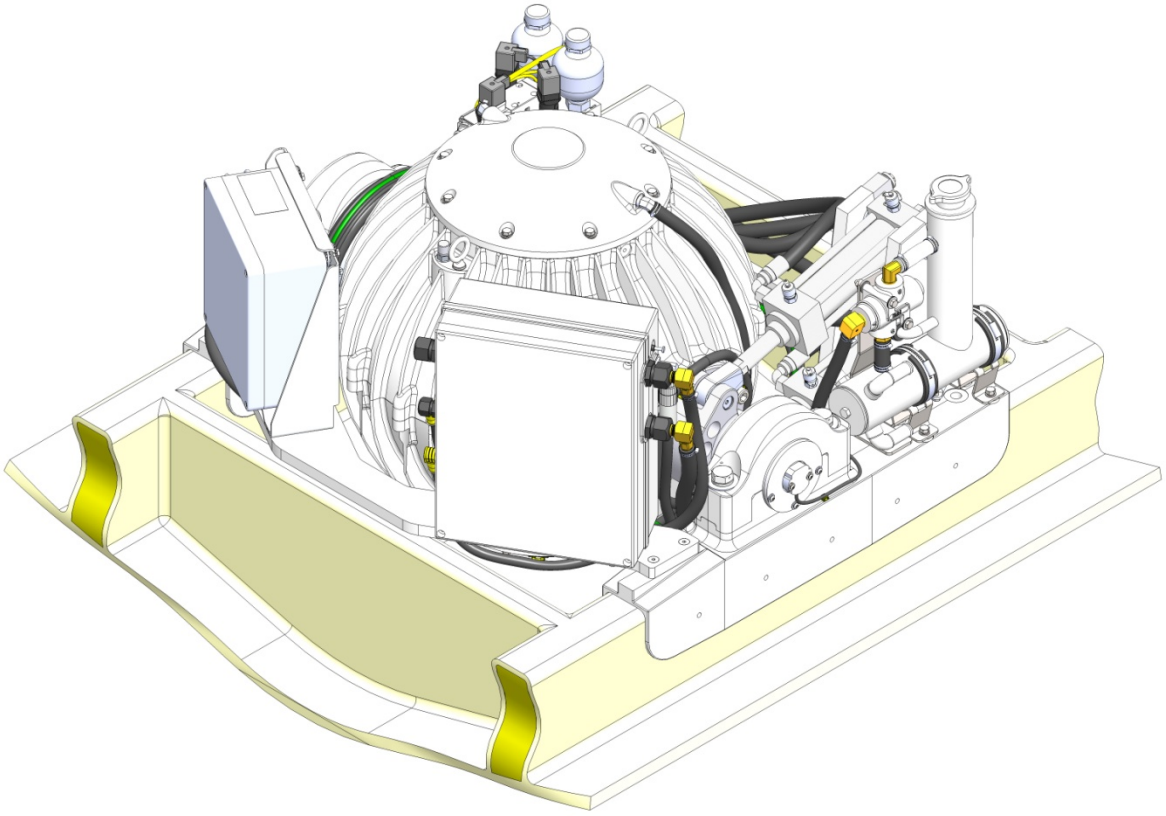
SEAKEEPER®

OPERATION MANUAL



MODEL 5500 GYRO

Rev 2 JULY 2013

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JULY 2013

Contents:

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1.0 System Overview

The Seakeeper Model 5500 Gyro uses gyroscopic principles to reduce boat roll motions in waves and wakes independent of boat speed. One Model 5500 Gyro will reduce the roll motions of a boat that displaces 5 to 15 tons. Boats with higher displacement typically require multiple gyros to provide good roll reduction. In multiple gyro installations, the gyros operate independently of each other and therefore this manual only discusses operation of a single unit.

A Model 5500 Gyro consists of a Gyro assembly (including Gyro Control Box and Compact Motor Drive Box), serial communications cable, and operator Display. Figure 1 illustrates the interconnection of these components and their interface with the boat.

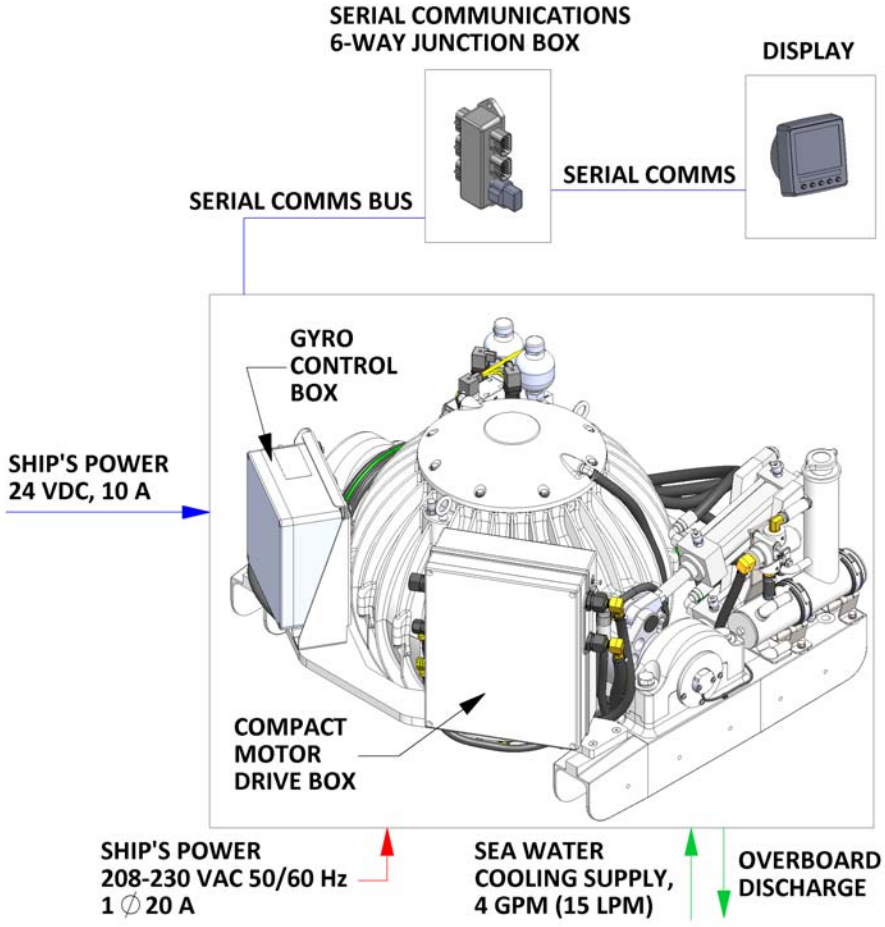


FIGURE 1 – MODEL 5500 GYRO STABILIZATION SYSTEM COMPONENTS

Technical specifications provided in Section 6 list the power consumption, total weight, and dimensions of the major components. Gyroscopic principals that apply to boat roll control are discussed on Seakeeper's web site at www.seakeeper.com. The Seakeeper web site also contains videos of gyro

operation and videos of several different boats operating in waves with the Model 7000 Gyro on and off. It is recommended that the reader play these videos prior to reading the remainder of this manual.

The gyro's gimbal angle and the gyro's rate of rotation about the gimbal axis (termed precession rate) play an important role in its operation. These parameters are illustrated in Figure 2. At zero degree gimbal angle, the gyro is vertical; it can precess a maximum of +/- 60 degrees about this position. The amount of torque that the gyro exerts on a boat's hull to counter the wave induced roll is directly proportional to the precession rate. The further the gyro is from vertical (zero degrees) the lower the anti-roll torque. The vertical arrows in Figure 2 illustrate the direction of the forces that the gyro exerts on the boat's hull to damp roll motion.

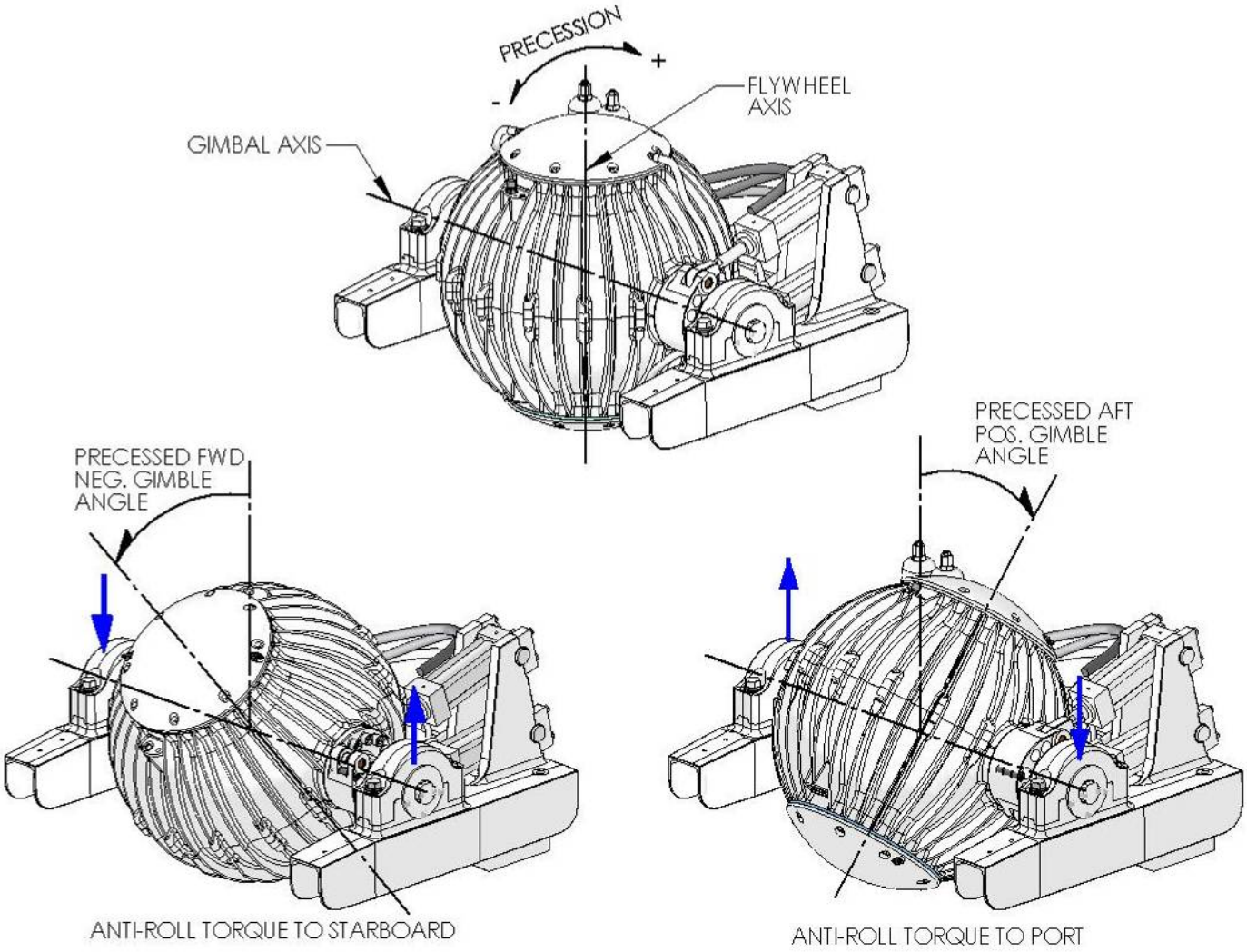


FIGURE 2 – GYRO PRECESSION

Seakeeper gyro precession is actively controlled by an electronic controller and a hydraulic brake throughout each roll cycle so the gyro supplies the maximum anti-roll torque and does not make mechanical contact with hard stops that limit the maximum gimbal angle travel to +/- 60°.

There is a large torque about the gimbal axis when the gyro is precessing. Therefore, the gyro should be housed in a compartment or installed in a cage so personnel cannot come into contact with the gyro while it is precessing. If it is ever necessary to touch the gyro while the flywheel is spinning, the Lock/Unlock button on the Display must be depressed to stop the gyro from precessing. Gyro maintenance should not be attempted unless the gyro is locked and the flywheel has stopped spinning.

1.1 Gyro Assembly

The gyro assembly consists of a flywheel housed in a cast aluminum vacuum-tight enclosure. The flywheel spins about a vertical axis and is supported by upper and lower pairs of bearings. A DC brushless motor mounted inside the enclosure spins the flywheel at high speed.

The enclosure is fastened to two gimbal shafts that are supported by gimbal bearings on either side. These shafts establish an athwartship gimbal axis about which the flywheel and enclosure precess or rotate up to +/- 60 degrees during operation. Each of the gimbal bearings is supported by a saddle beam which is bonded to the hull structure. These beams transfer the loads that the gyro produces to the hull structure.

An active hydraulic brake mechanism is located on the gyro assembly to regulate the gyro's precession motions about the gimbal shaft. It includes two hydraulic cylinders mounted on the brake saddle beam and a hydraulic manifold on the non-brake saddle beam.

A coolant pump, heat exchanger with reservoir, and thermostatic mixing valve are located on the brake saddle beam near the hydraulic cylinders. Braces forward and aft of the enclosure connect the brake and non-brake saddle beams. A glycol/water mix is circulated thru a closed loop to the motor drive box, hydraulic manifold, and the end caps of the enclosure to remove heat.

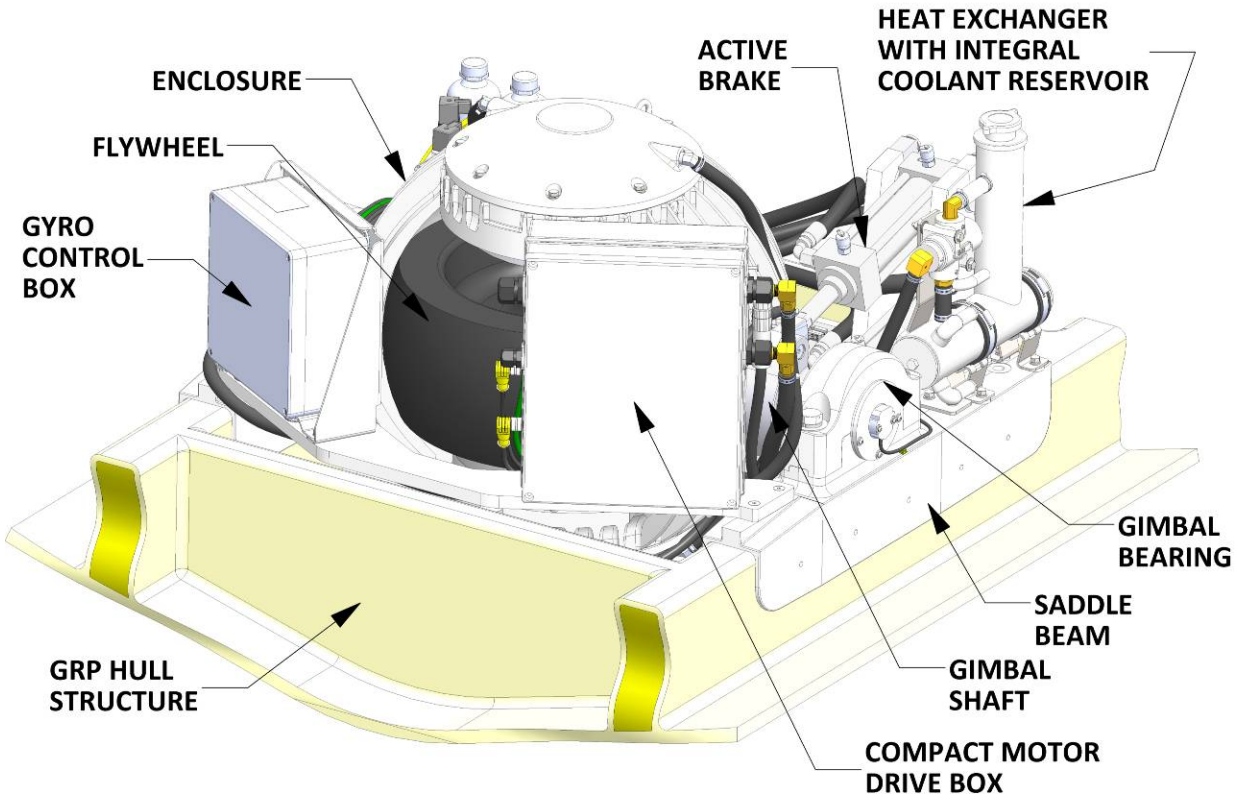


FIGURE 3 – GYRO ASSEMBLY

1.2 Display

The display shown below is the user interface to the Model 5500 Gyro and should be mounted at the primary helm station. It is used to start, operate, monitor and shutdown the Gyro. Sensors, alarms and shutdowns are provided to allow unattended operation. However the gyro is a high-speed machine and special attention should be paid to vibration and noise as this could be the first hint of a mechanical problem.

The display provides information in the event of an alarm. Alarms cause precession to stop (LOCK) and the gyro to start coasting down (STOP).

FIGURE 4 – OPERATOR DISPLAY

1.3 Compact Motor Drive Box

The Compact Motor Drive Box contains the electronic components that take 208-230 VAC at 50/60 Hz from the boat's generator or shore power and supply current to the flywheel motor according to commands from the Gyro Control Box. The glycol/water mix that cools the gyro is also circulated through a cold plate inside the drive box to remove heat from hi-power electronic components.

The Compact Motor Drive Box contains high voltage electronics and the cover should not be removed while the flywheel is spinning except by an authorized technician. This high voltage exists even if the flywheel is coasting down and the supply voltage has been shut off.

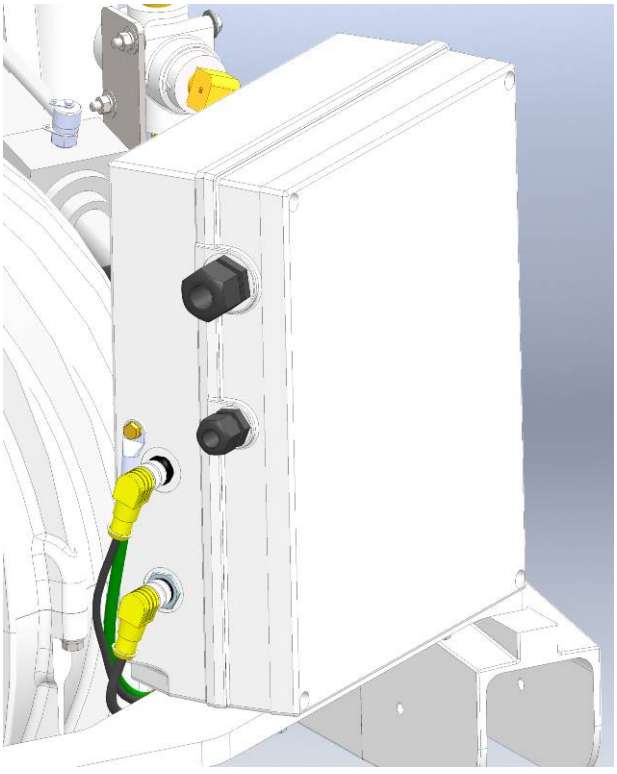


FIGURE 5 – COMPACT MOTOR DRIVE BOX (Left)

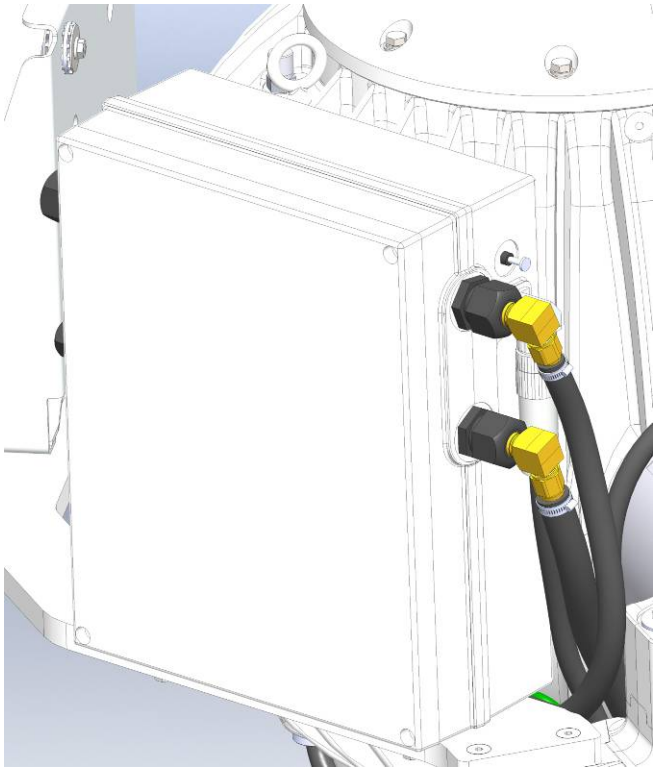


FIGURE 6 – COMPACT MOTOR DRIVE BOX (Right)

1.4 Gyro Control Box

The Gyro Control Box contains motion sensors and a controller module that monitors and automatically regulates operation of the gyro.

The motion sensor suite contains rate sensors that measure the angular movements of the vessel and accelerometers that measure the vertical and lateral boat movement.

The controller commands the motor speed and regulates the gyro's precession rate and gimbal angle. This is accomplished by commands to a high response flow control valve in the hydraulic brake circuit that increases or decreases brake pressure.

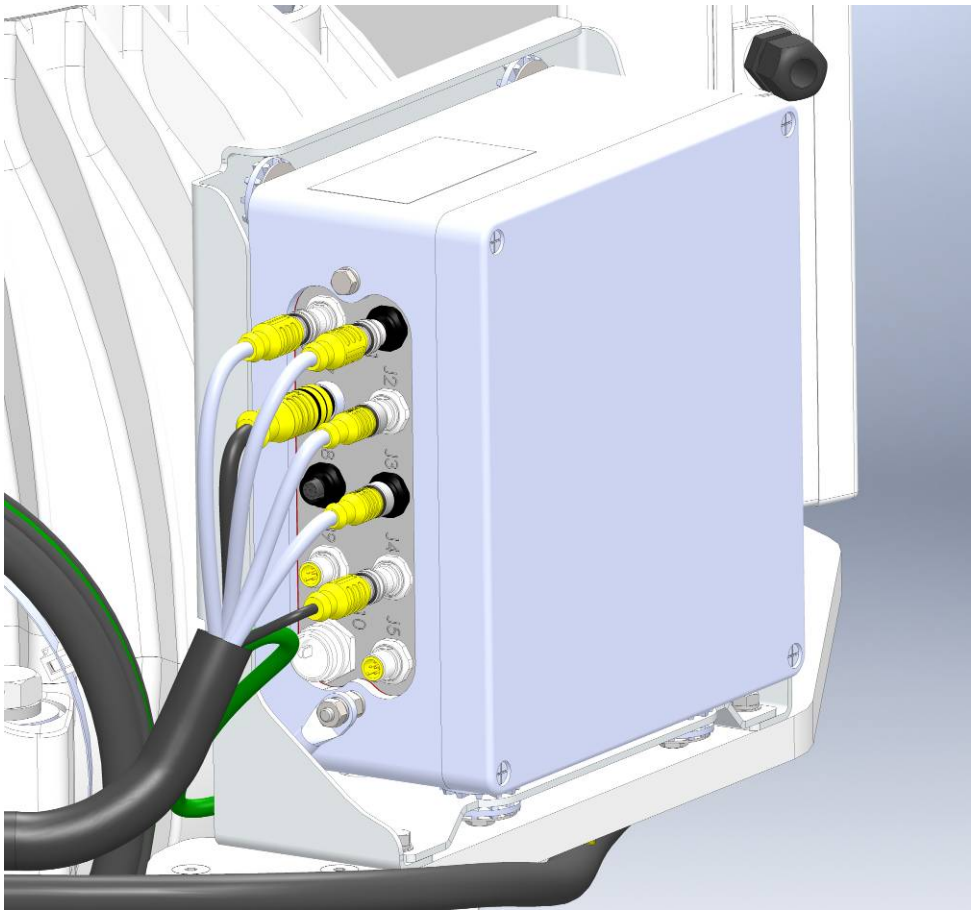


FIGURE 7 – GYRO MOUNTED CONTROL BOX

1.5 Brake

The brake mechanism consists of two hydraulic cylinders which are mounted on the brake saddle beam and attach to a crank arm on the gyro gimbal shaft. The hydraulic cylinders are plumbed to a manifold / valve assembly so when the gyro rotates about the gimbal axis, oil from one side of each cylinder is pushed through the high response flow control valve into the same side of the other cylinder. The gyro controller modulates how fast the oil can flow through the control valve thus controlling the precession rate of the gyro.

The brake hydraulic circuit is a pre-charged closed loop – that is, there is no pump, motor or reservoir in the circuit. Accumulators are installed in the circuit so the precharge pressure does not increase as the fluid temperature rises due to the braking action. Locking solenoids are installed in the circuit to lock the gyro so it cannot precess if there is a leak in the circuit or a mechanical problem with the gyro.

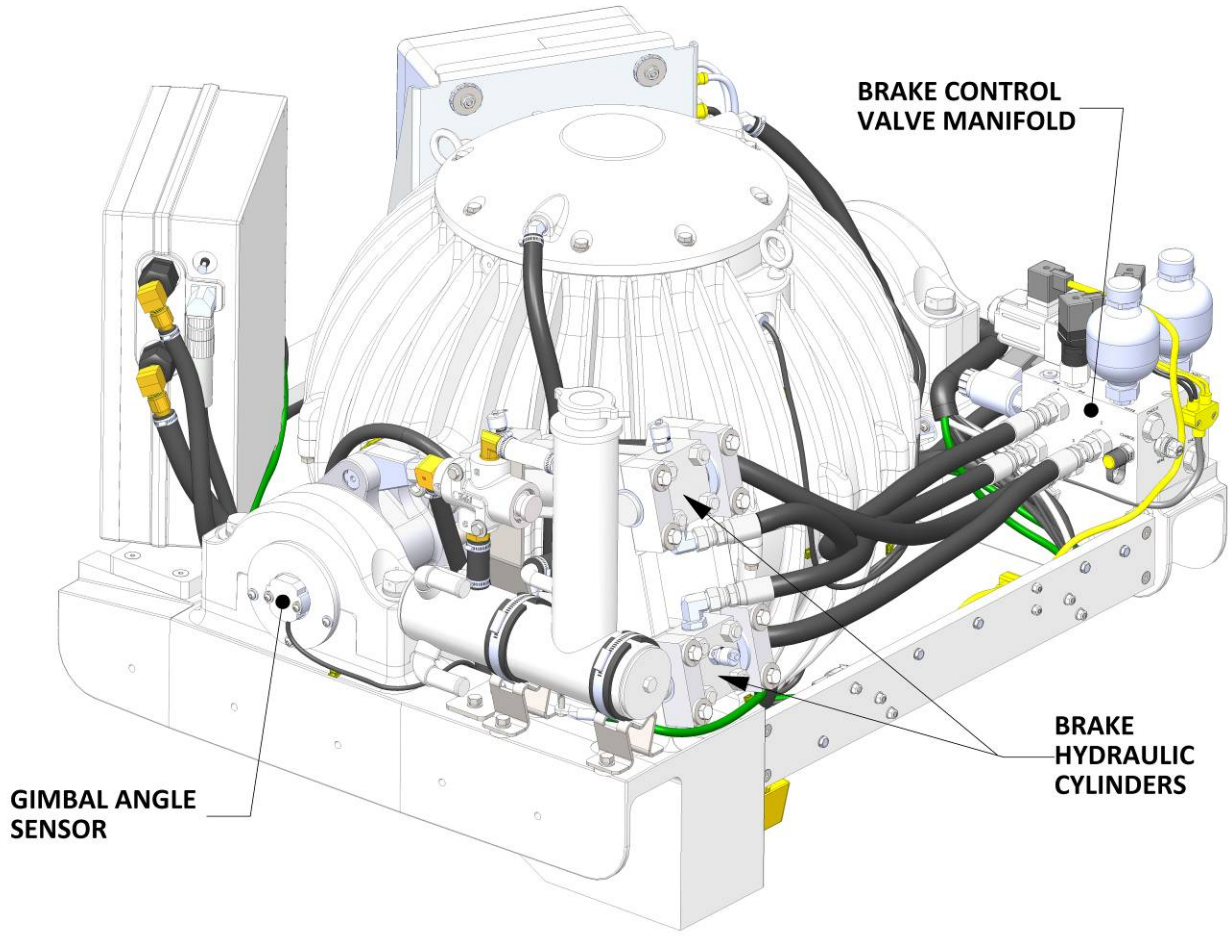


FIGURE 8 – BRAKE

1.6 Cooling

The cooling circuit is a closed loop that supplies a glycol/water (50% distilled water and 50% glycol) mix to:

- The motor drive box to remove heat from the drive electronics
- The brake manifold to remove heat from the brake hydraulic circuit
- The gyro enclosure water jackets to remove heat from the flywheel bearings

The heated fluid then passes through a thermostatic mixing valve before bypassing or flowing through a heat exchanger that has sea water on the cold side. The circuit also contains a coolant reservoir for coolant expansion and to make filling easy. The reservoir contains a 7 psi (0.5 bar) pressure cap.

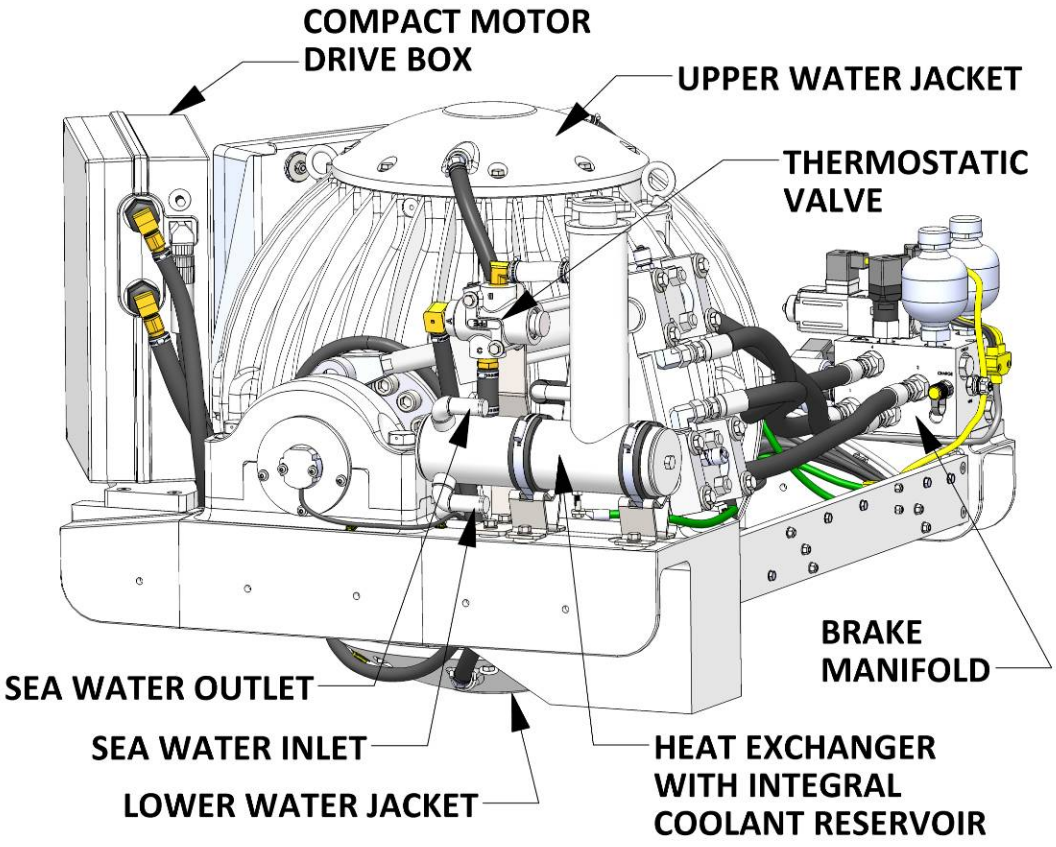


FIGURE 9 – COOLING SYSTEM COMPONENTS

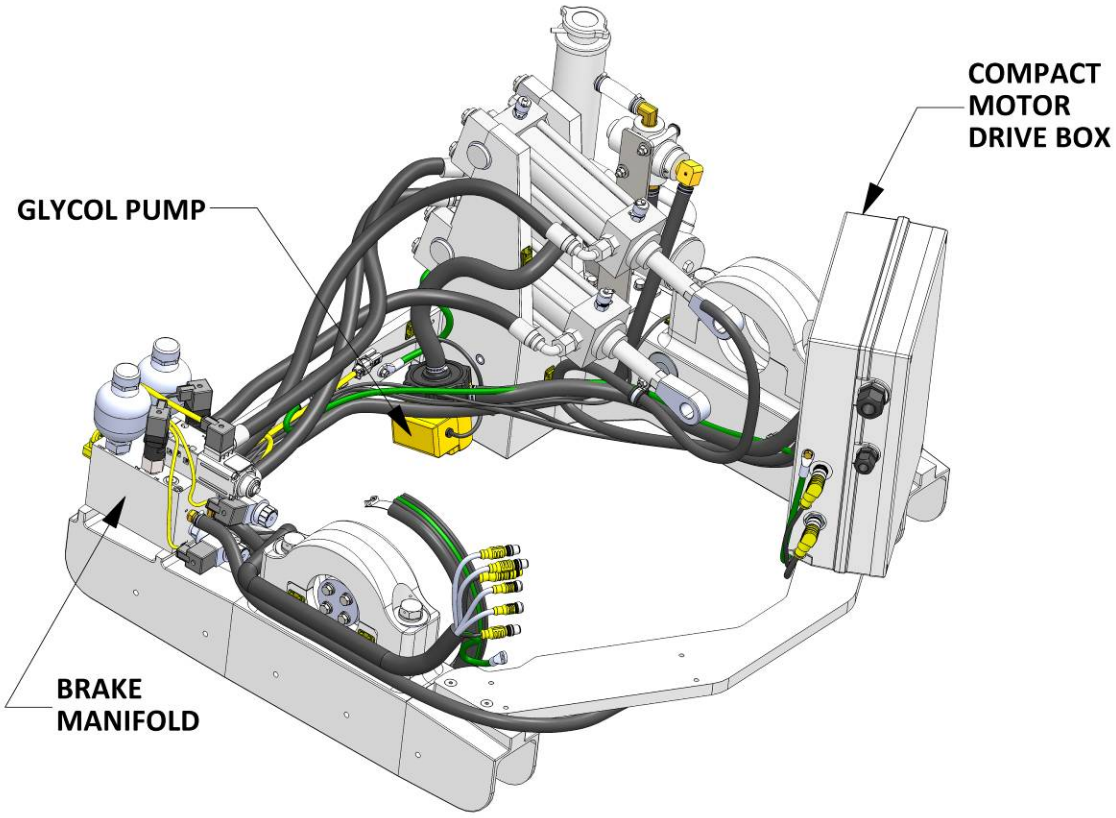


FIGURE 10 – COOLING SYSTEM COMPONENTS (Gyro Enclosure Hidden)

2.0 Introduction

This section describes operation of the Seakeeper Model 5500 Gyro system.

2.1 Display Screens: Overview

1) When 24 Vdc is applied to the Gyro Control Box the DISPLAY will power up and initialize. The SPLASH screen will be displayed

2) After the DISPLAY has initialized the HOME screen will be displayed

3) The DISPLAY has a set of five buttons that are under the BUTTON ICONS that appear on the display screen. The BUTTONS are the means for selecting the functions of the DISPLAY.

a. HOME Screen BUTTON ICON function

i.  GYRO ON/OFF and FAULT RESET

1. The ICON will change from red (GYRO OFF) to green (GYRO ON)
2. The ICON will turn red indicating the GYRO is off when a fault appears
3. When a FAULT occurs the BUTTON is used to reset the active fault

ii.  GYRO LOCK/UNLOCK

1. When the GYRO control is initializing, or the GYRO off, the lock symbols will both be blue
2. When the GYRO is in LOCK mode, stabilization is off, the LOCK symbol will be red 
3. When the GYRO is UNLOCK, stabilization is on, the UNLOCK symbol will be green 

iii.  DISPLAY DAY/NIGHT

1. Toggles the DISPLAY brightness between the Day and Night settings

iv.  HOME SCREEN VIEW

1. Switches the HOME screen views from an animation screen, to a screen displaying arrows with no animation, to a screen that shows GYRO rate on a graph

Home Screen with Animation: Flywheel will be spinning and gyro stabilizing

Home Screen with Arrows for flywheel spinning and stabilizing

Home Screen indicating Gyro Rate

v.  SETTINGS SCREEN

1. Changes from the HOME screen to the SETTINGS screen

4) When the button is depressed for the SETTINGS screen  the DISPLAY changes to the SETTINGS screen

a. SETTINGS screen BUTTON ICON functions

i.  Allows the brightness of the DISPLAY to be increased or decreased. The brightness settings for the DAY or NIGHT modes can be independently adjusted by selecting the DAY or NIGHT on the main page before entering the SETTINGS screen.

1. When the button is depressed the BRIGHTNESS settings appears

2. The BRIGHTNESS is decreased or increased by depressing the MINUS button  or the PLUS button 

3. To navigate back to the SETTINGS screen the BACK button is depressed 

ii.  Adjusts the sleep function of the DISPLAY from one minute to 30 minutes or the DISPLAY screen on all of the time

1. When the button is depressed the DISPLAY SLEEP TIMER setting appears

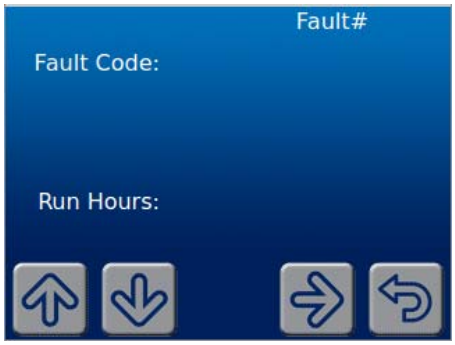
2. The SLEEP TIME is decreased or increased by depressing the MINUS button  or the PLUS button 

3. To return back to the SETTINGS screen the BACK button is depressed 

iii.  Changes the DISPLAY to the SERVICE screen

iv.  Returns the DISPLAY to the HOME screen

5) When the button is depressed for the SERVICE screen  the DISPLAY changes to the SERVICE screen. The SERVICE screen displays the FAULT history of the GYRO



a. SERVICE screen BUTTON ICON functions

i. To scroll through the ALARM history the UP button  and DOWN button  are depressed

ii. To change to the GYRO information screen the NEXT button is depressed 

iii. To change back to the SETTINGS screen the BACK button is depressed 

6) The GYRO information screen displays the GYRO model, GYRO serial number, GYRO software version, DISPLAY software version, RUN hours, and SEA hours. This screen also allows Seakeeper Service personnel access to additional service functions.

a. The RETURN button  will return the DISPLAY to the SERVICE screen

2.2 Start-up

1) Make sure AC and DC power are available.
2) Turn on the boat's DC circuit breaker that supplies power to the Gyro Control Box.
3) Turn on the boat's AC circuit breaker that supplies power to the Motor Drive Box.
4) In most cases, the seawater pump will be wired to turn on when the Gyro Control Box or Motor Drive Box is turned on. However, in some cases the seawater pump is on a separate AC or DC circuit breaker and it is necessary to turn it on.
5) When the DC power is turned on the DISPLAY will initialize and the HOME screen will appear. If a FAULT is present an ALARM screen will appear.

To turn the GYRO ON depress the POWER ON/OFF FAULT RESET button, the button will turn GREEN, the flywheel will spin (or arrow appear), and a RED PROGRESS BAR will appear. The PROGRESS BAR indicates how soon the gyro will be available for stabilization. When the Gyro Control Box is initialized and when the GYRO is up to minimum operating speed the PROGRESS BAR will turn from RED to GREEN. At this point, the GYRO is available for stabilization.

6) When the GYRO reaches its maximum operating speed where maximum stabilization is available, the PROGRESS BAR will disappear and the GYRO is available for maximum stabilization.

2.3 Stabilization

For stabilization at sea or at anchor after GYRO is ON and at speed:

1) Press the LOCK/UNLOCK button. The button will turn GREEN indicating that the Gyro is precessing and stabilizing the roll motion. The stabilization mode starts gradually; it takes 5-10 seconds to reach full effectiveness.

If it is necessary to shutoff power to the flywheel motor and slow the flywheel for any reason, press GYRO ON/OFF button; the button will turn RED and the LOCK/UNLOCK button will turn RED indicating the command has been accepted. It takes approximately 3 hours for the speed to drop to zero rpm.

If it is necessary to stop Gyro motion for any reason press the LOCK/UNLOCK button. The LOCK symbol will turn RED indicating that the Gyro is locked. Never attempt to work on the gyro until the flywheel has stopped spinning. In the event that the Gyro system has automatically locked the gyro due to an alarm or failure, no attempt should be made to bypass the alarm or automatic lock.

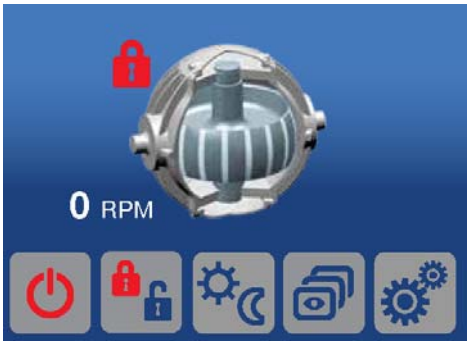
2.4 Normal Shut-Down

1) Verify that no alarms are on the Gyro display. The gyro should be stopped when pulling into port and stabilization is no longer required. This maximizes long term life as it allows the gyro to start the coast down cycle before cooling is shutoff. Once the vessel is secured in the slip and the crew has shut down the generator and engines, the AC and DC breakers that control the gyro should be switched to the OFF position. The gyro will continue to spool down to zero rpm. No cooling is required during this time.

2) Press LOCK/UNLOCK button. The LOCK symbol will turn RED

3) Press GYRO ON/OFF button. The ON/OFF symbol will turn RED

4) When the GYRO is turned off the flywheel is still spinning. When the flywheel has come to a complete stop 0 RPM will appear on the screen indicating that the flywheel has stopped. It can take up to 3 hours for the flywheel to stop spinning.



5) The boat's AC and DC circuit breakers that supply power to the gyro and sea water pump can be turned off.

The circuit breakers should be left on as long as possible while the gyro is spinning to remove heat from the gyro. During normal operation, the gyro should be stopped when pulling into port and stabilization is no longer required. This maximizes long term life as it allows the gyro to start the coast down cycle before cooling is shutoff. Once the vessel is secured in the slip and the crew has shut down the generator and engines, the AC and DC breakers that control the gyro should be switched to the OFF position. The gyro will continue to spool down to zero rpm. No cooling is required during this time. Note gyro will take 3 hours to coast down to zero rpm from full speed. The Display will indicate 0 RPM when the flywheel has stopped.

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3.0 Power Failures

There are two sources of power to the Seakeeper Model 5500 Gyro system:

- 24 Volts DC powers the Gyro Control Box for all the control electronics.
- 208 - 230 Volts AC powers the Motor Drive Box to drive the motor inside the Gyro.

These are supplied on Cables 1 and 2 which are shown on Seakeeper drawing 90149, Cable Block Diagram.

The Motor Drive Junction Box contains hazardous voltage and the cover should not be removed while the flywheel is spinning except by an authorized technician. This high voltage exists even if the flywheel is coasting down and the supply voltage has been shut off.

3.1 +24 VDC Failure

The display will be blank. Gyro flywheel speed will decrease. The brake is locked (no precession).

- Verify the boat's circuit breaker supplying +24 VDC has not tripped and the AC breaker is On.

When +24 VDC is restored, the display will be powered up, Splash Screen will appear, and then Home Screen will appear.

- Press POWER ON/OFF 

  The progress bar will appear and indicate Gyro flywheel speed. When Gyro flywheel is at minimum operating speed the progress bar will turn green and stabilization can resume.

- Press LOCK/UNLOCK 

  Stabilization will begin.

3.2 230 VAC Failure

If an AC failure longer than thirty seconds occurs, the motor will be disabled and the flywheel speed will start to decrease. The brake is locked and the gyro will stop moving. A "Drive Fault" alarm will occur.

- Verify the boat's circuit breaker supplying 230 VAC to the Motor Drive Box has not tripped.
- Verify that the circuit breaker on the Motor Drive Box has not tripped.

Once 230 VAC is restored:

- Press POWER ON/OFF 

  The progress bar will appear and indicate Gyro flywheel speed. When Gyro flywheel is at minimum operating speed the progress bar will turn green and stabilization can resume.

- Press LOCK/UNLOCK 

  Stabilization will begin.

3.3 230 VAC Fluctuation, Spike or Momentary Failure

If the AC voltage to the Motor Drive Box is outside Seakeeper's specified range (208 – 230 VAC) or if the AC voltage fails for less than thirty seconds, the Motor Drive Box will briefly shut down for protection, but will reset itself and continue operating. In this case a "Drive Fault" alarm will not occur. The operator will not be aware of the power disturbance unless there are 4 power disturbances in 1 hour. In this case, a FREQUENT DRIVE RESET warning will be issued. If this warning occurs, Seakeeper recommends that the cause of this large voltage variation be investigated as it could damage electronic components on the boat.

A brief fluctuation can happen when the generator is unable to regulate its output voltage, particularly when a large AC load is switched on or off. A momentary AC failure also happens during transition from shore power to ship's power.

3.4 Alarms

The Model 5500 Gyro issues an alarm when it detects a malfunction that could cause damage or erratic operation. When an alarm occurs the Gyro switches to Stop and Lock, and an alarm message is shown on the Display. If installed, the audible alarm will sound until the operator presses the POWER ON/OFF key on the Display.

The alarm will not clear until the reset condition listed on the table below is achieved and the operator presses the POWER ON/OFF button. The operator can then press LOCK/UNLOCK on the Display home page to continue stabilization. The Gyro will not automatically switch to POWER ON and UNLOCK.

Display Indication	Description	Reset condition	Troubleshooting
ALARM 1 BEARING 1 TEMP HIGH	Bearing 1 temperature above 80 °C	Bearing 1 temperature below 55 °C	Refer to Seakeeper Drawing 90149 & verify: (1) boat seawater pump is on, (2) seawater supplied to gyro heat exchanger (3) gyro glycol pump is running, (4) no glycol leaks.
ALARM 2 BEARING 2 TEMP HIGH	Bearing 2 temperature above 80 °C	Bearing 2 temperature below 55 °C	Refer to Seakeeper Drawing 90149 & verify: (1) boat seawater pump is on, (2) seawater supplied to gyro heat exchanger (3) gyro glycol pump is running, (4) no glycol leaks.
ALARM 3 BEARING 3 TEMP HIGH	Bearing 3 temperature above 80 °C	Bearing 3 temperature below 55 °C	Refer to Seakeeper Drawing 90149 & verify: (1) boat seawater pump is on, (2) seawater supplied to gyro heat exchanger (3) gyro glycol pump is running, (4) no glycol leaks.
ALARM 4 BEARING 4 TEMP HIGH	Bearing 4 temperature above 80 °C	Bearing 4 temperature below 55 °C	Refer to Seakeeper Drawing 90149 & verify: (1) boat seawater pump is on, (2) seawater supplied to gyro heat exchanger (3) gyro glycol pump is running, (4) no glycol leaks.
ALARM 5 MOTOR TEMP HIGH	Motor temperature above 110 °C	Motor temperature below 85 °C	Refer to Seakeeper Drawing 90149 & verify: (1) boat seawater pump is on, (2) seawater supplied to gyro heat exchanger (3) gyro glycol pump is running, (4) no glycol leaks.
ALARM 6 DRIVE TEMP HIGH	Temperature of Motor Drive Box electronics above 55 °C	Temperature of Motor Drive Box electronics below 45 °C	Refer to Seakeeper Drawing 90149 & verify: (1) boat seawater pump is on, (2) seawater supplied to gyro heat exchanger (3) gyro glycol pump is running, (4) no glycol leaks.
ALARM 8 COOLANT PUMP FAULT	Coolant pump current draw less than 0.5 A indicating a bad connection, a bad pump, or a lack of coolant.	Coolant pump current draw more than 0.5 A.	1) Determine if the pump is running by sound or touch. 2) If the pump appears to be running but is noisy, then it is likely that there is air in the glycol loop. Add glycol/water to reservoir until 2/3 full. 3) If pump is not running refer to Seakeeper Drawing 90149 Cable Block Diagram and check J2 connector on Gyro Control Box and pump connector next to pump. 4) Contact Seakeeper distributor for cooling circuit parts and service.
ALARM 11 DRIVE FAULT	Fault signal in Motor Drive Box	(none)	1) Verify boat's AC breaker supplying power to the Gyro is on. 2) Refer to Seakeeper Drawing 90149 Cable Block Diagram & check for AC power. 3) Check motor connector on Motor Drive Box
ALARM 12 LOW BRAKE PRESSURE	Hydraulic pressure in brake low	Hydraulic pressure in brake in normal range	1) Check all hydraulic components for leaks. 2) Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connectors on Brake Pressure Switches and on Gyro Control Box. 3) Contact Seakeeper distributor for brake circuit parts and service.

Display Indication	Description	Reset condition	Troubleshooting
ALARM 19 ANGLE SENSOR FAULT	Gyro angle reading less than -75° indicating sensor damage or a bad connection.	Gyro angle reading above -75°	1) Refer to Seakeeper Drawing 90149 Cable Block Diagram and check sensor connector on Gyro Control Box. 2) Refer to Seakeeper Drawing 90218 Model 5500 Gyro Assembly and Parts List under Port Side View and confirm sensor is still firmly mounted to Gyro.
ALARM 20 X RATE SENSOR FAULT	X Rate sensor inside Control Box not working	Functioning sensor	Contact Seakeeper distributor for service
ALARM 21 Z RATE SENSOR FAULT	Z Rate sensor inside Control Box not working	Functioning sensor	Contact Seakeeper distributor for service
ALARM 22 Y RATE SENSOR FAULT	Y Rate sensor inside Control Box not working	Functioning sensor	Contact Seakeeper distributor for service
ALARM 26 SOLENOID VALVE 1 FAULT	One of the four brake solenoid valves is not operating correctly in SEA mode.	(none)	1) Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connectors on Brake Solenoid Valves and on Gyro Control Box. 2) Contact Seakeeper distributor for brake circuit parts and service.
ALARM 27 SOLENOID VALVE 2 FAULT	One of the four brake solenoid valves is not operating correctly in SEA mode.	(none)	1) Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connectors on Brake Solenoid Valves and on Gyro Control Box. 2) Contact Seakeeper distributor for brake circuit parts and service.
ALARM 28 Y RATE SENSOR HIGH	Invalid reading from Y Rate sensor inside Control Box	Valid readings from sensors	Contact Seakeeper distributor for service
ALARM 29 X RATE SENSOR HIGH	Invalid reading from X Rate sensor inside Control Box	Valid readings from sensors	Contact Seakeeper distributor for service
ALARM 30 Z RATE SENSOR HIGH	Invalid reading from Z Rate sensor inside Control Box	Valid readings from sensors	Contact Seakeeper distributor for service
ALARM 31 LATERAL ACCEL HIGH	Lateral boat acceleration above 1 g	Lateral boat accelerations below 1g for 1 minute	If sea condition is this severe, operator should slow down and/or alter course to reduce boat motion.
ALARM 32 VERTICAL ACCEL HIGH	Vertical boat accelerations above 2 g	Vertical boat accelerations below 2g for 1 min	If sea condition is this severe, operator should slow down and/or alter course to reduce boat motion.

Display Indication	Description	Reset condition	Troubleshooting
ALARM 33 MOTOR FAULT	Flywheel not spinning when RUN commanded.	Motor off for 1 minute	1) Verify boat's AC breaker supplying power to the Gyro is on. 2) Refer to Seakeeper Drawing 90149 Cable Block Diagram & check for AC power. 3) Check connectors on Motor Drive Box.
ALARM 35 DISPLAY FAULT	Display not communicating with Control Box	Display operational for 1 minute	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check Display connector on Serial Comms Connection Box.
ALARM 36 MOTOR OVERSPEED	Motor speed is over 5.6 KRPM.	Motor speed below 5.6 KRPM.	1) Check connectors on Motor Drive Box and Gyro Control Box. 2) Contact Seakeeper distributor for service.
ALARM 37 GYRO TRAVEL FAULT	Gyro angular rate high near mechanical stop	(none)	1) Refer to Seakeeper Drawing 90218 Model 5500 Gyro Assembly and Parts List under Port Side View and confirm sensor is still firmly mounted to Gyro. 2) Inspect the brake system, including electrical, mechanical and hydraulic connections.
ALARM 38 GYRO MOTION FAULT	Gyro angular rate more than 150 degrees per second	(none)	1) Refer to Seakeeper Drawing 90218 Model 5500 Gyro Assembly and Parts List under Port Side View and confirm sensor is still firmly mounted to Gyro. 2) Inspect the brake system, including electrical, mechanical and hydraulic connections.
ALARM 40 INPUT POWER HIGH	DC power to Control Box above 32V	DC power between 17V and 32V	Verify DC input power is between 17V and 32V; excessive load
ALARM 41 INPUT POWER LOW	DC power to Control Box below 17V	DC power between 17V and 32V	Verify DC input power is between 17V and 32V; excessive load
ALARM 42 CONTROL POWER HIGH	DC power to brake and coolant pump above 32V	DC control power between 17V and 32V	Verify DC input power is between 17V and 32V; excessive load
ALARM 43 CONTROL POWER HIGH	DC power to brake and coolant pump below 17V	DC control power between 17V and 32V	Verify DC input power is between 17V and 32V; excessive load
ALARM 44 SENSOR POWER HIGH	DC power from Control Box to Gyro Angle Sensor and Motor Drive Box above 5.25 V.	DC power from Control Box to between 4.75 V and 5.25 V.	Inspect gyro angle sensor for damage
ALARM 45 SENSOR POWER LOW	DC power from Control Box to Gyro Angle Sensor and Motor Drive Box below 4.75 V.	DC power from Control Box to between 4.75 V and 5.25 V.	Inspect gyro angle sensor for damage

Display Indication	Description	Reset condition	Troubleshooting
ALARM 46 VALVE 1 CURRENT HIGH	Two of the four brake solenoid valves are drawing more than 2.5A indicating a bad connection or a bad valve.	Brake solenoid current draw less than 2.5 A.	1) Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connectors on Brake Solenoid Valves and on Gyro Control Box. 2) Contact Seakeeper distributor for brake circuit parts and service.
ALARM 47 VALVE 2 CURRENT HIGH	Two of the four brake solenoid valves are drawing more than 2.5A indicating a bad connection or a bad valve.	Brake solenoid current draw less than 2.5 A.	1) Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connectors on Brake Solenoid Valves and on Gyro Control Box. 2) Contact Seakeeper distributor for brake circuit parts and service.
ALARM 48 FAULTS ON BEARINGS 1 & 2	'Bearing 1 Sensor Fault' and 'Bearing 2 Sensor Fault'	Bearing 1 temperature sensor working, or bearing 2 temperature sensor working, or both sensors working	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
ALARM 49 FAULTS ON BEARINGS 3 & 4	'Bearing 3 Sensor Fault' and 'Bearing 4 Sensor Fault'	Bearing 3 temperature sensor working, or bearing 4 temperature sensor working, or both sensors working	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
ALARM 50 ANGLE SENSOR FAULT	Gyro angle reading more than 64° from center indicating sensor misalignment, sensor damage, or a bad connection.	Gyro angle reading within 64° of center	1) Refer to Seakeeper Drawing 90149 Cable Block Diagram and check sensor connector on Gyro Control Box. 2) Refer to Seakeeper Drawing 90218 Model 5500 Gyro Assembly and Parts List under Port Side View and confirm sensor is still firmly mounted to Gyro.
ALARM 51 SPEED SENSOR FAULT	Three sensors inside the gyro are used for speed measurement and motor operation. One inoperable sensor will cause this alarm.	All three sensors working or the flywheel not spinning.	1) Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Motor Drive Box. 2) Contact Seakeeper distributor for service.
MOTOR 53 ADJUST FAULT	Adjustment to motor settings while motor running.	(none)	Wait for gyro to coast to 0.0 krpm before restarting.
ALARM 54 DRIVE START FAULT	Drive runs briefly than stops (3 occurrences in 1 minute).	(none)	Wait for gyro to coast to 0.0 krpm before restarting.

Display Indication	Description	Reset condition	Troubleshooting
ALARM 55 ANGLE SENSOR FAULT	Gyro angle reading above 81° sensor damage or a bad connection.	Gyro angle reading below 81°	1) Refer to Seakeeper Drawing 90149 Cable Block Diagram and check sensor connector on Gyro Control Box. 2) Refer to Seakeeper Drawing 90218 Model 5500 Gyro Assembly and Parts List under Port Side View and confirm sensor is still firmly mounted to Gyro.
ALARM 56 ANGLE SENSOR FAULT	Gyro angle sensor reading erratic.	Steady gyro angle reading.	1) Refer to Seakeeper Drawing 90149 Cable Block Diagram and check sensor connector on Gyro Control Box. 2) Refer to Seakeeper Drawing 90218 Model 5500 Gyro Assembly and Parts List under Port Side View and confirm sensor is still firmly mounted to Gyro.
ALARM 67 X RATE SENSOR FAULT	X Rate sensor inside Control Box not working	Functioning sensor	Contact Seakeeper distributor for service
ALARM 68 Z RATE SENSOR FAULT	Z Rate sensor inside Control Box not working	Functioning sensor	Contact Seakeeper distributor for service
ALARM 69 Y RATE SENSOR FAULT	Y Rate sensor inside Control Box not working	Functioning sensor	Contact Seakeeper distributor for service
ALARM 70 SOLENOID VALVE 1 FAULT	One of the four brake solenoid valves is not operating correctly in LOCK mode.	(none)	1) Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connectors on Brake Solenoid Valves and on Gyro Control Box. 2) Contact Seakeeper distributor for brake circuit parts and service.
ALARM 71 SOLENOID VALVE 2 FAULT	One of the four brake solenoid valves is not operating correctly in LOCK mode.	(none)	1) Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connectors on Brake Solenoid Valves and on Gyro Control Box. 2) Contact Seakeeper distributor for brake circuit parts and service.
ALARM 72 MOTOR UNDERSPEED	Gyro unable to maintain speed during SEA	(none)	1) Check connectors on Motor Drive Box and Gyro Control Box. 2) Contact Seakeeper distributor for service.
ALARM 251 NO CONNECTION TO GYRO	Control Box not communicating with Display	None. Alarm will clear when communications resume	If problem persists contact Seakeeper distributor for service

3.5 Warnings

The Model 5500 Gyro issues a warning when it detects a malfunction that is not hazardous (but still should be corrected). Warning messages are displayed on the fault history page.

Display Indication	Description	Reset condition	Troubleshooting
WARN 128 VACUUM LEAK	Enclosure pressure more than 60 torr	Enclosure pressure less than 30 torr	Contact Seakeeper distributor for service
WARN 129 BEARING 1 SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
WARN 130 BEARING 2 SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
WARN 131 BEARING 3 SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
WARN 132 BEARING 4 SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
WARN 133 MOTOR SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
WARN 134 DRIVE SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
WARN 135 Z ACCEL SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Contact Seakeeper distributor for service
WARN 136 X ACCEL SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Contact Seakeeper distributor for service
WARN 137 VACUUM SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
WARN 138 Y ACCEL SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Contact Seakeeper distributor for service

Display Indication	Description	Reset condition	Troubleshooting
WARN 139 FREQUENT DRIVE RESET	The Gyro will operate through AC power failures less than 30 seconds, e.g. ship to shore power transfers or voltage dips due to switching large generator loads. Four AC power disturbances in one hour produce this warning.	(none)	Verify AC power source is stable.
WARN 140 BEARING 1 SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
WARN 141 BEARING 2 SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
WARN 142 BEARING 3 SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
WARN 143 BEARING 4 SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
WARN 144 MOTOR SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
WARN 145 DRIVE SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
WARN 146 VACUUM SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Refer to Seakeeper Drawing 90149 Cable Block Diagram & check connector on Gyro Control Box
WARN 147 Z ACCEL SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Contact Seakeeper distributor for service

Display Indication	Description	Reset condition	Troubleshooting
WARN 148 X ACCEL SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Contact Seakeeper distributor for service
WARN 149 Y ACCEL SENSOR FAULT	Bad sensor or bad connection	Functioning sensor	Contact Seakeeper distributor for service

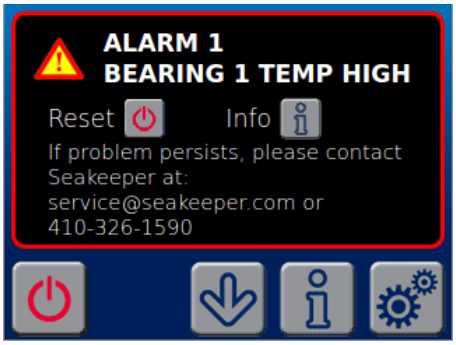
3.6 Alarm and Warning History

The Service page on the Display shows the recent alarms and warnings. The alarms are in chronological order starting with the most recent.

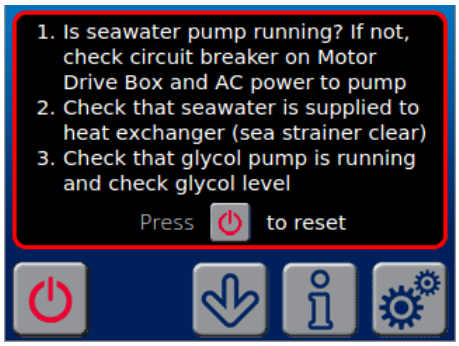
1) From the Home Screen at the Display, go to SETTINGS screen by depressing the SETTINGS screen key  and then go to the SERVICE screen by depressing the SERVICE screen key 

2) View the ALARMS and WARNINGS in the history by pressing UP and DOWN arrow keys.

3) A view of a typical ALARM screen.



If the ALARM appears and there is an INFORMATION button  on the screen the ALARM has more information associated with it. By depressing the INFORMATION button the INFORMATION screen will appear.



To reset the ALARM utilize the GYRO ON/OFF FAULT RESET button 

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4.0 MAINTENANCE

The gyro system is designed to require as little maintenance as possible. However, since the system is comprised of mechanical and electrical components that operate in a marine environment, some periodic inspections and maintenance are recommended. Seakeeper recommends an annual inspection and a 2000 hr service interval to keep the gyro running trouble-free.

If the gyro is installed in a wet space, efforts should be made to keep gyro free of salt residue from either condensation or direct exposure to salt spray. If exposed, a regular wipe down with mild soap and water with a rinse will help limit corrosion and keep the gyro assembly in good cosmetic condition. Refer to Service Bulletin 90106 for details.

4.1 REFERENCES

- Seakeeper 90025, Service Bulletin, Brake Bleeding
- Seakeeper 90026, Service Bulletin, Gyro Paint Information
- Seakeeper 90083, Service Bulletin, Gimbal Angle Sensor Replacement and Calibration
- Seakeeper 90106, Service Bulletin, Fresh Water Rinse Notice
- Seakeeper 90133, Service Bulletin, Gyro Annual Inspection Instructions
- Seakeeper 90134, Service Bulletin, Gyro 2000 Hour Service Instructions

4.2 PRECAUTIONS

- **Gyro Hydraulic Hand Pump Kit, Part No. 10384, is required for servicing the brake. Pressure should NOT be relieved unless this tool is available.**
- **Never charge the nitrogen charged accumulators with oxygen or shop air!**

4.3 PARTS AND SPECIAL TOOLS

Part No.	Description	Comments
10384	Gyro Hydraulic Hand Pump Kit	Required for all brake service tasks.
10449	Brake Bushing Replacement Tool Kit	Contains tools used for changing bushings on all model gyros.
10512	Model 7000 Gyro Raw Water Fitting Kit	Contains bronze fittings for seawater ports in heat exchanger. Used on all M7000 gyros and on M7000A gyros with serial numbers of G269 and below.
10606	Model 7000/Model 7000A Gyro Hydraulic Brake Parts Kit	Contains parts required for 2000 hour hydraulic brake service.

4.4 SCHEDULED MAINTENANCE TABLE

- The following pages contain the scheduled maintenance table organized by systems: Mechanical, Hydraulic, Cooling, and Electrical.

SYSTEM / COMPONENT	TASK PER SERVICE BULLETIN 90133	INTERVAL	PARTS / SPECIAL TOOLS
Mechanical / Corrosion	Inspect unit for severely corroded areas and clean and touch up with paint. See Service Bulletin 90026.	Annual	
Hydraulic / Hoses	Check for cracks or chafing. If chafing found, reposition hose to provide clearance around hose. If chafing is severe, replace hose. Charge system per Service Bulletin 90025.	Annual	Hydraulic hand pump kit
Cooling / Zinc Anode	Replace zinc anode as needed.	With other zincs or Annual	
Cooling / Hoses	Check for cracks or chafing. If damaged, replace hose. Fill cooling system and purge air.	Annual	Anti-freeze
Cooling / Seawater side	Inspect heat exchanger for signs of leaks.	With other zincs or Annual	
Cooling / Seawater side	Fill with environmentally safe, marine anti-freeze during winter or periods of in-operation.	Winter	
Electrical / Connectors	Inspect all connectors for corrosion, clean as necessary, and treat with corrosion inhibitor.	Annual	
Electrical / Grounds	Inspect all ground points for corrosion, clean as necessary, and treat with corrosion inhibitor.	Annual	
Electrical / Gimbal Angle Sensor	Check calibration of sensor. See Service Bulletin 90083 for instructions.	Annual	
Electrical / Cables	Check all cables for cracks or chafing.	Annual	
Electrical / Power Input	Check for seal at cable glands.	Annual	
Electrical / Motor Power	Check integrity of motor power cable jacket.	Annual	

SYSTEM / COMPONENT	TASK PER SERVICE BULLETIN 90134	INTERVAL	PARTS / SPECIAL TOOLS
Mechanical / Hydraulic Brake	Replace brake bushings, hydraulic accumulators and check valves, and flush hydraulic oil.	2000 hrs	Hydraulic hand pump kit, Brake bushing replacement tool kit, Hydraulic brake parts kit
Cooling / System	Cooling system flush	2000 hrs	Fill reservoir or jug and tubing, antifreeze
Electrical / Motor Drive	Check internal circulator fan inside Motor Drive J-Box.	2000 hrs	

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5.0 WARRANTY, LIMITATION OF LIABILITY, PROPERTY RIGHTS

5.1 WARRANTY

Seakeeper warrants that the Goods sold hereunder are free from defects in material and workmanship for a period of 24 months of operation from the date of delivery to the End User or 2000 hours, whichever event occurs first. This express warranty is in lieu of and excludes all other warranties, express or implied, by operation or law or otherwise including THE WARRANTY OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE (WHETHER KNOWN TO SEAKEEPER OR NOT), all other such warranties being hereby expressly disclaimed by Seakeeper and waived by Buyer/User.

Written notice of claimed defects shall have been given to Seakeeper within the Warranty Period, and within thirty (30) days from the date any such defect is first discovered. The Goods or parts claimed to be defective must be returned to Seakeeper, accompanied by a Return Material Authorization (RMA) issued by Seakeeper's facility responsible for supplying Goods, with transportation prepaid by Buyer/User, with written specifications of the claimed defect.

If a warranty claim is valid, Seakeeper shall pay reasonable one-way costs of transportation of the defective Goods from either the original destination or the location where defect occurred, whichever is closest to Seakeeper's facility.

Under no circumstances shall Seakeeper be liable for removal of Seakeeper's Goods from Buyer's/User’s equipment or re-installation into Buyer's/User’s equipment. No person including any agent, distributor, or representative of Seakeeper is authorized to make any representation or warranty on behalf of Seakeeper concerning any Goods manufactured by Seakeeper.

5.2 LIMITATION OF LIABILITY

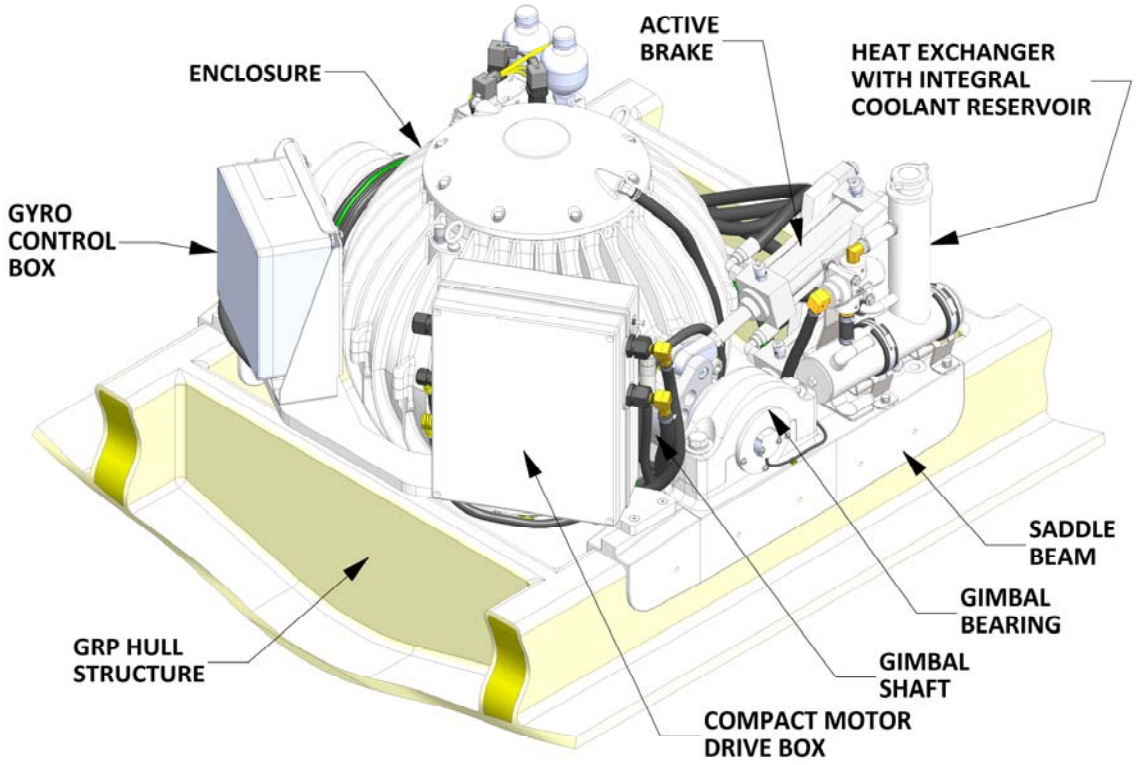
NOTWITHSTANDING ANYTHING TO THE CONTRARY, SEAKEEPER SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, INDIRECT OR CONSEQUENTIAL DAMAGES INCLUDING BUT NOT LIMITED TO LOST PROFITS ARISING OUT OF THE PERFORMANCE, DELAYED PERFORMANCE OR BREACH OF PERFORMANCE OF THIS ORDER REGARDLESS WHETHER SUCH LIABILITY BE CLAIMED IN CONTRACT, EQUITY, TORT OR OTHERWISE. SEAKEEPER'S OBLIGATION IS LIMITED SOLELY TO REPAIRING OR REPLACING (AT ITS OPTION AND AS SET FORTH IN SECTION 5), AT ITS APPROVED REPAIR FACILITY, ANY GOODS OR PARTS WHICH PROVE TO SEAKEEPER'S SATISFACTION TO BE DEFECTIVE AS A RESULT OF DEFECTIVE MATERIALS OR WORKMANSHIP, IN ACCORDANCE WITH SEAKEEPER'S STATED WARRANTY. IN NO EVENT SHALL SEAKEEPER'S LIABILITY EXCEED THE TOTAL PURCHASE PRICE SET FORTH IN THIS ORDER.

5.3 PROPERTY RIGHTS

Except where otherwise expressly agreed, all patterns, tools, jigs and fixtures, drawings, designs, software and other materials and data developed, fabricated by Seakeeper shall be and shall remain Seakeeper's property. Except as specifically provided for in the order, Buyer shall have no right in any technical data, Intellectual Property Rights, and computer software associated with the order. Buyer shall not use or permit the use of the Goods that in any way could result in the disclosure of Seakeeper's proprietary information.

Model 5500 Gyro Specifications & Summary

Rated RPM	7,500 RPM
Angular Momentum at Rated RPM	5,500 N-M-S
Anti-Rolling Torque at Rated RPM	9,600 N-M
Spool-up Time to Rated RPM	35 Minutes
Spool-up Time to Stabilization (75% Rated RPM)	20 Minutes
Spool-up Power	
AC Motor	2000 Watts Max
DC Motor	240 Watts
Operating Power	
AC Motor (Sea state dependent)	1500-2000 Watts
DC Control	240 Watts
Voltage	
AC Input	208-230 VAC (±10%), 50/60 Hz, Single Phase
DC Input	24 VDC @ 10 Amps
Sea Water Supply to Heat Exchanger	30 LPM (8 GPM) maximum 15 LPM (4 GPM) minimum
Maximum Ambient Air Temperature	60 Deg C (140 Deg F)
Weight	485 Kg (1069 Lbs)



Arrangement

The Model 5500 Gyro System consists of the Gyro unit, Motor Drive Box, Gyro Control Box, Cooling Loop Components, Display, and Cables (for cables not supplied by Seakeeper, refer to Seakeeper Drawing 90149).

Installation Location

The Gyro is a torque device and does not have to be installed in a specific hull location or on the centerline. However, the Gyro should not be installed forward of the longitudinal center of gravity in a planing vessel where the vertical accelerations exceed ±1 G.

Mounting Dimensions

See Seakeeper Installation Details Drawing 90219.

Loads

The installer is responsible for designing the foundation to which the Gyro's saddle beams are attached and for ensuring that this foundation can safely transfer the concentrated Gyro loads from the saddle beams to the adjacent hull structure. Loads that the Gyro imposes on the saddle beams are explained on page 6 of Seakeeper Drawing 90219.

Cooling

The Gyro bearings, Motor Drive Box, and hydraulic manifold are cooled by a closed water / glycol mix cooling loop that incorporates a sea water heat exchanger. The installer is responsible for providing 15 LPM (4 GPM) minimum and 30 LPM (8 GPM) maximum raw water at ambient sea temperature and 1.4 Bar (20 psi) maximum sea water pressure to the heat exchanger. The ambient air temperature in the compartment in which the Motor Drive Box is mounted should not exceed 60^{o} C.

Electrical

The installer is responsible for supplying 208-230 VAC, 50/60 Hz, single phase power on a 20A service to the Motor Drive Box and 24 VDC @ 10A service to the Gyro Control Box. Separate circuit breakers should be used for each Motor Drive Box in multiple gyro installations. Similarly, separate circuit breakers should be used for each Gyro Control Box in multiple gyro installations.

Operator Controls

A Display is provided to start, operate, monitor, and shutdown the Gyro.

Performance

Gyro reduction of boat roll is a function of the boat's displacement, transverse metacentric height (GM_T) and hull damping as well as the operating conditions (speed and heading with respect to waves) and sea state. The Gyro controller regulates the active hydraulic brake to ensure the Gyro's anti-roll torque is maximized irrespective of hull characteristics or operating conditions. In heavy seas, the Gyro rpm may droop when the required power exceeds 2000 watts – this is normal and is designed to limit large power demands at the expense of a small loss of performance

Alarm and Monitoring

Sensors, alarms and shutdowns are provided to allow unattended operation. Sensors measure flywheel bearing temperatures, motor and drive temperatures, vacuum pressure, gimbal angle, brake pressure, and ship motion. The Gyro controller sends sensor values and alarm information to the display and also locks the brake and shuts down the motor drive in the event of an alarm condition. Gyro operating history during faults or alarms is recorded in the controller's memory for subsequent recall if service is needed.

Safety

The brake automatically locks the Gyro so it cannot generate excessive anti-rolling torque loads in the event of a system fault or alarm, loss of electrical power or loss of brake pressure. The brake can be locked from the Display or by shutting off power locally at the Motor Drive Box or Gyro Control Box.