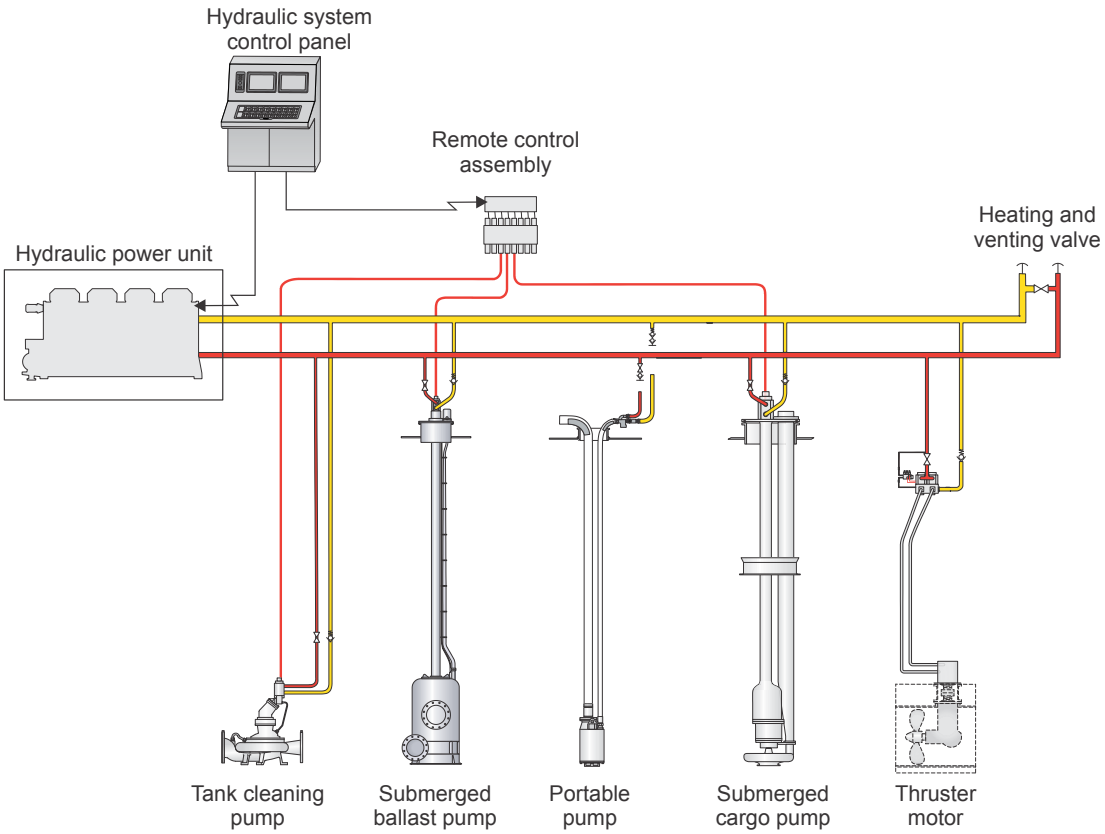
2.0 GENERAL DESCRIPTION

2.1 System description (design/ hydraulic)

The cargo pumping system is designed for a flexible and safe operation of all equipment installed. It consists of one hydraulic motor driven cargo pump installed in each cargo tank, ballast pumps, tank cleaning pumps, portable pumps and other consumers, all connected via a hydraulic ring line system to a hydraulic power unit. The submerged cargo pump is a single stage centrifugal pump with the impeller close to the tank top, giving a good pumping performance of all kinds of liquids and with excellent stripping performance. The hydraulic section is surrounded by a cofferdam that completely segregates the hydraulic oil from the cargo.



The hydraulic power unit consists of electric motor- and/or diesel engine driven hydraulic power packs, where the hydraulic pumps are of axial piston type and swash plate design with variable displacement. The pump displacement is hydraulically controlled via the pressure regulator on each pump and by this system, the oil delivery from the hydraulic pumps will always be the same as the oil consumption for the hydraulic motors. To control and limit the speed of the motor, a control valve is fitted for each motor.

To keep the hydraulic oil clean and hydraulic oil temperature within desired range, a full flow filter and cooler are installed in the main return line. To regulate the oil temperature, a cooling water inlet valve is controlled from the Framo control system.

To prevent impurities from entering the hydraulic system, the system is also pressurized (2-6 bar) when not in operation.
Depending on the installation, this is done by a jockey- or feed pump.

The discharge from all cargo-, ballast- and other pumps connected to the system may be remotely controlled from Framo control panel, vessel's integrated control system (ICS) or locally at each pump via the control valve. The portable pump is controlled locally at the pump via the control valve.

The equipment is manufactured in Norway and the most important benefits of the system are:
- Segregation of cargoes for vessel's safety and the environment.
- Maximum transport volume.
- Efficient stripping and tank cleaning.
- Hydraulic system without any electrical power equipment in cargo area.
- Automatic regulation of power needed and impossible to overload.

2.2 Control description

The Framo cargo pumping system is controlled by a Programmable Logic Control (PLC) installed inside the control panel. The PLC is programmed by Framo and provides the logic for safe operation of the system.

The control panel is provided with redundant 15 inch colour HMI's (Human Machine Interface). Refer to user guide document for graphic details and operator guidance.

This section should be read in conjunction with dedicated system drawings.

2.2.1 ALARM SYSTEM

All alarm inputs, except "Wear indication" are normally closed, meaning that the system is built up on normally closed contacts. Hence if a contact opens or there is a loose wire, an alarm condition occurs, i.e. FAIL TO SAFE.

Refer to hydraulic diagram for applicable alarms and time delay.

All alarms are displayed in HMI alarm list and provided an acoustic signal. The horn is silenced by the "Acknowledge button". Warning alarms are reset automatically when condition has returned to normal state, while the "Reset" button must be activated for trip alarms before system can be restarted.

In the alarm list, select the specific alarm and push the "Info" button for recommended action/trouble shooting.

Messages and Info is displayed in alarm list in blue text.

2.2.2 POWER SUPPLY

Most hydraulic system control panels are supplied via two separate power feeders, main- and back-up. In case of failure to main feeder, automatic change-over to back-up will take place.

The 24 VDC power supplies for HPU-and pump control are redundant and provided with diode module and insulation monitoring and alarm.

The feeders and DC power supplies are monitored by relays provided with status LED's. The LED's illuminate when corresponding feeder/ supply is in good condition. A failure on any of the feeders/ supplies or short circuit will generate a potential free (dry contact) power failure alarm to the engine control room in addition to alarm at the control panel.

Refer to wiring diagrams for detailed arrangement.

2.2.3 FEED PUMPS

The electric starters for the three feed pumps are Direct On Line (DOL) for two of them and a Variable Speed Drive (VSD) for the third feed pump.

The feed pumps can be started and stopped from the control panel, the electric starters or the ICS (the latter depending on the actual installation). Only two feed pumps can run simultaneously and interlocks are made to prevent running of all three.

The feed pump with VSD must always be running when the system is not in operation (standby mode) to maintain a minimum overpressure in the system by controlling the speed of the feed pump (energy saving). When power packs are stopped, the DOL driven pumps will then be automatically stopped and the VSD driven pump will therefore start automatically after 10 minutes if this is not done by operator. The feed pump starter (VSD type) will continuous keep the protection pressure (PT3) to approximately 3 bar (energy saving) by controlling the speed of feed pump motor based on feedback from pressure sensor PT3 (HPU location). In case no feed pump is running, the alarm "Protection pressure low" alarm is initiated.

When start request is initiated for a power pack, the DOL driven feed pumps will be started, VSD driven pump stopped before the power pack started. This is also an automatic sequence.

Two feed pumps running are required for sufficient feed pressure at the suction side of the main hydraulic pumps during operation of the system. If one of the feed pumps stops and the power packs are still running, the feed pump with VSD will start automatically at full speed. If the running signal for this pump is not obtained within 1 second, the hydraulic system will be stopped.

At hydraulic system stop, the first power pack and the feed pumps stops immediately.

2.2.4 POWER PACKS

In order to operate a power pack, the local service valve must be fully open. If the valve is closed either halfway or completely the corresponding power pack will be prevented to start or stopped. An alarm light is provided for each power pack to indicate closed suction line.

If the hydraulic oil temperature increases to 65°C or above (pre-warning alarm at oil temperature 60°C), the control system will automatically unload the power packs in one minute intervals except for one. The pump symbol will start flashing for the unloaded power packs, and a message is displayed in the alarm list. The power packs will automatically be reloaded in sequence when the hydraulic oil temperature has decreased below 59°C.

Manual mode:
The power packs are started/stopped manually from control panel or from the electric starter cabinet.

The power packs can be started in any sequence. Maximum 4 starts should be made during an hour. Maximum 2 following starts can be made, then 15 minutes between each. The starts are controlled by the PLC, including starts from the electric starter cabinet.

Auto stop mode:

The Control system will automatically stop a power pack after a time delay of 15 minutes if the hydraulic oil flow capacity by remaining power packs is higher or equal to the hydraulic oil flow requirement. The flow requirement is calculated by means of measured power consumption for each power pack and measured system pressure.

The stop order is first in - first out and the last started power pack will stop 15 minutes after stopping the last consumer.
If the hydraulic power unit consists of both electric motor- and diesel engine driven power packs, the operator can decide which type of power pack to stop first by the “Stop priority” button
Note that the power packs can also be started and stopped manually by the operator in this mode.

The mode can be turned on and off when the system is in operation, but is activated by default when starting the system.

During operation of deck machinery only, manual mode must be selected (Auto stop mode turned off).

2.2.5 SYSTEM PRESSURE CONTROL

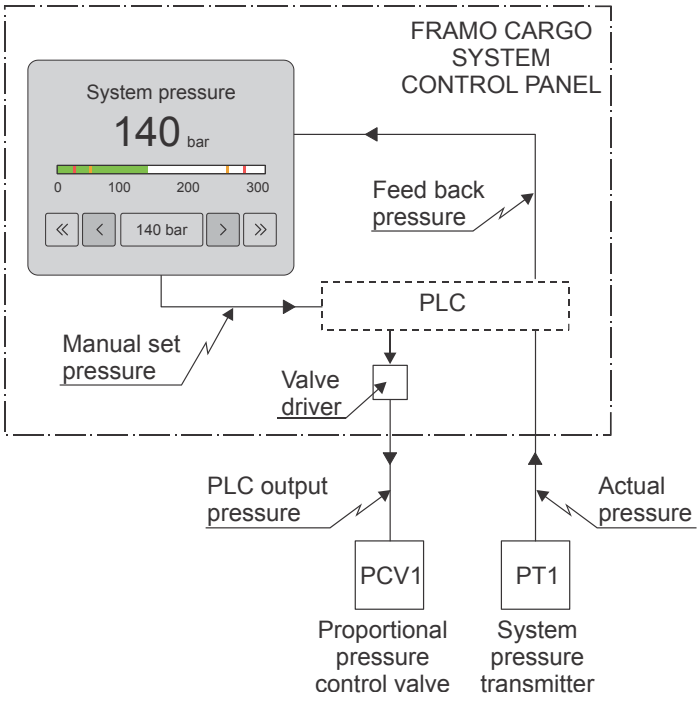
Manual mode:

The set pressure is automatically compared to the actual pressure.
If a pressure drop occurred, for example by starting too many consumers relative to number of power packs running, the PLC is limiting its output set pressure to maximum 60 bar above actual pressure.
This is to avoid pressure surge when starting another power pack or stopping a consumer.
This function can be manually overruled in manual override mode1 and is automatically overruled in mode 2.

Auto mode:

For fuel saving and environment protection, the difference between system pressure and pump pressure should be kept a low as possible.
For pressure drop compensation, the PLC adds a margin to the highest pump hydraulic pressure feedback and use value as system pressure command. This margin can be set manually by operator depending on oil flow requirement in the various offloading scenarios. As example - when system is running at maximum capacity, the margin must be higher than operation of a limited number of pumps. However, a higher system pressure can be set manually by the operator also in this mode if required for operation of deck machinery etc.
The mode can be turned on and off when the system is in operation, but is activated by default when starting the system.

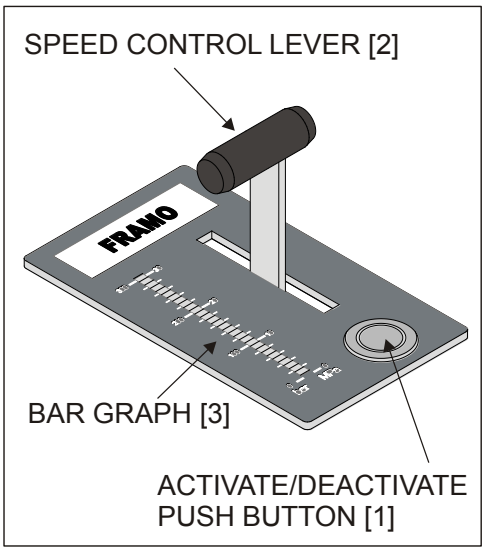
During operation of deck machinery only, manual mode must be selected (Auto pressure control mode turned off).



In manual mode, system pressure is set by HMI numeric input field and can be fine tuned by the < > keys in 1 bar steps or, << >> in 10 bar steps.
The PLC output is amplified by a valve driver card controlling the proportional pressure control valve for the system pressure.
The set pressure is automatically set to zero until one of the power packs has been loaded.

2.2.6 REMOTE CONTROL OF HYDRAULICALLY DRIVEN PUMPS

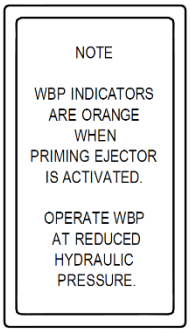
The command signals from speed controllers in front of the control panel are fed directly into the control valves. The built in pressure transmitters give a 4-20 mA (0-300 bar) feedback signal to the indicator and PLC/HMI.



To activate the speed control, push the button [1] on the controller.
A LED indicator in the button will have steady light with green colour.
To set the speed of the pump, adjust the speed control lever [2] until desired pump hydraulic pressure feedback is indicated with green colour by the bar graph [3].

If the pump is stopped by the control system, the controller is disabled and the LED indicator in the button [1] will flash slowly with green colour for 15 sec. before it turns off.
When the controller is enabled again, the controller must be activated by pushing the button [1], hence no automatic activation of the controller and start of the pump.
The control lever [2] must be set to minimum before activating the controller.

For ballast pumps, the LED indicator in the button [1] and the bar graph [3] indication will have steady light with orange colour, when the priming ejector is activated by the control panel PLC, refer to section 2.2.10.
This to alert the operator to reduce the pump speed at the end of de-ballasting.



To stop the pump, adjust the speed control lever [2] back to minimum and push the button [1] to deactivate the speed control. The LED indicator in the button [1] will flash slowly with green colour for 15 sec. before it turns off.
If the pump hydraulic pressure feedback does not turn to zero after 15 sec. and remain above approx. 20 bar (5 mA feedback signal), the LED indicator in the button [1] will flash fast with orange colour and the bar graph[3] indication will have steady light with orange colour.
This to alert the operator of a possible proportional valve malfunction and that the pump may still be running. In this case, further investigation is required.

2.2.7 EMERGENCY STOP ARRANGEMENT

Following emergency stop arrangement is provided by Framo according to class requirements:

- Emergency stop push buttons located on deck are stopping the cargo pumps only, other consumers are not affected.

- Emergency stop push button located on hydraulic system control panel and central location outside engine room are stopping the hydraulic system.

2.2.8 SYSTEM SHUT DOWN

Refer to instrument list for applicable shut down functions.
If a shut down function is initiated, the PLC will give shut down command to the power packs in sequence. The first power pack stops immediately and delay between shut down command of each following power pack is 0.75 seconds.

2.2.9 COOLING WATER INLET VALVE

The valve is automatically controlled and will open at hydraulic oil temperature above 50°C. It will stay open until the temperature decreases to below 30°C, then it will close.

If no power packs are running and the hydraulic oil temperature is below 49°C, the valve will be closed. However, the valve will be re-opened if the temperature increases above 55°C.

If there is a mismatch between command- and feedback signal, an alarm will be released. If failure in the temperature monitoring loop, the valve will be opened.

If no power packs are running and the hydraulic oil temperature is below 49°C, the pump will be stopped.

If there is a mismatch between command- and feedback signal, an alarm will be released. If failure in the temperature monitoring loop, the pump will be started.

2.2.10 ELECTRICALLY CONTROLLED BALLAST PUMP EJECTOR

The ejector for the priming system is automatically controlled by the PLC.
The PLC receives input from a level switch installed in the pump casing and controls the solenoid valve for the ejector pilot air, starting and stopping the ejector.
Time delay for start and stop is 2 seconds and the logic incorporates an interlock to prevent starting the ejector unless at least one power pack is running and that pump controller is activated.

2.2.11 HYDRAULIC OIL CONDITION MONITORING

The Framo HPU is equipped with an oil particle counter and oil humidity sensor. Alarms are initiated when high level of 6 micron and 12 micron particle sizes and high humidity level. Signals are displayed and trended on control panel HMI’s, and included in list of signals sent to ICS.

2.2.12 INERT GAS PRESSURE LOW

Input from external system for shut down of cargo pumps:
- visual and audible alarm provided, group a).

2.2.13 CARGO PRESSURE HIGH

Input from external system for shut down of cargo pumps:
- visual and audible alarm provided, group a).

2.2.14 HYDRAULIC OIL HEATING

In order to select hydraulic oil heating mode, not more than one power pack must be running and system pressure must be below 100 bar. Heating lamp will flash if the conditions are not fulfilled. During heating, max. allowed system pressure is 150 bar. This control sequence overrules the "auto system pressure control" and "power pack auto stop function" as described above.

2.2.15 DIESEL ENGINE CONTROL SYSTEM

Refer to separate instruction.

2.2.16 INTERFACE TO VESSEL'S INTEGRATED CONTROL SYSTEM (ICS)

Framo control system is provided with a Modbus RTU Module for transmitting data from Framo PLC to ICS and further to shore for remote monitoring if applicable.

If operation from ICS is applicable, the list of signal is extended with command signals from ICS to Framo PLC. In this case, local/remote mode is normally selected on Framo panel.

For signal details, refer to dedicated signal list.

2.2.17 POWER PACK ELECTRIC MOTOR STARTERS

Starters supplied by Framo are arranged to send a "start request" signal to vessels Power Management System.
Start is inhibited until a "power available" feed back signal is received.

Some starters are provided with a power meter and some with ampere meter. Signals are displayed the HMI and sent on the Modbus link to ICS. Refer to dedicated system documents for detailed arrangement.