panel:
 - 2.1 Remove the nuts (A2) and the brackets (A3) from the threaded pins (A4) on the new VCS panel.
 - 2.2 Insert the new VCS panel into the cut out hole on the control panel.
 - 2.3 Install the nuts (A2) to attach the bracket (A3) to the threaded pins (A4) under the VCS panel.
 - 2.4 Tighten the nuts to fasten the VCS panel to the bridge panel.
 - 2.5 Connect the cables to the VCS panel.
- 3 Task completed.



Caution!

Before you connect the cables, examine each cable to make sure there is no damage on the cables and that all labels are correct.

- 2.6 Power on and start the system.
- 2.7 Calibrate the control levers, see *3.4.3 Control Levers, Calibrate*.
- 2.8 Make sure that the VCS panel operates correctly.

3.4.15 Control System Components and Waterjet operation test

Task Summary

The task is to confirm that all control system components and Waterjets works trouble-free in operation..

Task Interval

Do this task during (after): • Yearly inspection



Caution!

Before you test the functionality of the Waterjet when the gearbox is clutched in, be aware of the vessel's surroundings.

Prerequisites

Conditions

The vessel is in the water, fully functional after yearly inspection.

Hydraulic pressure is required.

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Authorized Service Technician	Dockside	4 hours

Procedure

- 1 Power on control system:
 - 1.1 Confirm system starts normally.
 - A.Record installed software version.
 - B.Confirm that no requirement to update software.
 - C.Download and clear log files.
 - D.Upload the log files to MJP server.
 - 1.2 Check the alarm log
 - E.If any relevant alarms are present these should be investigated.
 - 1.3 Switch to the control signal page
 - F.Check that each control head is correctly calibrated.
 - G.If a control head is out of calibration, this could indicate a control head is due for replacement.
 - 1.4 Visually inspect display, check for dead pixels.

2 Jet operation tests

Note!

It is required to clutch in, in order to test the Waterjets. Ensure the vessel is in a safe state for this, either securely moored or in open water.

- 2.1 Use all the different primary controls.

- H.Move each bucket and nozzle slowly through its full range of motion.

- I. Monitor the jet page on the display. Ensure that responses correctly match the demand.

- J. Look for any sign of signal noise on the feedbacks.

DRAFT

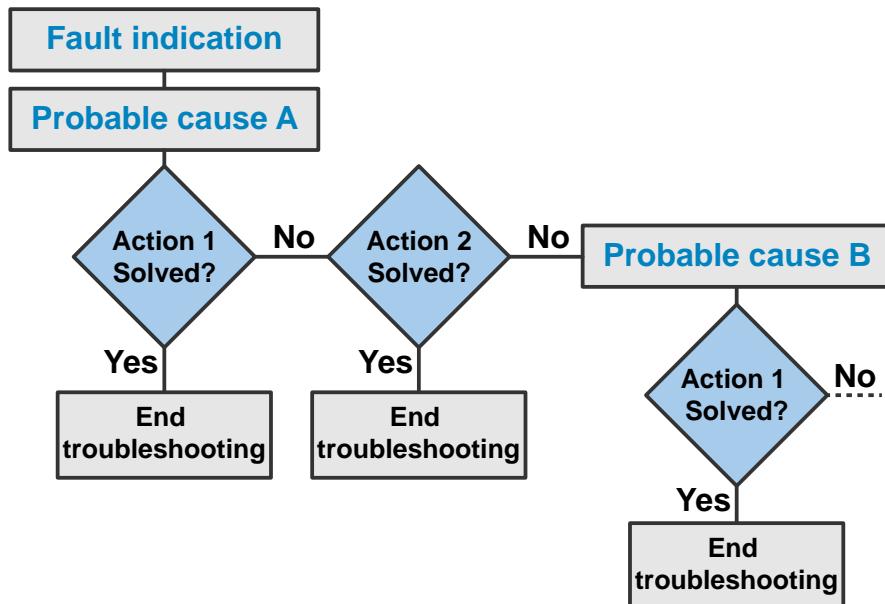
4 Fault Indication

4.1 Troubleshooting

Troubleshooting must be performed under controlled circumstances by authorised personnel. See the Service Manual for required skill level for each task.

4.1.1 How to Read

The action procedure is described in the flow chart.



GEN-0225-02

Figure 232

4.1.2 Troubleshooting Procedure

Vibration from Waterjet/Shafline

Probable cause	Action
A. Waterjet operated at very high RPM in low speed resulting in pump cavitation.	Lower RPM.
B. Debris in intake or pump.	See 3.2.1 <i>Intake and pump, Inspect.</i>
C. Bearing damage.	Make sure the shaft is rotating freely.
D. Shafting wear/damage.	Check the condition of intermediate shaft U-joint or CV-joint.
E. Impeller damage or housing contact.	See 3.2.2 <i>Pump Unit, Inspect Impeller Blade Tip Clearance</i>

Low Hydraulic Oil Level

Probable cause	Action
A. Leaking cylinders, connections, pipes or hoses.	<p>1. See 3.3.1 <i>Hydraulic Cylinders and Hoses, Inspect</i></p> <p>2. Repair any leakage and fill up with oil. See 3.3.13 <i>Hydraulic System, Add Oil</i></p>

Low Hydraulic Pressure

Probable cause	Action
A. Valve or pressure regulator malfunction.	<p>1. See 3.3.19 <i>Hydraulic System, Inspect Working Pressure</i> and 3.3.20 <i>Hydraulic System, Adjust Working Pressure</i>.</p> <p>2. 3.3.21 <i>Hydraulic System, Inspect Pressure Limit</i> and 3.3.22 <i>Hydraulic System, Adjust Pressure Limit</i>.</p> <p>3. Still not solved - Contact MJP.</p>

High Temperature, Hydraulic Oil

Probable cause	Action
A. Low oil volume in the system.	See 3.3.10 <i>Hydraulic System, Inspect Oil Level</i>
B. Malfunction in the load sensing system.	<p>1. See 3.3.19 <i>Hydraulic System, Inspect Working Pressure</i></p> <p>2. Monitor the pressure gauge during operation. Monitor that the working pressure drops when no manoeuvring is done. See <i>Hydraulic Tank, Inspect Standby Pressure</i>.</p> <p>3. If the cylinder reach the mechanical end position, the pressure will not drop. Calibrate the steering and reversing function on related jet. See <i>Service Menu, Controls</i></p>
C. Steering and / or reversing is behaving "nervously".	<p>1. During operation, monitor hydraulic control valves (manual handles) to make sure that the valves are not operating when no course corrections are made. If levers are moving / shaking, the gain parameter needs to be adjusted.</p> <p>2. Contact authorized MJP support for the correct parameter tuning.</p>
D. The relief valve is limiting the pressure instead of the load sensing system.	<p>1. See 3.3.20 <i>Hydraulic System, Adjust Working Pressure</i></p> <p>2. See 3.3.21 <i>Hydraulic System, Inspect Pressure Limit</i> and 3.3.22 <i>Hydraulic System, Adjust Pressure Limit</i></p>
E. Oil viscosity is too high.	<p>1. See 3.3.12 <i>Hydraulic System, Inspect Oil Quality</i></p> <p>2. Consider using oil with lower viscosity.</p>
F. Abnormal oil leakage in the hydraulic pump.	1. See 3.3.29 <i>Hydraulic Pump, Inspect</i> .

4.2 Alarms

4.2.1 Display Panel, Acknowledge the Alarms



GEN-2986-01

Figure 233

Task Summary

The task is to correct the alarms on display panel.

Prerequisites

Conditions

None

Number of personnel	Skill level	Maintenance facility level	Estimated time
1	Crew	On equipment / at sea	-

Procedure



Figure 234

When a system alarm is raised, the buzzer and the display panels will sound. If a command panel is specified, the alarm indicator will be blinking.

- 1 Tap the ALARMS button (A) to change to the alarm list.
- 2 Select the active alarm (B) and press the ACKNOWLEDGE SELECTED button (C) to let the system know that you have seen the alarm.

Note!

If you tap the ACKNOWLEDGE SELECTED button (C) without any alarm selected, the buzzer will be silenced. All alarms in the list will still be unacknowledged. If a new alarm is raised, the alarm buzzer will start sounding again.

- 3 Identify the alarm in the software alarms list and follow the "Operator Action" instruction details.

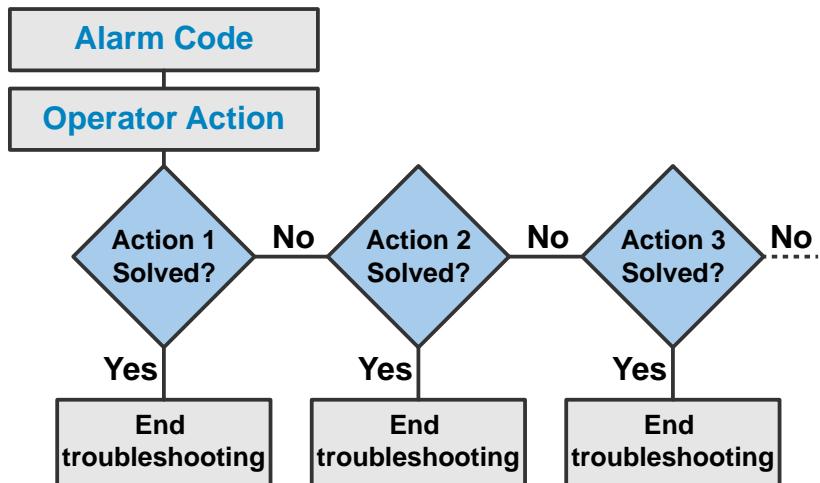
Note!

If an alarm is still active in the system, the ALARMS button (A) will indicate this by a steady red light.

- 4 Press the HOME button (D) to change the screen to home screen.
- 5 Task completed.

4.2.2 Alarm List

The action procedure is described in the flow chart.



GEN-0550-02

Figure 235

Display Alarms – DD

Alarm Code DD Port MCU	Alarm Code DD Stbd MCU	Alarm Description	Operator Action
Port Control System Fail to safe	Stbd Control System Fail to safe	The system has entered fail to safe mode.	<ol style="list-style-type: none"> 1 Return all the controls to neutral position, refer to alarm list for faults which need to be fixed. 2 Do a check of the calibration. 3 Do a check of the connected cable and the connectors. 4 Return to the harbour, switch to backup controls if present.
Port Controls not calibrated	Stbd Controls not calibrated	A control head has been detected which is not calibrated.	<ol style="list-style-type: none"> 1 Do a check of the calibration. 2 Return to the harbour, switch to backup controls if present.
Port Steering pots out of sync	Stbd Steering pots out of sync	A mismatch has occurred between the steering control head sensors.	<ol style="list-style-type: none"> 1 Do a check of the calibration. 2 Do a check of the connected cable and the connectors. 3 Return to the harbour, switch to backup controls if present.
Port Steering pots out of span	Stbd Steering pots out of span	A steering control head sensor has a fault.	<ol style="list-style-type: none"> 1 Do a check of the calibration. 2 Do a check of the connected cable and the connectors. 3 Return to the harbour, switch to backup controls if present.

Display Alarms – DD (cont'd.)

Alarm Code DD Port MCU	Alarm Code DD Stbd MCU	Alarm Description	Operator Action
Port Thrust lever out of span	Stbd Thrust lever out of span	A thrust controller sensor has a fault.	<ol style="list-style-type: none"> Do a check of the calibration. Do a check of the connected cable and the connectors. Return to the harbour, switch to backup controls if present.
Port VCS out of span	Stbd VCS out of span	A VCS control sensor has a fault.	<ol style="list-style-type: none"> The VCS function must not be used. Do a check of the calibration. Do a check of the connected cable and the connectors.
Port engine lost while clutched	Stbd engine lost while clutched	Engine Running signal for specified engine has been lost whilst clutched in.	<ol style="list-style-type: none"> Make sure that the engine is running. Do a check of the connected cable and the connectors. Return to the harbour, switch to backup controls if present.
Port RPM knob A out of span	Stbd RPM knob A out of span	A separate RPM dial has a fault.	<ol style="list-style-type: none"> Do a check of the calibration. Do a check of the connected cable and the connectors.
Port RPM knob B out of span	Stbd RPM knob B out of span	A separate RPM dial has a fault.	<ol style="list-style-type: none"> Do a check of the calibration. Do a check of the connected cable and the connectors.
Port Station out of sync	Stbd Station out of sync	Active station has been forced back to Main station because active station differed between the MCU's.	-
Port MCU - Stbd MCU communication fault	Stbd MCU - Port MCU communication fault	A communication fault has occurred between the MCU's.	<ol style="list-style-type: none"> Examine the cross link cable. Note: Separate mode only is available on the main controls. Return to the harbour, switch to backup controls if present.
Port MCU - Display communication fault	Stbd MCU - Display communication fault	A communication fault has occurred between the display and MCU.	Do a check of the Ethernet connections.
Port BCU - Port MCU communication fault	Stbd BCU - Stbd MCU communication fault	A communication fault has occurred between the display and MCU.	Do a check of the Ethernet connections.
Port Backup fault	Stbd Backup fault	The MCU does not receive Backup OK signal.	<ol style="list-style-type: none"> Do a check of the power supply to the Backup unit. Do a check of the connected cable and the connectors. Return to the harbour, switch to backup controls if present.

Display Alarms – DD (cont'd.)

Alarm Code DD Port MCU	Alarm Code DD Stbd MCU	Alarm Description	Operator Action
Port clutch feedback fault	Stbd clutch feedback fault	Confirm that the clutch is operational.	1. Do a check of the connected cable and the connectors. 2. Return to the harbour, switch to backup controls if present.
Port hydraulic oil level	Stbd hydraulic oil level	Hydraulic oil is outside the expected level.	1. Make sure the oil level in the level glass on the tank is OK: 2. Do a check of the connected cables and the connectors.
Port hydraulic oil tempera- ture	Stbd hydraulic oil tempera- ture	Hydraulic oil is above the expected temperature.	1. Check the oil temperature on the tank. If it is OK: 2. Do a check of the connected cables and the connectors.
Port hydraulic oil pressure	Stbd hydraulic oil pressure	Hydraulic oil is below the expected pressure.	1. Make sure the oil pressure on the tank is OK: 2. Do a check of the connected cables and the connectors.
Port analogue sensor fault	Stbd analogue sensor fault	A fault has occurred with the analogue sensors on the tank.	1. Do a check of the calibration. 2. Do a check of the connected cable and the connectors.
Port waterjet bucket not at setpoint	Stbd waterjet bucket not at setpoint	The reversing bucket is not in its expected position.	1. Make sure that the bucket operates correctly with the backup system, if so it indicates a fault with the PWM drive circuit. 2. Do a check of the calibration. 3. Do a check of the connected cable and the connectors. 4. Return to the harbour, switch to backup controls if present.
Port waterjet bucket out of span	Stbd waterjet bucket out of span	The reversing bucket feedback sensor is not operational.	1. Do a check of the calibration. 2. Do a check of the connected cable and the connectors. 3. Return to the harbour, switch to backup controls if present.
Port waterjet nozzle not at setpoint	Stbd waterjet nozzle not at setpoint	The steering nozzle is not in its expected position.	1. Make sure that the bucket operates correctly with the backup system, if so it indicates a fault with the PWM drive circuit. 2. Do a check of the calibration. 3. Do a check of the connected cable and the connectors. 4. Return to the harbour, switch to backup controls if present.
Port waterjet	Stbd waterjet	The steering nozzle feedback sensor is not operational.	1. Do a check of the calibration. 2. Do a check of the connected cable and the connectors.

Display Alarms – DD (cont'd.)

Alarm Code DD Port MCU	Alarm Code DD Stbd MCU	Alarm Description	Operator Action
nozzle out of span	nozzle out of span		3 Return to the harbour, switch to backup controls if present.
Port DP system lost	Stbd DP system lost	The control system has lost communication with the DP system.	1. Start the DP system again. 2. Do a check of the connected cable and the connectors.
Port DP no acknowl- edgement	Stbd DP no acknowl- edgement	The control system has not received acknowledgement from the DP system.	Do a check of the connected cable and the connectors.
Port DP signal invalid	Stbd DP signal invalid	A DP signal from the control system is invalid.	Do a check of the connected cable and the connectors.
Port DP Autopilot communi- cation fault	Stbd DP Autopilot communi- cation fault	The control system has lost communication with the DP system (in AP mode).	1. Start the DP system again. 2. Do a check of the connected cable and the connectors.
Port DP Autopilot no acknowl- edgement	Stbd DP Autopilot no acknowl- edgement	The control system has not received acknowledgement from the DP system (in AP mode).	Do a check of the connected cable and the connectors.
Port Configura- tion file fault	Stbd Configura- tion file fault	Unable to load configuration.	1. Contact authorized MJP support. 2. Return to the harbour, switch to backup controls if present.
Port feedback fault	Stbd feedback fault	A feedback sensor of nozzle or bucket is not operational.	1. Do a check of the connected cable and the connectors. 2. Return to the harbour, switch to backup controls if present.
Display - Port MCU communi- cation fault	Display - Stbd MCU communi- cation fault	The display has lost its connection to the MCU.	1. Do a check of the connected cable and the connectors. 2. Return to the harbour, switch to backup controls if present.

Ship Monitoring System Alarms – DD

Location	Alarms	Alarm Description	Operator Action
All MCU and Backup Units	Primary Power Fault	A fault has occurred with the primary supply to the unit.	<ol style="list-style-type: none"> 1. Make sure that the power supply is present. If multiple units are affected it is most likely an external problem. 2. If a single unit is affected, make sure that both positive and negative fuses are OK and that the power supply unit has a green light.
All MCU and Backup Units	Secondary Power Fault	A fault has occurred with the secondary supply to the unit.	<ol style="list-style-type: none"> 1. Make sure that the power supply is present. If multiple units are affected it is most likely an external problem. 2. If a single unit is affected, make sure that both positive and negative fuses are OK and that the power supply unit has a green light.
All MCU and Backup Units	System OK	Confirm primary or secondary power is present at the unit.	Make sure that the PLC is set to run load and 'RUN' status light on the PLC is green.

5 Appendix

5.1 Paint Program



Caution!

Copper and other metallic based anti-fouling paint must NOT be used. This is due to the risk of galvanic corrosion.

5.1.1 General

The Waterjets shall be painted with Anti Fouling paint at the same interval as the hull.

The waterjet unit is painted with epoxy-based paint at delivery, and it is important to make sure that the epoxy - based paint is intact prior to applying the Anti Fouling paint during service.

- 1 The first, second, third, and forth coats are painted by Marine Jet Power and are epoxy-based.
- 2 The fifth and sixth coats are painted by the shipyard personnel when the vessel is outfitted. Marine Jet Power recommends that the fifth layer of primer is added for sufficient adhesion of the anti-fouling paint.

Layer	PPG	Paint type	Color/Shade	Thickness	Painted by
First	PR143	Epoxy-based paint	Grey	20	Marine Jet Power personnel (before delivery)
Second	EC75	Epoxy-based paint	Grey/Black	25/35	Marine Jet Power personnel (before delivery)
Third	EC75	Epoxy-based paint	Grey/Black	25/35	Marine Jet Power personnel (before delivery)
Fourth	EC75	Epoxy-based paint	Grey/Black	25/35	Marine Jet Power personnel (before delivery)
Fifth		Anti-fouling paint primer			Shipyard personnel
Sixth		Anti-fouling paint			Shipyard personnel

5.1.2 Touch Up Paint or Repaint

For best results, remove all of the old coatings. If that is not possible, remove all of the loose paint.

5.2 Torque



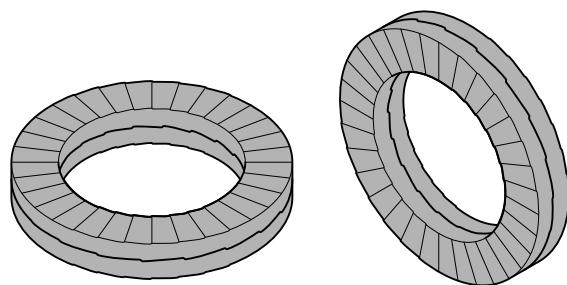
Caution!

All bolted connections are critical in an MJP waterjet. It is important to have lock washers correctly mounted and they have to be in good condition.

5.2.1 Screws and washers

The material used in screws is A4-80 or A4-100. The anti-seizing lubrication Molybdendisulphide (MoS_2) must be used for all bolts from Marine Jet Power.

Most screw joints are secured with nordlock washers. These washers may be re-tightened 5 times before they need to be replaced.



GEN-0903-01

Figure 236

5.2.2 Specifications for Screws with Nordlock Washer



GEN-3043-01

Figure 237

Dimension	Normal A4–80, M _v (Nm)	Impeller screws A4/100, M _v (Nm)
M4	2.4	3.7
M5	4.8	7.3
M6	8.3	12.5
M8	20	30
M10	38	59
M12	67	102
M14	107	161
M16	164	251
M18	229	347
M20	321	489
M22	445	654
M24	553	842
M27	805	1235
M30	1093	1682
M33	1474	2289
M36	1902	2931
M39	2452	3776

5.2.3 Specifications for Screws with Plain Washer

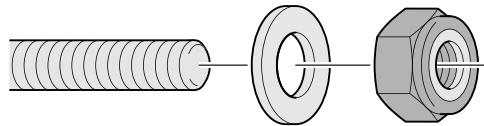


GEN-3044-01

Figure 238

Dimension	Normal A4-70, Mv(Nm)	Normal A4-80, Mv(Nm)
M4	2.1	2.7
M5	4,1	5,4
M6	7,0	9,3
M8	17	22
M10	33	44
M12	57	76
M14	91	121
M16	140	187
M18	195	261
M20	273	364
M24	472	629
M27	682	909
M30	930	1240
M36	1620	2160

5.2.4 Specifications for Lock Nuts



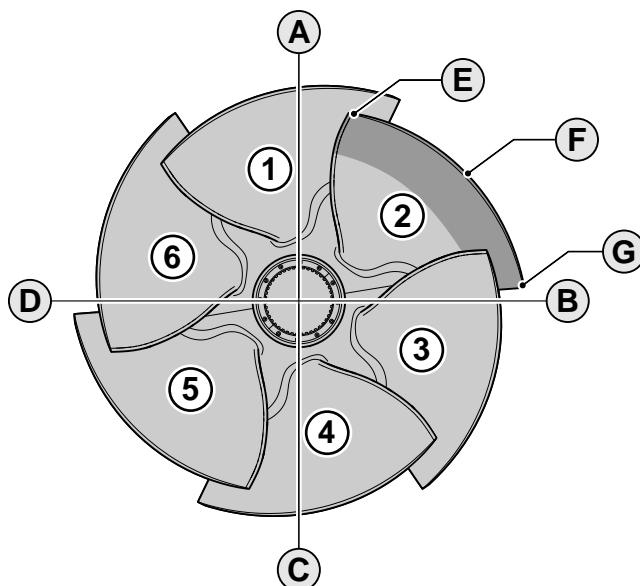
GEN-3045-01

Figure 239

Dimension	Normal A4-70, M _v (Nm)
M5	4 - 4.6
M6	7 - 8
M8	17 - 19
M10	31 - 34
M12	60 - 65
M16	110 - 120
M20	203 - 224

5.3 Impeller Clearance Protocol

Date	MJP project	Waterjet ID	Written by



GEN-1296-01

Blade 1 (mm)	Leading edge (E)	Middle (F)	Trailing edge (G)
TOP (A):			
RIGHT (B):			
BOTTOM (C):			
LEFT (D):			

Blade 2 (mm)	Leading edge (E)	Middle (F)	Trailing edge (G)
TOP (A):			
RIGHT (B):			
BOTTOM (C):			
LEFT (D):			

Blade 3 (mm)	Leading edge (E)	Middle (F)	Trailing edge (G)
TOP (A):			
RIGHT (B):			
BOTTOM (C):			
LEFT (D):			

Blade 4 (mm)	Leading edge (E)	Middle (F)	Trailing edge (G)
TOP (A):			
RIGHT (B):			
BOTTOM (C):			
LEFT (D):			

Blade 5 (mm)	Leading edge (E)	Middle (F)	Trailing edge (G)
TOP (A):			
RIGHT (B):			
BOTTOM (C):			
LEFT (D):			

Blade 6 (mm)	Leading edge (E)	Middle (F)	Trailing edge (G)
TOP (A):			
RIGHT (B):			
BOTTOM (C):			
LEFT (D):			

5.4 Oil Contamination Limits

Cleanliness levels are defined by three numbers separated by slashes (/). These numbers correspond to 4, 6 and 14 micron, in that order. Each number refers to an ISO range code, which is determined by the number of particles for that size (4, 6 & 14μm) and larger, present in 1 ml of fluid. The oil contamination limits are valid for both hydraulic and lubrication systems. Refer to the "Particles / ml" column in the chart below to see the actual particle ranges.

Cleanliness requirements for both hydraulic and lubricating oil for Marine Jet Power are according to ISO 4406 with the number of particles as 22/18/13.

Particles / ml	4μm	6μm	14μm	ISO code
2,500,000 to 1,300,000				28
1,300,000 to 640,000				27
640,000 to 320,000				26
320,000 to 160,000				25
160,000 to 80,000				24
80,000 to 40,000				23
40,000 to 20,000	22			22
20,000 to 10,000				21
10,000 to 5,000				20
5,000 to 2,500				19
2,500 to 1,300		18		18
1,300 to 640				17
640 to 320				16
320 to 160				15
160 to 80				14
80 to 40			13	13
40 to 20				12
20 to 10				11
10 to 5				10
5 to 2.5				9
2.5 to 1.3				8
1.3 to 0.64				7
0.64 to 0.32				6
0.32 to 0.16				5
0.16 to 0.08				4
0.08 to 0.04				3
0.04 to 0.02				2
0.02 to 0.01				1
0.01 to 0.00				0

Example of ISO code generation

Larger than 4 µm = 22340 pieces	
Larger than 6 µm = 1950 pieces	Generates ISO Code = 22/18/13
Larger than 14 µm = 43 pieces	

5.4.1 Water Content per DIN ISO 3733

In a new fluid, the water content must be out of the quantitative detectable range. Unless otherwise specified in individual fluid standards, the water content for continuous operation must not exceed 1% (1 g / kg). The lower, the better. In principle, water is a harmful contaminant, reducing the life of the hydraulic fluid and the mechanical components. Water in a system may result in corrosion, cavitation and altered fluid viscosity. Depending on the fluid, water may also react with the fluid to create harmful chemical by-products or destroy important additives. Left unchecked, water contamination may result in microbial growth. At this stage, system components may already have been damaged.

**Caution!**

If the water content value is above 1%, locate the water infusion source and repair it before a oil change is completed. This will help to prevent damage to the equipment.

Hydraulic

Replace the hydraulic cylinder seals	
Inspect cylinders and hoses	
Replace the air filter	

Mechanics

Inspect the pump unit	
-----------------------	--

5.5 Weld Specifications

Make sure to contact MJP before any welding of the Waterjet is performed, to sort out why it is necessary.



Warning!

Welding can destroy electronic components. Before performing welding on the vessel, make sure that all earth cables and control system cables are removed from the control system cabinets. Damage due to inappropriate handling is not covered by the warranty.

Welding procedure

Welds	To be full penetration and conform to Classification Society rules for Aluminium vessels (Welding in Hull construction). The responsibility for WPS and WPQR to be developed lies with the customer or the contracted company which performs the welding. Classification Society to be informed of WPS. Material ID of MJP goods are stamped in castings, if not available contact Marine Jet Power.		
Welder qualifications	Properly qualified welder with Classification Society welder qualification or equivalent.		
Inspection	Inspection to be done by a qualified welding inspector.		
Site	The site must be: a) Dry and free from steel grinding dust or other contaminants that could affect the finished weld condition. b) Sheltered from draughts to prevent disturbance to shielding gas.		
Welding process	M.I.G or T.I.G		
Welding filler wire	Material of Jet component:	Filler material:	Hull material:
	42100 (4000-series)	5183 / 5356	5000-series
	44100/44200(4000-series)	5183 / 5356	5000-series
	42100 (4000-series)	4043	6000-series
	44100/44200 (4000-series)	4043	6000-series
Shield gas	Pure Argon or an Argon / Helium mix. Preferred option is Argon / Helium mix.		
Weld position	Flat down-hand is preferred. If not possible, the use of a backing strip will be necessary. Weld down-hand from one side only, then grind off the backing strip.		

5.6 Fluids and Lubricants

5.6.1 Hazardous Substances

Marine Jet Power have used fluids and lubricants that are free from asbestos, polychlorinated biphenyls, ozone depleting substances and organotin compounds. The fluids and lubricants may however contain hazardous ingredients that will cause personal injury and affect the environment. Read the material safety data sheets to find information of the products and contact the manufacturer for more information.

5.6.2 Assembly Adhesives, Sealants and Lubricants

Specifications for the adhesives, sealants and lubricants used by MJP

Product	Source of supply	Essential Characteristics	Use
Molykote® DX paste	DuPont	High viscosity, paste, off-white, excellent corrosion prevention, thermally stable up to 125 °C.	For assembly and running in of metallic components. Used for bolts.
Molykote® 111 Compound	DuPont	High viscosity, grease, translucent white, flash point 101 °C.	O-ring, valve and seal lubrication.
Ethyl cyanoacrylate adhesive	Loctite® 495 or equivalent	Low viscosity, colourless, instant adhesive.	Offers fast bonding on a wide range of materials.
Silicon grease	Greasil 4000 or equivalent	Water repellent, non-melting silicone grease lubricant, nontoxic, environmental user friendly.	O-ring, valve and seal lubrication.
Polyurethane marine sealant	Sikaflex 291 or equivalent	Noncorrosive, odourless, good grip, several colours, can be painted.	Flexible, vibration-resistant, waterproof seals.
2 component epoxy resin	Chockfast orange or equivalent	Low viscosity, heat resistant up to 90 °C, very low shrinkage, resistant to corrosion, oils, fuels and many chemicals.	Alignment of equipment or surfaces 12-100 mm.

5.6.3 Oil Specifications

Hydraulic oil

The oil specification for the hydraulic system

Oil quality	ISO VG 32 or ISO VG 22 for colder climates. Oil with good corrosion protective properties must be used.
Oil viscosity	Maximum. 300 centiStoke, Minimum 12 centiStoke
Maximum cold start viscosity	460 centiStoke
Minimum oil temperature in tank	is governed by the oil quality and viscosities above
Maximum oil temperature in tank	+70 °C
Recommended tank temperature	+40 to +60 °C

Lubrication oil

The oil specification for the bearing unit

Oil quality

Gear and bearing oil (Synthetic), ISO VG 68 HC.

5.6.4 Grease Specifications

DIN 51825 German Grease Classification System

Type of grease lubricant and lubricating material	Consistency index	Upper operating temperature	Lower service temperature
---	-------------------	-----------------------------	---------------------------

Type of Grease Lubricant and Lubricating Material

Code letter Explanation

K	K grease lubricants are high-viscosity lubricants made of mineral oil and/or synthetic oil plus a thickening agent. The addition of active ingredients and/or solid lubricants is permitted.
KP	K grease lubricants with active ingredients for reducing friction and wear in the mixed friction zone and/or for increasing load capacity are identified with the additional code letter P (KP grease lubricants). They are used, for example, to lubricate anti friction bearings whose dynamic equivalent load P exceeds one tenth of the dynamic load capacity C (see the information published by the manufacturer of the anti friction bearings).
KF	K grease lubricants with solid lubricating additives are identified with the additional code letter F.
KPF	K grease lubricants containing active ingredients and solid lubricating additives are identified by the two additional code letters P and F.

Consistency Index

NLGI-class

Worked penetration according to DIN ISO 2137

000	44,5 mm to 47,5 mm
00	40,0 mm to 43,0 mm
0	35,5 mm to 38,5 mm
1	31,0 mm to 34,0 mm
2	26,5 mm to 29,5 mm
3	22,0 mm to 25,0 mm
4	17,5 mm to 20,5 mm
5	13,0 mm to 16,0 mm
6	8,5 mm to 11,5 mm

Upper Operating Temperature

Code letter	Upper operating temp.	Reaction to water
C	+ 60 °C	0-40 or 1-40
D	+ 60 °C	2-40 or 3-40
E	+ 80 °C	0-40 or 1-40
F	+ 80 °C	2-40 or 3-40
G	+ 100 °C	0-90 or 1-90
H	+ 100 °C	2-90 or 3-90
K	+ 120 °C	0-90 or 1-90
M	+ 120 °C	2-90 or 3-90
N	+ 140 °C	by agreement
P	+ 160 °C	by agreement
R	+ 180 °C	by agreement
S	+ 200 °C	by agreement
T	+ 220 °C	by agreement
U	over + 220 °C	by agreement

Lower Service Temperature

Code number	Lower service temp.
-10	-10 °C
-20	-20 °C
-30	-30 °C
-40	-40 °C
-50	-50 °C
-60	-60 °C

5.7 Equipment Disposal

Dispose the components in accordance to Marine Jet Powers recommendations:

Specifications for disposal of the components.

Item	Expected life	Disposal	Logistic
Water jet unit, cast and machined parts	Life of vessel	Recycle	Send back to MJP
Bolts, nuts and washers	Life of vessel or changed when unit is serviced	Recycle	Transport to metal recycling central
Bushings	Approximately 4 years or 4 000 operating hours depending on operating water conditions	Recycle	Transport to metal recycling central
Bearings	Approximately 8 000 hours ("L10") possible life of vessel depending on oil condition	Recycle	Transport to metal recycling central
O-rings	Changed at service of jet unit	Burn	Transport to recycling central
Water jet unit and mechanical seal	5years or 8 000 operating hours	Recycle	Transport to recycling central
Water jet unit, mechanical seal and seal element	N/A	Recycle	Transport to recycling central
Water jet unit, mechanical seal and metal parts	N/A	Recycle	Transport to recycling central
Drive shaft and drive shaft couplings with bolts, washers and nuts	Life of vessel	Recycle	Transport to metal recycling central
Shaft system with couplings and seals	Life of vessel	Recycle	Transport to metal recycling central
Hydraulic and lubrication oils	Change every second year or based on oil test sample	Recycle	Transport to recycling central
Hydraulic filters	Change yearly or when the indicator is red	Recycle	Transport to recycling central
Hydraulic tank unit	Life of vessel	Scrap. Remove metal parts and recycle	Transport to scrapping facility
Hydraulic hoses	Change every 5th year	Scrap. Remove metal parts and recycle	Transport to scrapping facility
Hydraulic cylinders	Life of vessel, depending on operating conditions, oil and water quality	Recycle	Send back to MJP

Specifications for disposal of the components. (cont'd.)

Item	Expected life	Disposal	Logistic
Hydraulic cylinder seal kits	Change every second year or 2 000 operating hours	Landfill	Transport to recycling central
Feedback sensors and built-in hydraulic cylinders	When malfunctioning	Electronic disposal	Transport to recycling central
Control system, complete system and or components of the system (for example control heads, panels, indicators and PLC components).	When malfunctioning or obsolete	Electronic disposal. Separate metal parts and recycle	Send back to MJP
Cables	Life of vessel	Electronic disposal. Separate metal parts and recycle	Transport to recycling central

DRAFT

MARINE JET POWER
Hansellisgatan 6
754 50 Uppsala
SWEDEN
+46 (0) 10 165 10 00

SOUTH KOREA
Gamcheonhang-ro 165-4, Saha-gu
49454 Busan
KOREA
+82 (51) 746 6428

AMERICAS
6740 Commerce Ct. Drive
Blacklick, OH 43004
USA
+1 614-759-9000