CONTENTS

System description

The antiheeling control system is designed to keep the vessel at a specific list, during loading and unloading. It also protects the pump from dry running and gear breakdown - and, if high level switches are provided, it prevents the pump from pressurising the heeling tanks. It should not be used as a stabilising system in open sea due to too slow response time.
The system consists normally of only two pieces of hardware - the pump starter and the control unit.

Starter

The starter is normally a “direct on line” starter, which can start the pump in either direction of rotation. The start should normally only be initiated by the control unit, and not locally from the starter. The starter has an insulating switch cutting power supply to the pump motor in the case of service to pump or motor.

The starter has possibility for local control. *This function should only be used if the controlsystem has failed (critical situations), or for short-time testrun of motor and valve.*

The tilt switch and the emergency stop button(s) are the only shutdown functions active when local control is activated. Care must be taken not to run the pump without water in heelingtanks or if valves are closed.

Local control will also open the valves, so that pumping between the tanks actually will take place.

Control unit

The control unit contains the inclinometer and the PLC (Programmable Logic Controller) with inputs and outputs for digital and analogue signals. One or more operator terminals are connected to the control unit. All control is done from the operator terminal. An emergency stop switch is also provided on the operator panel. In the rare case of breakdown/malfunction of the plc, the pump can be run locally from the starter. An independent critical heel switch will stop the pump and close the valves if setpoint is exceeded.

General about operator terminal

The operator terminal has:

- a display to represent various information
- 16 LED lamps
- keys
- buzzer built in

The display is of backlight LCD type.

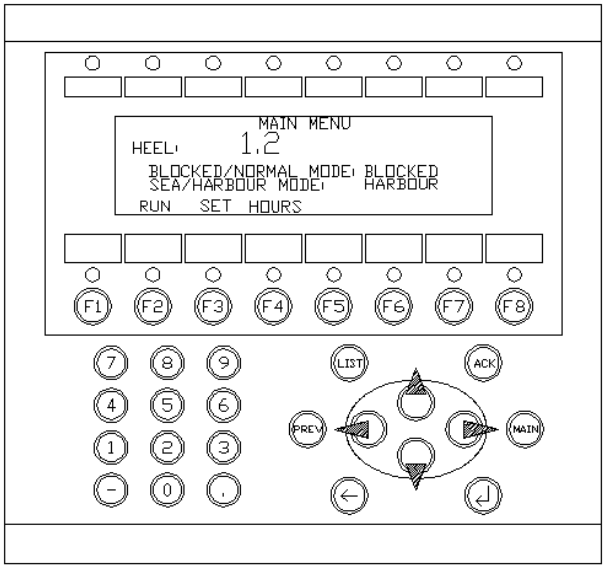

Figure 1: Operator terminal

The LED lamps have fixed functions, e.g. to indicate if a pump is running. LED lamps are of colour red or green, and can flash with various frequencies. The LED's on the upper line are referred to as 1-8, and the lower line 9-16. The intensity of the LED's can not be adjusted.

The 8 function keys are referred to as F1-F8. The individual function keys have different functions depending on what is shown on the display. The lower part of the screen is referred to as 'key-field'. The 'key-field' corresponds to the function keys F2-F7.

The orange arrow keys are for manoeuvring around the cursor in the display. The cursor can only be moved to areas where the operator can key in information to the system. Such input can be setpoints etc. The number-keys including the minus sign and the decimal point are for keying in set-values.

Around the orange arrow keys are six keys:

'MAIN':	This key will show the same information on the display as after power-up.
'Enter':	Used after a number is entered, or to confirm selections
'Backspace':	To erase last character keyed in.
'PREV':	Go back to the previous window.
'LIST':	Show/hide the alarm list
'ACK'	Accept an alarm

The content on the display shows one window at a time. Many different windows exist. Each window contains related information. To manoeuvre between windows, function keys F2-F7 in combination with keyfield are used.

If the current window contains one or more fields, which can be altered by the operator, a flashing box will surround one of them. To manoeuvre to other fields (if any), use the arrow keys. If the current marked field contains a number, a new value can be keyed in (use number keys, minus sign and decimal point as appropriate). If current field is a choice between two states, select the other state by pressing the enter key.

Running the system

Before the system can be run in any way, it must be set up and tuned to the actual ship. If this is not already done, or other working conditions arise, read the chapter ‘Tuning the system’ first.

Main menu

The first window shown on the display after power on, or after the key MAIN is activated, is ‘MAIN MENU’ window. Information shown is:

- Current heel of ship. A minus sign (negative value) means heel to port, no sign means heel to stbd.
- State of Normal/Blocked mode
- State of Harbour/Seamode
- If starter is in local or remote
- Display field for function keys on lower line
- If an alarm is present, text ‘ALARM’ is shown in upper right corner. See separate chapter about alarms.

Normal/Blocked

The whole system can be deactivated when not in use. This is done by the selection of BLOCKED mode as opposed to NORMAL mode. If mode is BLOCKED, it is not possible to run the pump or open the valve. For safety, this is the mode after power on. Alarms related to level in tanks and heel of ship are inhibited, so is the common alarm output. Use the arrow-keys to select field and then press key ENTER to toggle between modes. It is not possible to select RUN if mode is BLOCKED.

Harbour/Seamode

The system is primarily intended for use in harbours during loading and unloading, but can also to a certain limit be used during voyage. However, rolling of the ship often makes the heel measurement unsuitable for controlling the pump; the start frequency would be to high. Manual operation of pump to compensate for wind forces etc is possible. The normal mode during voyage should therefore be SEAMODE (as opposed to HARBOUR mode). SEAMODE allows manual operation of pump and valve. Alarms related to level in tanks (only if pump is not running) and heel of ship are inhibited. The output signal ‘heeling signal’ is inhibited. Use the arrow-keys to select field and then press key ENTER to toggle between modes.

Select how to operate the system

There are five main ways to operate the anti heeling system, these are:

- Auto — Start and stop are decided by heel measurement, to keep the vessel at a fixed heel.
- Manual — Start and stop is decided by operator.
- Goto — Operator keys in a desired heel, and pump will run until that heel is obtained.
- Valve — Valve only is opened, for gravitating water between tanks.
- Local — Start and stop is decided by operator locally

Auto

To get into the right window for auto control, start from main menu (key MAIN will take you there), select ‘RUN’, and then ‘AUTO’. It is not possible to select ‘RUN’ if mode is BLOCKED. In this window you have three choices: ‘START’, ‘STOP’ and ‘SET’.

Before you start, select ‘SET’. You are now in the window ‘AUTO SETTINGS’. You must verify that the settings are as desired.

- WORKING POINT: This is the reference value, normally set to 0 degrees. If, for some reason, maybe side port alignment, you want another value, key it in. Note that positive values means stbd and negative values means port.

- START AT: The pump will start when deviation from working point exceeds this value. Pump will always start in correct direction. Factory setting is 1 degree. Only positive values permitted.

- STOP AT: Pump will stop when deviation gets lower than this value. Typical value is 0 degrees. Value must be at least 0.5 degrees less than start value to avoid too frequent start and stop. Only positive values permitted.

- START DELAY: If you know that the start limit will be exceeded for a short time only, and do not want the pump to start for that reason, you can here specify how many seconds the start limit can be exceeded before the pump starts. Can be useful if certain types of cranes are in duty. Normal setting is 0 seconds.

When all values are set, return to the previous window by pressing the PREV key. The current heel of ship is displayed.

If text NOT READY is shown above the field START, check out the alarms, and make sure that mode is not SEAMODE.

If READY is displayed, the START key can be operated. An LED indicates that system now is in auto. Two LEDs indicates when the pump is actually running to port or stbd. The run LEDs are flashing at start when the valve opens, and steady when the motor starts.

It is possible to jump to the alarm list when ‘auto’ is activated (pump is running or is ready to run according to measured heel). Jump to other windows will stop the pump and close the valve.

An example:
Say you specified a working point of 0.8 degrees (stbd), start at 1.0 degrees and stop at 0.3 degrees.

Ship is loaded at stbd side: Pump will start to pump in port direction when heel reaches 1.8 degrees (stbd), and it will stop at 1.1 degrees (stbd).

If loaded at port side: Pump will start to pump in stbd direction when heel reaches -0.2 degrees (port), and it will stop at 0.5 degrees (stbd).

Manual

To get into the right window for manual control, start from main menu (key MAIN will take you there), select ‘RUN’, and then ‘MANUAL’. It is not possible to select ‘RUN’ if mode is blocked. In this window you have four choices: ‘PORT’, ‘STOP’, ‘STBD’ and ‘TIMER’.

If text NOT READY is shown above the field PORT or STBD, check out the alarms, and make sure that mode is not BLOCKED.

It is possible to jump to the alarm list when ‘manual’ is activated (pump is running). Jump to other windows will stop the pump and close the valve.

Operating the key ‘PORT’ (‘STBD’) will open the valve and start the pump in port (stbd) direction. Key ‘STOP’ will interrupt the process. Two LEDs indicates when the pump is actually running to port or stbd. The run LEDs are flashing at start when the valve is opening, and steady when the motor starts.

A count down timer will stop the pump when zero is reached. The pre-set value of this timer can be set by operator, within certain limits. If the timer approaches zero when pump is run, but you want to run the pump further without stop, operate the ‘TIMER’ key. The timer will then start over again from the pre-set value.

Goto

To get into the right window for goto control, start from main menu (key MAIN will take you there), select ‘RUN’, and then ‘GOTO’. It is not possible to select ‘RUN’ if mode is blocked. In this window you have two choices: ‘START’ and ‘STOP’.

If text NOT READY is shown above the field START, check out the alarms, and make sure that mode is not BLOCKED or SEAMODE. NOT READY will also be shown if current value is exactly the same as set value.

The input field ‘SET VALUE’ is where you key in the heel to go to. Note that positive values means stbd and negative values means port.

Operating the key ‘START’ will open the valve and start the pump in correct direction. Pump will stop when desired heel is reached. Key ‘STOP’ will interrupt the process. Two LEDs indicates when the pump is actually running to port or stbd. The run LEDs are flashing at start when the valve is opening, and steady when the motor starts.

It is possible to jump to the alarm list when ‘goto’ is activated (pump is running). Jump to other windows will stop the pump and close the valve.

Valve

To get into the right window for valve control, start from main menu (key MAIN will take you there), select ‘RUN’, and then ‘VALVE’. It is not possible to select ‘RUN’ if mode is blocked. In this window you have three choices: ‘OPEN’ and ‘CLOSE’ and ‘TIMER’.

If text NOT READY is shown above the field OPEN, check out the alarms, and make sure that mode is not BLOCKED or SEAMODE.

Operating the key ‘OPEN’ will open the valve. Key ‘CLOSE’ will interrupt the process. Valve position is indicated by a text showing: CLOSED, OPEN, CLOSING and OPENING.

A count down timer will close the valve when zero is reached. The pre-set value of this timer can be set by operator, within certain limits. If the timer approaches zero when valve is open, but you want to keep the valve open further, operate the ‘TIMER’ key. The timer will then start over again from the pre-set value.

It is possible to jump to the alarm list when 'valve' is activated (valve is open). Jump to other windows will close the valve.

Local

To get into the right window for local control, start from main menu, select 'RUN', and then 'LOCAL'. It is not possible to select 'LOCAL' if mode is blocked. Before 'LOCAL' can be performed, operator must make sure that the text 'LOCAL START' is present on the operator panel. This window shows if it at the moment is possible to run either port or stbd, ('NOT READY TO RUN PORT/STBD' or 'OK TO RUN PORT/STBD'). If not ready, check the alarmlist.

Tuning the system

For best performance and adaptation to various installations, some adjustments and settings must be set before the system is put into operation. These are:

- Alarm times for valve open/close
- Angle setting for heeling signal, critical heeling alarm
- Verify and set direction of inclinometer
- Calibration of heel indication
- Set delay between valve starts to open and start of pump
- Set start delay between the two pumps (if two pumpes installed)
- Set correct date & time (only used for date stamping of alarms)

The settings are stored in the controller, in battery backed up memory.

This chapter describes settings for the system as a whole. There are also 'local' settings in the various run windows. These settings are explained the chapter 'Running the system'.

To get into the right window for settings, start from main menu (key MAIN will take you there) and select 'SET'. The display shows 'Settings menu' on the first line. In this window it is possible to turn on and off the backlight of the display by pressing the Enter key.

The settings are divided into four groups: VALVE, ANGLE, DELAY and TIME. Select a group by pressing the corresponding function key.

Verify and set direction of inclinometer and critical heel switch

The system contains a device (inclinometer) for measuring the heel of the ship. The inclinometer must be mounted in a certain orientation related to the ship. The inclinometer (a small blue metal box) is located on an adjustable bracket at the same mounting plate as the controller. The top (the side with printed text) of inclinometer must be horizontal with a tolerance of about +- 3º. The cable entry must face towards port side !

The system also contains a critical heel switch for shutting down the system independent of the plc. The critical heel switch must be mounted in a certain orientation related to the ship. The critical heel switch (a small grey metal box) is located on a bracket below the inclinometer. The lid should always face the astern direction of the ship !

Settings: VALVE

In this window (First line: VALVE SETTINGS) you will see six numbers.

The four first lines: The values shown are measured open/close times for the valve; operator can not alter these values. The last successful operation of valve is reflected. The purpose is to verify that valve operates as intended.

- Measured start to open: Time in seconds from open signal is given until closed feedback is lost.
- Measured start to close: Time in seconds from open signal is switched off until open feedback is lost.
- Measured open time: Time in seconds from closed feedback is lost to open feedback is on.
- Measured close time: Time in seconds from open feedback is lost to closed feedback is on.
- Alarm open time: Delay in seconds before alarm is given.
- Alarm close time: Delay in seconds before alarm is given

Settings: ANGLE

In this window (First line: ANGLE SETTINGS), you have three choices: LIMIT, REVERT and ZERO.

LIMIT
In this window there are two different settings:

- Heeling signal. This is an output signal (potential free contact) to other systems like deck cranes. You can define the set-value and the reset value. The reset value must be at least 0.5º less than the set-value. Range for set value is 1-7.5º and for reset value 0.5-7º.

- Critical heel. If this value is exceeded, it will cause an alarm and shut down the system. You can define the set-value and the reset value. The reset value must be at least 0.5º less than the set-value. Range for set value is 1-8º and for reset value 1.5-7.5º.

Only positive values can be entered, but the settings are valid at both sides.

The factory setting is 5.0º, and factory setting of independent tilt swich is 9.9º.

ZERO
To compensate for minor mounting errors of inclinometer, a zero calibration must be carried out. Be sure that the ship is completely at even heel when performing this calibration. When key ‘CAL’ is pressed, the display will show 0.0º.

Because this setting is essential for the system, a security function is provided: Normally the text ‘FUNCTION DISABLED’ is shown (as opposed to ‘READY’). At commissioning and later service, a temporary connection between +24VDC and input ‘CALIBRATE’ (see el. drawings for the system) on the PLC is necessary. When this connection is made, text ‘FUNCTION DISABLED’ will change to ‘READY’. Remember to remove this connection afterwards to avoid unauthorised access!

Settings: DELAY

Delay Valve/Pump:
The best time to start the pump is when the valve is half-open. If it is started too early the result is heavy start (long starting time). If it is started too late, result is backflow of water in pipe (heavy start and bad performance) and slow response of the system. Here the delay can be adjusted form 1 to 10 seconds. Key in the best value based on measurements.

Hour counter

From Main Menu, select 'HOURS'. In this window run hour for pump and number of starts is displayed.

The counters can be reset if text 'READY FOR RESET' is displayed.

To avoid unwanted reset, a security function is provided: Normally the text 'RESET DISABLED' is shown (as opposed to 'READY FOR RESET'). At commissioning and later service, a temporary connection between +24VDC and input 'CALIBRATE' (see el. drawings for the system) on the PLC is necessary. When this connection is made, text 'RESET DISABLED' will change to 'READY FOR RESET'. Remember to remove this connection afterwards to avoid unauthorised access!

ALARM SYSTEM

When an alarm occurs, a buzzer in operator terminal will sound and a mark 'ALARM' will appear in upper right corner of display. Depending on the actual alarm and state of system (operational function auto / manual), the pump may stop and valve close. The tables in following sections explain all possible alarms in the system.

To accept an alarm, first press the key **LIST**.

If more than six alarms are present, use arrow keys to view all of them. Display of date/time line can be turned on/off by pressing the TIME soft key.

A symbol is shown to the left of an alarm message. There are three different symbols:

*	New alarm, still present, not accepted
$	New alarm, turned off, but not accepted
-	Alarm still present and already accepted. Will disappear from display when fault condition is corrected.

Note that the same source of an alarm (e.g. a low-level switch) can generate several alarm lines if the switch is activated and deactivated several times. Each line has to be accepted.

Press the key **ACK** to accept the current selected alarm. Symbol * changes to -, and alarms with symbol $ disappear.

The buzzer is turned off when all alarms are accepted, i.e. when no * or $ symbols are present.

Valve alarms

VALVE NOT OPEN

Control system tries to open the valve, but cannot get open feedback. Operator specifies delay; range is 1.0 to 20.0 s. It is important to set this value at commissioning.

VALVE NOT CLOSED

Control system tries to close the valve, but cannot get closed feedback. Operator specifies delay; range is 1.0 to 20.0 s. It is important to set this value at commissioning. Note that if starter is set in local, this alarm will be inhibited.

VALVE ERROR

Both open and closed feedback at the same time.
Faultfinding: Check air (hydraulic) and electric supply to valve. Check that valve is not stuck in any position. Check function of open and closed limit switch.

Pump alarms

PUMP STILL RUN PORT / PUMP STILL RUN STBD

Control system gives no start command, but run feedback from starter is received. Cause could be bad wiring or burned contactor in starter. Note that if starter is set in local, this alarm will be inhibited.

PUMP START FAIL PORT / PUMP START FAIL STBD

Control system gives start command, but does not receive run feedback from starter. Emergency stop switch on starter must be in normal position. Isolating switch must be on, and there must be power to starter. Note that if starter is set in local, this alarm will be inhibited.

PUMP HIGH START FREQUENCY

If the start-frequency exceeds 30 starts per hour for some time, alarm occurs. Turns off after a while if frequency is reduced.
Reduce start frequency by either:
- increase difference between start and stop angle
- use start delay

PUMP LEAKAGE DETECTION

Level in leakage detector box is too high. Check level in tank manually. Replace pump seals if necessary.

Heeling tank level alarms

LOW LEVEL IN PORT TANKS / LOW LEVEL IN STBD TANKS

Water level in port/stbd heeling tank is below level switch or setting for level transmitter. Delay is 3s. Disabled if mode is BLOCKED, or if mode is SEAMODE and pump is *not* running. Use the ballast system to make a coarse adjustment of heel. Both tank sets must have low level before the alarm is initiated.

HIGH LEVEL IN PORT TANKS / HIGH LEVEL IN STBD TANKS

Water level in port/stbd heeling tank is above level switch or setting for level transmitter. Delay is 3s. Disabled if mode is BLOCKED, or if mode is SEAMODE and pump is *not* running. Use the ballast system to make a coarse adjustment of heel. Both tank sets must have low level before the alarm is initiated.

Vessel's list alarms

CRITICAL HEEL TO PORT / CRITICAL HEEL TO STBD

Heel to port/stbd exceeds the set point for critical heeling alarm. The source can also be the independent heel switch. One set point when alarm is activated, and another when it is deactivated. Port and stbd set points have same value, but at different sides. Alarm is disabled if mode is BLOCKED or SEAMODE, except if source is tilt switch.

Control system alarms

LOW BATTERY LEVEL IN CONTROLLER

The battery in PLC has low voltage. Battery is used for keeping setpoints (like alarm limits) when power to control system is turned off. Service life of battery is approximately 5 years. PLC will operate correctly for about one month after first alarm occurs.
The battery must be replaced to prevent leakage from battery/consequential damages, at least every 5 years or at a shorter interval if the alarm is initiated.
Battery type: Mitsubishi F2-40BL. (FM Id.no.A30662)

INCLINOMETER FAULT

The inclinometer is faulty or not mounted properly, or the wiring is bad. Current in loop is below 2mA.

EMERGENCY STOP

Emergency switch on control panel(s) is (are) operated. Emergency stop switch on starter is not included in this alarm.

COMM ERROR

Connection between operator terminal and PLC is faulty, or there is no power supply to PLC. Check connection of cable between panel and PLC.

Effect of alarms / modes

These table shows, which operations are not allowed (X) when various alarms are present. The table also shows which operations are not allowed when mode is BLOCKED or SEAMODE.

	Auto	Goto port	Goto stbd	Manual port	Manual stbd	Manual valve
VALVE NOT OPEN	X	X	X	X	X	X
VALVE NOT CLOSED	X	X	X	X	X	X
PUMP STILL RUN PORT	X	X	X	X	X	X
PUMP STILL RUN STBD	X	X	X	X	X	X
PUMP START FAIL PORT	X	X		X		
PUMP START FAIL STBD	X		X		X	
PUMP HIGH START FREQUENCY	X					
PUMP LEAKAGE DETECTION	X					
LOW LEVEL IN PORT TANKS	X		X		X	
LOW LEVEL IN STBD TANKS	X	X		X		
HIGH LEVEL IN PORT TANKS	X	X		X		
HIGH LEVEL IN STBD TANKS	X		X		X	
CRITICAL HEEL TO PORT	X	X		X		X
CRITICAL HEEL TO STBD	X		X		X	X
LOW BATTERY LEVEL IN CONTROLLER						
INCLINOMETER FAULT	X	X	X	X	X	X
EMERGENCY STOP	X	X	X	X	X	X
BLOCKED MODE	X	X	X	X	X	X
SEA MODE	X	X	X			

INTERFACE SIGNALS BETWEEN HEELING SYSTEM AND SHIPS MONITORING SYSTEM

The following output signals from heeling system to vessel's monitoring system are included:

- Heeling signal
  Heeling signal occurs when vessel's list exceeds a certain angle. Operator can set the angle. Heeling signal is only an output signal to other systems like deck cranes. It does not affect common alarm output or alarm system on operator terminal.

- Common alarm.
  This is an output to vessel's alarm system, indicating that an alarm is present on heeling system.

- For other signals ref. actual interconnection diagram.