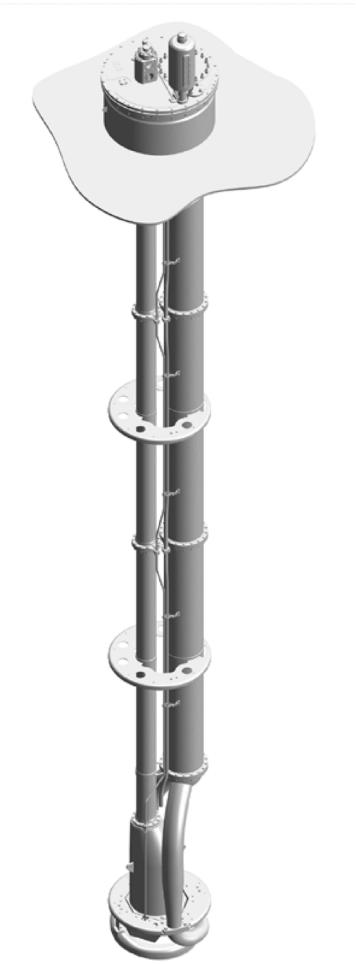
Framo
Cargo Pumps

No.1000-0294-4
Rev. A 03Apr19

Operation manual



Cargo pumps for FPSO/FSO/FLNG installations

SD100
SD125
SD150
SD200
SD250
SD300
SD350

Original Instruction

CONTENTS

Ref. to associated instructions:
1000-0109-4: Interchange of pump control valve (STC)
1375-0027-4/0107-4: Service manual for Speed Torque Controller (STC)

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1 GENERAL DESCRIPTION

1.1 Top plate

The cargo pump is supported by a deck trunk welded to the deck. All connections are at the top plate, to which the pump control valve STC (Speed Torque Controller) is also mounted. This control valve for remote and local operation of the cargo pump regulates the inlet pressure to the hydraulic motor. Thereby the pump speed can be regulated step less from 0 – to max. speed.

1.2 Pipe stack

The pipe stack connects the pump head to the top plate by a cargo pipe and a hydraulic section.

1.3 Pump head

The pump head is welded or flanged to the pipe stack/casing and supported by the bottom support. The hydraulic motor is connected to a single stage impeller by a short rigid shaft supported by bearings. Motor, shaft and bearings are continuously lubricated by the hydraulic oil.

The hydraulic section is surrounded by a cofferdam that completely segregates the hydraulic oil from the cargo. The cofferdam is either filled with liquid or dry. Condition monitoring of the seal arrangement by inspection the cofferdam, see chaper 2.5, "Cofferdam control".
The seal arrangement consists of a mechanical oil seal, single cofferdam lip seal and a cargo seal. The cargo seal is exposed only to static head from the cargo.

Wear rings are fitted between the impeller and the volute casing.

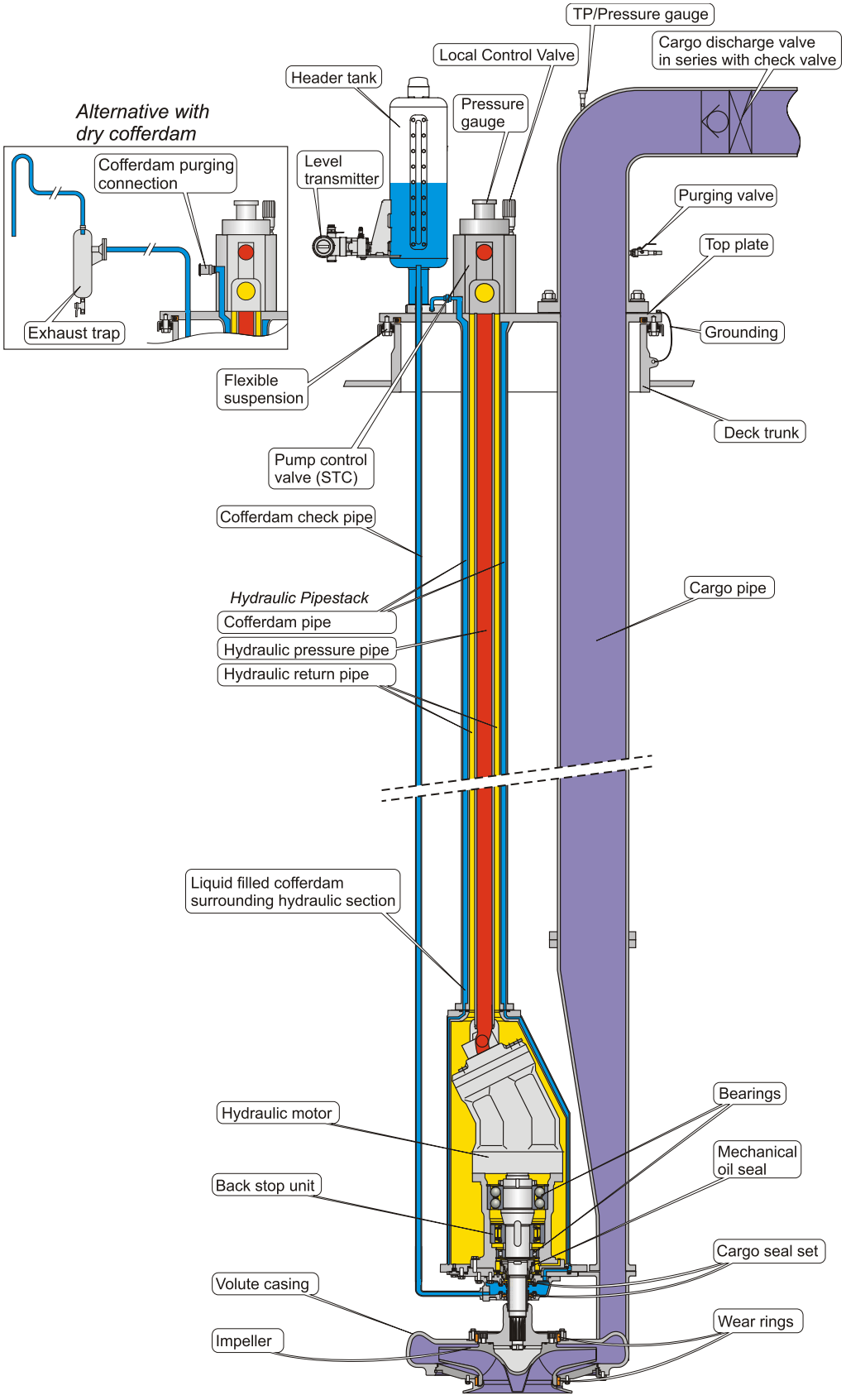

TP/Pressure gauge
Cargo discharge valve in series with check valve
Local Control Valve
Header tank
Pressure gauge
Alternative with dry cofferdam
Cofferdam purging connection
Level transmitter
Purging valve
Top plate
Exhaust trap
Grounding
Flexible suspension
Deck trunk
Pump control valve (STC)
Cofferdam check pipe
Hydraulic Pipestack
Cofferdam pipe
Hydraulic pressure pipe
Hydraulic return pipe
Cargo pipe
Liquid filled cofferdam surrounding hydraulic section
Bearings
Hydraulic motor
Mechanical oil seal
Back stop unit
Cargo seal set
Volute casing
Wear rings
Impeller

Fig. 1

2 OPERATING INFORMATION

Framo philosophy is to use the built-in flexibility of the hydraulic system with step less regulation of the Framo cargo pumps rather than throttling on discharge valves / valves on metering station.
The offloading rate should be controlled by the hydraulic system pressure or the hydraulic motor pressure for the pump.
The offloading rate or the discharge pressure should be used as control parameter for the system pressure. This will assure an optimal and simple operation.
For offloading system with booster pumps we recommend to control the booster pump suction feed pressure by the hydraulic system pressure.

To get maximum lifetime of the pumps, operate the pumps within the operation range,
see Framo Service Manual, Chapter 3, Technical Data.

Avoid running pumps against closed cargo valves with high discharge pressure for a longer period than 2 minutes.

Running the pump outside recommended limits will release "Out of operation range" alarm after 60 seconds time delay.

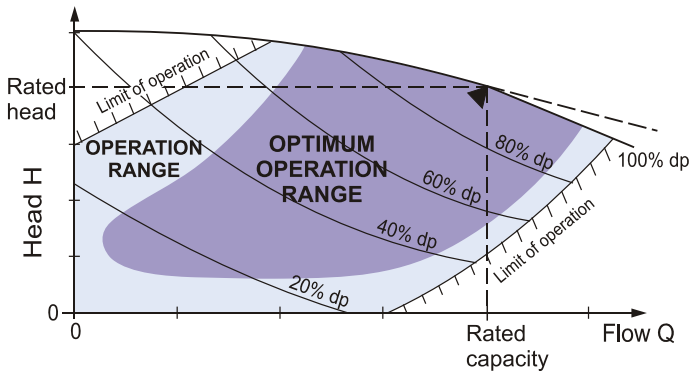


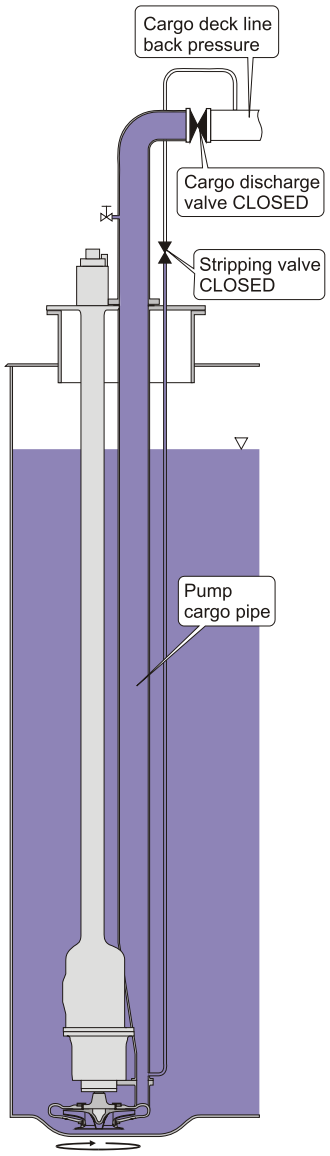
Fig. 2

2.1 Definition of operation modes

Closed cargo discharge valve

(Dead heading)

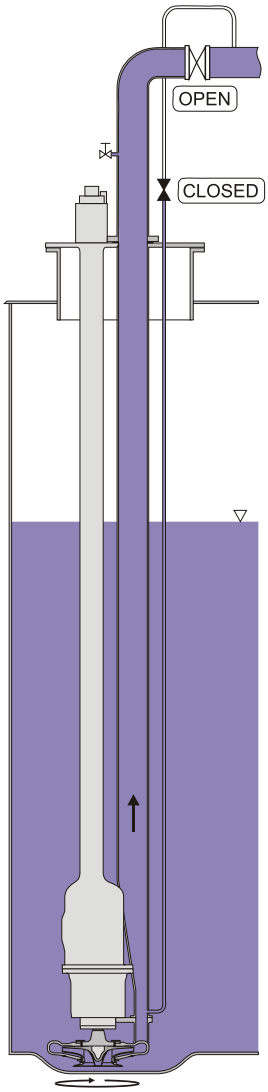
⚠ CAUTION!
Limit time.
Running the pump against close discharge valve for a longer period can damage the pump.



Rotating parts submerged

Pumping/Discharging

(Normal operation)



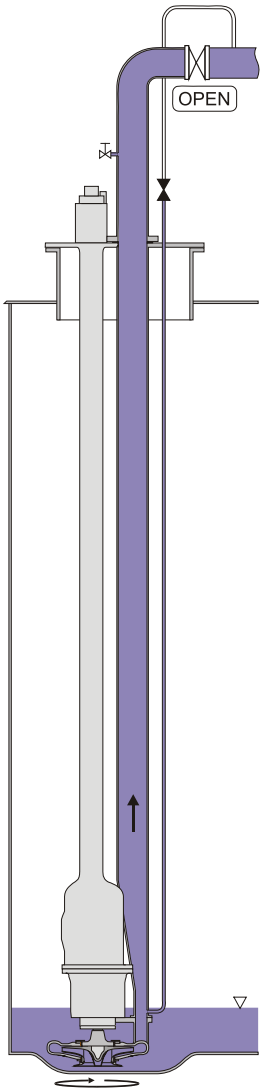
Rotating parts submerged

Draining

(Reduced hydraulic motor pressure)

⚠ CAUTION!
Follow the pump operation closely to avoid loss of suction.
Monitor tank level closely.

⚠ CAUTION!
When the tank is close to empty, operate locally.
If any abnormal noise or vibration are noticed, stop the pump.



Rotating parts submerged

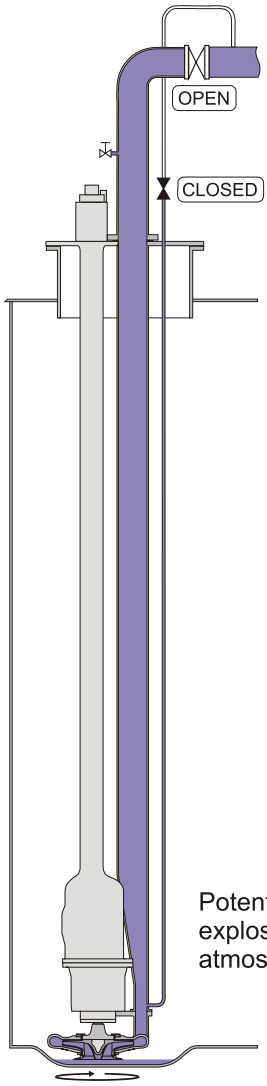
Tank empty

(Close cargo discharge valve and stop the pump)

⚠ CAUTION!
Limit time.
Recirculation of cargo can build up heat.

⚠ CAUTION!
Stop the pump when the tank is empty.

⚠ CAUTION!
Operate locally. If any abnormal noise or vibrations are indicated, stop the pump.



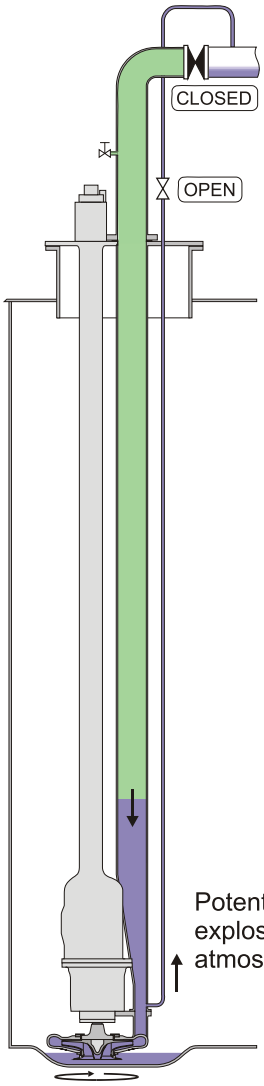
Stripping

(Reduced hydraulic motor pressure)

⚠ CAUTION!
Limit time.
Recirculation of cargo can build up heat.

⚠ CAUTION!

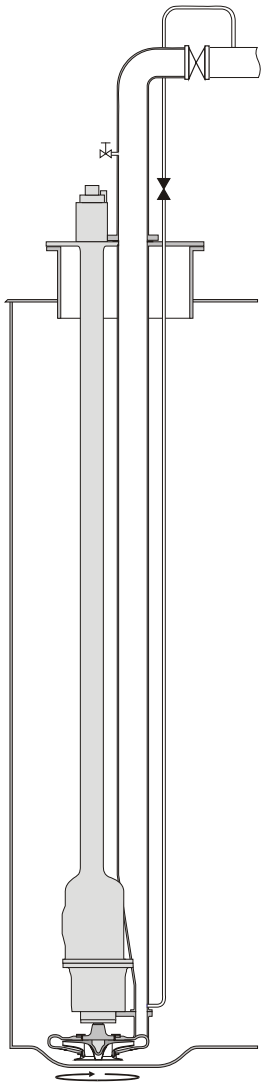
Operate locally. If any abnormal noise or vibrations are indicated, stop the pump.



Dry running

(Not allowed, not an operating mode)

⚠ CAUTION!
Never operate the pump in an empty tank.



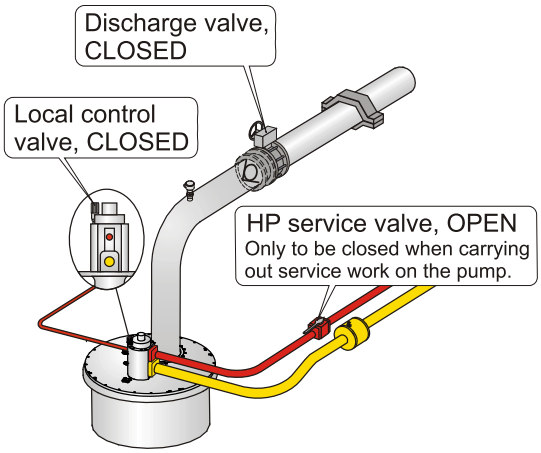
Rotating parts inside volute casing dry

2.2 Normal operation

2.2.1 Operation of single pump

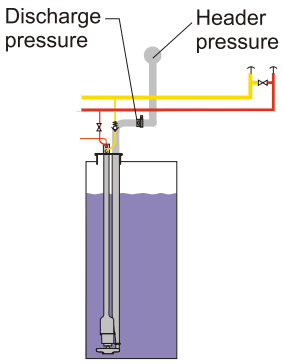
Check that the hydraulic system is started and sufficient quantity of power packs are running.

1) Local control valve and discharge valve must be in closed position.

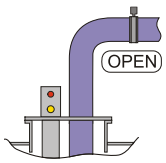


2) Start the pump and let it run with hydraulic motor pressure at approx 50 bar for 2 minute.
The command is automatically limited to 35 bar for 1 minute, to avoid liquid hammering.

3) Gradually increase hydraulic motor pressure until the pump discharge pressure is above main header pressure.



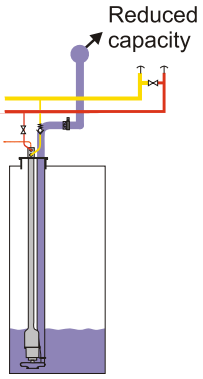
4) Open discharge valve.



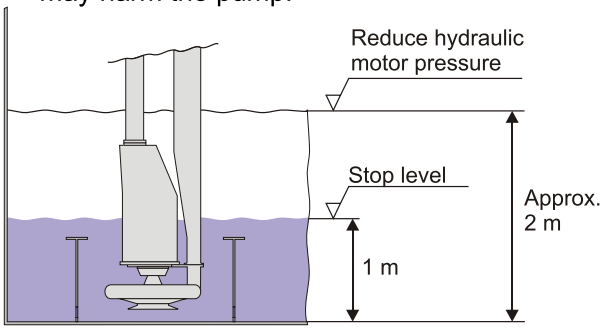
5) Increase hydraulic motor pressure until required header pressure or target flow rate is achieved.

Note!
The system pressure can be automatically regulated in the control system (typically to 15-25 bar above the highest motor pressure of the consumer).

6) <u>End of discharging</u>
When the tank is close to empty reduce pumping capacity to avoid loss of suction.



7) <u>Stop of pump at low level</u>
Pump to be stopped at a level above stiffeners (if any), and minimum 1 meter. This to prevent loss of suction, which in long term may harm the pump.



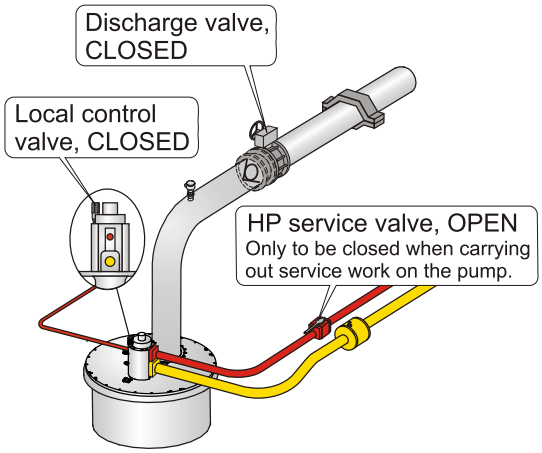
CAUTION

Running of pump below stop level must be considered as a special operation, ref. Chapter 2.3, Draining/Stripping.

2.2.2 Offloading / Parallel pumping

As an example, 5 pumps running in parallel.

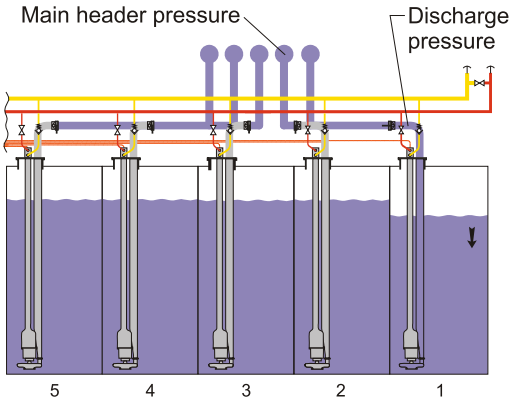
1) Local control valve and pump discharge valve must be in closed position.
All other valves in the discharge system(s), including booster pump(s) by-pass valve(s) to be open.



2) Start the hydraulic system with minimum system pressure (70 bar).

3) Start the first pump and set the pump hydraulic motor pressure to 50 bar for 2 minutes. Ref. fig. 13 pos. A.
(The command is automatically limited to 35 bar for 1 minute, to avoid cargo liquid hammering.)

4) Open the pump discharge valve and fill/vent. the discharge/offloading line.
Ref. fig. 13 pos. B.

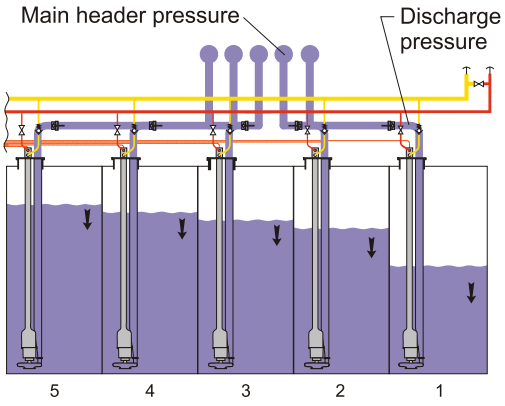


5) Start the next pumps, one by one, following the same procedure. Ensure that enough hydraulic power is available for the pumps to be run in parallel. Ref. fig.13 pos. C→F

6) Raise the pumps hydraulic motor pressure command to maximum.

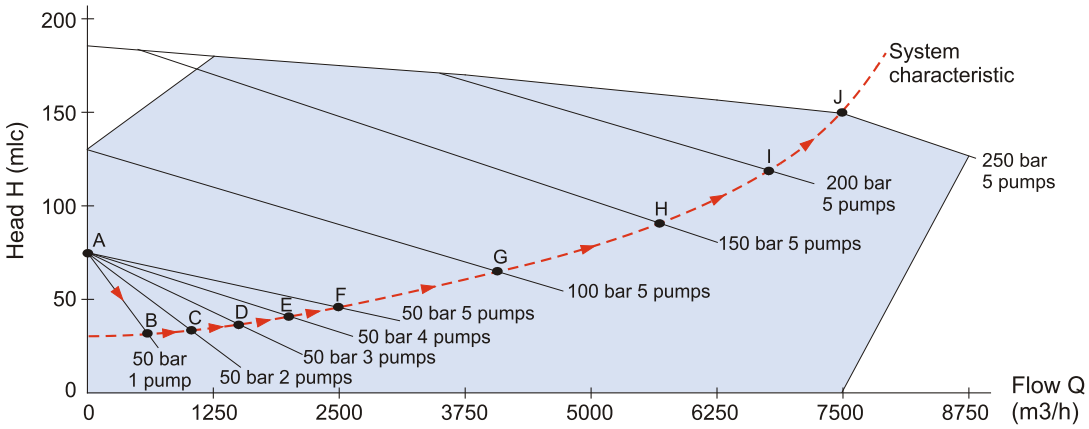
7) Gradually increase the hydraulic system pressure (and thereby pump speed) until required discharge pressure or rate is achieved. Ref. fig. 13 pos. G→J

Pump capacity to be controlled by the pump hydraulic motor pressure, not by throttling the pump discharge valve or any other valve in the discharge line / offloading line.
Keep the pump hydraulic motor pressure commands of all cargo pumps in maximum position. Regulate the main hydraulic system pressure until required discharge pressure or rate is achieved. If necessary, the cargo pump capacity can be individually adjusted by the pump hydraulic motor pressure command.



8) When the tank is close to empty reduce pumping capacity to avoid loss of suction.

A) Closed valve - 50 bar
B) Open cargo discharge valve - 50 bar
C) Open cargo discharge valve - 2 pumps
D) Open cargo discharge valve - 3 pumps
E) Open cargo discharge valve - 4 pumps
F) Open cargo discharge valve - 5 pumps
G) 5 pumps at 100 bar
H) 5 pumps at 150 bar
I) 5 pumps at 200 bar
J) 5 pumps at 250 bar



Typical capacity/head diagram, 5 x SD 350

Fig. 13

9) Stop of pump at low level

The pump speed to be reduced at a cargo level of approx. 2 meter. To be verified during operation at site.
Pump to be stopped at a level above stiffeners (if any), and minimum 1 meter. This to prevent loss of suction, which in long term may harm the pump.

CAUTION

Running of pump below stop level must be considered as a special operation, ref. Chapter 2.3, Draining/Stripping.

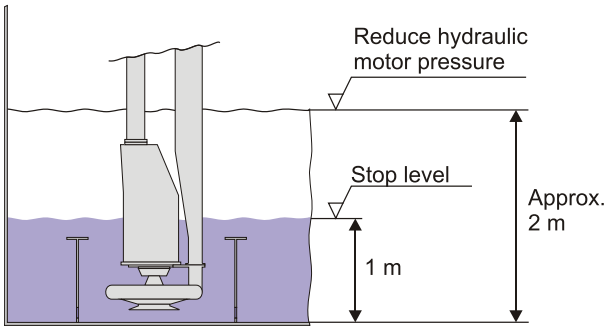


Fig. 14

Start of new pump during offloading

10) The local control valve and discharge valve for cargo pump to be closed.

11) Start the cargo pump and set the pump hydraulic motor pressure to 50 bar for 2 minutes.

12) Increase the hydraulic motor pressure until the discharge pressure is above main header pressure.

13) Open pump discharge valve. Raise the pump hydraulic motor pressure command to maximum.
If necessary, adjust the hydraulic system pressure or balance the pump command.

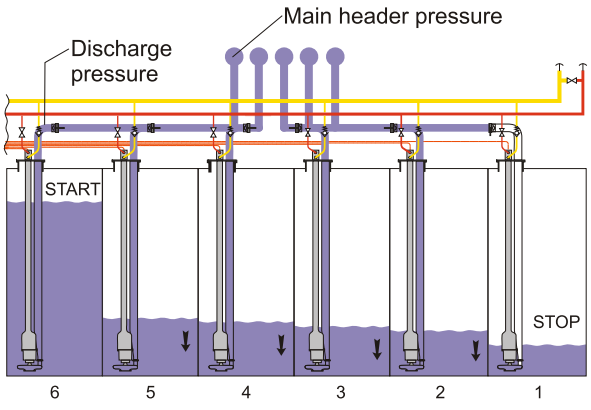


Fig. 15

Start of booster pumps (if any)

14) Follow the procedure “Start of pumps and discharge” until required suction feed pressure (i.e. discharge pressure at booster pumps inlet) is achieved, with discharge through open booster pump by-pass valve(s).

15) Start first booster pump according to operating instruction for the booster pumps.
The hydraulic system pressure to be adjusted to maintain required feed pressure.

16) Booster pump by-pass valve(s) to stay open until booster pump discharge pressure is above required feed pressure.

17) Start the next booster pumps, one by one, following the same procedure.

18) Increase speed of the booster pumps until required booster rate is achieved. Adjust the hydraulic system pressure to maintain required feed pressure.

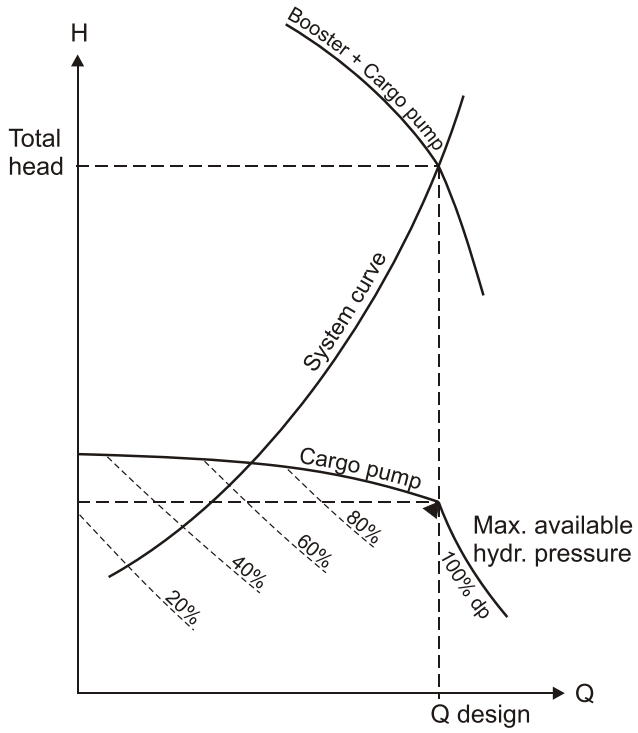


Fig. 16

Stop of booster pumps

19) Reduce speed of booster pumps and stop one by one according to operating information for the booster pumps.

20) Open the booster pump by-pass valve(s) when the booster pumps discharge pressure is equal to required feed pressure.

2.2.3 Transferring from tank to tank

When transferring, the differential height may be very low or even negative. In this case, there will be a risk of high vibrations that may cause damage to the pump. To avoid this, the pump discharge valve must be throttled. Run pump with reduced hydraulic pressure and a minimum “head H” of 20% (25-30 mlc). The pumps capacity must not exceed 100%.

Head H = Hm + U + Hs (mlc)

Loading to be done through separate drop line, not through the pump

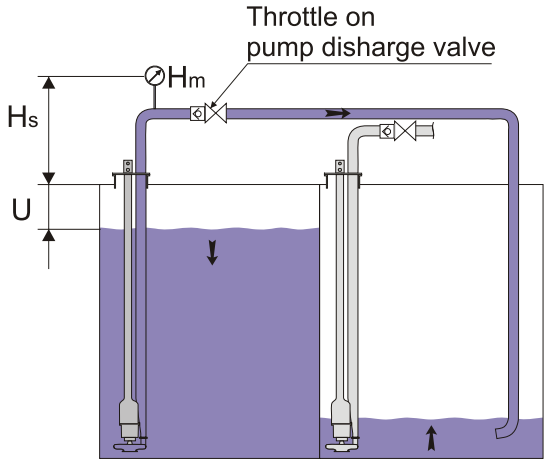
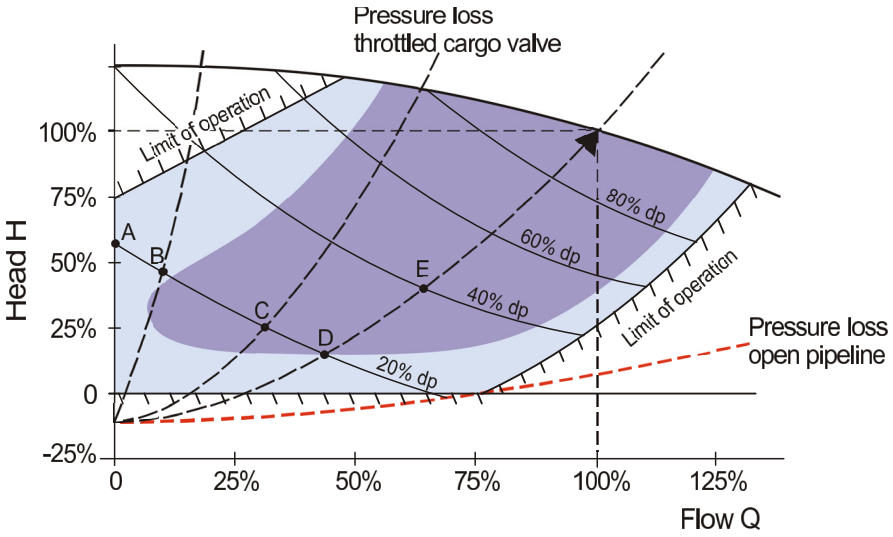


Fig. 17



A)	Closed valve	- 20% motor pressure
B, C and D)	Partly open cargo valve	- 20% motor pressure
E)	Partly open cargo valve	- 40% motor pressure

Fig. 18

2.3 Draining and stripping

CAUTION!

Draining and stripping is to be considered as a special operation, which requires safety measures and work permit.
Running of pump below the auto stop liquid level will require a stripping mode operation. During this operation the auto stop will be deactivated. Validity of the deactivation shall be limited until next stop of pump. This is for safety reasons.

2.3.1 Draining of tank

If it is required to drain the tank, the auto stop must be overridden. Provision for override to be arranged in ICSS. Run the pump with reduced hydraulic pressure.
It might also be necessary to throttle on pump discharge valve to reduce the capacity and avoid loss of suction.

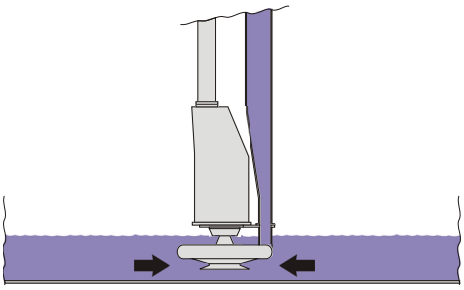


Fig. 18

The capacity depends on the inflow to the area where the pump is located (ref. fig. 18-21).

The remaining cargo should preferably be transferred to another tank:

- Start the pump and let it run with hydraulic motor pressure 50 bar for 2 minute.
- Increase hydraulic pressure to 50-100 bar. Open pump discharge valve until discharge pressure equals 20-30 mlc.
- If the pump loose suction, indicated by sudden drop in hydraulic motor pressure, run the pump at lowest possible hydraulic pressure.
- If the hydraulic motor pressure drops again, close the pump discharge valve and stop the pump.

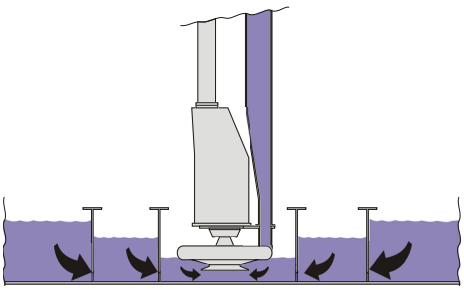


Fig. 20

When the pump is stopped, the override function should be automatically reset.

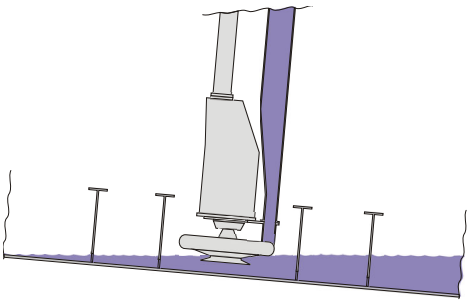


Fig. 21

2.3.2 Crude oil washing (COW)

The crude oil washing may start during discharge sequence. Continue COW during discharging / end of discharging.
During draining/cleaning of tank top, the pump speed/capacity must be reduced to avoid loss of suction.

2.3.3 Stripping

Stripping is to reduce remaining cargo in pump cargo pipe upon service/tank inspection.
The stripping is done by running the pump locally at reduced hydraulic motor pressure against closed discharge valve while purging the pump discharge pipe.The cargo is then purged into the loading line via the stripping valve.

The pump impeller acts as a non-return valve, preventing cargo from returning to tank. If the pump speed (hydraulic motor pressure) is too low, cargo will flow through the impeller back to the tank.

The arrangement of deck piping must be taken into consideration during stripping. Optimal procedure for tank stripping to be based on experience on board.

The best stripping result is obtained when stripping to another tank via a separate loading line.
At increased back pressure the cargo flow is reduced, and stripping time is increased. High cargo viscosity will also increase stripping time.

Examples:
Purging press. - Static head - Back press. = Available purging pressure

I	7 bar	-	2 bar	-	0 bar	= 5 bar
II	7 bar	-	2 bar	-	3 bar	= 2 bar

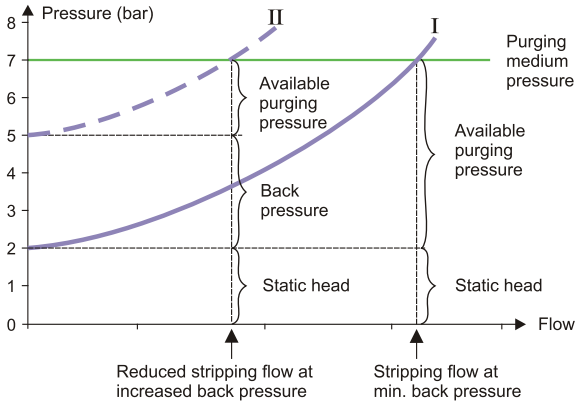


Fig. 23

Estimated time to empty the pump cargo pipe (Backpressure 0 bar(g), 1cSt, spgr. 1.0) *	
SD100 / SD125 / SD150	2 – 4 min.
SD200 / SD250 / SD300	4 – 7 min
SD350	8 – 9 min

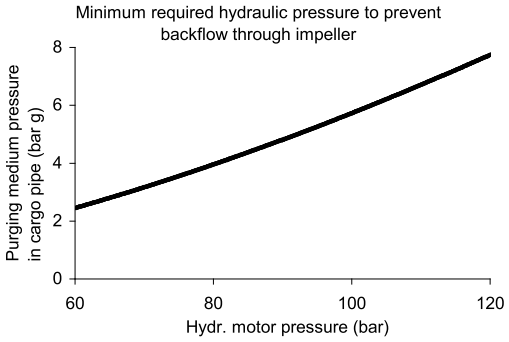


Fig. 22

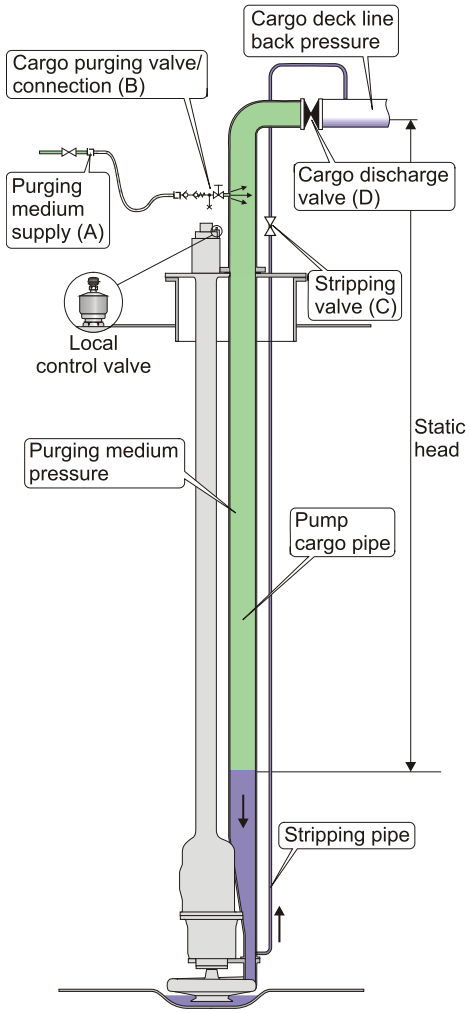


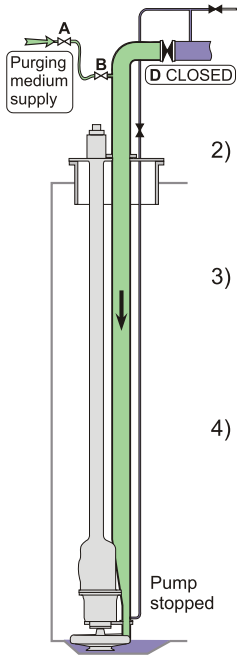
Fig. 24

* Time will be influenced by pump length, back pressure, piping system, type of suction well, cargo, purging medium pressure etc.

Stripping procedure

Preparations

Relieving vacuum in pump cargo pipe



1) When the tank is empty, close cargo discharge valve(D) and stop the pump.

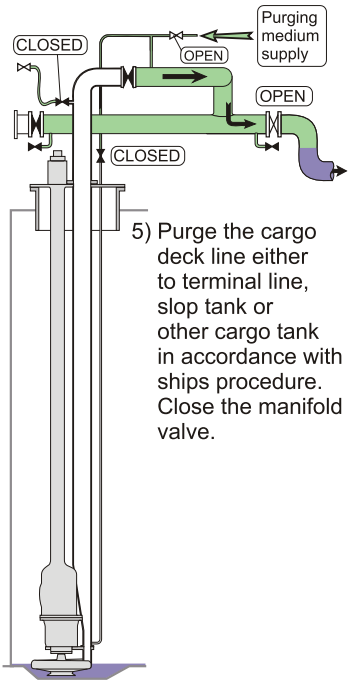
2) Connect purging hose to the purging medium supply (A) and cargo purging valve (B).

3) Relieve vacuum in pump cargo pipe by opening valves at purging medium supply (valve A and B).

4) Close the cargo purging valve (B).

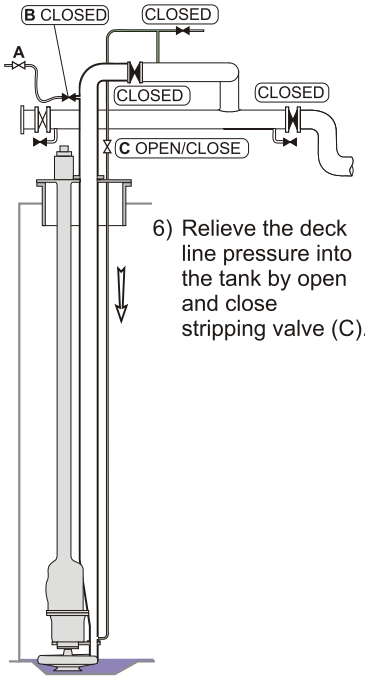
Note!
Purging medium pressure in the hose must always be higher than the pressure in the cargo pipe.

Purging of cargo deck line



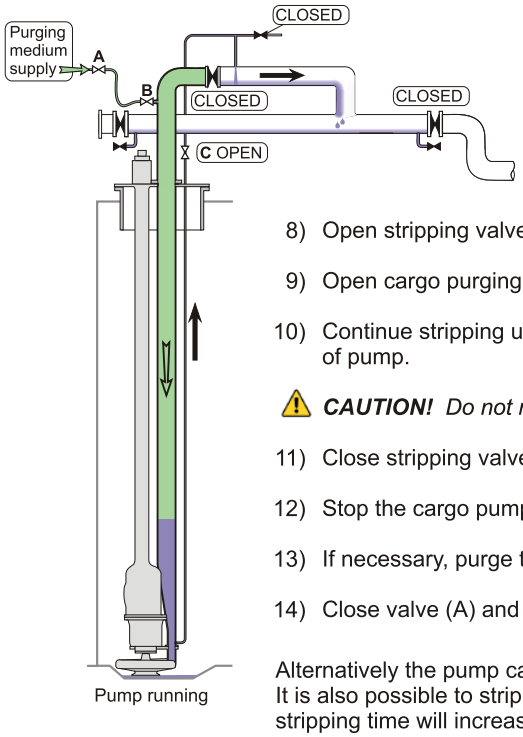
5) Purge the cargo deck line either to terminal line, slop tank or other cargo tank in accordance with ships procedure. Close the manifold valve.

Relieving deck line pressure



6) Relieve the deck line pressure into the tank by open and close stripping valve (C).

Stripping



7) Start the pump by using the local control valve, and increase hydraulic pump pressure to 90-120 bar.

Note!
Optimum hydraulic pressure depends on cargo specific gravity and viscosity, purging medium pressure, static head etc., and must be based on experience on board.

8) Open stripping valve (C)

9) Open cargo purging valve (B) to start the stripping.

10) Continue stripping until pump cargo pipe is empty, identified by frequent speed variations of pump.

⚠ ***CAUTION!*** *Do not run the pump unnecessary during stripping.*

11) Close stripping valve (C) and valve at cargo purging connection (B).

12) Stop the cargo pump.

13) If necessary, purge the cargo deck line and repeat the stripping sequence.

14) Close valve (A) and disconnect purging medium hose.

Alternatively the pump can be stripped into a slop tank through a dedicated deck line. It is also possible to strip to a cargo deck line at low manifold pressure, however stripping time will increase with increased cargo pressure.

Fig. 25

2.3.4 Tank cleaning

Framo recommend tank cleaning to be done with a steady inflow to the area where the pump is located. During tank washing the pump should be run at approximately the same flow rate as cleaning water/liquid supply. Halfway through the tank washing, stop the pump and let the cleaning water level in tank raise to 200-300 mm. Operate pump at full speed for a short period in order to get a good cleaning of wear rings, seal rings and pumps parts. For cleaning of stripping pipe (option), open the stripping valve and run the pump at full speed for a short period

Note!
Cleaning water residues in tank to be removed to avoid galvanic corrosion.

Note!
If steam is used to clean the pump, the steaming period must not exceed 10 minutes, to avoid damage of seals or hydraulic motor.

CAUTION

Use of steam can generate electrostatic charged mist.

Note!
If using seawater for tank cleaning, see chapter 2.4.

2.4 Precautions if using cargo pumps in seawater

Recommended maximum time/temperatures
(Curves for AISI 316 L)

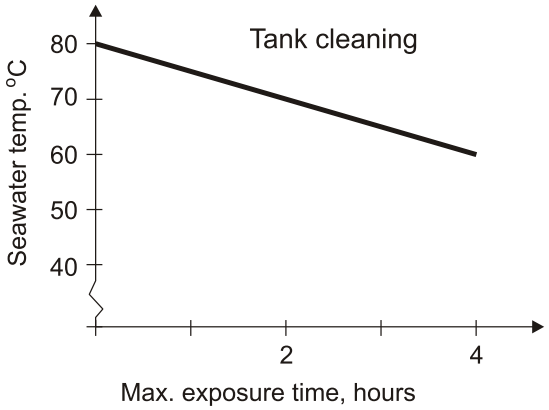


Fig. 26

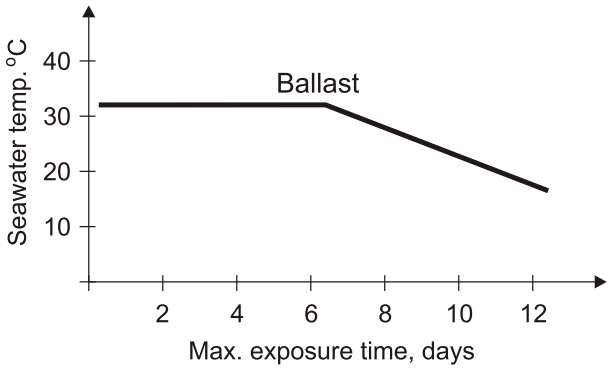


Fig. 27

Seawater tank cleaning (Continuous circulation)

The nominal corrosion rate for stainless steel in sea water is low. However, under certain circumstances, local corrosive attack can take place and the corrosion rate might be severe. High chloride concentrations and low pH increase the probability of pitting and crevice corrosion as do high temperatures and stagnant solutions. Tank cleaning using sea water must therefore be carried out according to qualified procedure.

- In general the tank cleaning should be carried out within limited time frame at temperature below 60°C. Higher temperature up to 80°C can be used for a shorter period. (Fig. 26, for guidance only.)
- If hot seawater is used, cool immediately with cold seawater until surface temp. is below 40°C before fresh water rinse. This to avoid concentration of chlorides from evaporation on hot steel surfaces.
- Tank cleaning with seawater must be followed by a thoroughly rinse with fresh water to remove chlorides.

Sea water in tanks

- Empty the tanks as soon as possible when the ballast is no longer required or when the testing is finished.
- Carefully clean the tank and the pump to ensure no chlorides remain on surfaces.

2.5 Cofferdam control

2.5.1 Liquid filled cofferdam

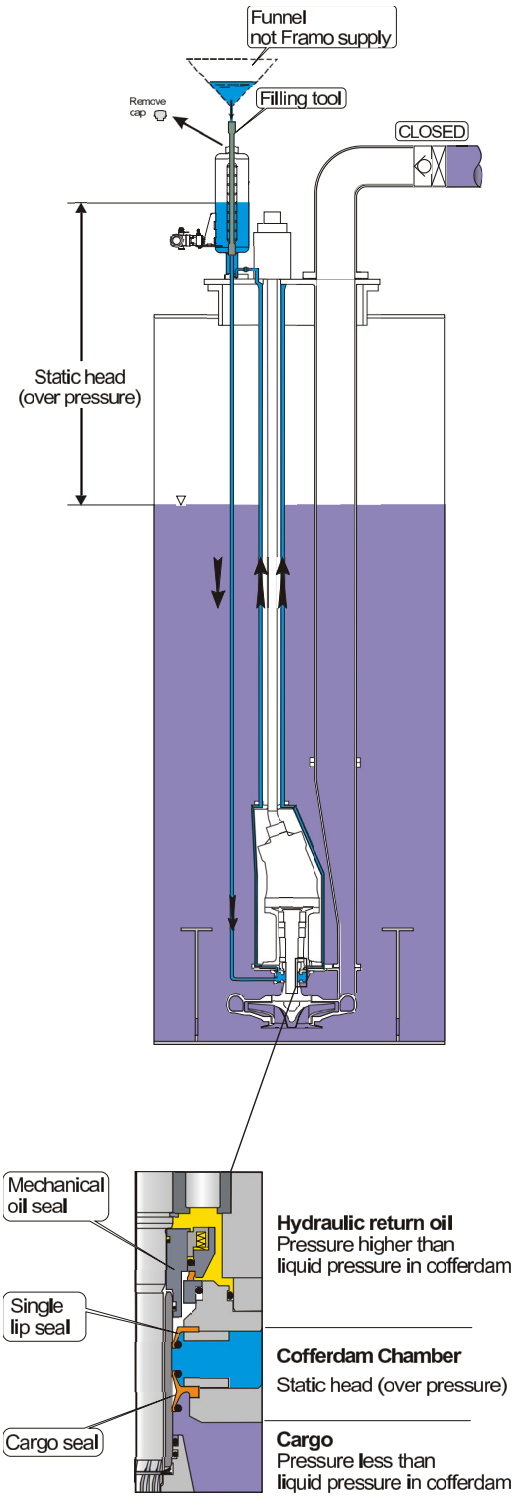


Fig. 28

The pump hydraulic section is surrounded by the liquid filled cofferdam that completely segregates the hydraulic oil from the cargo. Static overpressure in the cofferdam gives clean cofferdam liquid to the seal faces and lubrication of these.

Condition monitoring of the shaft seal arrangement is carried out by surveillance of the liquid level in the header tank.

FILLING

- Hydraulic oil filling of pump must be done before cofferdam is filled.

- Fill the cofferdam through the header tank until liquid level stabilizes at the middle of the sight glass (Filling tool included in tool box).

  Note!
  The filling medium supply pressure must not exceed 2 bar. To avoid this, a funnel can be used when filling the cofferdam.

- Use a ISO VG10 or VG15 hydraulic oil in the cofferdam. (DIN51524 part 2)
  Due to expansion and air in the system, the level will stabilize between 2 to 7 days after filling.

- The cofferdam volume depends on pump type and pump length. The following formulas give approx. volume required to fill cofferdam to the middle of the sight glass: (volume in litres)

Pump type	Volume in litres
SD100	(L x 0,6) + 10
SD125/SD150	(L x 0,6) + 15
SD200	(L x 3,7) + 12
SD250	(L x 3,7) + 17
SD300	(L x 4,3) + 16
SD350	(L x 5,1) + 22

L = Pump length in metres. (See Framo specification)

MONITORING OF COFFERDAM LEVEL

The level in header tank is displayed on the cargo control panel and locally on the level transmitter.

The liquid level in the header tank varies with the temperature of the crude oil, hydraulic oil and ambient temperature, as well as the ullage. Figure 29 indicates normal level variations for the different pump types with a temperature change of ±10°C on the cofferdam liquid.

Because of level changes due to temperature variations, the level should always be monitored at the same temperature, i.e. at normal operating temperature.

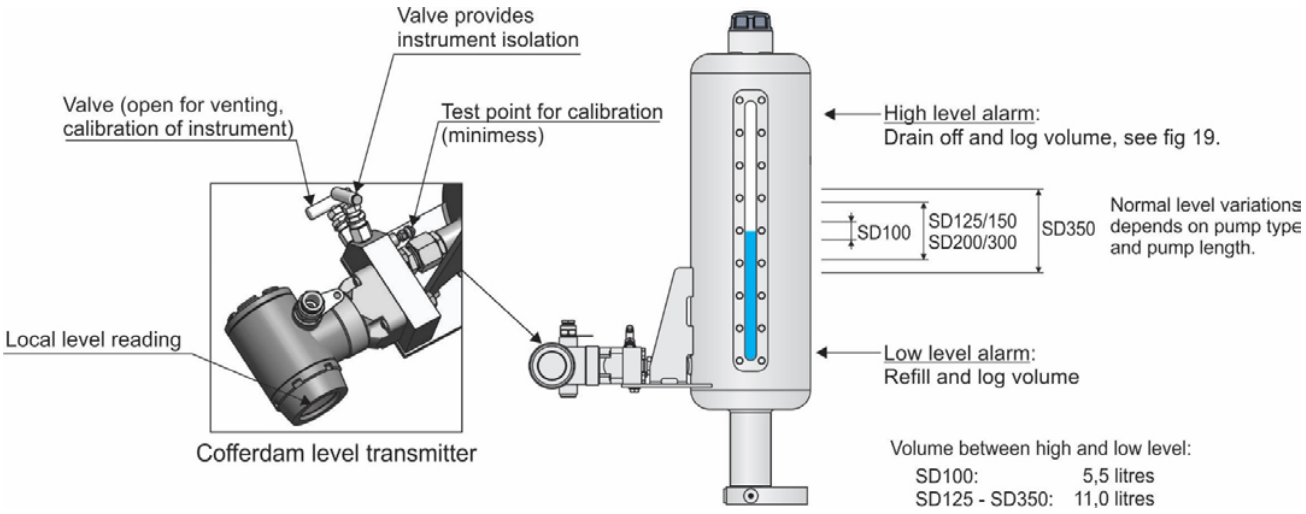


Fig. 29 Header tank

By using the enclosed log form (page 24), it is possible to establish a trend towards increasing or decreasing level. The filled in example below indicates how to use the log form.

Header tank level to be read on cargo control panel (measured in mm or %).

Leakage rate (reading %) = $\frac{(H_2 - H_1)x167*}{h}$ [ml/h] * 59 for header tank on SD100

LOG FORM FOR LIQUID FILLED COFFERDAM ON FRAMO SUBMERGED CARGO PUMPS

VESSEL NAME: _____ TYPE OF LIQUID USED IN COFFERDAM: _____

Header tank level to be measured in mm above bottom of sight glass. 1 mm on sight glass is equivalent to:
• For header tanks with outside diameter 206 mm, 31 millilitres volume. • For header tanks with outside diameter 131 mm, 13 millilitres volume.

Tank no.	Date	Header tank level (H) (mm)	Crude oil temperature (°C)	Hydraulic oil temperature (°C)	Number of discharges since last control	Hours of operation since last control (h)	Leakage rate (ml/h)*	Comments / Remarks (Action taken)	Signature / Date
1	01.08.10	146	50	45					
1	08.08.10	147	50	44		12	2,6		
1	15.08.10	143	50	45		12	-10,3		

If low level alarm, refill the header tank. Log the volume.

If high level alarm, the header tank must be drained (see page 20). Log the volume, and refill the header tank.

Evaliation of changes in liquid level in header tank

When pump is not running, the leakage rate from the mechanical seal and the cargo seal is very low (up to 0.1 ml/h). Therefore increasing or decreasing level due to leakages from the seals should not be expected when pump is not in operation.

Changes in liquid level	Possible reason
Sudden decrease	Can indicate that it is air in the cofferdam system, which most likely occurs in the first period after initial cofferdam filling or complete refill after service.
Decreasing level (Leak from pump cofferdam to tank)	Different temperature compared to the previous measurement (temperature of the cofferdam medium, hydraulic oil and ambient temperature), ref. fig. 29. When pump is running the normal leakage rate can be up to 20 ml/h. For a shorter period of time, higher leakage peaks can occur. Abnormal decreasing level over a period of time, see chapter 4, “Trouble shooting”.
Increasing level (Hydraulic oil leak into pump cofferdam)	Different temperature compared to the previous measurement (temperature of the cofferdam medium, hydraulic oil and ambient temperature), ref. fig. 29. Normal leakage rate can be up to 5 ml/h from the mechanical oil seal. For a shorter period of time, higher leakage peaks can occur. A continuous leakage rate > 20 ml/h or a sudden increasing level in header tank, see chapter 4, Trouble shooting.

IN CASE OF ANY DOUBT, please contact a Framo Service Station for assistance.

DRAINING OF HEADER TANK AND COFFERDAM

Draining of header tank and cofferdam shall be done by using the special draining tool in Framo toolbox:

- Drain liquid in header tank.
- To collect the liquid from the header tank and the cofferdam, connect the drain hose (from the tool box) to header tank flange and drain into a suitable container.
- Disconnect pipe between STC valve block and header tank flange. Plug the pipe connection on the header tank flange.
- Connect the drain tool to the STC valve block.
- Connect air/inert gas supply to the tool. (Maximum supply pressure is 7 bar.)

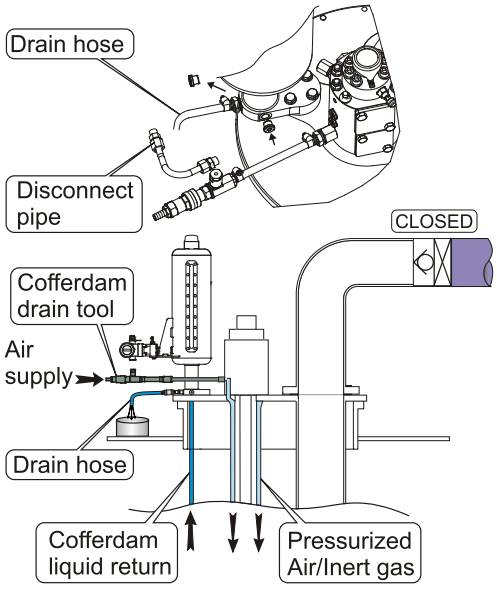


Fig. 30

2.5.2 Dry cofferdam

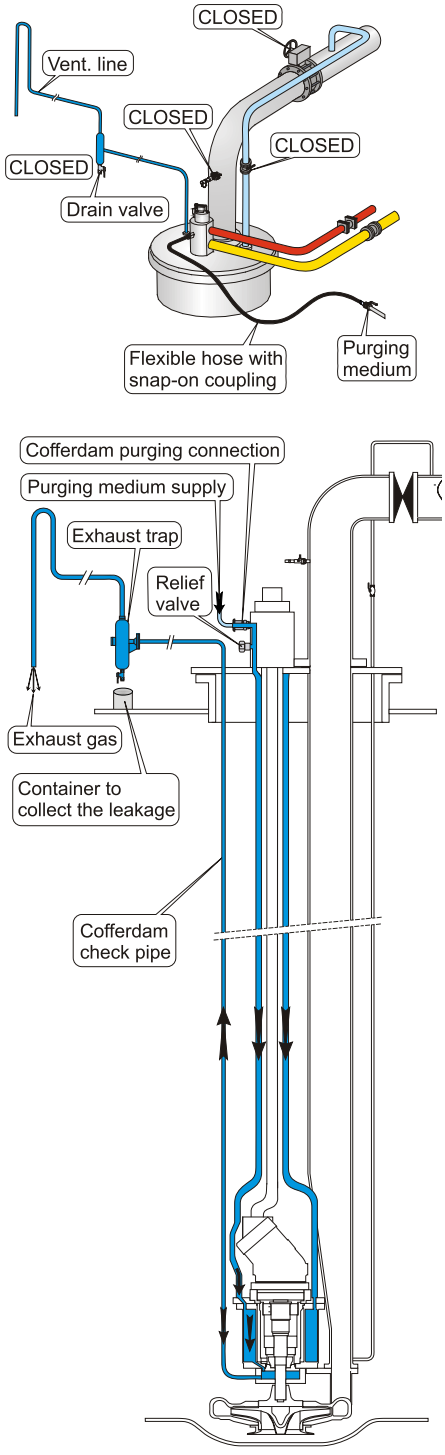


Fig. 31

The cargo pump cofferdam is essential for segregation of the pump hydraulic section from the cargo – and for seal monitoring. Purging to be carried out at regular intervals for the purpose of:

- Leakage rate detection
- Condition monitoring of the shaft seal system
- Avoid that leakages are blocking the cofferdam

How to purge the cofferdam

CAUTION:
Exhaust gas and liquid may be hazardous.
Wear safety gear and avoid contact with drain from exhaust trap and venting line.

Preparation:

1) Place a suitable container underneath the exhaust trap to collect the leakage.
2) Check that drain valve at bottom of exhaust trap is not blocked.
3) Drain the purging medium supply line for condensed water.
4) Connect purging hose (max. supply pressure 7 bar).

Purging:

5) Start the purging by opening the valve at purging medium supply line.

Note!
A relief valve is fitted at cofferdam purging connection. This is set at 3-3,5 bar to limit the purging pressure for protection of the pump seals. A small leakage from the relief valve is normal when liquid is purged from cofferdam. The valve will also open if the cofferdam is blocked.

6) Check that exhaust gas is coming out of the exhaust trap vent line (to verify that cofferdam is open).

CAUTION! *Exhaust gas and liquid – watch out!*

7) Purge cofferdam in several sequences if required. Drain exhaust trap between each sequence.
8) Disconnect purging hose.
9) Close exhaust trap drain valve.
10) Log the amount of leakage, -evaluate the result.

Purging intervals, - logging of purging result

LOADING		DISCHARGE
1. Shortly before loading.	1. 1-2 days after loading. 2. If no leakage at step 1, purge every fortnight. 3. If leakage is detected at step 1, or at a later stage during the voyage, purge this pump every day. 4. If pumps are used for circulation, the cofferdam must be purged before start and after stop.	1. Shortly before discharging. 2. Shortly after discharging.

Note! *Neglecting of purging can result in a blocked cofferdam and lack of leakage control.*

The purging form should be filled in with the results from every purging operation. Each horizontal line in the form represents one cargo in one tank from loading till discharging. If a vessel loads and discharges some tanks more frequently than other, an extra form should be filled in for those tanks.

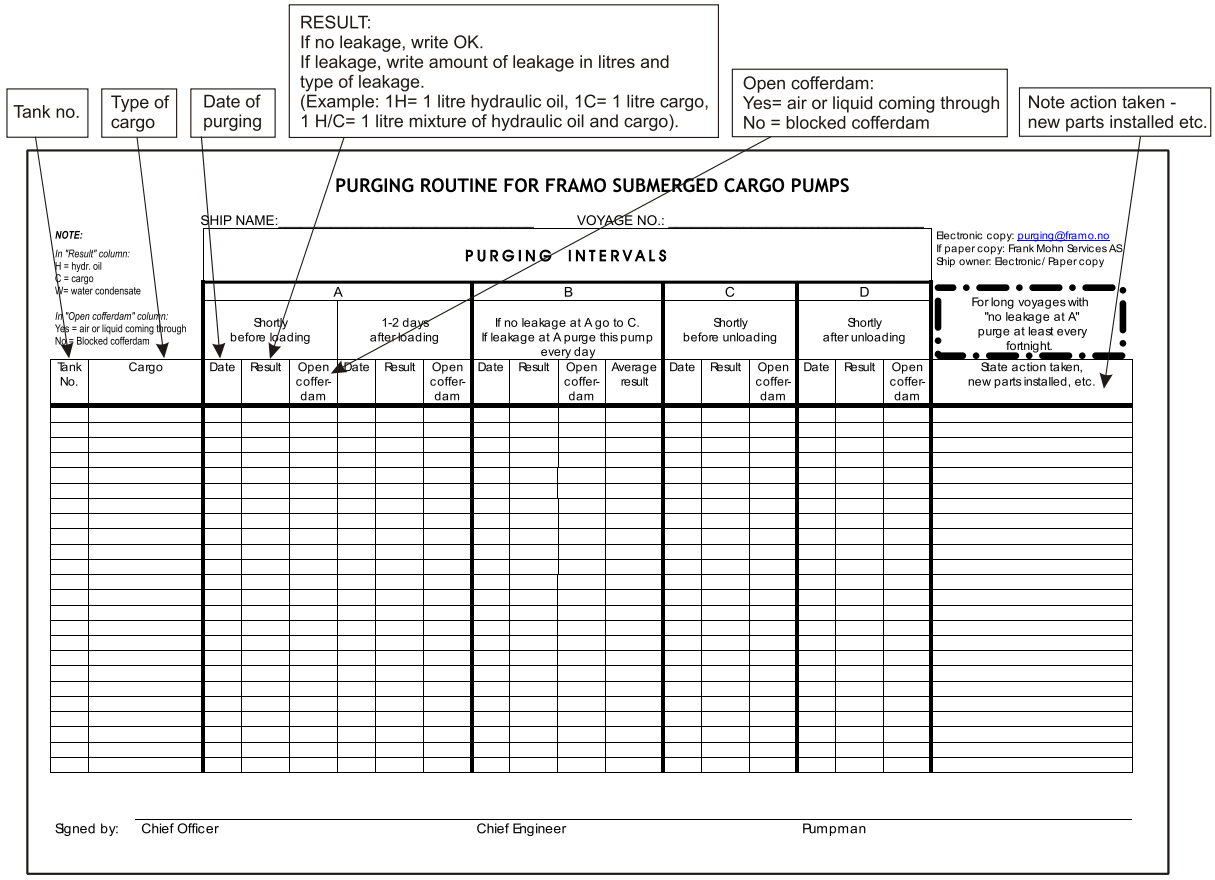


Fig. 32 Example of FRAMO purging form

Filled in purging form to be sent to Vessel owner and to Framo (purging@framo.no).
(Green copy for the vessel, red copy for the Vessel owner and white copy for Framo.)

Vessel's crew to evaluate the purging results and to take necessary action – however in case the crew needs advice, contact a Framo Service Station.

Evaluation of the purging result

Cargo leakage

A small leakage rate of up to about 0.5 l/day (and higher with light cargoes) during pump operation is normal.

Acceptable leakage rate depends on the type of cargo and possible consequences in case of leakage.

- Risk for clogging of pump cofferdam

Cargoes like naphtha, condensate etc. penetrates the shaft seals more easily than lubricating oils, vegetable oils and other viscous cargoes.
It is therefore recommended to carefully monitor the leakage rate over a period of time, preferable with different type of cargoes.

For critical cargoes, when the leakage rate is about 2 litres/day or higher, the pump must be purged a couple of times daily and service (pressure test-repair) carried out at first opportunity.

Intensify the purging if the leakage rate is exceeding acceptable limits. If this is not sufficient to keep the leakage under control it must, depending on the nature of the cargo, be considered to discharge the tank using the portable pump.

Cargo leakage to cofferdam normally indicates shaft seal leakage. But the leakage might come from flange connections or damage (cracks/pin holes) in pump/pipe stack (ref. chapter 4, Trouble shooting).

The development of a cargo leakage can be monitored if purging is done according to instructions. Thereby maintenance work can be planned, and unexpected shut down due to leakage can be avoided.

Hydraulic oil leakage

Hydraulic oil in the cofferdam normally indicates shaft seal leakage, but might come from flange face seals in pipe stack/ pump head or damage in the pipe stack/pump head.

A small leakage rate into the cofferdam up to about 10 ml/h (0.25 l/day) from the mechanical oil seal or lip seal during pump operation is normal. For short periods of time, higher leakage peaks can occur.

If the leakage rate is increasing above acceptable level, the pump must be purged a couple of times daily and inspected as soon as possible to find the reason for the leakage. Intensify the purging if the leakage rate is increasing above the acceptable level. If this is not keeping the leakage under control, close the hydraulic service valve. Depending of the nature of the cargo consider to use the portable pump to discharge the cargo.

Blocked cofferdam

In general we do not recommend operating the cargo pump with blocked cofferdam.
For advice, depending of type of cargo etc., contact a Framo Service Station.

Note! *Always remember to pressure test the cofferdam with 3 bar to locate the leakage prior to any dismantling of the cargo pump.*

2.6 Loading of cargo tank

Loading to be done through separate drop line.

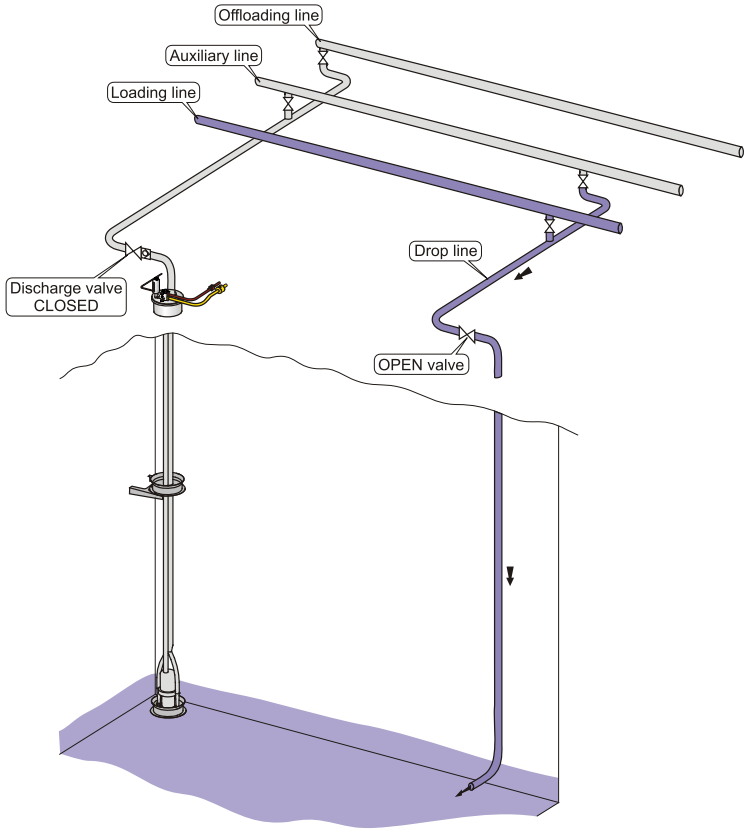


Fig. 33

3 MAINTENANCE INFORMATION

Prior to entering a cargo tank for doing service it is essential to follow with the vessel's safety rules and requirements regarding cargo-handling equipment. Do not enter a cargo tank before the tank is confirmed gas free and safe. Before doing service on pump, always close and lock the hydraulic pressure inlet valve. Close the pump discharge valve. Ensure that the valve is in closed position until the work/service is finished (info sign to be placed at the control panel/computer).

Before dismantling the cargo seal, drain the cofferdam according to chapter 2.5.

Caution: *Venting gas and liquid may be dangerous.*

To prevent hazardous situations it is important to remove oil spill during maintenance and service work. The operator should be confident that all flange connections are in satisfactory condition so as to prevent hydraulic oil and cargo spills.

4 TROUBLE SHOOTING

Warning: *To prevent damage from hazardous cargoes, take necessary precautions, wear safety gear and avoid contact with spray/gases.*

Symptom:	**POSSIBLE REASON:**	**Remedy: *)**
COP operational problem (First it is necessary to verify if the problem is in the pump control system or in the pump unit itself).	General	Ref. system service manual - Trouble shooting section
The pump will not start	a) Cargo pump remote control system failure b) Pump control valve failure c) Pump impeller stuck. c1)Frozen /solidified cargo c2)Foreign objects stuck in pump or other mechanical problem	a) Ref. instruction for Pump remote control b) Ref. Instruction for Pump control valve (STC) c1) Heat the cargo in the pump suction well. c2) Pump unit to be inspected.
Pump is vibrating heavily	a) Control system problem b) Rotating parts out of balance. Impurities stuck in impeller or other mechanical problem.	a) Ref. instr. for Pump control system. b) Pump unit to be inspected
Too low pumping capacity	a) Control system problem b) Worn wear rings. Impurities stuck in impeller, or other mechanical problem	a) Ref. instr. for Pump control system and instr. for Pump control valve. (If required interchange pump control valve as described in instr. 1000-0109-4) b) Pump unit to be inspected

**) Ref. instruction for maintenance and repair for actual pump.*

Symptom:	**Possible reason:**	**Remedy:**
Header tank: Decreasing level in header tank. Dry cofferdam: Cargo leakage to pump cofferdam See also chapt. 2.5	General ***Note!*** *Always pressure test pump prior to and after dismantling. This is required to locate possible leakage and to confirm no leakage upon completion of repair.* a) Worn out cargo seal set. Note; If no leakage is detected by pressure test it is likely that the leakage to cofferdam is caused by worn cargo seal. (The upper seal lip is sealing when pressurizing cofferdam) b) Leaking seal element in flange connection c) Crack/pinhole in cofferdam check pipe or pipe stack	Log level in header tank / leakage rate for a period of time. Evaluate the changes (see chapt. 2.5). Pressure test pump cofferdam system at approx. 3 bar. Check for leakage – if required spray with soapy water to locate the leakage. a) Replace cargo seal set. Also, carefully check ceramic sleeve for possible damage-wear. b) Check for loose bolts and for pitting corrosion in seal faces – in case of corrosion repair is required. When assemble, renew damaged seal element. c) Contact a Framo Service Station.
Header tank: Increasing level in header tank. Dry cofferdam: Hydraulic oil leakage to pump cofferdam. See also chapt. 2.5	General a) Worn out mechanical oil seal b) Leaking seal element in flange connection. c) Crack/pinhole in cofferdam check pipe or pipe stack	Log level in header tank / leakage rate for a period of time. Evaluate the changes (see chapt. 2.5). Drain the pump return side prior to dismantling. Disconnect pump head/unit from pipe stack/casing. Pressurize pump unit return side at approx 4 bar and check for leakage to cofferdam side. Pressure test pump pipe stack / casing at max 3 bar on cofferdam side and check for leakage to return side. a) Replace mechanical oil seal (replaced seal to be reconditioned if feasible). b) Check sealing surface for possible damage – repair if damaged. When assemble, renew damaged seal element. c) Contact a Framo Service Station.

*) Ref. instruction for maintenance and repair for actual pump.

Note!
Evaluate if changed parts as sleeves, mechanical seals etc. are possible to recondition.
Send these parts to a Framo Service Station and ask for an evaluation.

LOG FORM FOR LIQUID FILLED COFFERDAM ON FRAMO SUBMERGED CARGO PUMPS

VESSEL NAME: _____ TYPE OF LIQUID USED IN COFFERDAM: _____

Header tank level to be measured in mm above bottom of sight glass. 1 mm on sight glass is equivalent to:
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Tank no.	Date	Header tank level (H) (mm)	Crude oil temperature (°C)	Hydraulic oil temperature (°C)	Number of discharges since last control	Hours of operation since last control (h)	Leakage rate (ml/h)*	Comments / Remarks (Action taken)	Signature / Date

*Leakage rate (to be calculated) = $\frac{(H_2 - H_1) x \Delta V *}{h}$ [ml/h] * 13 for header tank with outside diameter 131 mm. ref. chapter 2.5, “Monitoring of cofferdam level”