



# **SEAKEEPER**

## ***OPERATION MANUAL***




**SEAKEEPER®**

**2**

THIS MANUAL COVERS SEAKEEPER 2 MODELS SERIAL  
NUMBERS 2-0001 THROUGH 2-203-0399

Revised 08MAY2018

|  |                             |                    |                    |             |
|--|-----------------------------|--------------------|--------------------|-------------|
|  <b>SEAKEEPER</b> | <b>OPERATION<br/>MANUAL</b> | <b>Product:</b>    | <b>Document #:</b> | <b>Rev:</b> |
|  |                             | <b>SEAKEEPER 2</b> | <b>90489</b>       | <b>1</b>    |

# **SEAKEEPER 2**

## **OPERATION MANUAL**

### **APRIL 2018**

#### **Contents:**

**Section 1 – System Overview**

**Section 2 – System Operation**

**Section 3 – Power Failures, Alarms, and Troubleshooting**

**Section 4 – Maintenance**

**Section 5 – Warranty, Limit of Liability, Property Rights**

**Section 6 – Specs and Summary**



**44425 PECAN COURT, SUITE 151  
CALIFORNIA, MARYLAND, 20619, U.S.A**

**PHONE: 410-326-1590**

**FAX: 410-326-1199**

**E-MAIL: [customerservice@seakeeper.com](mailto:customerservice@seakeeper.com)**

**Section 1: SYSTEM OVERVIEW**

## 1.0 System Overview

The Seakeeper 2 uses gyroscopic principles to reduce boat roll motions in waves and wakes independent of boat speed. In multiple Seakeeper installations, the Seakeepers operate independently of each other and therefore this manual only discusses operation of a single unit.

A Seakeeper 2 consists of a Gyro assembly, a CAN communications cable, and a Display. Figure 1 illustrates the interconnection of these components and their interface with the boat.

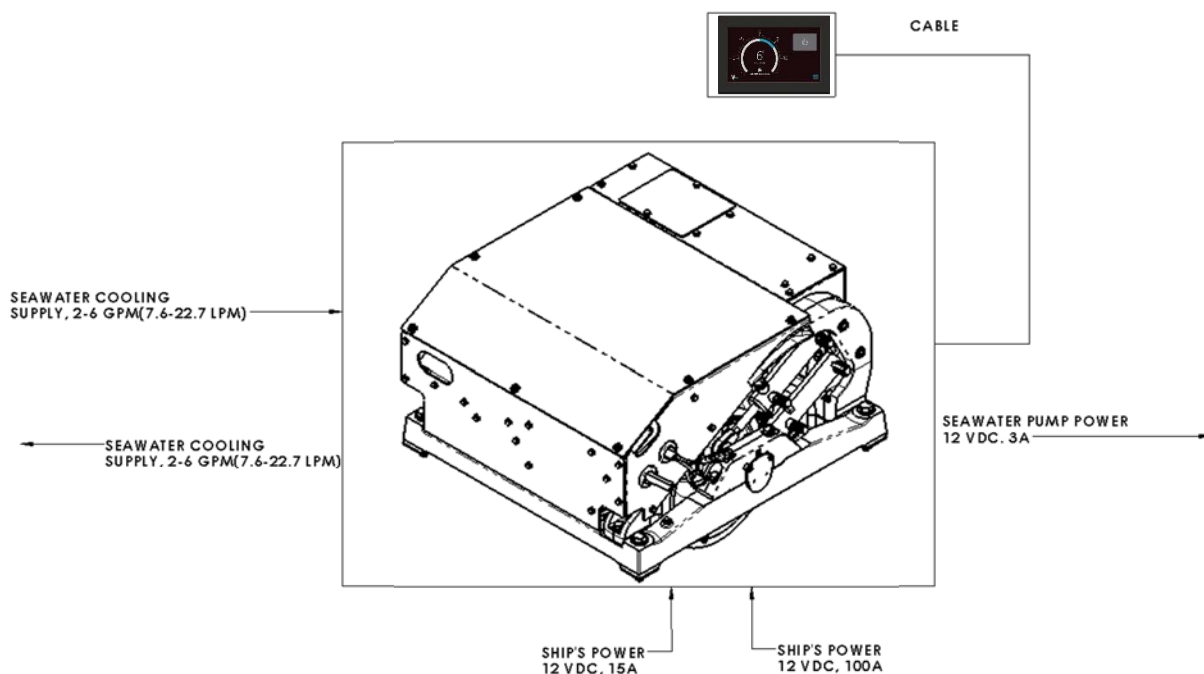
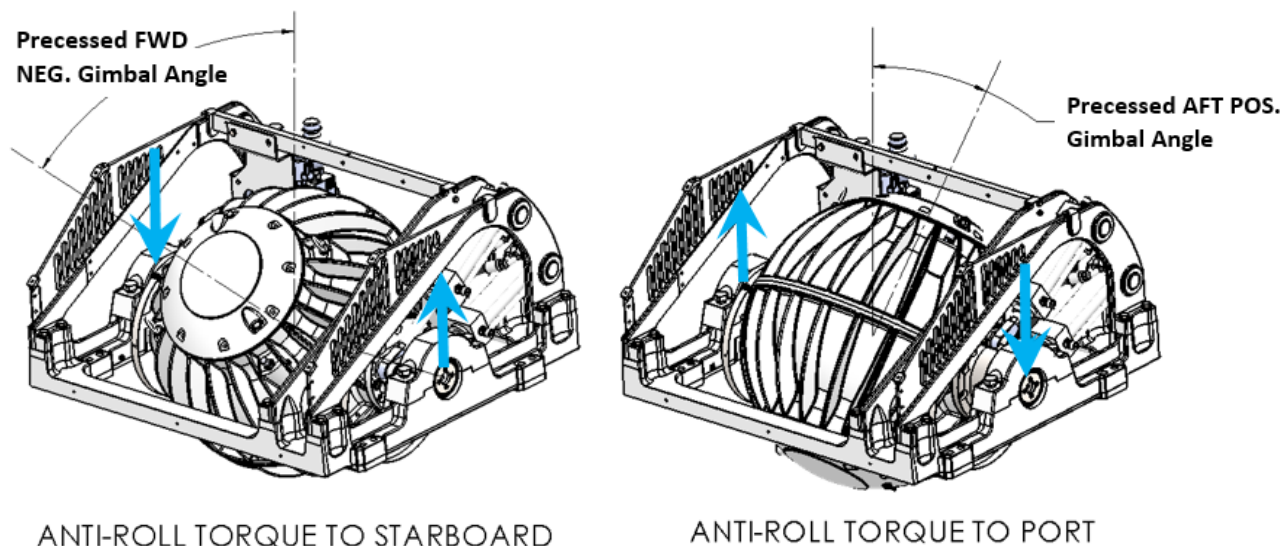


FIGURE 1 – SEAKEEPER 2 STABILIZATION SYSTEM COMPONENTS

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](http://www.seakeeper.com). The Seakeeper web site also contains videos of Seakeeper operation and videos of several different boats operating in waves with the Seakeeper on and off. It is recommended that the reader play these videos prior to reading the remainder of this manual.

**Section 1: SYSTEM OVERVIEW**

The gimbal angle and the 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 sphere is vertical; it can precess a maximum of  $\pm 68$  degrees about this position. The amount of torque that the Seakeeper exerts on a boat's hull to counter the wave induced roll is directly proportional to the precession rate. The further the Seakeeper 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 Seakeeper exerts on the boat's hull to damp roll motion.



**FIGURE 2 – SEAKEEPER PRECESSION**

Seakeeper precession is actively controlled by an electronic controller and a hydraulic brake throughout each roll cycle so the Seakeeper supplies the maximum anti-roll torque and limits mechanical contact with the hard stops that limit the maximum gimbal angle travel to  $\pm 68^\circ$ .

**Section 1: SYSTEM OVERVIEW**

There is a large torque about the gimbal axis when the Seakeeper is precessing. Seakeeper cover panels are provided to prevent personnel or equipment from contacting the Seakeeper while it is in operation. These covers should not be stood on, or have anything placed on top. The covers should always be in place during operation. If it is ever necessary to touch the Seakeeper while the flywheel is spinning, the Seakeeper must be locked at the display to stop the Seakeeper from precessing. Seakeeper maintenance should not be attempted unless the Seakeeper is locked and the flywheel has stopped spinning.

**Section 1: SYSTEM OVERVIEW**

## 1.1 Seakeeper Assembly

The Seakeeper 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  $\pm 68$  degrees during operation. The gimbal bearings are supported by a foundation which is attached to the hull structure. This foundation transfers the loads that the Seakeeper produces to the hull structure.

An active hydraulic brake mechanism is located on the Seakeeper assembly to regulate the Seakeeper's precession motions about the gimbal shaft. It includes two hydraulic cylinders and a hydraulic manifold.

A coolant pump and heat exchanger with reservoir are located near the manifold. 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.

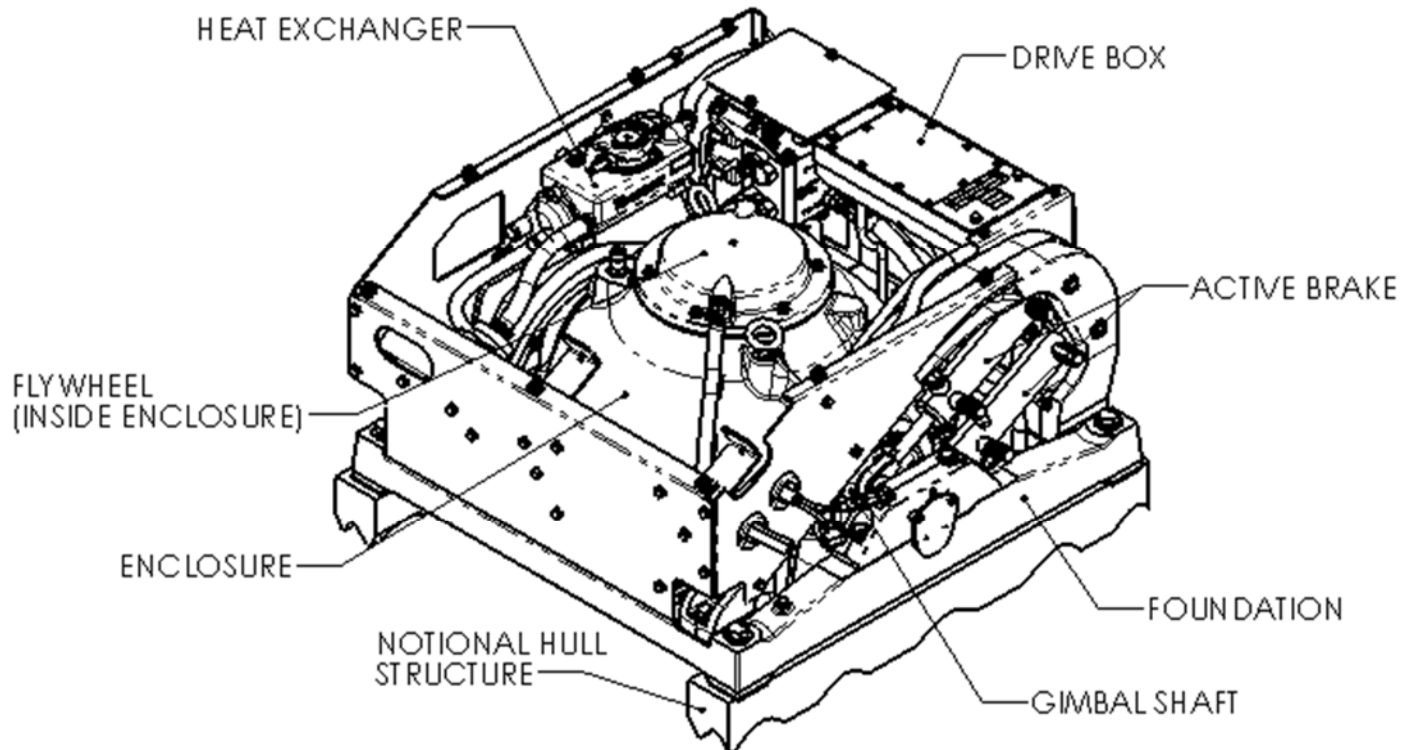


FIGURE 3 – SEAKEEPER ASSEMBLY

**Section 1: SYSTEM OVERVIEW**

## 1.2 Display

The display shown below is the user interface to the Seakeeper 2 and should be mounted at the primary helm station. It is used to start, operate, monitor and shutdown the Seakeeper. Sensors, alarms and shutdowns are provided to allow unattended operation.

The display provides information in the event of an alarm. Alarms cause precession to stop and the Seakeeper to start coasting down.

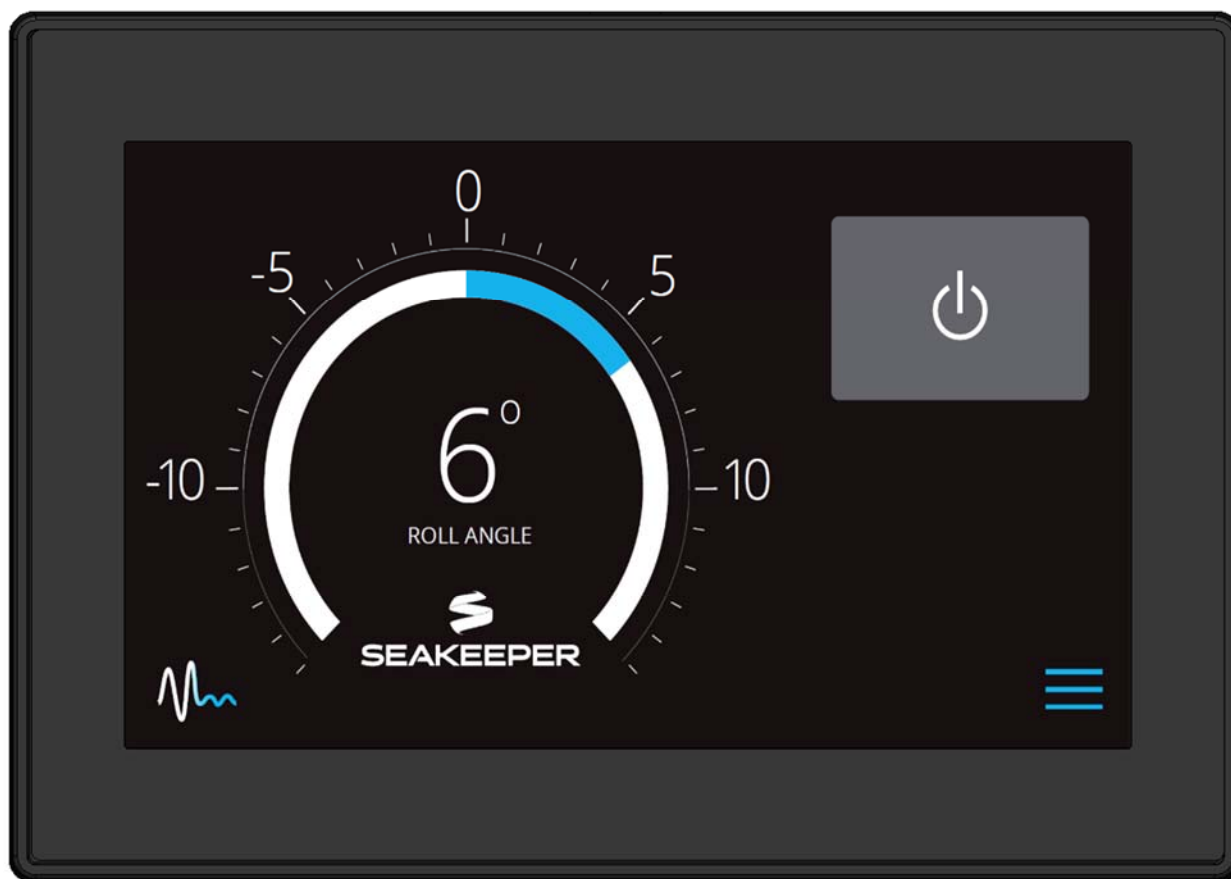


FIGURE 4 – OPERATOR DISPLAY



**Section 1: SYSTEM OVERVIEW**

### 1.3 Drive Box

The glycol/water mix that cools the Seakeeper is also circulated through a cold plate inside the Drive Box to remove heat from high-power electronic components.



The Motor Drive Box contains an electrical hazard and the cover should not be removed while the flywheel is spinning and the DC input voltage is present. The electrical hazard exists even if the flywheel is coasting down and the supply voltage has been shut off. The flywheel must be at Zero (0) RPM and DC input power disconnected for at least 10 minutes prior to any service work on the motor drive box.

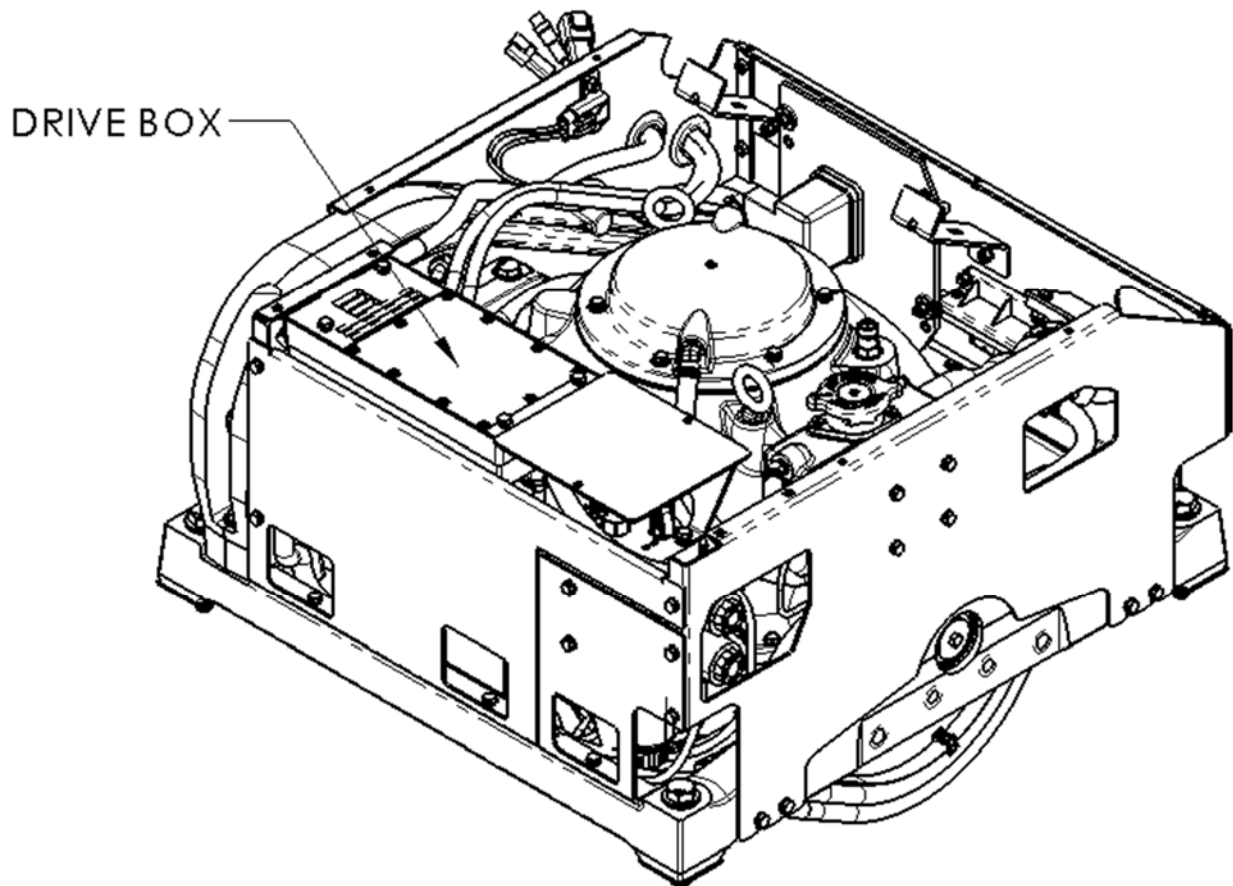


FIGURE 5 – DRIVE BOX



**Section 1: SYSTEM OVERVIEW**

## 1.4 Electronic Control Module

The Electronic Control Module (ECM) monitors all the system sensors and automatically regulates operation of the Seakeeper.

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

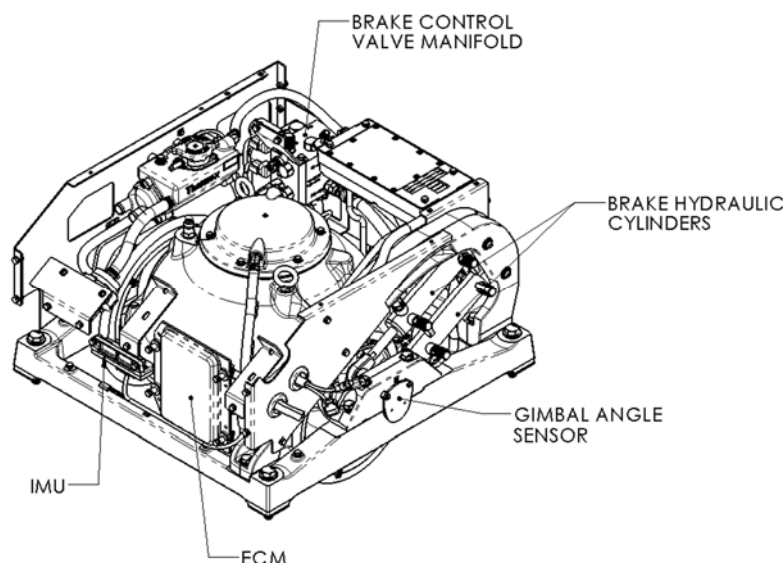
## 1.5 Inertia Measurement Unit (IMU)

The motion sensor suite in the IMU measures the angular movements of the vessel and the vertical and lateral boat movement. These signals are communicated to the ECM through the Seakeeper's wiring harness.

## 1.6 Brake

The brake mechanism consists of two hydraulic cylinders that attach to a crank arm on the Seakeeper gimbal shaft. The Seakeeper controller modulates how fast the oil can flow through a control valve thus controlling the precession rate of the Seakeeper.

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 to help maintain a more consistent pressure during operation and provide some make-up oil in the event of minor fluid loss. Locking solenoids are installed in the circuit to lock the Seakeeper so it cannot precess if there are any alarms or a mechanical problem with the Seakeeper.



**FIGURE 6 – BRAKE SYSTEM COMPONENTS**

Hydraulic Hand Pump Kit, P/N 10384, is required for servicing the brake system. Pressure should never be relieved unless this tool is available.

**Section 1: SYSTEM OVERVIEW**

## 1.7 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 enclosure water jackets to remove heat from the flywheel bearings

The heated fluid then passes through a heat exchanger that has seawater on the cold side. The seawater pump output will operate for two minutes after the Seakeeper is turned on. During operation, the seawater pump output is turned on and off based on the temperature of the Seakeeper. 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.

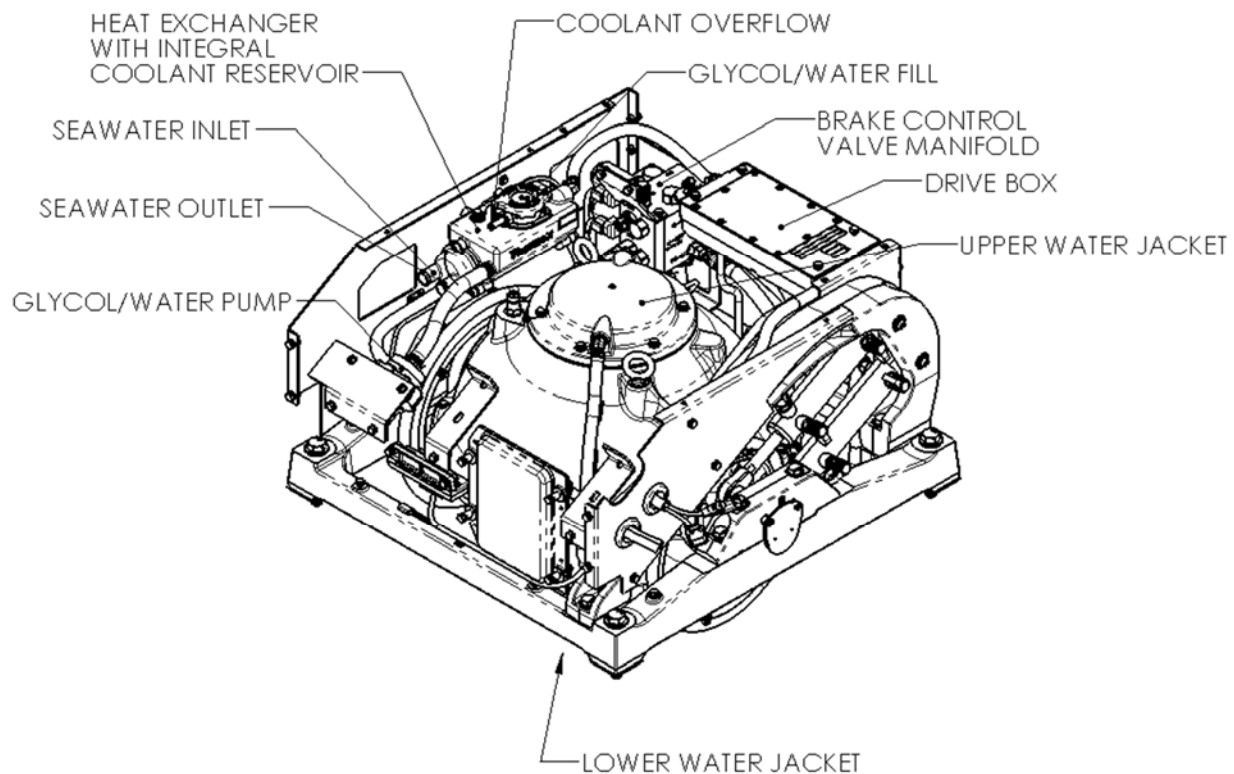


FIGURE 7 – COOLING SYSTEM COMPONENTS

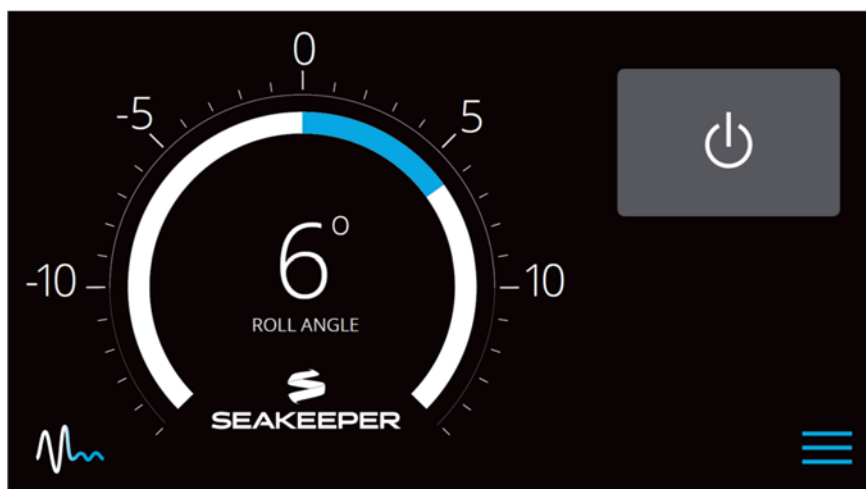
**Section 2: SYSTEM OPERATION**

## 2.1 Display Screens: Overview

- 1) When 12 VDC power is applied to the Seakeeper, 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 uses a touch screen to allow users to select functions.



Seakeeper On/Off. The button will change from grey (Seakeeper Off) to blue (Seakeeper On)

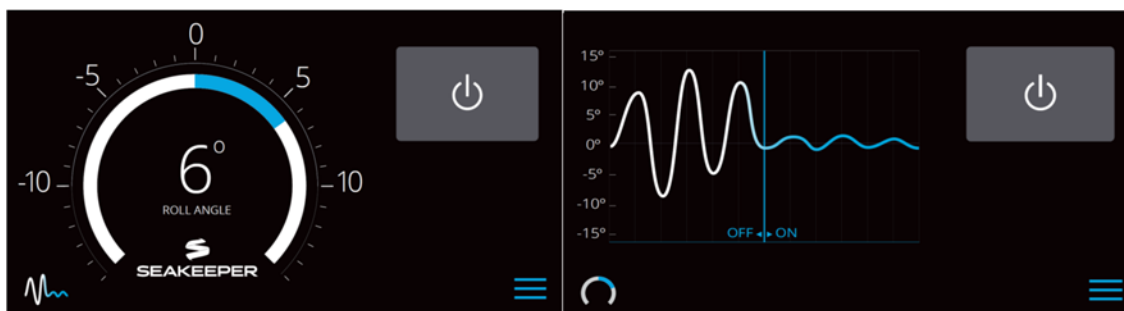
## Section 2: SYSTEM OPERATION



Seakeeper Stabilize On/Off. The button will change from grey (Stabilize Off) to blue (Stabilize On)



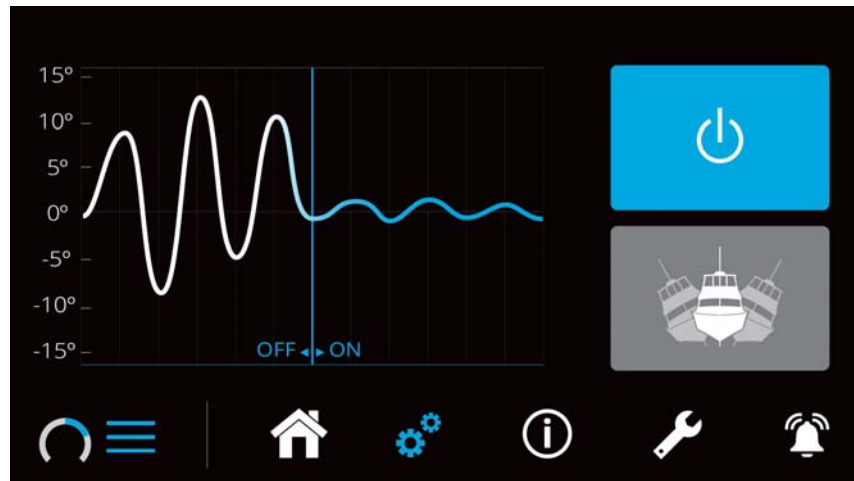
Home screen view. These buttons toggle home screen between the Roll Angle Gauge and the Roll Angle Graph as shown below.



- 4) When the menu button is pressed, the menu bar will appear or disappear at the bottom of the screen.



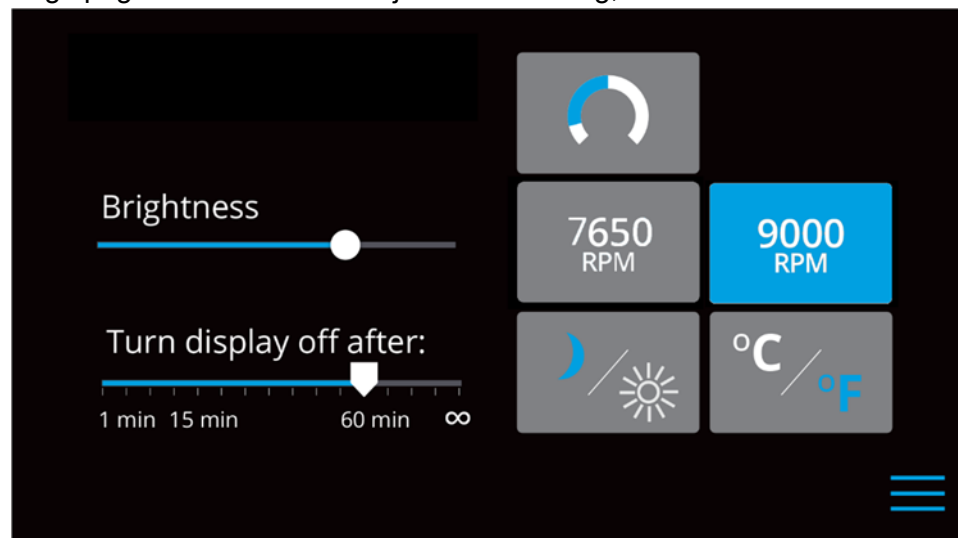
## Section 2: SYSTEM OPERATION



The menu bar is used to navigate between pages. From left to right, the available pages are home, settings, information, service and alarm history. The selected page is highlighted in blue on the menu bar.



5) The settings page allows the user adjust the following;

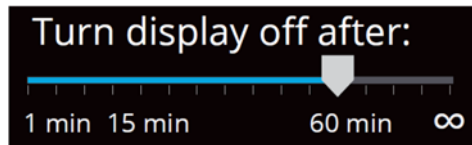


Increase or decrease the brightness of the display with the brightness slider.



**Section 2: SYSTEM OPERATION**

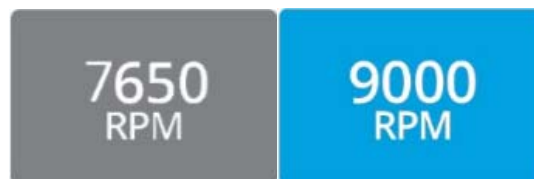
Adjust the sleep timer from 1 minutes to 60 minutes or on all of the time using sleep time slider. Touching the screen will wake the display up after it has gone to sleep.



Change the sign of the roll angle value displayed in the roll angle gauge so the gauge matches the motion of the boat. This will depend on installation orientation and will only need to be adjusted once.



Change the speed of the gyro between normal operation and low power operation. The selected speed is colored blue. When power is cycled (or Seakeeper turned Off), this speed will default back to the normal operating speed. Speed selection buttons shown below are examples and may not match operating speed of installed Seakeeper.



Change the display between day and night mode. The selected mode is colored blue.



Change the units of the temperatures displayed on the service page between degrees Celsius and degrees Fahrenheit. The selected units are colored blue.



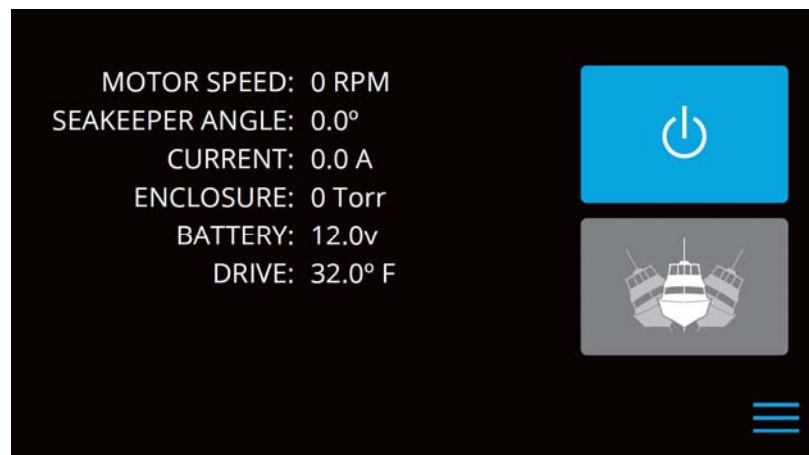
**Section 2: SYSTEM OPERATION**



- 6) The information page displays the Seakeeper model, Seakeeper serial number, Seakeeper software versions, RUN hours, and SEA hours, and other information. The information page below are examples and may not match information details of installed Seakeeper.



- 7) The service page displays operating information from the Seakeeper.



- 8) The alarm history page shows what alarms have occurred in the past and the associated run hours. The scroll bar is used to move up and down through the list.

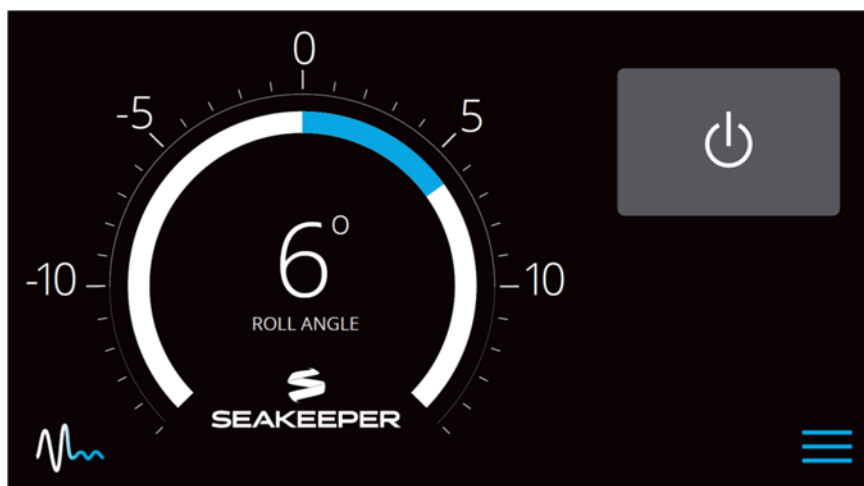


**Section 2: SYSTEM OPERATION**



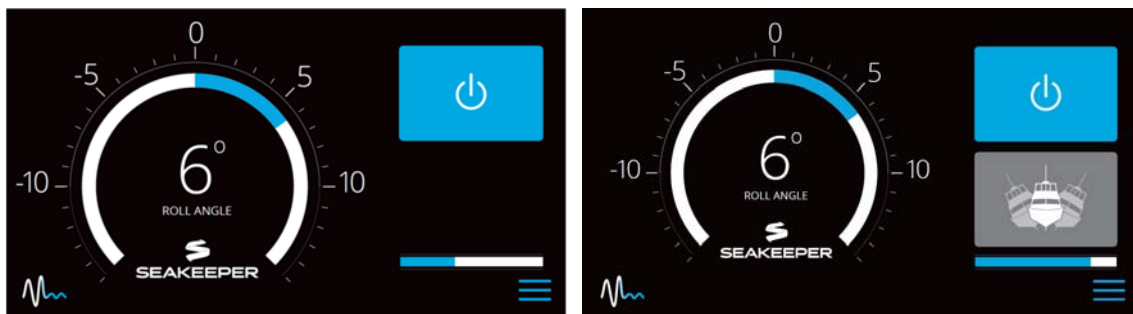
## 2.2 Start-up

- 1) Make sure high current and low current DC inputs to the gyro are turned on.
- 2) When the low DC power is turned on the Display will initialize and the Home screen will appear.

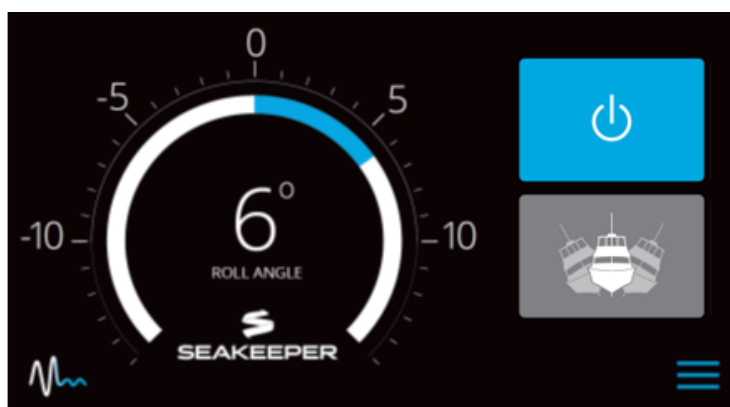


To turn the Seakeeper on, press the On/Off button, the button will turn blue. The progress bar will appear and indicate how soon the Seakeeper will be available for stabilization. When the Seakeeper is initialized and up to minimum operating speed the stabilize button will appear. At this point, the Seakeeper is available for stabilization.

## Section 2: SYSTEM OPERATION



- 3) When the Seakeeper reaches its maximum operating speed where maximum stabilization is available, the progress bar will disappear and the Seakeeper is available for maximum stabilization.



### 2.3 Stabilization

To stabilize the boat after Seakeeper is on and above the minimum operating speed:

- 1) Press the stabilize button. The button will turn blue indicating that the Seakeeper is stabilizing the roll motion.



**Section 2: SYSTEM OPERATION**

If it is necessary to shutoff power to the flywheel motor and slow the flywheel for any reason, press Seakeeper On/Off button; the button will turn grey and the stabilize button will disappear indicating the command has been accepted. It takes approximately 16+ hours for the speed to drop to zero rpm.



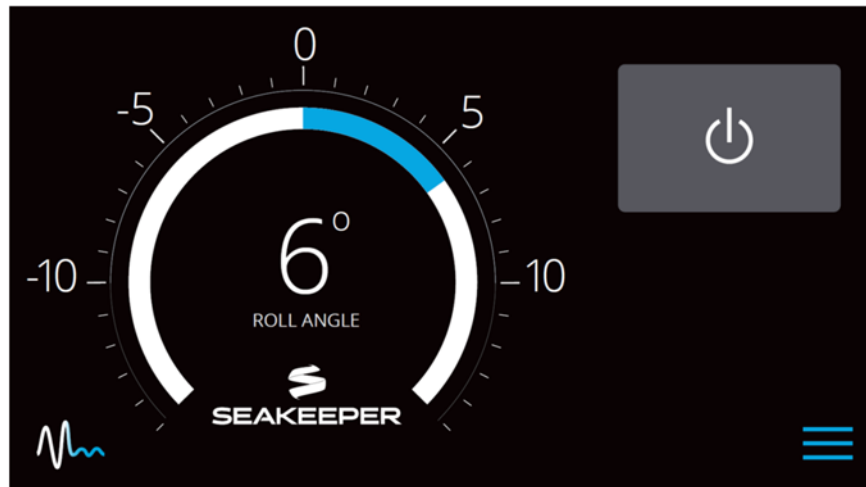
If it is necessary to stop Seakeeper motion for any reason press the stabilize button. The stabilize button will turn grey indicating that the Seakeeper is locked. Never attempt to work on the Seakeeper until the flywheel has stopped spinning. In the event that the brake system has automatically locked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

**Section 2: SYSTEM OPERATION**

## 2.4 Normal Shut-Down

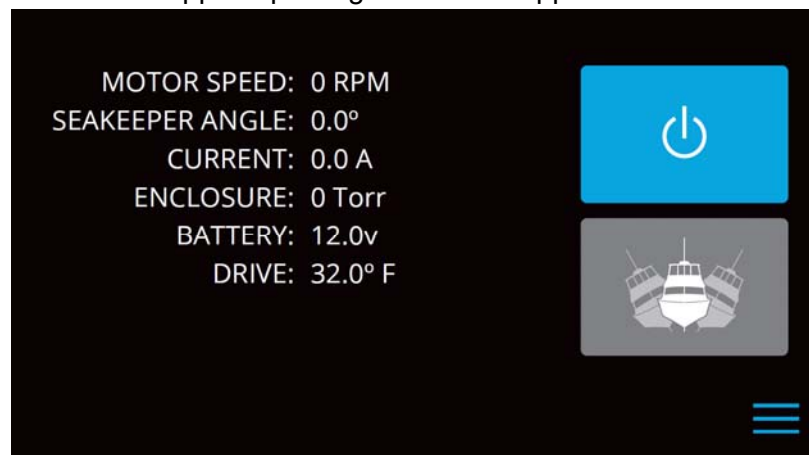
The Seakeeper should be stopped when stabilization is no longer required.

- 1) Press Seakeeper On/Off button. The On/Off button will turn grey. The Seakeeper will start coasting.



- 2) Once the vessel is secured in the slip, switch the high current and low current DC power to the Seakeeper off. The flywheel will continue to spool down to zero rpm. This can take 16+ hours from full speed.

When the flywheel has stopped spinning 0 RPM will appear on the service screen.



**Section 2: SYSTEM OPERATION**

**The Seakeeper should be stopped when stabilization is no longer required. Once the vessel is secured in the slip, the high and low current DC power to the Seakeeper should be switched to the Off position. The Seakeeper will continue to spool down to zero rpm. No cooling is required during this time. Note Seakeeper will take 16+ hours to coast down to zero rpm from full speed.**

*Note: The seawater pump may run for up to 5 minutes after the Seakeeper is switched off and is coasting (with low current DC power applied).*

**Section 3: POWER FAILURES, ALARMS, AND TROUBLESHOOTING**

### 3.0 Power Failures

There are two sources of power to the Seakeeper 2:

- 12 Volts DC low current powers the Seakeeper for all the control electronics.
- 12 Volts DC high current powers the Motor Drive Box to drive the motor inside the Seakeeper.

These are supplied on Conductors 1 and 2 and Cable 7 which are shown on Seakeeper drawing 90470, Cable Block Diagram.



**The Motor Drive Box contains a voltage hazard and the cover should not be removed while the flywheel is spinning or the DC input voltage is present. This voltage hazard exists even if the flywheel is coasting down and the supply voltage has been shut off. The flywheel must be at Zero (0) RPM and DC input power disconnected for at least 10 minutes prior to any service work on the Motor Drive Box.**

### 3.1 12 VDC Low Current Failure

If the 12 VDC low current is disconnected, the display will be blank. Flywheel speed will decrease. The Seakeeper will be turned off (no stabilization).

- Verify the boat's circuit breaker or fuse supplying +12 VDC low current has not tripped or blown.
- When +12 VDC low current is restored, the display will power up, the Splash Screen will appear, and then the Home Screen will appear.

- Press Power On/Off button



The progress bar will appear and indicate flywheel speed. When the flywheel is at minimum operating speed, the stabilize button will appear so stabilization can be turned on. This may take up to 30 minutes, depending on the speed of the flywheel when the +12 VDC low current is turned back on.

**Section 3: POWER FAILURES, ALARMS, AND TROUBLESHOOTING**

## 3.2 12 VDC High Current Failure

If the 12 VDC High Current is disconnected, a notification screen will indicate “High Current DC Voltage Low”. If the failure is not corrected within two minutes, an “High Current DC Voltage Low” alarm will occur. The brake will lock.

- Verify the boat’s circuit breaker or fuse supplying +12 VDC high current has not tripped or blown.
- When +12 VDC high current is restored, the display will power up, the Splash Screen will appear, and then the Home Screen will appear.

- Press Power On/Off button



The progress bar will appear and indicate flywheel speed. When the flywheel is at minimum operating speed, the stabilize button will appear so stabilization can be turned off. This may take up to 30 minutes, depending on the speed of the flywheel when +12 VDC high current is turned back on.

## 3.3 Alarms

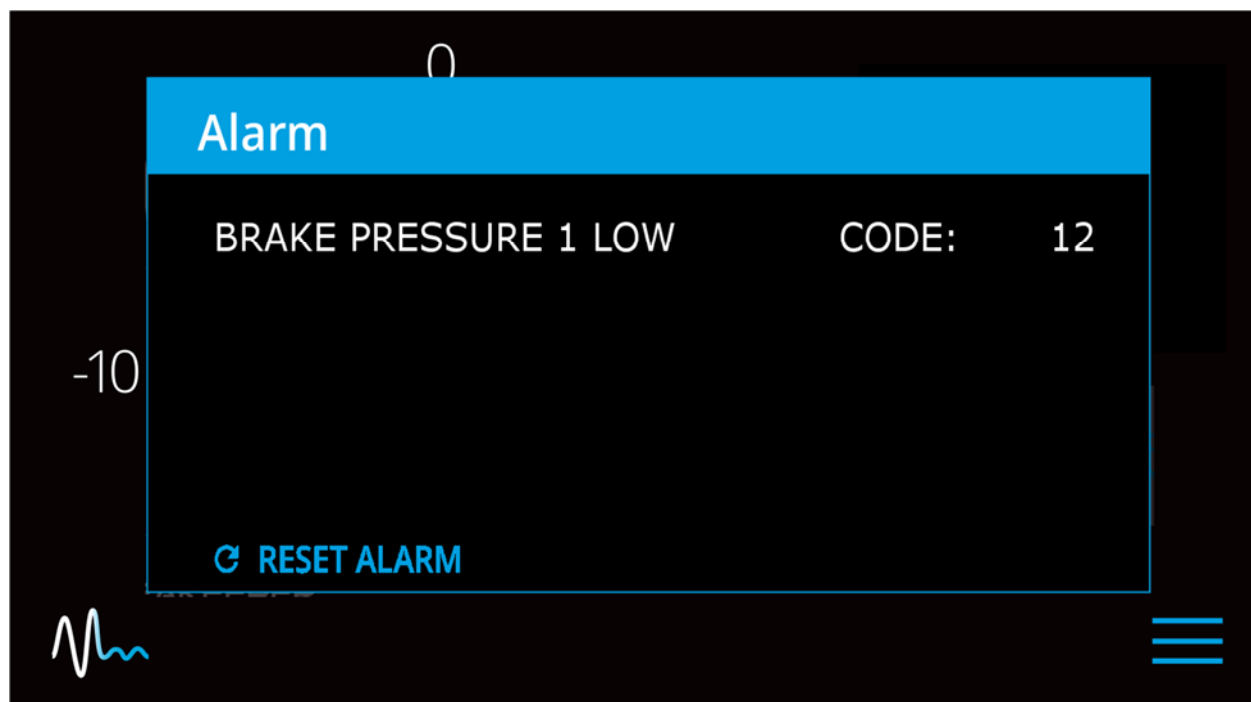
The Seakeeper issues an alarm when it detects a malfunction that could cause damage or erratic operation. When an alarm occurs, the Seakeeper will stop and an alarm message is shown on the Display.

The alarm will not clear until the operator presses the Reset Alarm button and the alarm condition is no longer present. The operator can then press the power On/Off button again to continue Seakeeper operation.



**Section 3: POWER FAILURES, ALARMS, AND TROUBLESHOOTING**

- A view of a typical Alarm screen.



- To reset the Alarm press the Reset Alarm button

 **RESET ALARM**

**Section 3: POWER FAILURES, ALARMS, AND TROUBLESHOOTING**

## 3.4 Alarm History

The alarm history page on the Display shows the recent alarms and warnings. The alarms are in chronological order starting with the most recent. Warnings included in the history page are for issues that do not affect gyro operation.

- 1) Press the menu button then select the alarm history screen.



**Section 4: MAINTENANCE**

## 4.0 MAINTENANCE

The Seakeeper 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 required. Seakeeper recommends a regular inspection interval and Scheduled Maintenance to keep the Seakeeper running trouble-free.

If the Seakeeper is installed in a wet space, efforts should be made to keep the Seakeeper 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 Seakeeper assembly in good cosmetic condition. Refer to Service Bulletin 90106 for details.

If any components of the Seakeeper or its sub-systems will be exposed to environmental temperatures where winterization is necessary for storage, reference Seakeeper service bulletin 90405.

The Seakeeper comes standard with sealant and thread locker on applicable fasteners. When reinstalling all fasteners use thread locker and sealant unless otherwise specified.

## 4.1 REFERENCES

- Seakeeper 90025, Service Bulletin, Brake Bleeding
- Seakeeper 90026, Service Bulletin, Seakeeper Paint Information
- Seakeeper 90083, Service Bulletin, Gimbal Angle Sensor Replacement and Calibration
- Seakeeper 90106, Service Bulletin, Fresh Water Rinse Notice
- Seakeeper 90426, Service Bulletin, Seakeeper Scheduled Maintenance Plan
- Seakeeper 90405, Service Bulletin, Seakeeper Winterization Process

## 4.2 PRECAUTIONS



- **Hydraulic Hand Pump Kit, Part No. 10384, is required for servicing the brake. Pressure should NOT be relieved unless this tool is available.**

## 4.3 PARTS AND SPECIAL TOOLS

| Part No. | Description                        | Comments                                  |
|----------|------------------------------------|---|
| 10384    | Hydraulic Hand Pump Kit            | Required for all brake service tasks.     |
| 11901    | Brake Bushing Replacement Tool Kit | Contains tools used for changing bushings |

**Section 4: MAINTENANCE**

## 4.4 SCHEDULED MAINTENANCE TABLE

- The following pages contain the scheduled maintenance table organized by systems: Mechanical, Hydraulic, Cooling, and Electrical. Scheduled maintenance is not covered under warranty.

| SYSTEM / COMPONENT               | TASK   | INTERVAL                   | PARTS / SPECIAL TOOLS   |
|----------------------------------|--|----------------------------|---|
| Mechanical / Corrosion           | Inspect unit for severely corroded areas and clean and touch up with paint. See Service Bulletin 90026.  | 12 Months or 1000 Hours    | Awlgrip Paint Part Numbers:<br>Primer: S9001<br>Primer Converter: S3001<br>Top Coat, Snow White: F8063<br>Top Coat Converter: G3010 |
| 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. | 12 Months or 1000 Hours    | Hydraulic hand pump kit   |
| Cooling / Hoses                  | Check for cracks or chafing. If damaged, replace hose. Fill cooling system and purge air.  | 12 Months or 1000 Hours    | Anti-freeze – 50/50 Ethylene Glycol mix.  |
| Cooling / Seawater side          | Inspect heat exchanger for signs of leaks.   | 3 Months or 150 Hours      |   |
| 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, replace if necessary.  | 12 Months or 1000 Hours    |   |
| Electrical / Grounds             | Inspect all ground points for corrosion, clean as necessary, and treat with corrosion inhibitor.   | 12 Months or 1000 Hours    |   |
| Electrical / Gimbal Angle Sensor | Check calibration of sensor. See Service Bulletin 90083 for instructions.  | Only if Angle Alarms occur |   |
| Electrical / Cables              | Check all cables and wire harness branches for cracks or chafing. Take special attention to gimbal shaft areas.  | 12 Months or 1000 Hours    |   |
| Electrical / Power Input         | Check for seal at cable glands.  | 12 Months or 1000 Hours    |   |
| Electrical / Motor Power         | Check integrity of motor power cable jacket.   | 12 Months or 1000 Hours    |   |

**Section 4: MAINTENANCE**

| <b>SYSTEM / COMPONENT</b>    | <b>TASK</b>   | <b>INTERVAL</b>   | <b>PARTS / SPECIAL TOOLS</b>   |
|------------------------------|---|---|--|
| Mechanical / Hydraulic Brake | Replace brake bushings, hydraulic accumulators and check valves | Inspect at 12 Months or 1000 Hours – Replace as needed or at 2000 Hours | Hydraulic hand pump kit, Brake bushing replacement tool kit, Hydraulic brake parts kit |
| Mechanical / Hydraulic Brake | Flush Hydraulic Oil   | 12 Months or 1000 Hours   | Hydraulic Hand Pump Kit<br>Oil: AW46   |
| Cooling / System             | Cooling system flush  | 12 Months or 1000 Hours   | Fill reservoir, antifreeze – 50/50 Ethylene Glycol mix                                 |

**Section 5: WARRANTY**

## **5.0 WARRANTY, LIMITATION OF LIABILITY, PROPERTY RIGHTS**

### **5.1 WARRANTY**

**The complete Seakeeper warranty details may be found on the Seakeeper website [www.seakeeper.com](http://www.seakeeper.com)**

#### **Seakeeper Standard Models:**

Seakeeper warrants that the Goods sold hereunder are free from defects in material and workmanship. This warranty is for the following period, whichever occurs first:

- a. 36 months from the date of shipment from SEAKEEPER factory
- b. 24 months from date the product put into service, which shall conclusively be presumed to be the date of sale of a vessel, on which a SEAKEEPER product is installed, to a retail customer or date put into service on an existing vessel (refit).
- c. Or, 2000 (two thousand) hours of use, subject to verification and confirmation by SEAKEEPER, INC.

#### **All Seakeeper models:**

This warranty does not cover normal wear of the following components or the costs associated with maintenance, repair or replacement:

- a. Surface Corrosion (Cosmetic) on any component due to exposure
- b. Heat exchanger
- c. Brake Bushings
- d. Isolation Bushings
- e. Normal preventive and scheduled maintenance and component inspections/replacements as specified in the SEAKEEPER, INC., Operation Manuals and any other Maintenance Schedule documentation.

**Section 5: WARRANTY**

This express warranty is in lieu of and excludes: ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, BY OPERATION OF LAW OR OTHERWISE INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE (WHETHER KNOWN TO SELLER OR NOT), AND ALL OTHER SUCH WARRANTIES ARE HEREBY EXPRESSLY DISCLAIMED BY SELLER AND WAIVED BY CUSTOMER/END USER. SEAKEEPER, INC. SHALL IN NO EVENT BE LIABLE TO ANY SPECIAL, DIRECT, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES FOR BREACH OF ANY WARRANTY OR OTHER OBLIGATION ARISING OUT OF THE SALE OF THE PRODUCTS, OR FROM THE USE OF THE PRODUCTS OR ANY INABILITY TO USE THE PRODUCTS.

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 Authorization (RA) 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, INC. will repair or replace the Product, or part of the Product, proven to be defective, at its sole discretion, in a timeframe provided by SEAKEEPER, INC., on a reasonable best effort basis.

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.



**Section 5: WARRANTY**

## **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.

**Section 6: SEAKEEPER SPECIFICATIONS**

## Seakeeper 2 Specifications & Summary

| <b>Seakeeper 2</b>                       |  |
|--|--|
| <b>Rated RPM</b>                         | 9,000 RPM  |
| <b>Angular Momentum at Rated RPM</b>     | 2,000 N-M-S  |
| <b>Anti-Rolling Torque at Rated RPM</b>  | 5,249 N-M  |
| <b>Spool-up Time to Rated Speed</b>      | 35 minutes (9,000 RPM)   |
| <b>Spool-up Time to Stabilization</b>    | 24 minutes (7,650 RPM)   |
| <b>Spool-up Power</b>                    |  |
| DC Motor                                 | 850 Watts Max  |
| <b>Operating Power</b>                   |  |
| DC (Sea state dependent)                 | 300-650 Watts  |
| <b>Voltage</b>                           |  |
| DC Input                                 | 12 VDC @ 85 Amps   |
| <b>Seawater Supply to Heat Exchanger</b> |  |
|  | 22 LPM (6 GPM) maximum<br>8 LPM (2 GPM) minimum                        |
| <b>Ambient Air Temperature</b>           | 0° - 60°C (32° - 140°F)  |
| <b>Weight</b>                            | 188 kg. (414 lbs)  |
| <b>Envelope Dimensions</b>               | 0.63 L x 0.648 W x 0.508 H (meters)<br>24.8 L x 25.5 W x 20 H (inches) |

**Noise Output**

At full operating RPM, steady state noise measured in the factory at a 1 meter distance measures 64-68 dBC (sound levels may be higher during spool-up).



**Section 6: SEAKEEPER SPECIFICATIONS****Arrangement**

The Seakeeper 2 consists of the Flywheel, Enclosure, Foundation, Electronics, Brake, Cooling, and Cover Subsystems.

**Installation Location**

The Seakeeper is a torque device and does not have to be installed in a specific hull location or on the centerline. However, the Seakeeper should not be installed forward of the longitudinal center of gravity to minimize high acceleration loadings due to hull/wave impacts during operation at high speed or in large waves.

**Mounting Dimensions**

See Seakeeper Drawing 90487 for bolt-in installation details.

**Loads**

The installer is responsible for designing the foundation to which the Seakeeper is attached and for ensuring that this foundation can safely transfer the concentrated Seakeeper loads from the frame to the adjacent hull structure. Loads that the Seakeeper imposes on the hull structure are explained on Seakeeper Drawing 90487; these loads do NOT include vessel motion accelerations, such as vertical slam loads which can be high for higher speed vessels.

**Cooling**

The Seakeeper bearings, Motor Drive Box, and hydraulic manifold are cooled by a closed water / glycol mix cooling loop that incorporates a seawater heat exchanger. The installer is responsible for providing 8 – 22 lpm (2 – 6 gpm) raw water at ambient sea temperature and a maximum pressure of 1.4 Bar (20 psi) to the heat exchanger.

**Electrical**

The installer is responsible for supplying 12VDC @100A service to the Motor Drive Box and 12 VDC @ 15A service to the Seakeeper Control System. Separate circuit breakers should be used for each Motor Drive Box in multiple Seakeeper installations. Similarly, separate circuit breakers should be used for each Seakeeper Control System in multiple Seakeeper installations.

**Section 6: SEAKEEPER SPECIFICATIONS****Operator Controls**

A Touchscreen Display is used to start, operate, monitor, and shutdown the Seakeeper.

**Performance**

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 Seakeeper controller regulates the active hydraulic brake to ensure the Seakeeper's anti-roll torque is maximized irrespective of hull characteristics or operating conditions.

**Alarm and Monitoring**

Sensors, alarms and shutdowns are provided to allow unattended operation. Sensors measure Seakeeper and drive temperatures, vacuum pressure, gimbal angle, brake pressure, and ship motion. The Seakeeper 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. Seakeeper operating history during faults or alarms is recorded in the controller's memory for subsequent recall if service is needed. Seakeeper may access the Seakeeper's software to gather run hours, bearing loading, and hull slamming information.

**Safety**

The brake automatically locks the Seakeeper 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 AC and DC power at the supply breakers.