SECTION 6
SPECIAL APPLICATIONS

Introduction

In addition to the standard operational modes and functions, various tailored functions are available to optimise vessel operation for a wide range of applications and vessels.

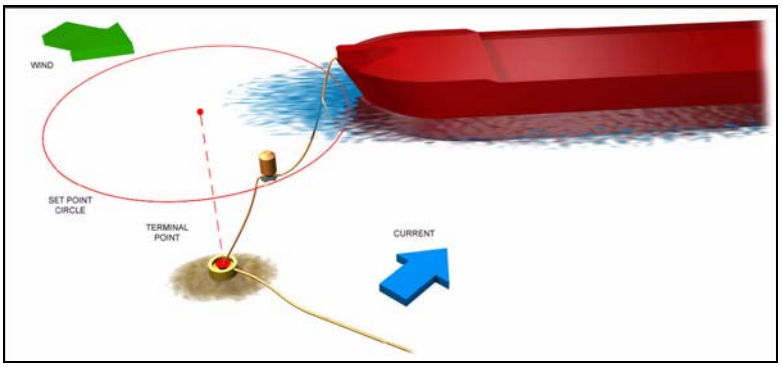
The following applications are described in this section:
- *Offshore loading*
- *Cable laying*
- *Pipe laying*
- *Trenching*
- *Dredging*
- *Drilling.*

Kongsberg Maritime AS also supplies tailored functions for many other special application areas.

Offshore Loading

When loading oil offshore, it is possible to reduce the thruster/propeller force required to retain the vessel's position relative to the offshore loading buoy, by utilising the stabilising effect of the environmental forces acting on the vessel's hull. In order to achieve this reduction, the vessel's bow must always face the environmental forces. The system therefore includes special *Weather Vaning* operation modes which cause the vessel to always point towards the environmental forces.

Weather Vaning causes the vessel to act like a weather vane. The vessel is allowed to rotate with the wind, current and waves around a fixed point called the **terminal point.** Neither the heading nor the position of the vessel is fixed. The heading of the vessel is controlled to point towards the terminal point, while the position is controlled to follow a circle, called the **setpoint circle**, around the terminal point. *Weather Vaning* is illustrated in the following diagram.



This kind of weather vaning requires a minimum sideways holding force, and the available thruster capacity on the vessel is

used for maintaining the correct distance and heading towards the terminal point.

The vessel's position is not controlled in the athwartships direction. The vessel's motions are only damped.

The terminal point, the setpoint circle and the maximum and minimum distances that the vessel may move from the terminal point are defined by the operator. The distance from the terminal point is monitored and an alarm is given if one of these limits is exceeded.

Depending on the type of offshore loading operation, the following functions may also be available:

• *Terminal Point Selection*

Displays a Terminal Point Definitions menu containing fixed locations where the vessel can perform weather vaning. Each definition consists of specific data for each terminal point, such as coordinates, default setpoint radius and alarm limits.

• *Setpoint Circle Radius*

Enables the operator to change the setpoint circle with predefined maximum and minimum limits.

• *Approach to Weather Vaning Location*

Causes the vessel to perform weather vaning while approaching the terminal point. This mode enables the selection of a *Setpoint Circle Radius* from 1000 meters and downwards to normal operational values.

The vessel's position relative to the outer alarm limits will not be monitored during the *Approach to Weather Vaning Location* mode.

• *"Drive-Off" Alert*

The following critical alarms will result in a "Drive-Off" alert displayed as a dialog box on the screen:

- Large speed towards buoy
- Setpoint / feedback errors on the main propellers
- Position Dropout
- Abnormal surge force towards buoy

This is in addition to the normal audible and visible alarm indications.

• *Hawser Tension Compensation*

Provides optimum positioning performance. This function automatically counteracts forces from the tensioning arrangement by using the tension measurement as input to

the DP system's mathematical model. Note that this function requires an interface to the tension measurement system.

• *Manual Bias*

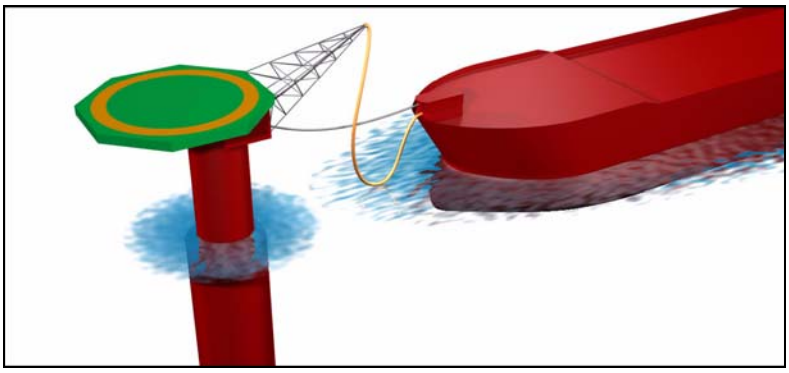
Reduces the vessel's position deviation caused by the impact of a series of high waves on the hull in rough weather. *Manual Bias* allows the operator to use the joystick on the DP console to adjust the thruster/propeller force, and thus counteract the expected wave force. The function is only available for some terminal point types (OLS, SAL, SPM, FLT/FLP).

Depending on the loading concept, different types of *Weather Vaning* operation modes will be used.

Single-Point Mooring (SPM)

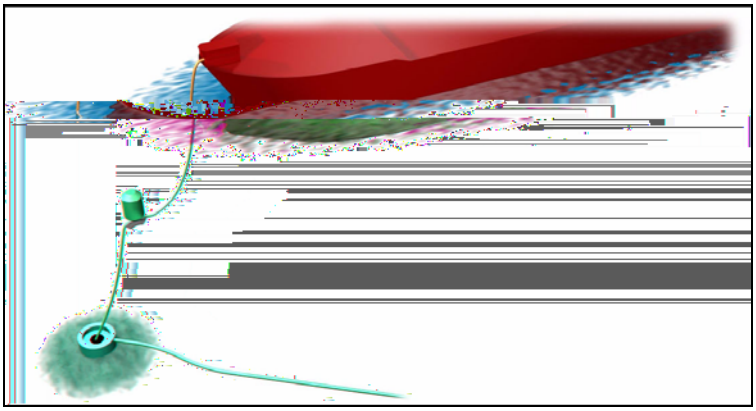
This type of weather vaning is made around the boom-tip of a mooring buoy. The boom-tip acts as the terminal point and the position of the terminal point will vary since the boom can move. The station-keeping may be performed with or without tension in the mooring hawser. If the vessel has sufficient thruster capacity, it is generally advisable to have zero tension in the mooring hawser.

One or more buoy-relative position-reference systems are needed.



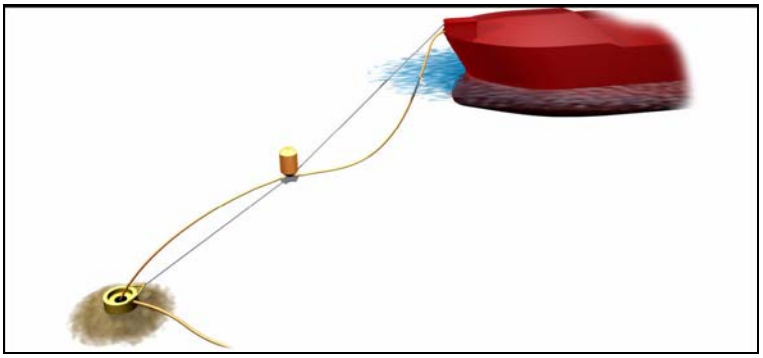
Loading Buoy without Mooring (OLS)

This type of weather vaning is made around a fixed terminal point. No mooring arrangement is used. One or more absolute position-reference systems are needed.



Single Anchor Loading (SAL)

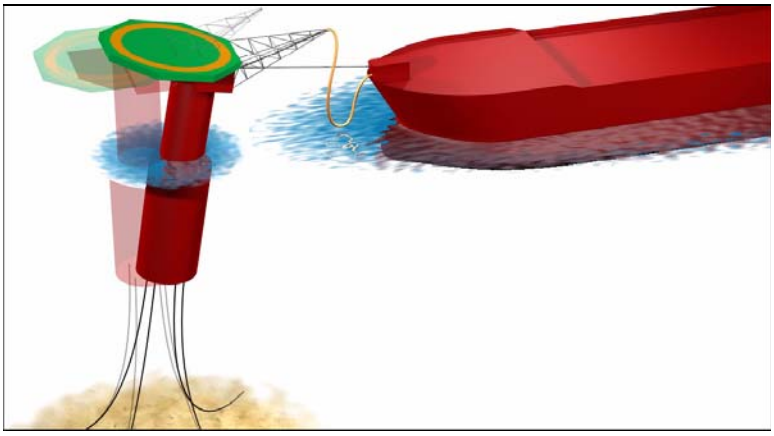
This type of weather vaning is made around a fixed terminal point i.e. the anchor (moored buoy). The vessel is linked to the buoy/anchor by a single mooring hawser. There is always tension in the mooring system. One or more absolute position-reference systems are needed.



Floating Loading Tower / Platform

This type of weather vaning is made around the boom-tip of a Floating Loading Tower/Platform (FLT/FLP). The boom-tip acts as the terminal point and the position of the terminal point will therefore vary. These variations will also be affected by the mooring arrangement for the FLT/FLP. The station-keeping may be performed with or without tension in the mooring hawser. If the vessel has sufficient thruster capacity, it is generally advisable to have zero tension in the mooring hawser.

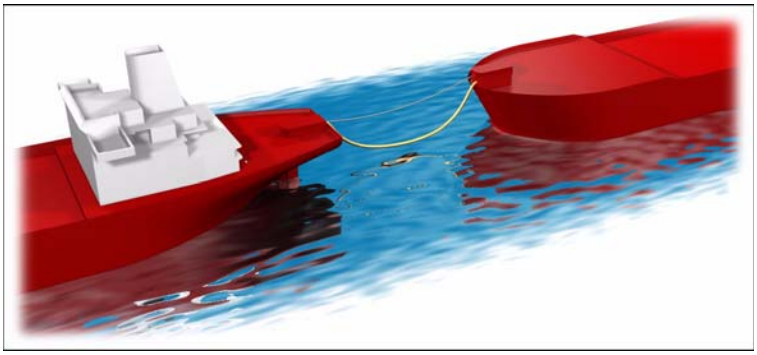
The best performance is obtained if both the vessel's position relative to the FLT/FLP boom-tip and the vessel's geographic position are measured. The actual platform position of the FLT/FLP will then be monitored against the nominal platform position.



Tandem Loading

This type of weather vaning is made around the stern of a Floating Storage Unit (FSU) or a Floating Production, Storage and Offloading (FPSO) vessel. The stern of the FSU/FPSO acts as the terminal point and the position of the terminal point will therefore vary. The station-keeping may be performed with or without tension in the mooring hawser. If the vessel has sufficient thruster capacity, it is generally advisable to have zero tension in the mooring hawser.

The best performance is obtained if both the vessel's position relative to the FSU/FPSO and its geographic position are measured and communicated to the DP system. Alternatively only relative position-reference systems may be used.



During *Tandem Loading* the terminal point will move due to the FSU/FPSO movement. *Special Tandem Loading function* may also be incorporated to increase the safety during Tandem Loading. In addition, reduced fuel consumption and reduced wear and tear on the thrusters will be achieved.

Special Tandem Loading functions:

• *Tandem position control* to counteract the effects of FSU/FPSO surge and fishtail movements.

• *Tandem heading control* to follow FSU/FPSO heading changes.

These functions require a combination of absolute and relative position-reference systems as well as access to/communication with the gyro of the FSU/FPSO.

Submerged Turret Loading

For Submerged Turret Loading (STL) the weather vaning is performed in three phases:

• Approaching the Submerged Turret. In this phase the DP control system is in *Approach to Weather Vaning Location* mode.

• Connecting (and Disconnecting) the Submerged Turret. In this phase the DP control system is in *Connect and Disconnect* mode.

• Loading while connected to the Submerged Turret. In this phase the DP control system is in *Loading* mode.

In all phases the weather vaning is made around the turret.

In the loading phase, the forces from the mooring arrangement are taken into consideration. The operator can also use the Axis Control and the Mean Offset functionality:

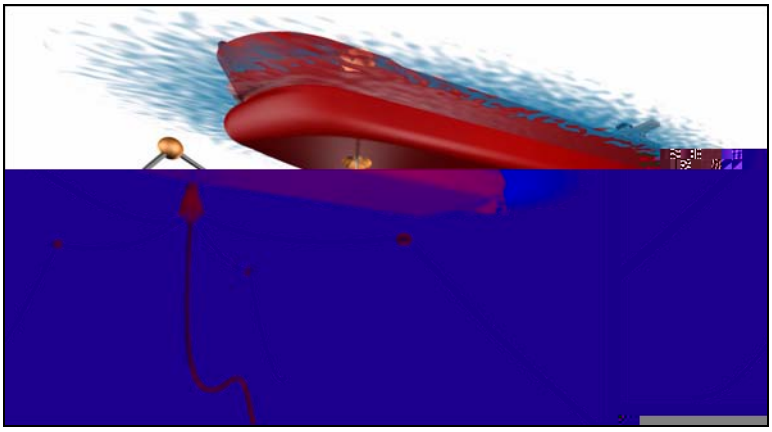
• Axis Control. Allows the operator to select automatic or manual position control, or only vessel-motion damping, in surge, sway and yaw axes. By selecting vessel-motion

damping alone, the vessel speed can be damped without using thruster force to maintain position.

• Mean Offset.The vesselwill be kept at the operator specified mean distance from the base position using only surge thrust in the positive direction. If automatic position control in the surge axis is selected, the Mean Offset functionality is not available. However, it can be combined with damping control in the surge axis.

One or more absolute position-reference systems are needed. An HPR system may be used to provide the position of the vessel relative to the base position. The additional HPR transponder located on the turret (STL buoy) allows the system to monitor the position and depth of the turret while it is not connected.

Submerged Turret Loading during the connecting phase is illustrated in the following diagram:



Cable Laying

Power and communication cables are transported on reels and are laid either over the stern of the vessel as the vessel moves forward, or over the side of the vessel as it moves sideways.

In *Auto Track (low-speed)* and *Auto Track (move-up)* modes, the vessel may be controlled either so that the vessel follows a defined vessel track or so that the pipe is laid along a defined pipe track.

In *Auto Position* mode, no track has to be inserted into the DP system.

• *One Pipe-Length Ahead*

Moves the vessel forward by a distance equal to one pipe-length. The pipe-length is specified by the operator. This functionality is available in *Auto Position* and *Auto Track (move-up)* modes.

• *Pipe Tension Monitoring*

Monitors the tension in the pipe and gives an alarm if the tension is higher or lower than the specified maximum or minimum tension limits. Note that this function requires an interface to the tension measurement system.

• *Pipe Tension Compensation*

This function automatically counteracts forces from the tensioning arrangement.The tensionmeasurement is used as input to the DP system'smathematical model. Note that this function requires an interface to the tension measurement system.

• *Emergency Stop*

If the pipe tension is above selected limits, automatic stop of the vessel along track can be activated to avoid further increase of tension.Adigital status signal from the tensioner system can also be used to activate the function. This functionality is available in *Auto Track (low-speed)* and *Auto Track (move-up)* modes. The stop function uses a special velocity controller in Surge to retard the vessel from any speed to "zero speed". At "zero speed" the system will use the normal *Stop On Track*.

• *Touchdown Track Control*

When controlling the vessel along a track, the distance from the vessel to the pipe touchdown point can be specified. During awaypoint turn, the vessel track will be calculated so that the pipe touchdown point will be located on the intended track.

• *Manual Forward Thrust*

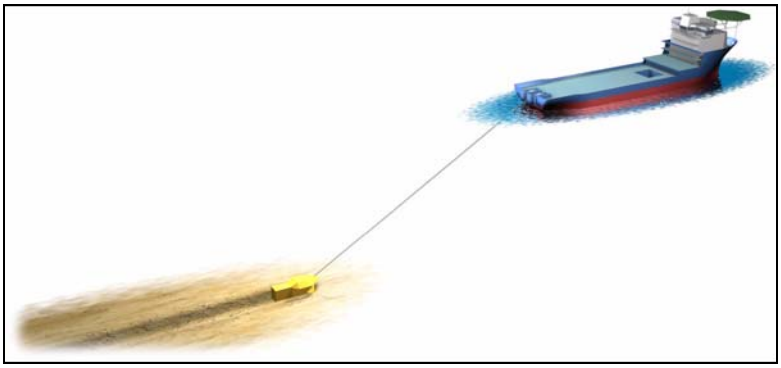
For continuous laying of flexible pipe, this function enables the operator to give a manual demand in the surge direction either from a lever/potentiometer, or using the dedicated

Alongships Control dialog. This *Manual Forward Thrust* is an alternative to the computer-calculated or joystick demand.

Trenching

Trenches may be dug prior to cable- or pipe-laying operations, and are used to secure the pipe or cable after installation. Trenches are dug by a self-driven trencher or by a vessel towing a plough.

When digging trenches, the DP system uses the *Follow Target* mode to follow the trencher's movements, whereas a special version of the *Auto Track (low-speed)* mode is used to control the vessel's movements when using a plough to dig the trenches.



During trenching operations, the Plough Tension Monitoring and Plough Tension Compensation functions are used to ensure the best performance.

• *Plough Tension Monitoring*

Monitors the tension in the plough and gives an alarm if the tension is higher or lower than the specified maximum or minimum tension limits. Note that this function requires an interface to the tension measurement system.

• *Plough Tension Compensation*

This function automatically counteracts forces from the tensioning arrangement.The tensionmeasurement is used as input to the DP system'smathematical model. Note that this function requires an interface to the tension measurement system.

• *Emergency Stop*

If the plough winch tension is above selected limits, automatic stop of the vessel along track can be activated to avoid further increase of tension.Adigital status signal from the plough winch can also be used to activate the function.

This functionality is available in *Auto Track (low-speed)* mode. The stop function uses a special velocity controller in Surge to retard the vessel from any speed to “zero speed”. At “zero speed” the system will use the normal *Stop On Track.*

• *Plough Track Control*

When controlling the vessel along a track, the distance from the vessel to the plough can be specified. During a waypoint turn, the vessel track will be calculated so the plough will be positioned on the intended track.

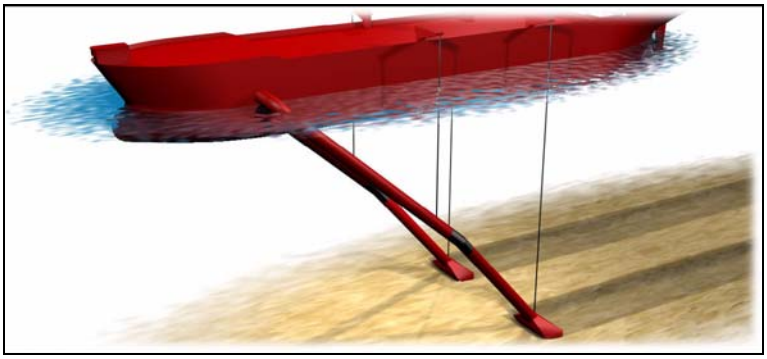
• *Manual Forward Thrust*

Enables the operator to give a manual demand in the surge direction either from a lever/potentiometer, or using the dedicated Alongships Control dialog. This *Manual Forward Thrust* is an alternative to the computer-calculated or joystick demand.

Dredging

The main function of dredgers is the removal and transport of material from the seabed. Specific activities in this field include:

• maintenance dredging work in harbours and waterways
• construction or deepening of harbours, waterways
• extraction of precious metals, minerals, sand and gravel
• build-up of sites, replenishment of beaches, and building of dams, dykes and artificial islands
• removal of polluted seabed
• digging of trenches for tunnels and pipelines
• land reclamation and improvement of infrastructure.



The DP system’s dredging functions measure the dredging forces and suction-pipe position relative to the vessel, and automatically compensate for these draghead forces. In addition, the DP system handles failure in draghead force measurements and thereby avoids uncontrolled vessel movement and damage to the dragheads. If a permanent failure occurs in the sensors monitoring the draghead’s position and tension, the operator can

specify the appropriate draghead data, thus enabling the dredging operation to continue.

The DP system and the special dredging functions offer:

• Precise coverage of the dredging area by accurately controlling the draghead position along a predefined track at a predefined speed.

• Handling of rapid changes in the sea current. This is especially important when dredging from a harbour through breakwaters to the open sea.

• Accurate and reliable vessel position and speed control which reduces the risk of damage to the dredging equipment and simplifies the continuation of the dredging activity after any interruptions in the operation.

The special dredging functions are as follows:

• *Draghead Position Control*

The *Draghead Position Control* function, in combination with the *Auto Track (low-speed)* mode of operation, automatically controls the vessel's position and heading, enabling the master draghead to follow a predefined track. The operator can select one of the dragheads, its pipe inlet point or no draghead (i.e. centre of gravity of the vessel) as the master draghead.

The *Auto Track (low-speed)* mode controls the vessel's speed and optimum heading for keeping the vessel on track. The determining factors here are wind, waves, current, vessel speed and draghead forces.

The Posplot view with track information is extended to show the position of the dragheads.

Note that this function requires an interface to the dredge head position sensors.

• *Suction-Pipe Ship-Side Limit*

In order to avoid damage to the suction pipe or the vessel, the shortest distance from the vessel to the suction-pipe gimbals, suction pipe or the lifting wires can be measured. If the distance is too short, an audible alarm is given, and the automatic heading control loop will be forced to avoid further decrease of the distance. When in *Auto Track (low-speed)* mode, this restriction of the heading can lead to drift off from the preplanned track.

• *Vessel Speed Control*

When the draghead is on the seabed, it is of vital importance that the draghead does not move backwards.

When enabled, this function prevents the forward speed of the dragheads from becoming too low. This requirement overrides any requirement for track keeping or required speed.

• *Draghead Force Compensation*

The *Draghead Force Compensation* function enables automatic compensation of the draghead forces acting on the vessel. One or twodragheadsmay be used, and the resistance from each draghead will vary depending on the seabed substance, the trail speed and the deflection angle of the suction pipes and dragheads.

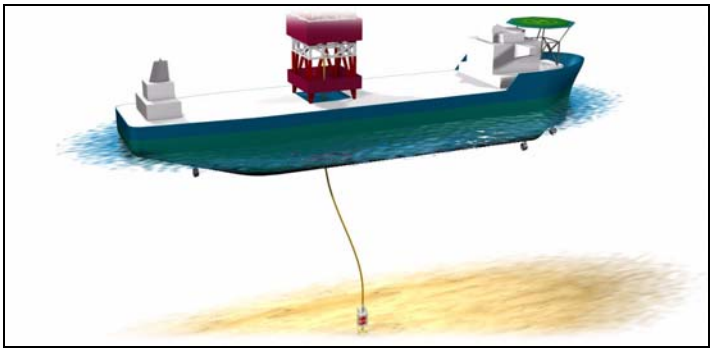
The dredging force from each draghead must be accurately measured. The thrusters directly compensate for the forces and moments from the dragheads. Draghead forces will also be used to update the mathematical model.

The system is also able to handle draghead-force measurement failure or total loss of measurements. This function is important in order to prevent the dragheads from moving backwards. The system design enables operation, even with the permanent loss of dredging force measurements, by using fixed, specified tensions on the suction pipes.

Note that this function requires an interface to the dredge force sensors.

Drilling

The Riser Angle Monitoring (RAM) function allows optimal vessel positioning during drilling operations.



The following functions are provided:

• *Monitoring of Flexjoint Sensors*

Monitoring of the lower flexjoint angle against defined limits.

• *Monitoring of Tensioner-Stroke Sensors*

Monitoring of the tensioner-stroke sensor values against upper and lower limits.

• *Zero-Angle-Position Advisory Function*

The lower flexjoint angle should be kept to a minimum to reducemechanical wear. The *Zero-Angle-Position Advisory Function* uses the riser angle measurements to calculate the vessel position advice that will bring the lower flexjoint angle to zero. The *Zero-Angle-Position Advisory Function* gives a zero-angle-position for each lower flexjoint angle sensor, and also a zero-angle-position for the composite angle.

• *Hold Flexjoint Angle Function*

The *Hold Flexjoint Angle Function (HFA)* is a submode of *Auto Position* mode and takes an active part in the positioning of the vessel. In this submode, the system will try to position the vessel tomaintain the lower flexjoint angle as it was when the submode was entered. Based on measured riser angles and estimated static riser angle response to vessel movements, the function will continuously adjust the required position to maintain the lower flexjoint angle.

• *Emergency Joystick Advisory Function*

In *Auto Position* mode (during position dropout) and in *Joystick* mode, the *Emergency Joystick Advisory Function* provides, on the relative Posplot view, a graphical indication of the direction in which manual thrust must be applied in order to move the vessel towards the optimum position calculated by the *Zero-Angle-Position Advisory Function.*

• *Illegal Heading Sector Limits*

Enables the operator to specify an illegal heading sector for riser configurations which do not permit a full 360_ rotation about the drilling axis. If the vessel's heading enters this sector, an alarm message is issued. An instruction to turn either to port or to starboard is included in the message, depending on the direction from which the heading entered the illegal sector. When these limits are enabled, the illegal heading sector is also displayed on the Posplot view.

• *Posplot View Extension*

Enables the operator to make some drilling features visible on the Posplot view. This includes the BOP position at the manually-configured BOP position coordinates, the calculated zero-angle-positions for each individual riser inclinometer and the zero-angle-position for the composite

angle. The hold flexjoint angle symbol and the illegal heading sector are also shown.

• *Riser View*

The Riser view shows graphical and numerical information about the riser and BOP inclinations, the riser angles and the riser angle limits. The tensioner-stroke sensor values are shown numerically and as bar graphs.