




SEAKEEPER

INSTALLATION MANUAL



****THIS MANUAL ALSO COVERS THE SEAKEEPER 20HD****

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|  SEAKEEPER | INSTALLATION MANUAL | Product: | Document #: | Rev: |
| | | SEAKEEPER 26 / 20HD | 90265 | 5 |

SEAKEEPER 26 / 20HD INSTALLATION MANUAL JANUARY 2017

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Section 1: MECHANICAL INSTALLATION

1.0 Introduction

This document is intended to give details and guidance to a boat builder or equipment installer to install the Seakeeper 26. The Seakeeper is capable of producing loads up to 35.89 KN (8,070 lbs.) at each of the four mounts and careful consideration should be given to foundation design to insure it is capable of transferring these loads into the hull. These loads do NOT include vessel motion accelerations, such as vertical slam loads which can be high for higher speed vessels.

There are two methods of installing the Seakeeper 26:

- 1) Bolt-In Installation
- 2) Bond-In (Saddle) Installation

It is assumed that the installer is familiar with bonding using high strength adhesives or mechanical fasteners to marine structures and has performed structural analysis to assure the structure to which the Seakeeper mounts can properly transfer the loads the Seakeeper creates into the hull structure. If the installer has any doubt about the ability of the structure to transfer the loads to the hull then he should contact a licensed naval architect or marine engineer to do a structural analysis.

The installer should review the following list of reference drawings to ensure the installation procedure is fully understood.

Reference Drawings

- 90244 Seakeeper 26 Hardware Scope of Supply**
- 90416 Seakeeper 20HD Hardware Scope of Supply**
- 90271 Seakeeper 26/20HD Installation Details – Bolt in Method**
- 90272 Seakeeper 26/20HD Installation Details – Bond in Method**
- 90085 Seakeeper 26/20HD Bond-in Saddle Kit**
- 90086 Seakeeper 26/20HD Bolt-in Installation Kit**
- 90088 Seakeeper 26/20HD Bond-In Installation Fixture Kit**
- 90089 Seakeeper 26/20HD Bolt-In Installation Fixture Kit**
- 90310 Seakeeper 26/20HD Cable Block Diagram**
- 90320 Seakeeper 26/20HD Cooling Water Schematic**

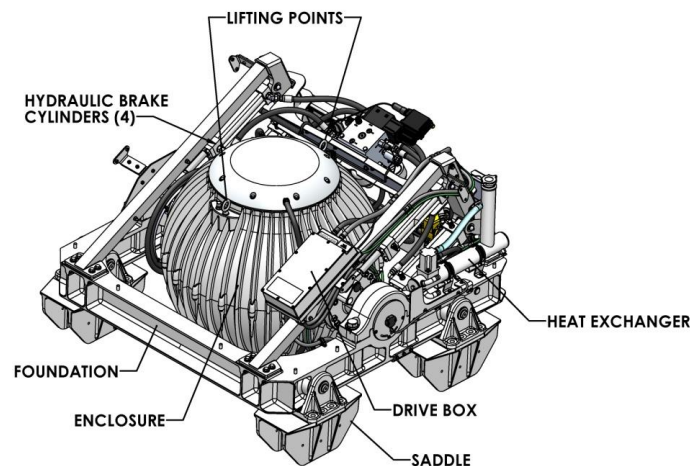


FIGURE 1 – SEAKEEPER 26

Section 1: MECHANICAL INSTALLATION

1.1 Precautions

- The Seakeeper must only be lifted from the supplied lifting eyes (See Section 1.4).
- The Seakeeper flywheel is supported by precision bearings. Make certain while unpacking and lifting the Seakeeper assembly to NOT drop or impart mechanical shock as damage to bearings could result.
- While handling / installing the Seakeeper assembly, protect exposed hydraulic brake cylinder rods (See Figure 1) from scratches or damage as this could lead to premature seal failure and oil leaks.
- While handling / installing the Seakeeper assembly, do not allow electrical fittings that exit bottom of enclosure to come in contact with any surface or object as this could damage the fittings and potentially affect the vacuum integrity of the enclosure.
- Exercise care to protect painted finish as damage to finish could lead to early appearance degradation of the installed Seakeeper.

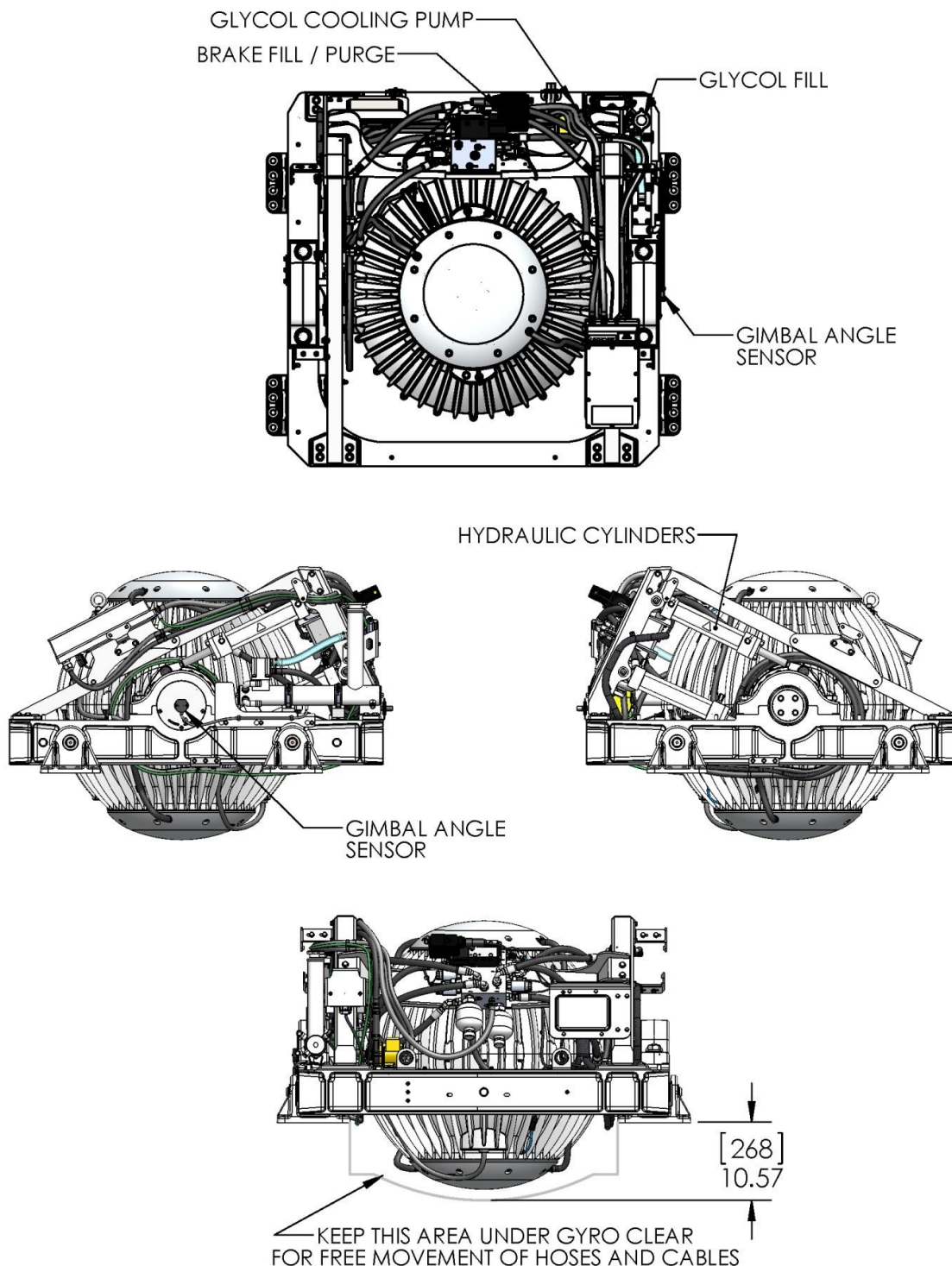
1.2 Selection of Seakeeper Installation Location

Selection of mounting location of the Seakeeper should consider the following desirable features:



The Seakeeper should be installed aft of amidships to minimize high acceleration loadings due to hull/wave impacts during operation at high speed or in large waves. If the only possible Seakeeper location is forward of amidships then the installer should have Seakeeper review the installation location prior to finalizing the design.

- **Overhead access or sufficient clearance for removal / re-installation of the Seakeeper for overhaul in future years.**
- The Seakeeper should be installed in a dry space to minimize effects of corrosion.
- Clearance for replacement of gimbal angle sensor on gimbal shaft (see Figure 2).
- Clearance for filling / purging brake hydraulic oil (see Figure 2).
- Clearance for filling water/glycol cooling circuit (see Figure 2).
- Clearance for replacement of brake hydraulic cylinders (see Figure 2).

Section 1: MECHANICAL INSTALLATION


**VIEWS SHOWING RECOMMENDED CLEARANCES AROUND THE SEAKEEPER FOR USE OF HAND TOOLS,
EASE OF MAINTENANCE, INSTALLATION, AND PROPER OPERATION**

FIGURE 2 – INSTALLED SEAKEEPER CLEARANCE CONSIDERATIONS

Section 1: MECHANICAL INSTALLATION

Safety



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 stepped on, or have anything placed on top. The covers should always be in place during operation. If it is ever necessary to access the Seakeeper while the flywheel is spinning, the Seakeeper must be locked at the display to stop the Seakeeper from precessing. Seakeeper regular maintenance should not be attempted unless the Seakeeper is locked and the flywheel has stopped spinning.

The Seakeeper should be treated with the same respect one gives a high speed rotating propeller shaft or engine shaft.

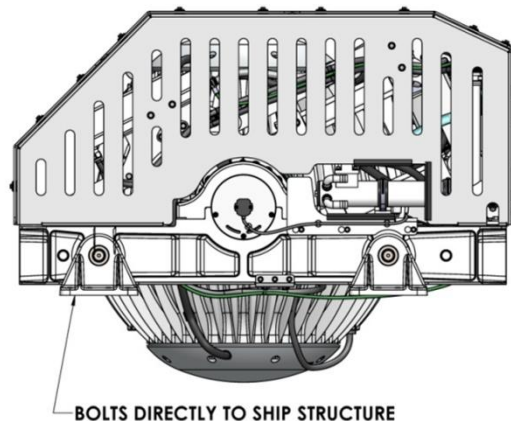
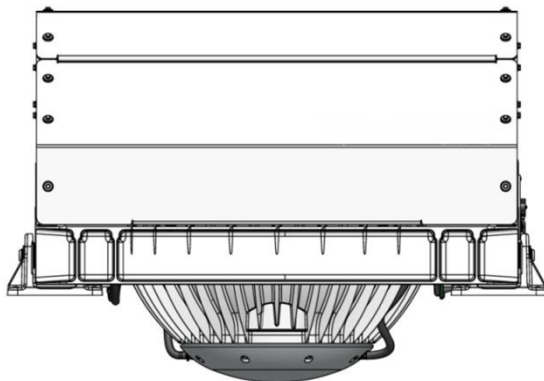
Noise/Soundproofing

Seakeeper noise has been measured under steady state conditions (no wave load) in Seakeeper's lab and in our test boat. The steady state noise is typically in the range of 70-75 dB un-weighted. As the frequencies emitting the highest sound pressures are low (like other marine machinery), it is recommended that the Seakeeper be installed in a machinery space that is already treated with soundproofing.

Section 1: MECHANICAL INSTALLATION

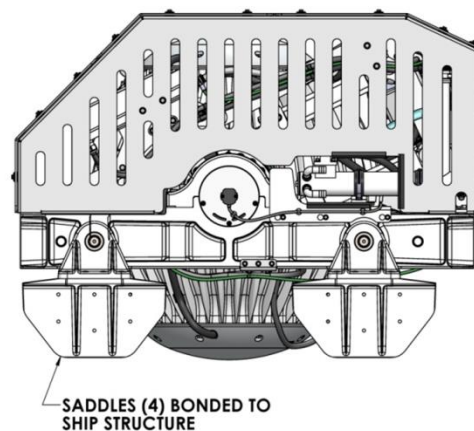
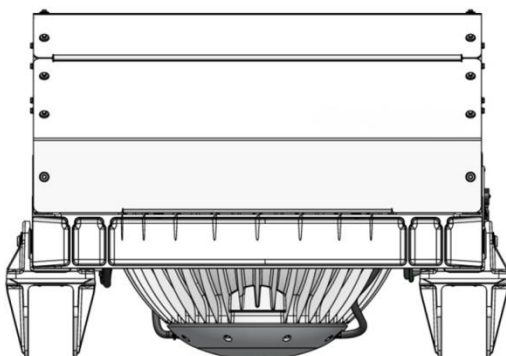
1.3 Selection of Installation Method

The Seakeeper 26 can be affixed to the hull structure using two methods 1) Bolt-In installation or 2) Bond-In (Saddle) installation. See figures below.



OPTION 1- DIRECT FASTENING OF SEAKEEPER FOUNDATION TO SHIPS STRUCTURE

Option 1 would be applied when a metal structure is available for attachment. The foundation would fasten directly to hull structure using isolation gaskets and either M16 or 5/8" fasteners. Depending on the structure to which the Seakeeper is fastened, blind threaded holes or thru-bolting can be utilized.



OPTION 2- SADDLE INSTALLATION (4 PLACES)

Option 2 would be most commonly used on a hull constructed of glass reinforced plastic (GRP) or fiberglass. For this option, four 16 inch (406 mm) long by 8 inch (203 mm) deep saddles are bonded to properly spaced and prepared structural members that are an integral part of the hull structure. Seakeeper recommends using a structural adhesive with a lap shear strength of 2000 psi (13.8 MPa) or greater. Careful consideration should be exercised by the installer while selecting the appropriate adhesive. Compatibility with the Seakeeper's cast aluminum A356-T6 saddles, hull structure and pot life are three important factors to consider. Proper surface preparation in accordance with adhesive manufacturer's recommendations prior to installation is very important.

Section 1: MECHANICAL INSTALLATION

1.4 Unpacking Crate

- 1) Reference Seakeeper Drawing No. 90244 Seakeeper 26 Hardware Scope of Supply and 90416 Seakeeper 20HD Hardware Scope of Supply for items that ship with the corresponding Seakeeper model.
- 2) Remove electrical components, cables, and misc. items and set aside.
- 3) Remove packing materials that secure Seakeeper assembly inside the crate.
- 4) Remove top and angled face cover panels to access lifting eyes.
- 5) Attach spreader bar to the two lifting eyes located on the top of the Seakeeper enclosure. Stay clear of any other parts on the Seakeeper. The Seakeeper 26 weighs 1388 kg (3060 lbs). See Figure 4 below.

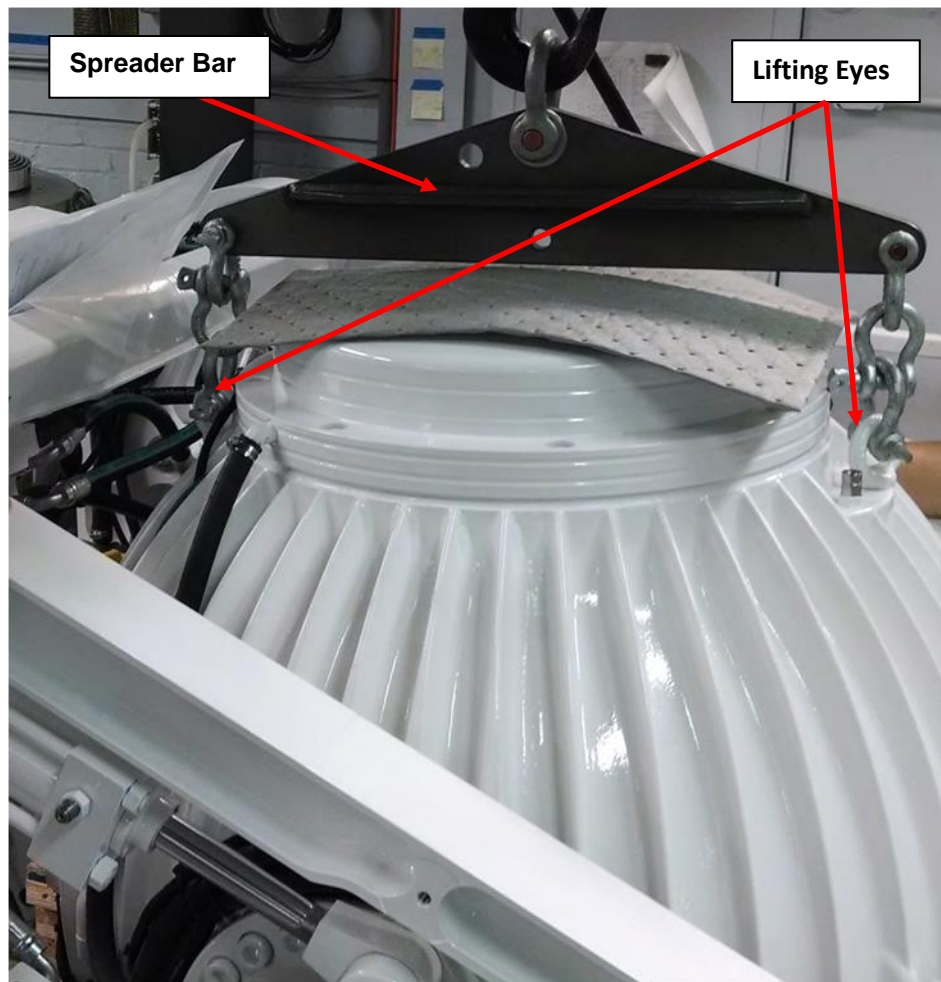


FIGURE 4 – LIFTING ARRANGEMENT

Section 1: MECHANICAL INSTALLATION

1.5 Bolt-In Installation

1.5.1 Check and Preparation of Hull Structure

Refer to Seakeeper **Drawing No. 90271, Seakeeper 26/20HD Installation Details – Bolt in Method**. Important dimensional and load information is given in this drawing that will impact the design details of the structure that will receive the Seakeeper. It is assumed that a proper structural analysis has been performed for the hull structure to which the Seakeeper will be fastened to insure proper strength margins for the loads the Seakeeper will create during operation.

The hull structure supporting the Seakeeper should be installed so the Seakeeper is parallel to the water plane in the port/starboard and forward/aft directions. **In addition, the four areas on top of the beams on which the isolation mounts will rest need to be co-planar within 1/8th inch (3 mm) to minimize potential distortion of Seakeeper support frame when installed. (Similar to Figure 9).**

Seakeeper provides an installation fixture assembly, P/N 90089 that contains four plates that mimic the mating surfaces of the four isolation mounts located on the Seakeeper's foundation. These plates have 8 holes located at the same centers as the holes in the isolation mounts. These smaller holes can be used to locate the holes in the ship's structure through use of a transfer punch. The fixture locates the hole patterns at the proper spacing, both in the fore-aft direction and the port-starboard direction. See Figures 5 & 6 below. Once assembled, the fixture can be used to check clearances and alignment of the hull structure.

Note: Do NOT use the installation fixture to establish the Seakeeper envelope dimensions. Refer to Drawing No. 90271 for envelope dimensions. A 3-D model of the Seakeeper is available on the Seakeeper website (www.seakeeper.com) to aid in designing the Seakeeper foundation and the space around the Seakeeper.

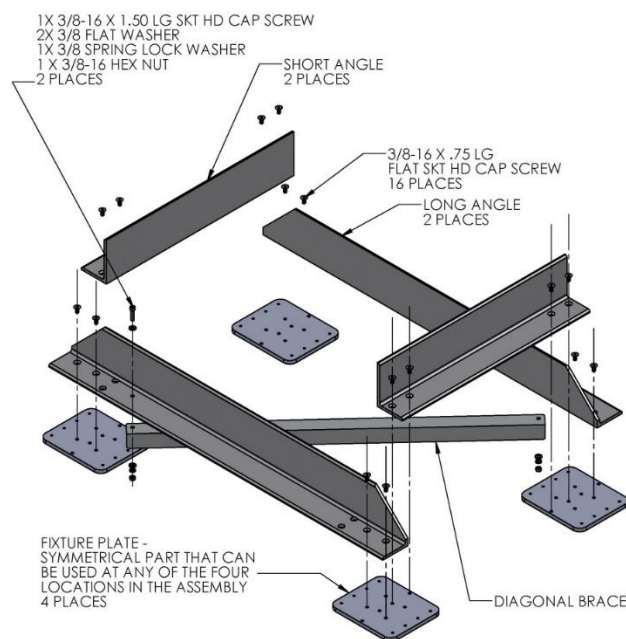
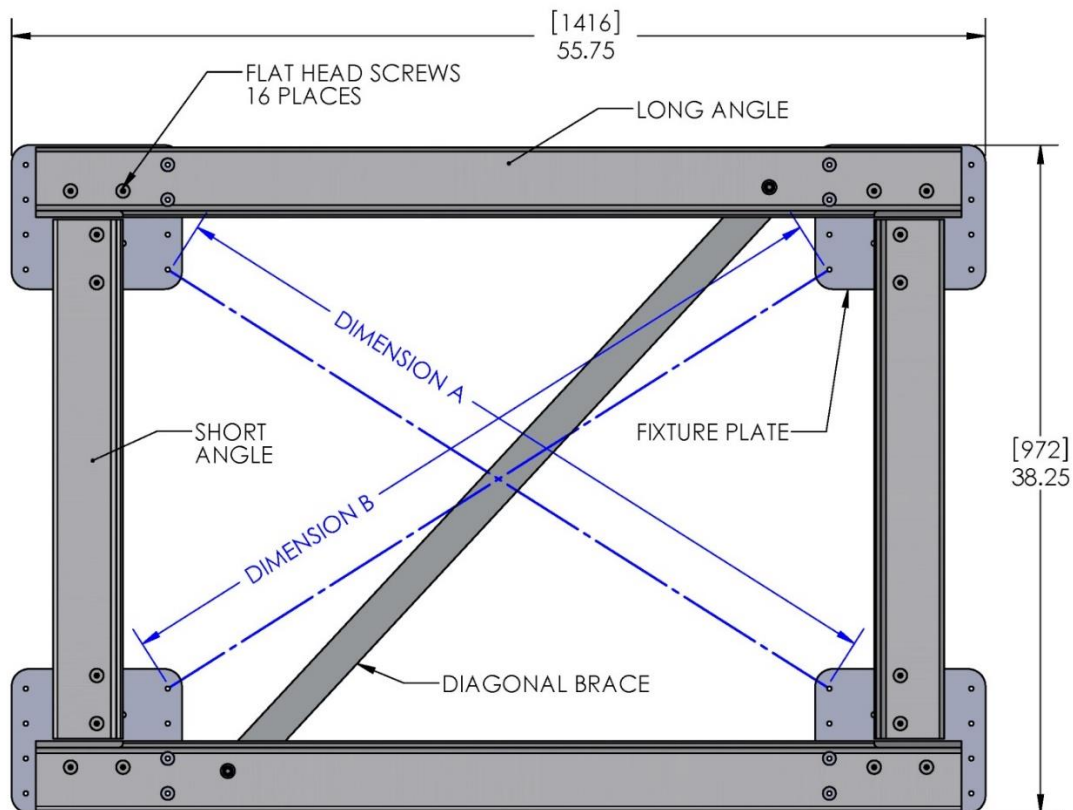


Figure 5 – Exploded View of Installation Fixture

Section 1: MECHANICAL INSTALLATION

- PLACE FIXTURE PLATES ON FLAT SURFACE AND ARRANGE IN APPROXIMATE LOCATIONS
- INSTALL SHORT AND LONG ANGLES AS SHOWN BUT DO NOT TIGHTEN FLAT HEAD FASTENERS UNTIL FINAL STEP.
- INSTALL DIAGONAL BRACE USING 3/8" SKT HD CAP SCREWS, WASHERS & NUTS.
- **CONFIRM SQUARE BY MATCHING DIMENSION A & B SHOWN BELOW WITHIN 1mm.**
- FIRMLY TIGHTEN ALL FASTENERS.
- DOUBLE-CHECK SQUARE AND RE-ADJUST IF NEEDED



VIEW FROM ABOVE FIXTURE

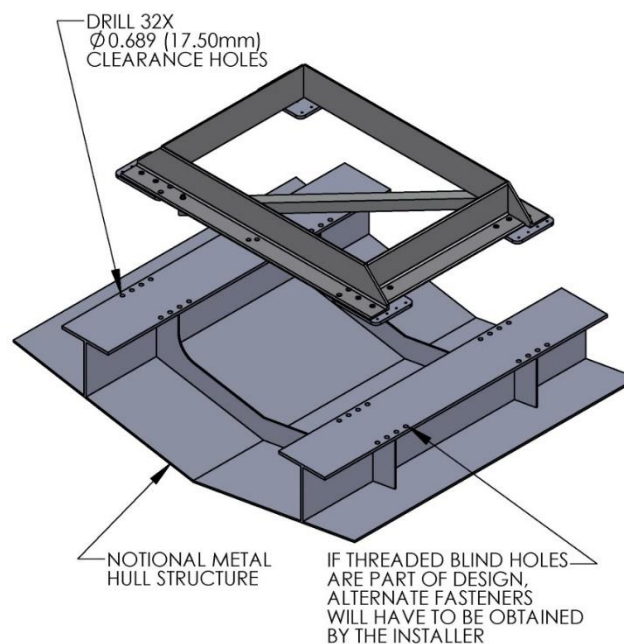
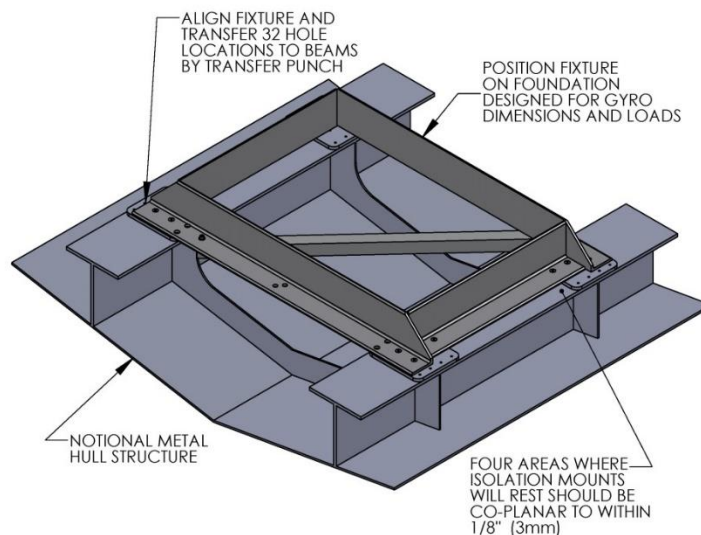
FIGURE 6 – NOTICE FOR CHECKING SQUARE OF ASSEMBLY

Section 1: MECHANICAL INSTALLATION

1.5.2 Transfer of Holes to Foundation

- 1) Lower assembled fixture onto hull structure.
- 2) **The four areas where the isolation mounts will rest should be coplanar to within 1/8" (3 mm). See Figure 9.** Do not use the fixture to check co-planarity as it is not stiff enough.
- 3) Align fixture in desired location and transfer holes from fixture plate to the hull structure. A transfer punch is recommended for this step. Note that holes in fixture plate are $\varnothing.257$ (6.5 mm).
- 4) Remove fixture and drill holes in foundation at marked locations to mate with holes in Seakeeper isolation mounts. A $\varnothing.689$ inch (17.5 mm) hole is recommended for the provided M16 fasteners.

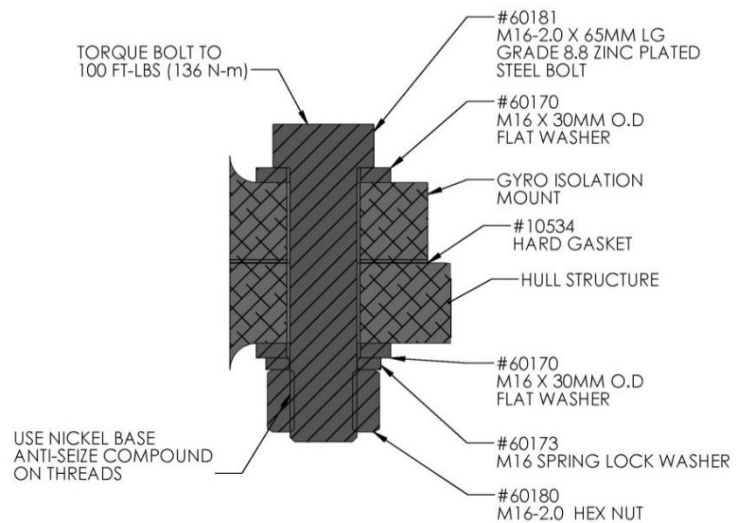
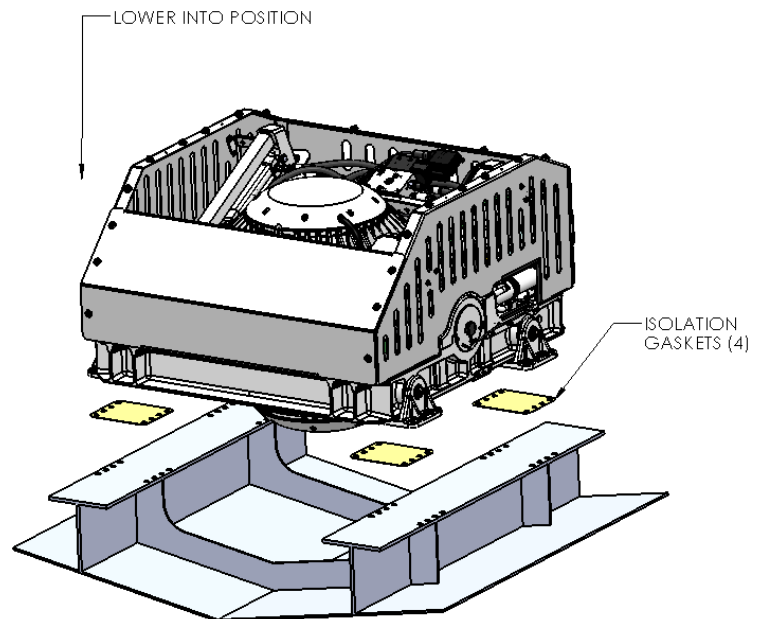
NOTE: Certain foundation designs that employ threaded blind holes in thick plates may require the installer to obtain alternate fasteners.



Section 1: MECHANICAL INSTALLATION

1.5.3 Installation of Seakeeper

- 1) Locate and position 4 isolation gaskets onto foundation beams.
NOTE: A **VERY SMALL** AMOUNT OF SEALANT MAY BE APPLIED TO THE GASKET TO KEEP WATER FROM WICKING INTO THE JOINT.
- 2) Lower Seakeeper into position onto foundation beams and align over drilled holes.
- 3) Install Seakeeper supplied M16 fasteners as shown in figure to right—**apply a moderate coat of nickel based anti-seize compound to the threads** of each bolt prior to installation.
- 4) **Torque all fasteners to 100 ft-lbs (136 N-m).**
- 5) Apply a small bead of sealant (silicone or caulk) around the perimeter of each isolation mount where it rests on the beam. This will prevent water from wicking between the parts and setting up corrosion.
- 6) Proceed to electrical and cooling portion of the installation.



SECTION THROUGH ISOLATION MOUNT / FOUNDATION BEAM

Section 1: MECHANICAL INSTALLATION

1.6 Saddle Installation

Seakeeper recommends a slow curing, non-sagging structural adhesive for bonding the saddles to the GRP hull structure. Such an adhesive is Plexus MA590 which is a two-part methacrylate adhesive. Details of the bonding procedure in this manual will involve the Plexus MA590 product, but that should not exclude other suitable adhesives the installer chooses to use. **See Sheet 6 of Seakeeper drawing no. 90272 for loads information and recommended adhesive properties.**

1.6.1 Initial Check and Preparation of Hull Structure

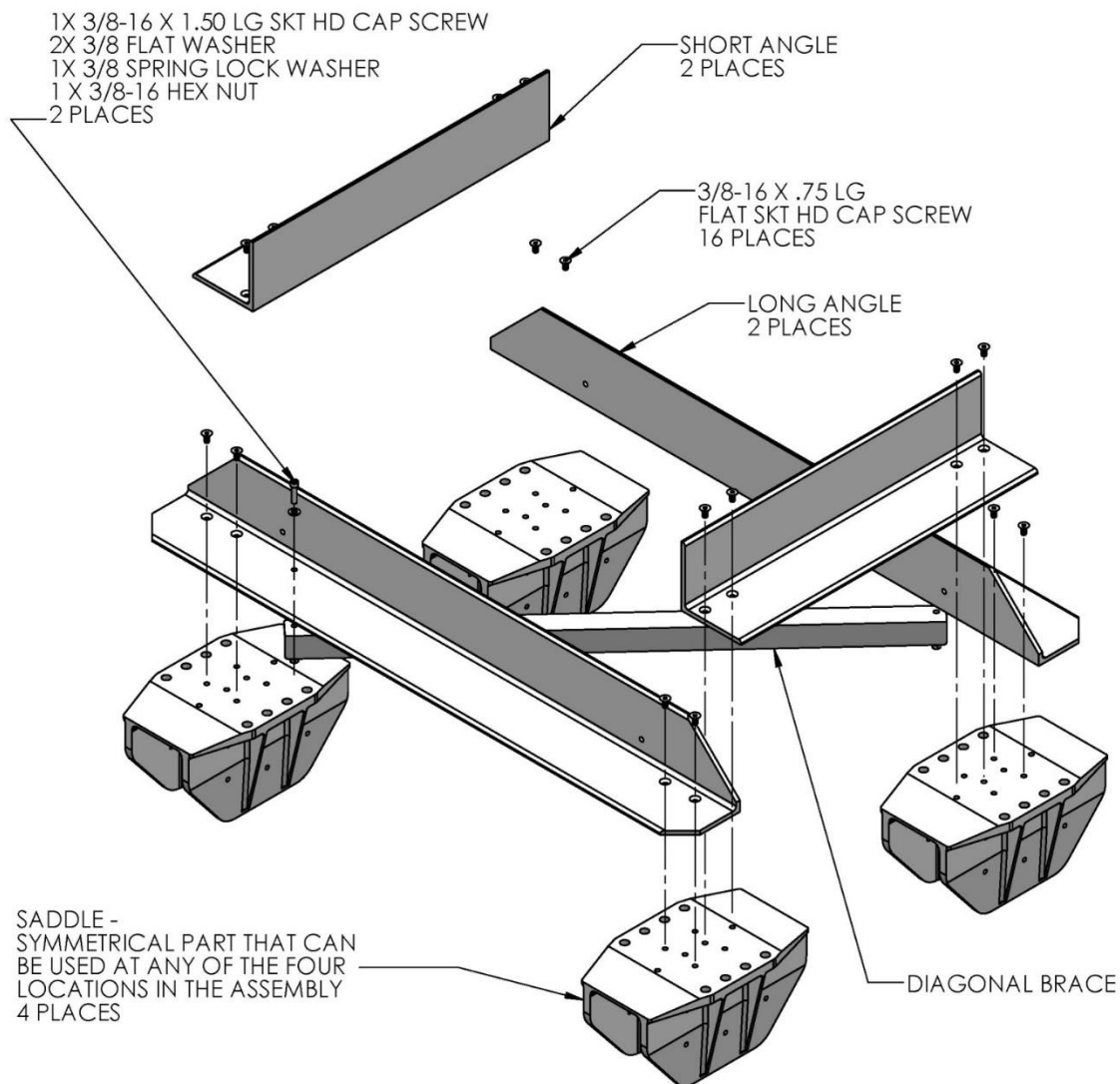
Refer to Seakeeper **Drawing No. 90272, Seakeeper 26/20HD Saddle Installation Details**. Important dimensional and load information is given in this drawing that will impact the design details of the structure that will receive the Seakeeper as well as selection of the adhesive to bond the Seakeeper into the hull.

The foundation “saddles” of the Seakeeper are designed to be bonded directly to the composite hull structure of the vessel to effectively distribute Seakeeper loads. **A complete bond is required between the inside surface of the saddles and the hull structure.** An estimate of adhesive volume required should be calculated for each installation based on gaps between saddles and structural members. There is some adhesive waste as a part of the process so a good rule of thumb is to purchase 50% more adhesive than estimated volume to bond. Depending on conditions and adhesive used, two workers may be required to apply the adhesive at the same time to finish the installation before the adhesive starts to cure. To aid in determining the quantity of adhesive required, the interior surface area (bonding surfaces) of **each** saddle is 287 in² (1852 cm²) for a total bonded surface area for all four saddles of 1148 in² (7406 cm²).

The hull structure supporting the Seakeeper should be installed so the Seakeeper is parallel to the water plane in the port/starboard and forward/aft directions. **In addition, the four areas on top of the beams that the saddles will bond to need to be co-planar within 1/8th inch (3 mm) to minimize potential distortion of Seakeeper support frame when installed.**

Note that any paint or gel-coat present in bond area should be removed so that adhesive will bond directly to laminate fibers and resin.

Seakeeper provides an installation fixture template, P/N 90088 that locates the saddles at the proper spacing both in the fore-aft direction and the port-starboard direction. See Figures 6, 7 & 8 below. Once assembled with the provided saddle fittings, the fixture can be used to check clearances and alignment of the hull structure. The fixture will allow the builder / installer to lay-up and adjust the foundation dimensions to create a low-clearance fit between the Seakeeper foundation saddles and the hull structure. Shear strength of the adhesive will be maximized if the cured thickness between the vessel structure and Seakeeper saddles is at the thinner end of the adhesive manufacturer's recommended range. Therefore, the fixture should be used to confirm that the overall dimensions of the foundations are square and level and that the adhesive gap is within Seakeeper's recommended range of 1 to 3 mm (.04" to .13").

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Note: Do NOT use the installation fixture to establish Seakeeper envelope dimensions. Refer to Drawing No. 90272 for envelope dimensions. A 3-D model of the Seakeeper is available on the Seakeeper website (www.seakeeper.com) to aid in designing the Seakeeper foundation and the space around the Seakeeper.

FIGURE 6 – EXPLODED VIEW OF SADDLE INSTALLATION FIXTURE

Section 1: MECHANICAL INSTALLATION

- PLACE SADDLES ON FLAT SURFACE AND ARRANGE IN APPROXIMATE LOCATIONS
- INSTALL SHORT AND LONG ANGLES AS SHOWN BUT DO NOT TIGHTEN FLAT HEAD FASTENERS UNTIL FINAL STEP.
- INSTALL DIAGONAL BRACE USING 3/8" SKT HD CAP SCREWS, WASHERS & NUTS.
- **CONFIRM SQUARE BY MATCHING DIMENSION A & B SHOWN BELOW WITHIN 1mm.**
- FIRMLY TIGHTEN ALL FASTENERS.
- DOUBLE-CHECK SQUARE AND RE-ADJUST IF NEEDED

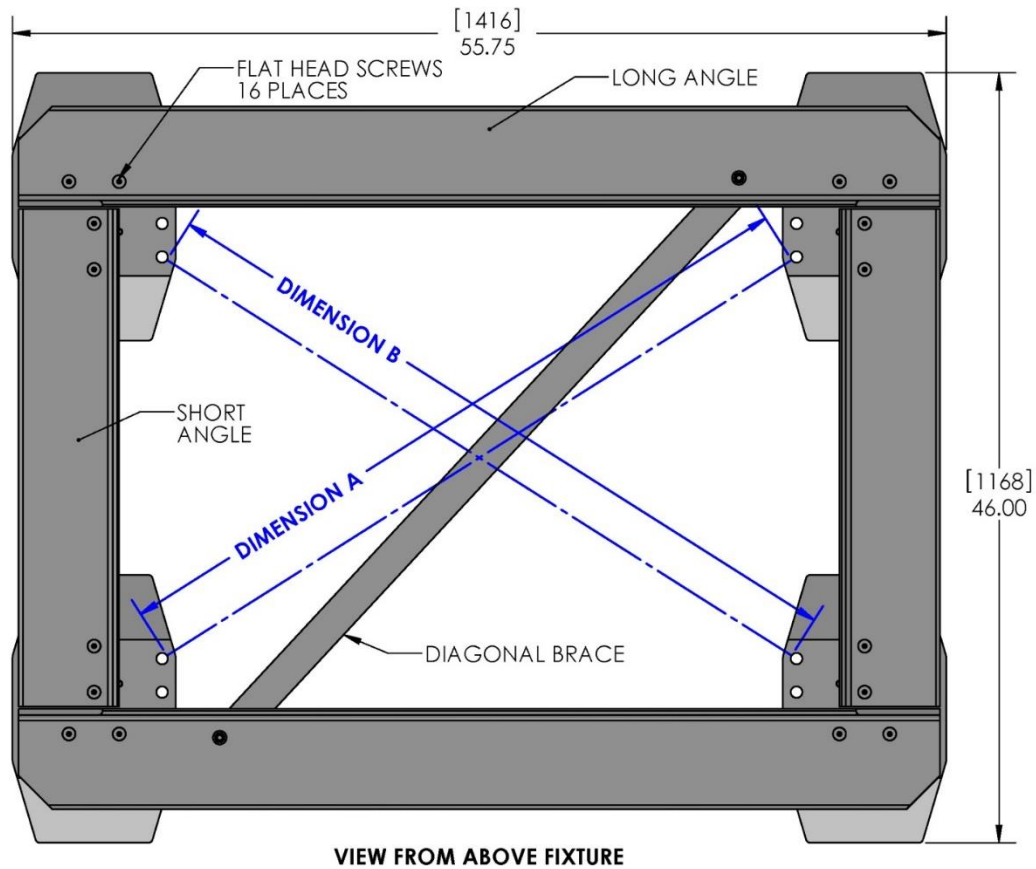
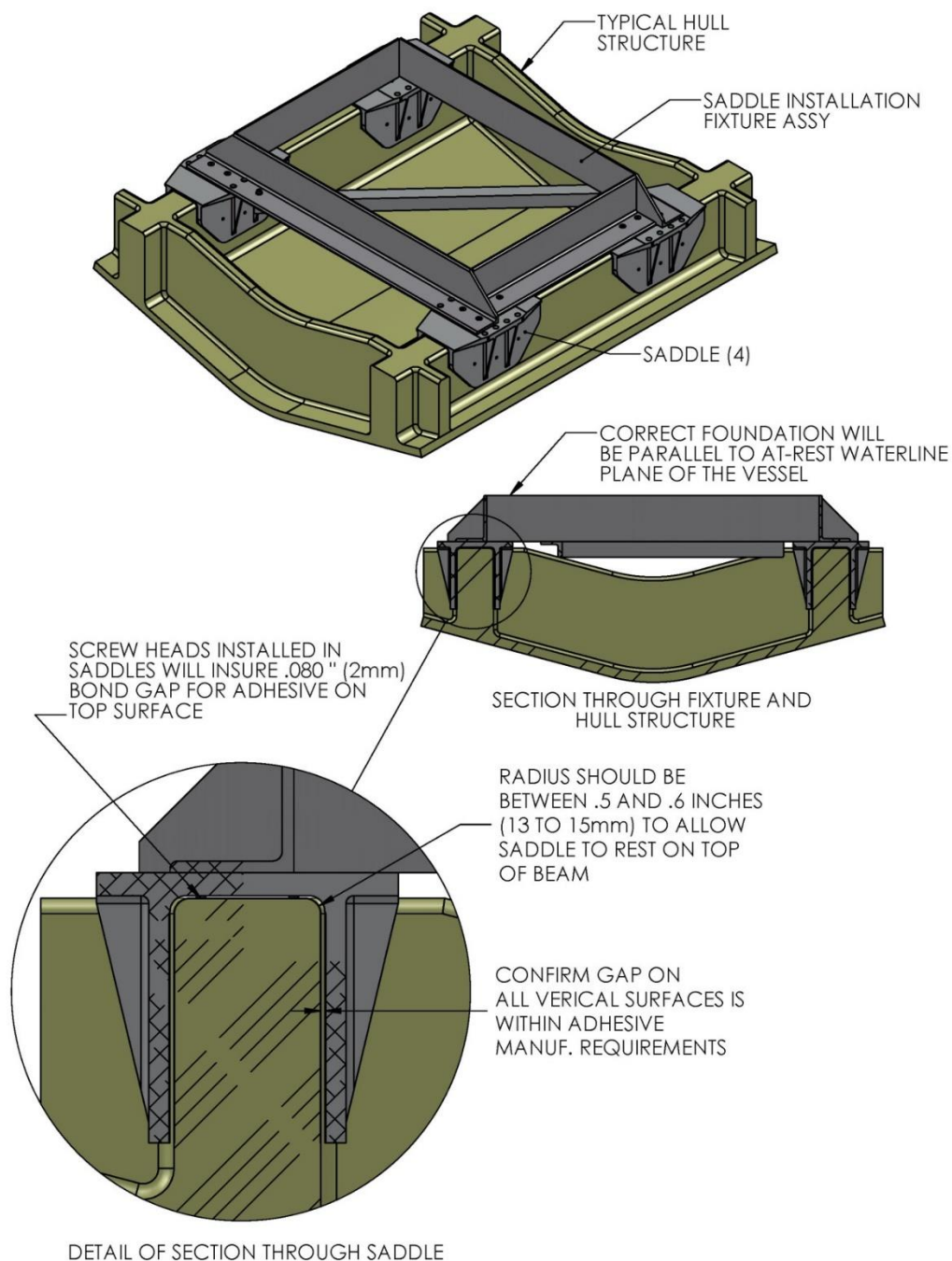


FIGURE 7 – NOTICE FOR CHECKING SQUARE OF ASSEMBLY

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FIGURE 8 – SADDLE INSTALLATION FIXTURE ON NOTIONAL HULL STRUCTURE

Section 1: MECHANICAL INSTALLATION

1.6.2 Fiberglass Hull Preparation

- 1) Position installation fixture (Fig 9) on hull girders noting recommended clearances for maintenance from Figure 2. Check that the screws fastening the saddles to the installation fixture are tight (Fig 6).

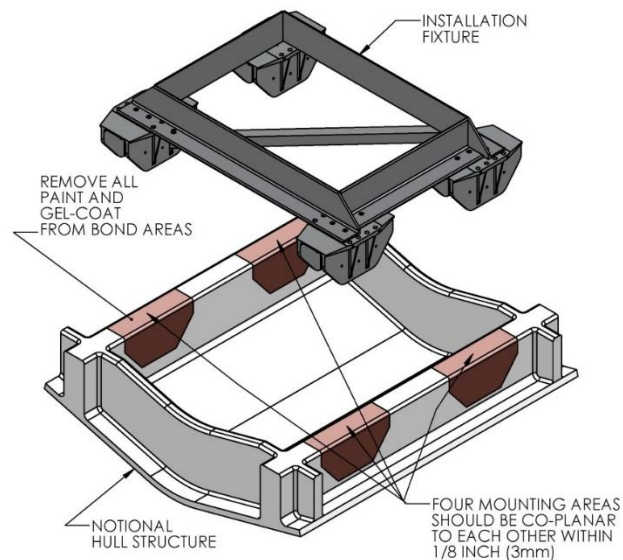


FIGURE 9 - INSTALLING FIXTURE ON HULL

- 2) Mask hull area (as shown in blue, Fig 10) around foundation saddles for easy clean-up and to create outline of surface area to receive adhesive as shown in brown, Fig 9. Insure that the bond gap is within adhesive manufacturer's recommended thickness, or 3 mm if using Plexus MA590.

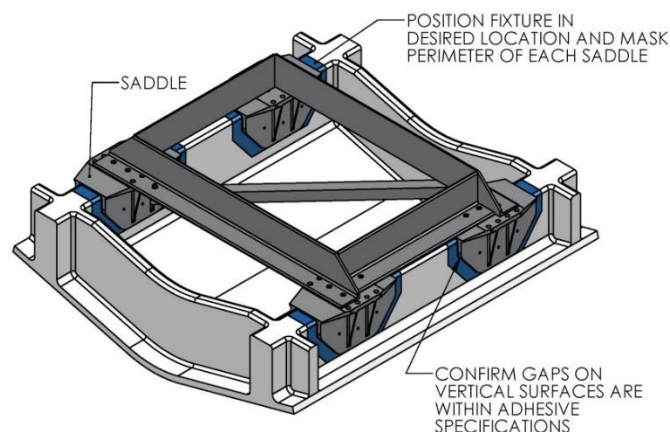


FIGURE 10 - MASKING PERIMETER OF SADDLES

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- 3) Raise fixture clear of foundation. Check all four mounting areas are co-planar to within 1/8" (3 mm) to each other, as well as parallel to the water line plane, as shown in Fig 11.

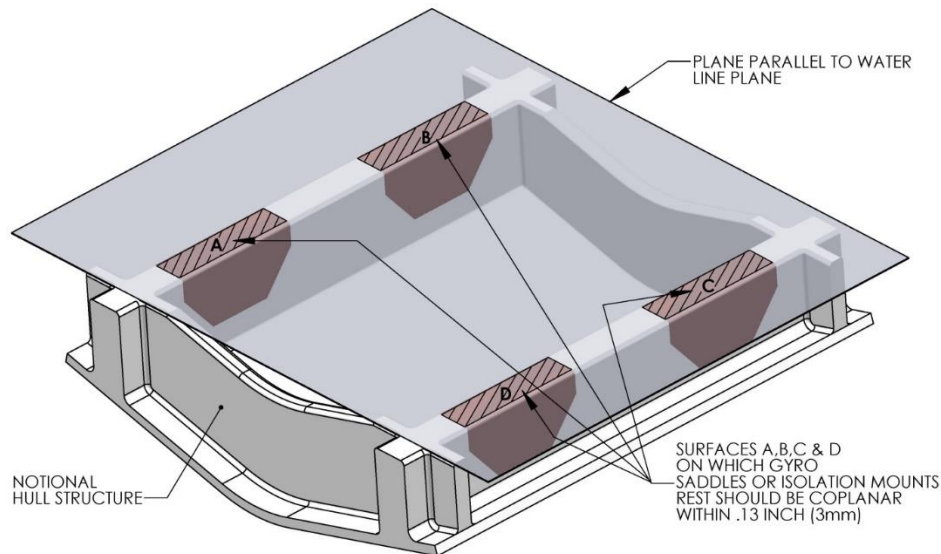


FIGURE 11 – COPLANAR PROPERTIES OF FOUNDATION

- 4) Thoroughly clean with alcohol or acetone all areas (highlighted in brown, Fig 9) of girders to be bonded to remove any contaminants. Use new paper towels for cleaning, not shop rags.
- 5) Remove all paint and gel-coat from bond surfaces so that adhesive will bond directly to laminate fibers and resin.
- 6) **Thoroughly sand girder bond surfaces with 80 grit sandpaper. (IMPORTANT – BOND STRENGTH MAY BE REDUCED IF THIS STEP IS SKIPPED.)**
- 7) Wipe surfaces clean from dust with alcohol or acetone using new paper towels, not shop rags.
- 8) Re-position installation fixture on girders and double-check that the adhesive gap is within the adhesive manufacturer's maximum recommended thickness. (Note gap will be larger due to absence of gel-coat.) Seakeeper recommends a maximum gap of 3 mm if using Plexus MA590.

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- 9) Lift installation fixture clear of foundation. Apply Seakeeper provided adhesive backed foam strips at the eight locations shown (each end of four saddles) in Figure 10 below. These strips are to serve as a dam to minimize adhesive escaping out the ends of the saddles as they are positioned over the bond area.

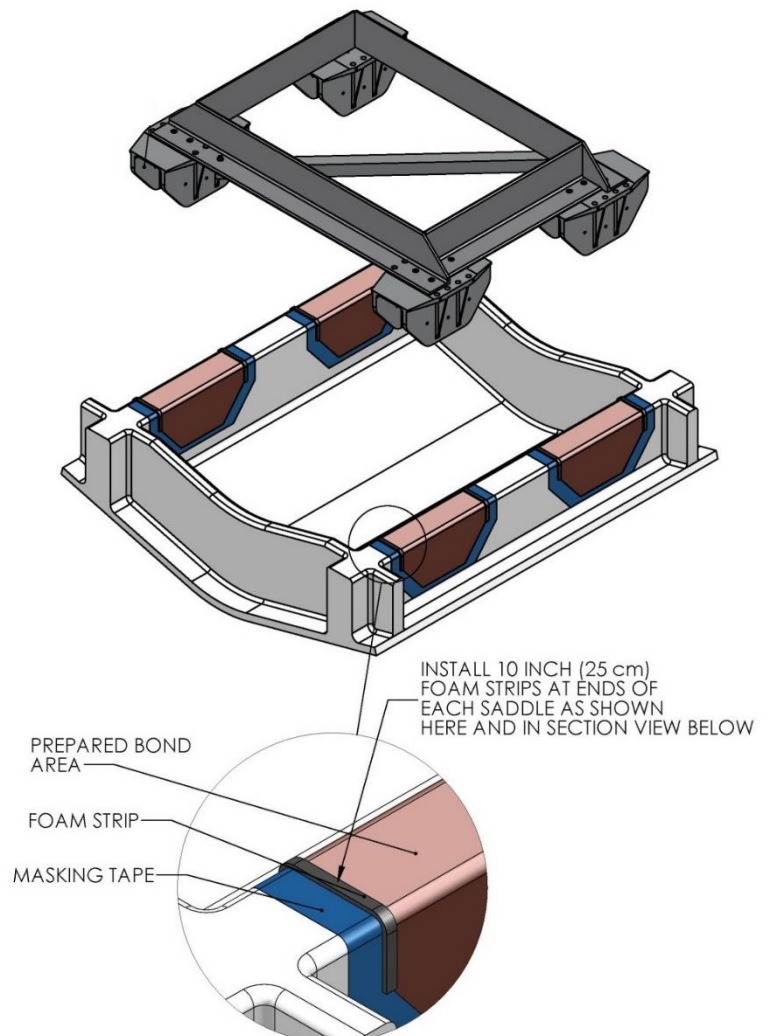
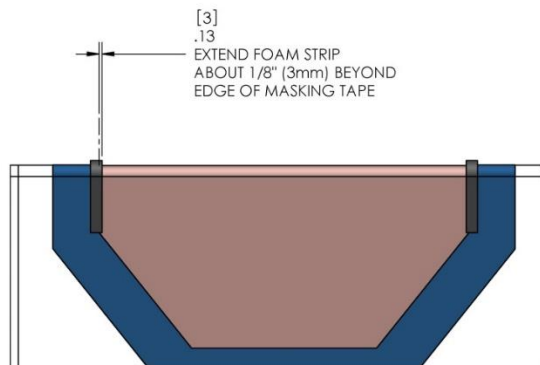


FIGURE 12 – FOAM STRIP INSTALLATION

Note if bonding saddles to a non-composite hull, contact Seakeeper for hull preparation instructions.

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1.6.3 Seakeeper Saddle Preparation

- 1) Ensure that screws fastening saddles to the installation fixture are tight (Fig 7).
- 2) Check that each saddle contains 4 plastic screws which will insure an adhesive gap of .080" (2 mm) on top surface of hull as shown in Figure 13.
- 3) Thoroughly clean with alcohol or acetone the inside surfaces of Seakeeper foundation saddles to remove any contaminants as shown in Figure 13. Use new paper towels for cleaning, not shop rags.

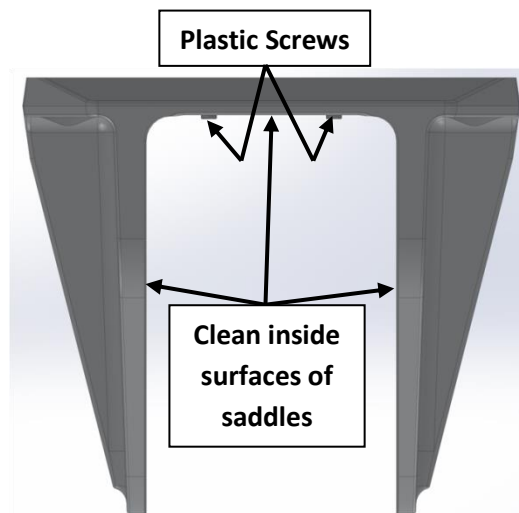


FIGURE 13 - SADDLE CLEANING

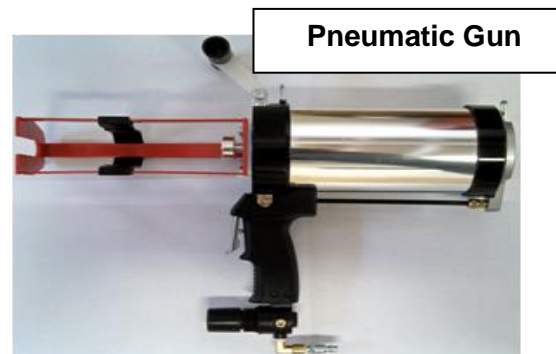
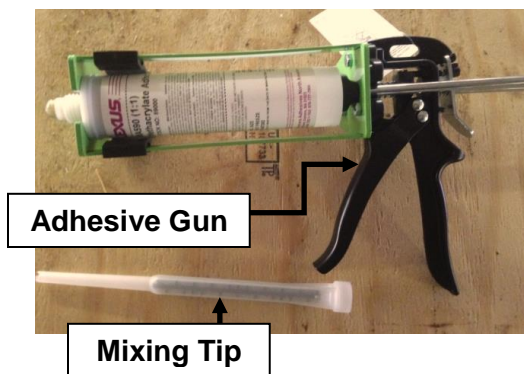
- 4) **Thoroughly sand all saddle inside surfaces with 80 grit sandpaper. (IMPORTANT – BOND STRENGTH MAY BE REDUCED IF THIS STEP IS SKIPPED.)**
- 5) Wipe surfaces clean from dust with alcohol or acetone using new paper towels, not shop rags.
- 6) If using Plexus MA590 adhesive, apply Plexus PC-120 surface conditioner to inside surfaces of Seakeeper foundation saddles in accordance with manufacturer instructions. These instructions are located at the end of this section. If using an alternate adhesive, check with manufacturer if any surface conditioner/etch is required for the aluminum saddles.

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1.6.4 Bonding Saddles to Hull

Note: If using Plexus MA590 adhesive, the Seakeeper saddles should be installed when PC-120 is confirmed dry.

- 1) Assemble Plexus cartridge into either the manual or pneumatic gun as shown. Remove cap on cartridge and attach mixing tip. For pneumatic gun, start with low air pressure and increase until desired flow rate is achieved.



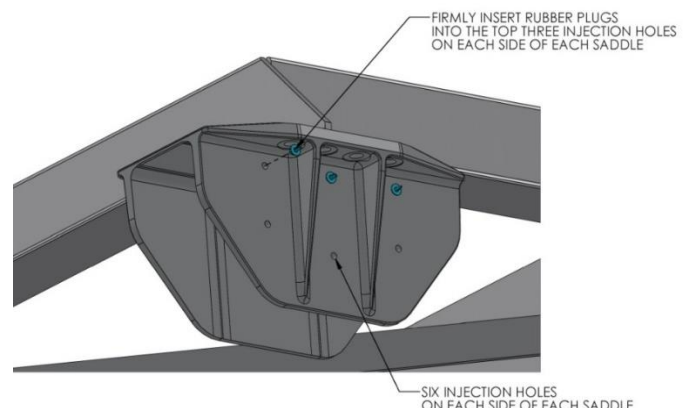
- 2) Cut tip of mixing wand as shown in photo.



- 3) Prepare a second mixing wand as shown in photo below by attaching the simple flexible nozzle to the end of the mixing tip. Set aside for now as this will be used to inject adhesive into the sides of each saddle after the fixture / saddles are in position.

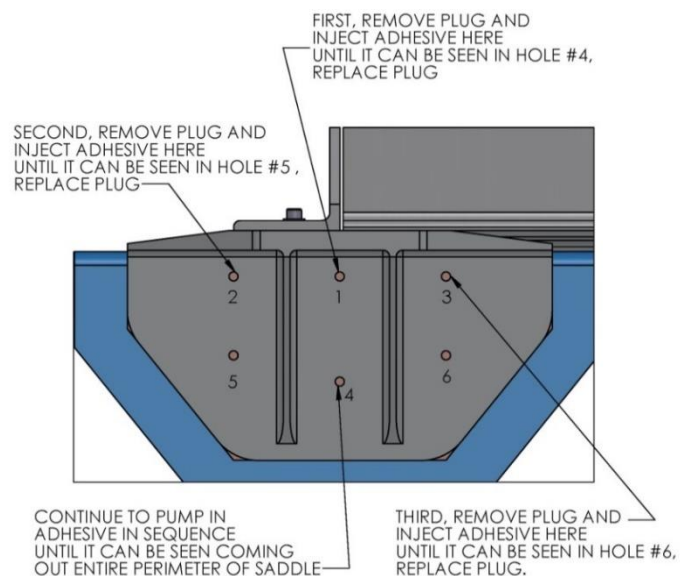
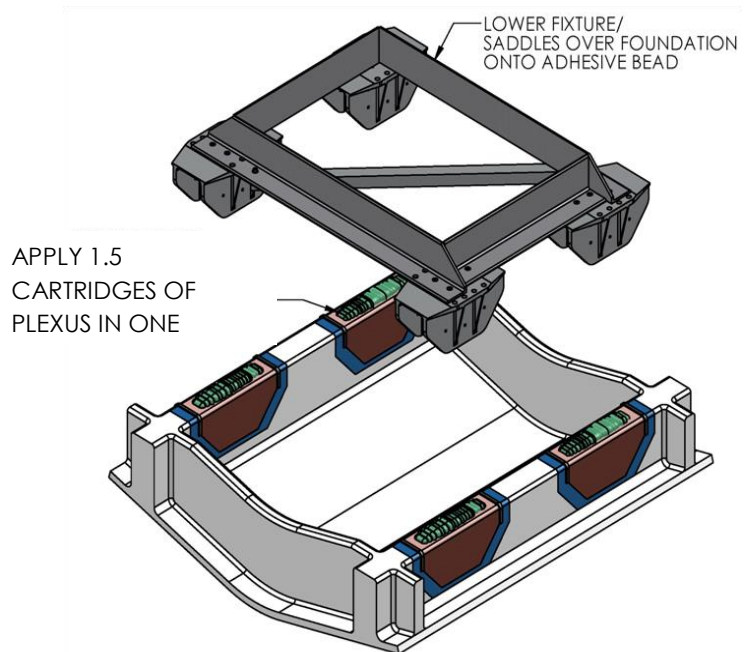


- 4) Install provided rubber plugs in 12 holes of each saddle. The plugs will limit the adhesive being forced out of the injection holes in step 6 below.



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- 5) Apply large bead of Plexus adhesive to the hull structure as shown in the figure to the right. Apply approximately 1 ½ cartridges at each of the four locations. **Work deliberate and fast as it takes some time to apply the adhesive to the structure. MA590 has a 90 minute working time at room temperature (23°C / 73°F). This working time can reduce to 40-50 minutes at elevated temperatures. Two workers should apply the adhesive at the same time to finish the installation before the adhesive starts to cure.**
- 6) Lower fixture and saddles over the hull structure and apply light downward pressure to each of the four saddles until the four nylon screws rest on the hull structure (SEE FIG. 8). The adhesive will be forced towards the forward and aft ends of each saddle and partially down the sides of the foundation beams.
- 7) Insert full adhesive cartridge along with mixing wand / nozzle assembled in step 3 above into gun.
- 8) Begin to inject adhesive into the six holes provided on each side of each of the four saddles. Follow the numbered sequence shown until the adhesive pushes out the edges of the saddle perimeter. The intent is to pump in the adhesive working from the top down and from the middle to the ends to fill the gaps and displace any air. **A complete bond is required – excess adhesive will be needed to make sure all bond gaps are filled.**
- 9) Repeat above step for remaining 7 sides of the saddles.

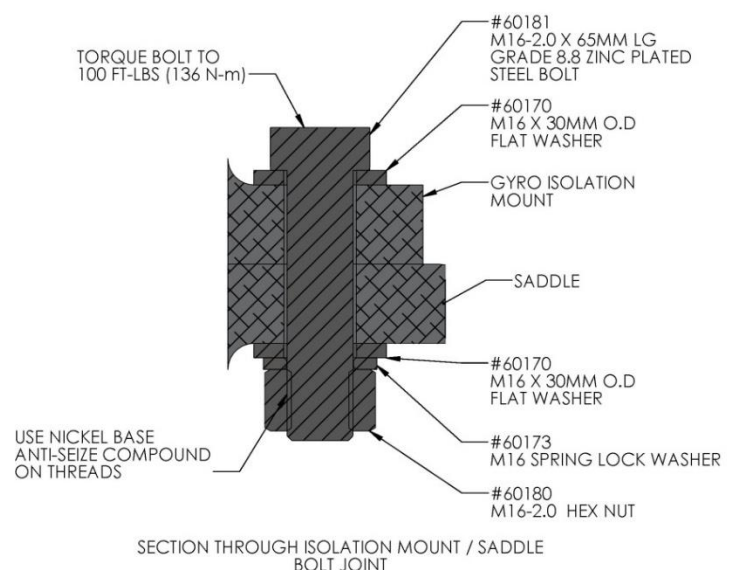
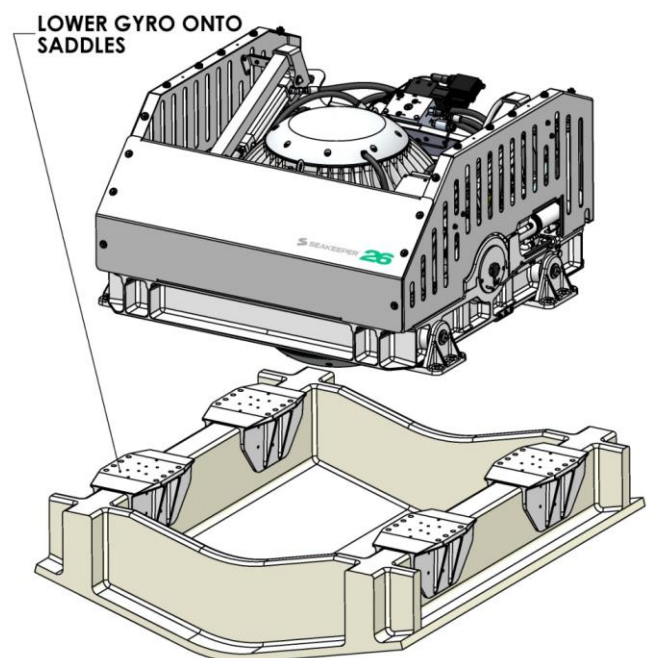



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- 10) When gaps have been completely filled, clean off excess adhesive, remove foam tape, remove plugs, and remove masking tape.
- 11) Allow adhesive to cure per manufacturer's recommendations. Follow adhesive guidelines for curing time versus temperature.
- 12) Bonding of Seakeeper saddles onto the hull is now complete. Remove installation fixture.

1.6.5 Installation of Seakeeper

- 1) Rig the Seakeeper for lifting and lower it into position onto top surface of four saddles.
- 2) Adjust position of the Seakeeper until alignment is achieved for the 32 fasteners that will attach the Seakeeper foundation frame to saddles.
- 3) Install Seakeeper supplied M16 fasteners as shown in figure to right– apply a moderate coat of nickel based anti-seize compound to the threads of each bolt prior to installation.
- 4) Torque all fasteners to 100 ft-lbs (136 N-m).
- 5) Apply a small bead of sealant (silicone or caulk) around the perimeter of each isolation mount where it rests on the saddle. This will prevent water from wicking between the parts and setting up corrosion.
- 6) Proceed to electrical and cooling portion of the installation.



| | | | |
|-----------------------------------------------------------------------------------|---------------------|---------------------|--------------------------|
|  | INSTRUCTIONS | Product: All | Document #: 90213 |
| Process: Plexus PC- 120 Application Instructions | | | Rev.: 1 |
| Process Description: Instructions for use of surface conditioner | | | Page 1 of 4 |

What is Plexus PC-120?

- Plexus PC-120 is a dual function primer/conditioner designed to clean surface contamination and leave a thin coating of primer on specific metal surfaces.
- Although designed specifically for cleaning and priming of Aluminum and Stainless Steel, PC-120 can be used to clean other surfaces in special situations. Contact Plexus Technical Service for recommendations on any surface other than Aluminum or Stainless Steel.

Plexus PC-120 works by:

- Cleaning the surface of contamination using Isopropyl Alcohol to “lift” machine oils and other contamination.
- Depositing a thin Phosphate based coating to retard corrosion.
- Leaving a light “pink” color to assist in determining what areas have, and have not, been treated with PC-120.

How should PC-120 be used?

- PC-120 can be brushed, wiped or sprayed onto the surface being primed.
- The PC-120 applied should then be wiped with a clean dry rag to remove any surface contamination cleaned by the PC-120 and leave only a thin, quick drying film.
- Dirty or oily rags should be replaced to avoid improper cleaning.
- Quality dye-free paper towels that don’t leave fibers behind are recommended.

Common mistakes with PC-120

- 1) Using too much PC-120
- 2) Not removing the oils lifted off the metal surface before the PC-120 dries.
- 3) Not abrading corrosion that is already on the surface of the metal.
- 4) Using PC-120 past its shelf life.

| | | | |
|--------------------------------------------------|-------------|--------------|-------------------|
| INSTRUCTIONS | Page 2 of 4 | Product: ALL | Document #: 90213 |
| Process: Plexus PC- 120 Application Instructions | | | Rev.: 1 |

1) Using too much PC-120

- Only a very thin coat should be left on the metal. You should be able to see a slight “pink” cast as illustrated below.

Too Much PC-120



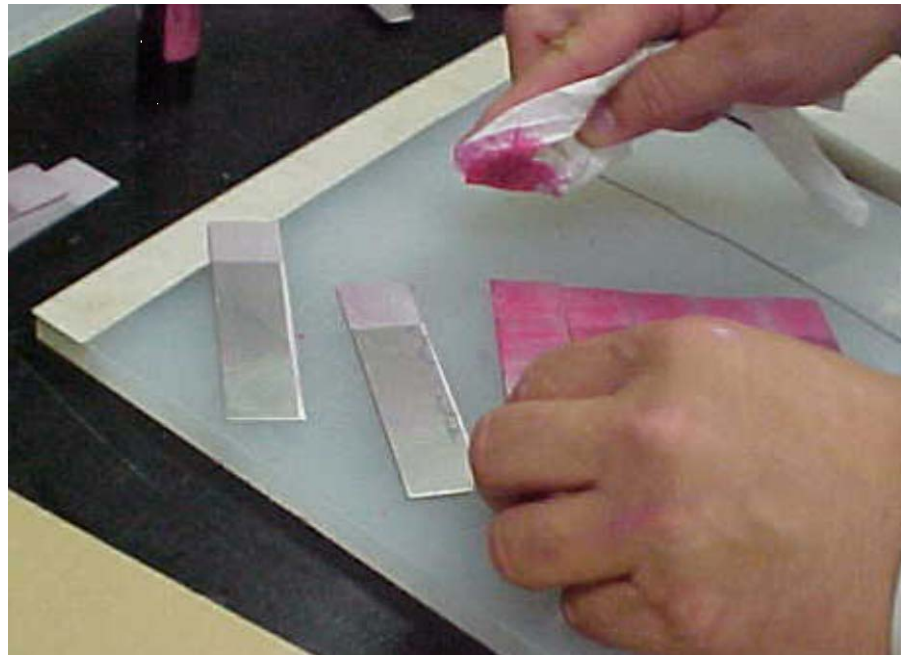
Correct Amount



2) Not removing oils once primed

- The solvents in PC-120 will clean and “lift” most machining oils, but if the metal isn’t wiped clean of these oils then they will be deposited right back onto the metal surface when the solvent in PC-120 evaporates!
- While still wet, wipe the PC-120 applied to the surface with a clean dry paper towel, changing the paper towel as needed.

Wipe the surface with a dry rag



Replace the rag when dirty

- Notice how much aluminum oxide was cleaned off “clean” looking Aluminum



| | | | |
|--------------------------------------------------|-------------|--------------|-------------------|
| INSTRUCTIONS | Page 3 of 4 | Product: ALL | Document #: 90213 |
| Process: Plexus PC- 120 Application Instructions | | | Rev.: 1 |

3) Not abrading corroded surfaces

- As good as PC-120 is, it can't help bonding performance if applied to a surface that is already corroded!
- Any surface that shows signs of corrosion should be cleaned by sanding or wire brushing to remove any scale or corrosion.
- After removal of corrosion then treat the surface with PC-120 as you normally would.

4) Using PC-120 past it's shelf life

- When stored under normal conditions PC-120 has a shelf life of 12 months in an unopened, original container.
- PC-120 bottles are marked with a lot number that is a simple 8 digit code that gives you the date of manufacture.
 - "807241" for example is 2008, 07 month (July), 24th day (the "1" refers to the first batch of PC-120 made that day). Use the lot number to make sure the material is still within shelf life.
- Since it contains isopropyl alcohol, PC-120 should be tightly capped when not in use to stop evaporation.



| | | | |
|---------------------------------------------------------|-------------|---------------------|--------------------------|
| INSTRUCTIONS | Page 4 of 4 | Product: ALL | Document #: 90213 |
| Process: Plexus PC- 120 Application Instructions | | | Rev.: 1 |

Remember these points! To avoid problems with Plexus PC-120:

- Don't use too much PC-120. Only a thin layer is needed.
- Use a clean rag to wipe PC-120 off before it completely dries to remove surface contaminants it has cleaned. Good quality paper towels are a better choice to minimize introduction of contaminants to surface.
- Any sign of corrosion already on the surface should be removed by abrading BEFORE priming.
- Check the lot number for the date to make sure the PC-120 is less than a year old.

Questions

- Please contact Plexus Technical Service at 1-800-851-6692 or info@itwplexus.com

Section 2: ELECTRICAL INSTALLATION

2.0 Introduction

This section for electrical installation explains how to mount the electrical equipment and how to connect the electrical cables.

Reference Documents & Drawings

90244 Seakeeper 26 Hardware Scope of Supply

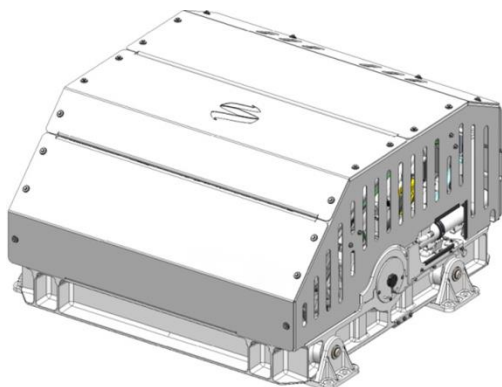
90416 Seakeeper 20HD Hardware Scope of Supply

90250 2nd Helm Control Station Kit

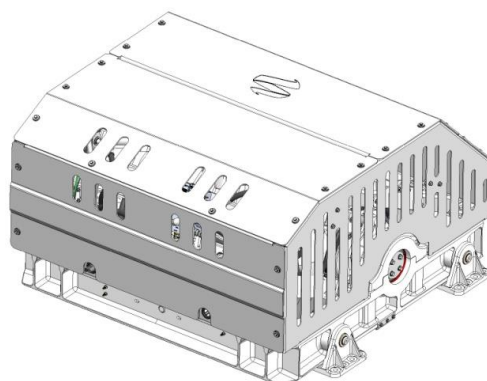
90266 Seakeeper 26/20HD Operation Manual

90310 Seakeeper 26/20HD Cable Block Diagram (includes 2nd Display Kit)

90337 Color Operator Display Envelope and Mounting Details



SEAKEEPER 26, Front Oblique View



SEAKEEPER 26, Rear Oblique View



24VDC Power Connector



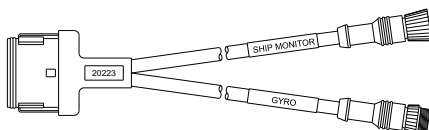
Terminator, Female



Tee Adapter



Color Display



Display Interface Cable



25m Cable

FIGURE 1 – ELECTRICAL EQUIPMENT FOR SEAKEEPER 26

Section 2: ELECTRICAL INSTALLATION

2.1 Electrical Equipment Mounting

Precautions

- Each item of electrical equipment has specific mounting instructions. These instructions should be followed to insure proper function of the Seakeeper.



Do NOT move Seakeeper mounted components from their locations or incorrect Seakeeper operation will result.

1. COLOR DISPLAY MOUNTING INSTRUCTIONS, SURFACE MOUNT

- a. Console space required: Approx. 4.57 W x 4.57 H inches (116 x 116 mm)
- b. Mounting Instructions, Surface Mount: See drawing 90337 for details

2. SERIAL COMMUNICATIONS TEE ADAPTER AND TERMINATOR MOUNTING INSTRUCTIONS

- a. Console space required, Rear: Approx. 4 W x 3 H inches (102 x 76 mm), rear
- b. Mounting Instructions: Rear mount on vessel console panel, within 1 ft (0.3m) of Display.
- c. Hardware required: One mounting screw for .197" (5mm) diameter mounting hole on Tee Adapter.

Section 2: ELECTRICAL INSTALLATION

2.2 Electrical Equipment Power Connections

1. 230 VAC POWER SOURCE REQUIREMENTS

- a. 230 VAC (nominal), 1 Phase, 50/60 Hz, 20 Amps.
- b. A separate circuit breaker should be used for each Seakeeper Motor Drive Box.

2. DRIVE BOX AC POWER INPUT CONNECTION INSTRUCTIONS

- a. Cable: 3 x 10AWG (3 x 6mm² CSA), 10' (3m) length, Seakeeper supplied pre-installed.
 - i. Locate CABLE 2 for AC power input to the Motor Drive Box at the outward of three cable glands.

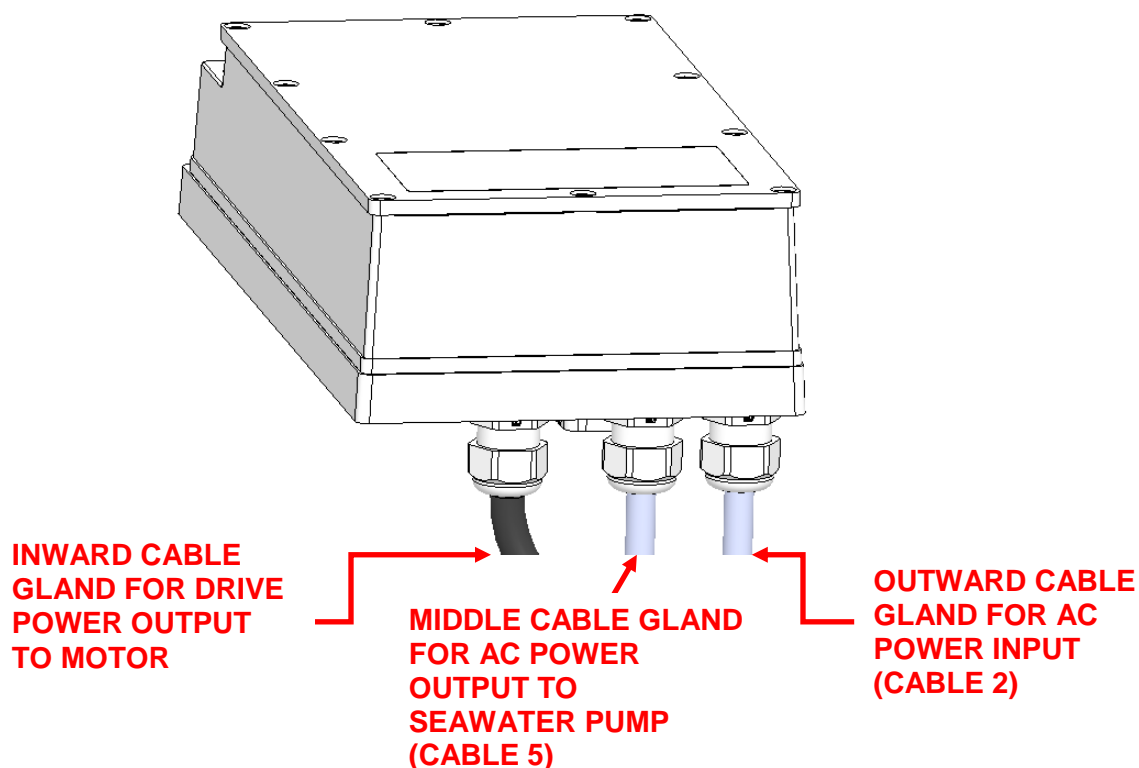


FIGURE 2 – MOTOR DRIVE BOX AC POWER INPUT & OUTPUT CABLE GLANDS

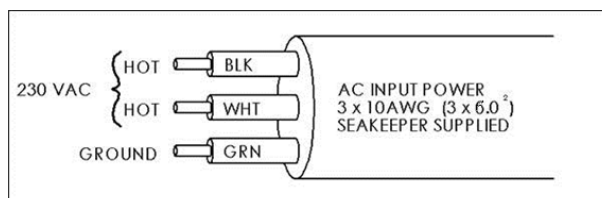


FIGURE 3 – CABLE 2 WIRE CONNECTIONS AT AC POWER DISTRIBUTION PANEL

- ii. Connect 230 VAC wires in CABLE 2 to a 20 Amp, double-pole Circuit Breaker at an AC power distribution panel according to Figure 3 above.

Section 2: ELECTRICAL INSTALLATION

3. DRIVE BOX AC POWER OUTPUT TO SEAWATER PUMP CONNECTION INSTRUCTIONS

- a. Cable: 3 x 14AWG (3 x 2.0mm² CSA) cable, 10' (3m) length, Seakeeper supplied pre-installed.
- b. Pumps rated at 230 VAC, 5 Amps max., Customer-supplied.



Verify that AC power is OFF to the Drive Box before connecting CABLE 5 to a Seawater Pump.

- i. Locate CABLE 5 for AC power output to the Seawater Pump from the Drive Box at the middle of three cable glands. (See Figure 2.)

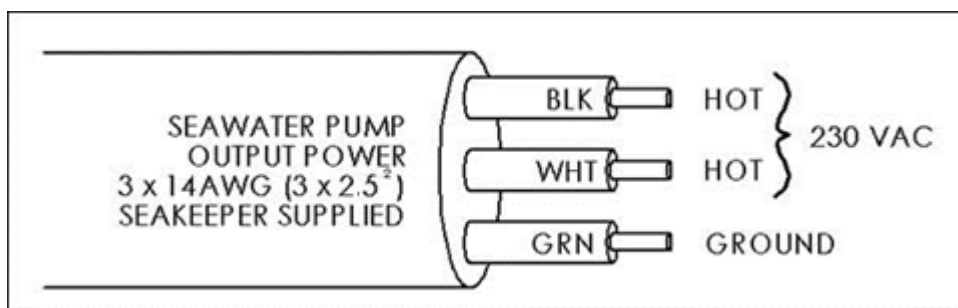


FIGURE 4 – CABLE 5, AC OUTPUT POWER CABLE

- ii. Connect the 230 VAC wires in CABLE 5 to a 5 Amp maximum, Seawater Pump (approximately 1/3 horsepower or 250 W) according to Figures 4 and 5.

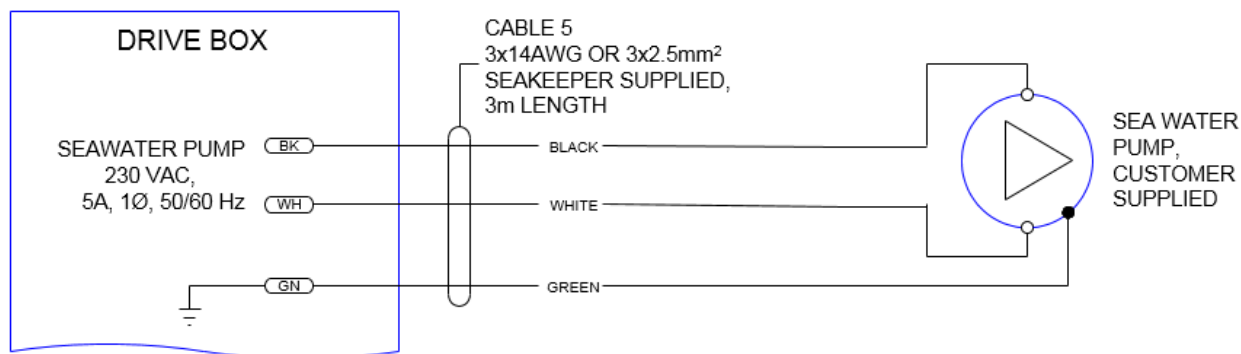


FIGURE 5 – CABLE 5, WIRE CONNECTIONS TO SEAWATER PUMP

- c. If the customer-supplied Seawater Pump is not rated for 230 VAC, the CABLE 5 output may be used to switch a customer-supplied relay.

Section 2: ELECTRICAL INSTALLATION

- i. Locate CABLE 5 for AC power output to the Seawater Pump from the Drive Box at the middle of three cable glands as shown in Figure 2.
- ii. The recommended wiring is shown in Figure 6. Refer to Figure 4 for Cable 5 wire connections.

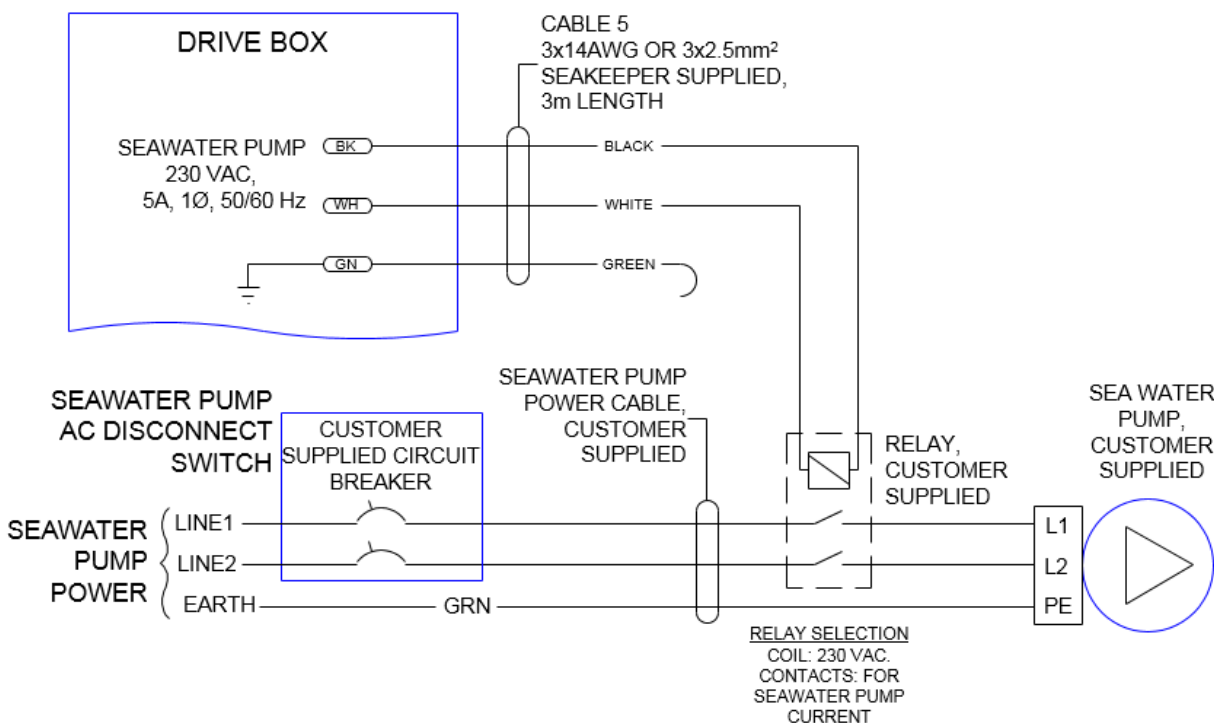


FIGURE 6 – RECOMMENDED WIRING FOR SEAWATER PUMPS NOT 230 VAC

- d. If CABLE 5 is not used, bundle cable and secure to forward brace or other area nearby which will not come in contact with moving parts during Seakeeper operation. Do NOT cut CABLE 5 as it contains live voltage when Seakeeper is in operation. Seakeeper ships with CABLE 5 permanently sealed at end of cable with protective cap in the event it is not used. Do NOT remove CABLE 5 from Drive Box as moisture will be free to enter box through open cable gland and corrode internal electronic components.



Cable 5 contains live voltage when Seakeeper is in operation. Do NOT cut Cable 5. Do not remove Cable 5 from Drive Box.

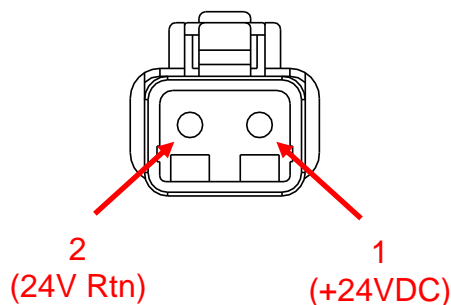
Section 2: ELECTRICAL INSTALLATION**4. 24 VDC POWER SOURCE REQUIREMENTS**

- a. 24 VDC, 10 Amps.
- b. A separate breaker should be used for each Seakeeper.

5. DC POWER CONNECTION INSTRUCTIONS

Reversing polarity on the DC power input to the Seakeeper can result in damaging the electronics in the control system.

- a. 24 VDC, 10 Amps. 2 x 12AWG (3 x 4mm² CSA) customer supplied.
 - i. Install Seakeeper provided DC Power Input Cable, P/N: 20248 as CABLE 1.
 1. Route CABLE 1 to DC Power Distribution Panel.
 2. Terminate RED conductor to +24 VDC. Terminate BLACK conductor to 24V Rtn or Zero VDC.
 - ii. Before connecting CABLE 1 to Seakeeper, check for proper voltage and polarity with a DC multimeter using Figure 7 below.



**FIGURE 7 – DC POWER INPUT CONNECTOR
CONTACT ASSIGNMENTS (front)**

- iii. Connect CABLE 1 to 24VDC input receptacle on the Seakeeper.



When energizing DC power the first time, if display does not power up immediately then disconnect and inspect connector polarity.

Section 2: ELECTRICAL INSTALLATION

2.3 Electrical Equipment Ground Connections

1. SEAKEEPER TO VESSEL GROUND CONNECTION INSTRUCTIONS

- a. Connect the Seakeeper foundation to vessel ground.
 - i. Install CABLE 6 (4AWG or 22.0 mm², Customer supplied) from the M6 brass ground stud on the Seakeeper rear brace to a suitable vessel ground.

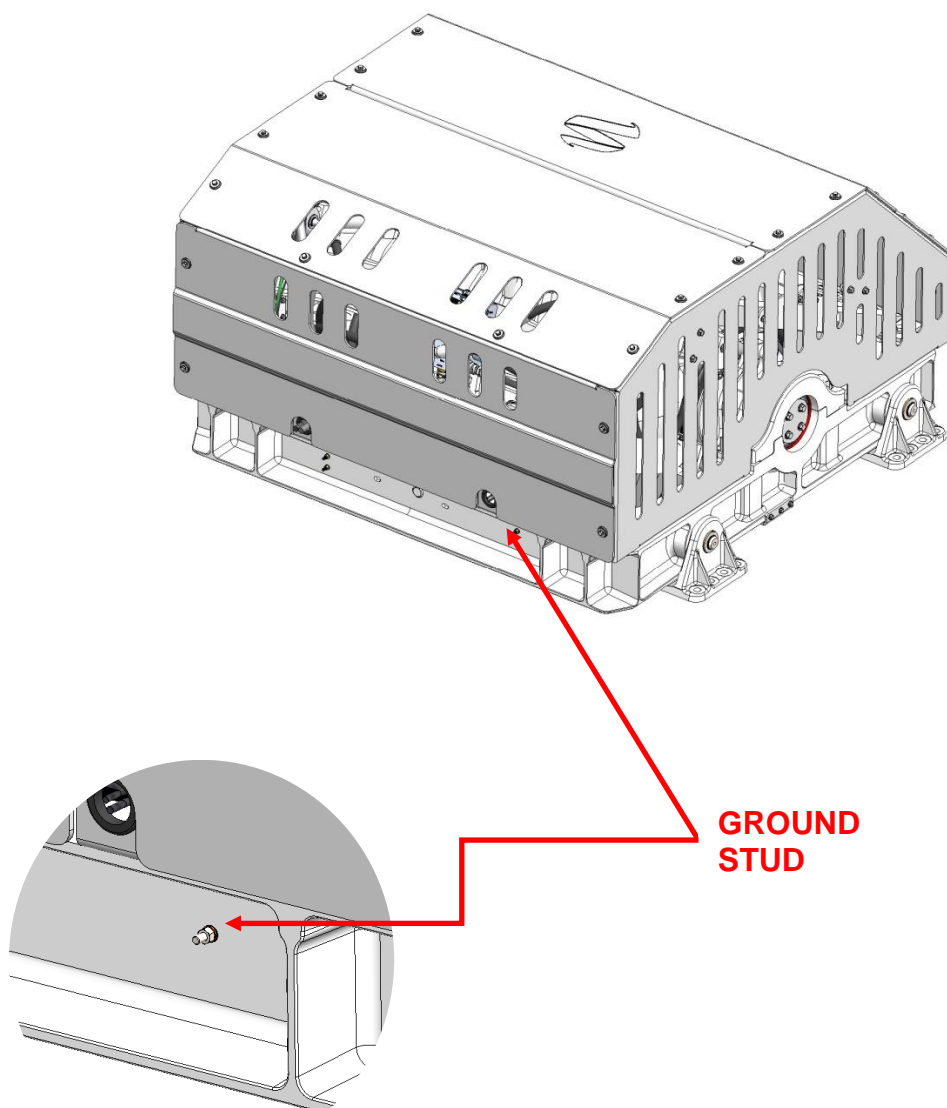


FIGURE 8 – SEAKEEPER GROUND STUD ON REAR BRACE

Section 2: ELECTRICAL INSTALLATION

2.4 Operator Station

This section explains the connection between the Operator Station equipment and the Seakeeper.

Reference Drawing - 90310 Seakeeper 26/20HD Cable Block Diagram

1. DETERMINE LOCATION OF OPERATOR STATION

- a. The desired location of the Operator Station must be determined with respect to the vessel arrangement.
- b. The operator display should be located on the bridge console.
- c. Figure 9 below shows the CANbus communications link for the Operator Station. The Terminator goes on the far end of the Tee Adapter from the Seakeeper.

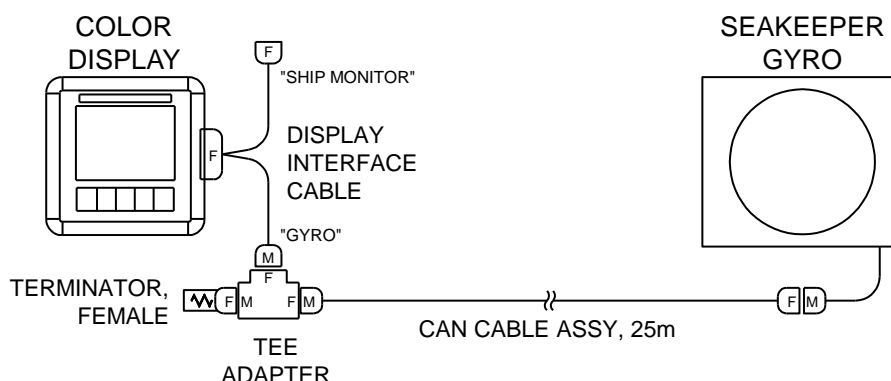


FIGURE 9 – SERIAL COMMUNICATIONS LINK FOR OPERATOR STATION

2. ROUTE SERIAL COMMUNICATIONS CABLE

- a. The CAN Cable Assembly (30243, CABLE 5) is a 25 meter shielded cable and the largest connector is a molded plug with maximum outer diameter of .58 inch (14.8mm).
- b. CABLE 5 must be routed and installed in the vessel from the Seakeeper (female end) to the Tee Adapter (male end) at the Operator Station.

3. INSTALL OPERATOR STATION EQUIPMENT

- a. The Operator Station equipment is installed at the selected location using Electrical Equipment Mounting Instructions in Section 2.1.

4. CONNECT OPERATOR STATION EQUIPMENT

- a. The Operator Station equipment is connected in accordance with the Cable Block Diagram, 90310.

Section 2: ELECTRICAL INSTALLATION

2.5 Second Operator Station Connection

This section explains how to connect the 2nd Operator Station Kit.

Reference Drawings

90250 Helm Display 2nd Operator Station Kit

90310 Seakeeper 26/20HD Cable Block Diagram (includes detail of 2nd Operator Station)

1. DETERMINE LOCATION OF 2ND OPERATOR STATION

- a. The desired location of the 2nd Operator Station must be determined with respect to the 1st Operator Station and the vessel arrangement.
- b. Typical locations include:
 - i. Flybridge
 - ii. Engine room

2. DETERMINE CABLING ARRANGEMENT

- a. Figure 10 below shows the entire serial communications link for 2 Operator Stations. The Terminator must be installed on the Tee Adapter farthest from the Seakeeper.

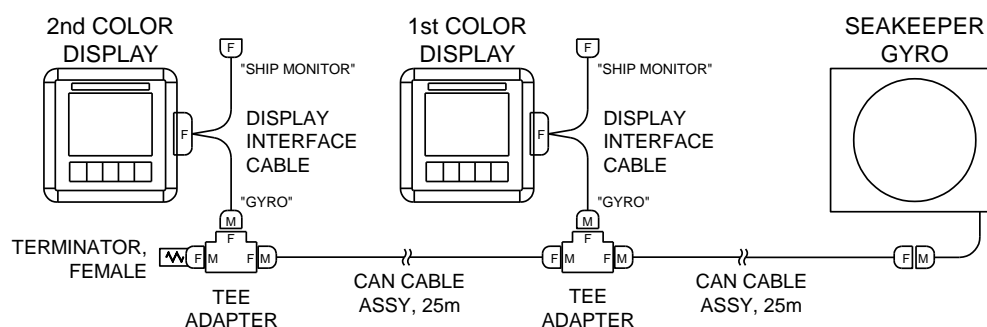


FIGURE 10 – CABLING FOR 2 OPERATOR STATIONS

- b. The Operator Station nearest the Seakeeper should be connected to CABLE 5.

Section 2: ELECTRICAL INSTALLATION**3. ROUTE 2ND OPERATOR STATION CABLE**

- a. A second CAN Cable Assembly (30243), also a 25 meter shielded cable, and the largest connector is a molded plug with maximum outer diameter of .58 inch (14.8mm)).
- b. The additional CAN Cable Assembly must be routed in the vessel from the 1st Operator Station (female end) to the 2nd (male end) Operator Station.

4. INSTALL 2ND OPERATOR STATION EQUIPMENT

- a. The 2nd Operator Station equipment is installed at the determined location using Electrical Equipment Mounting Instructions in Section 2.1.

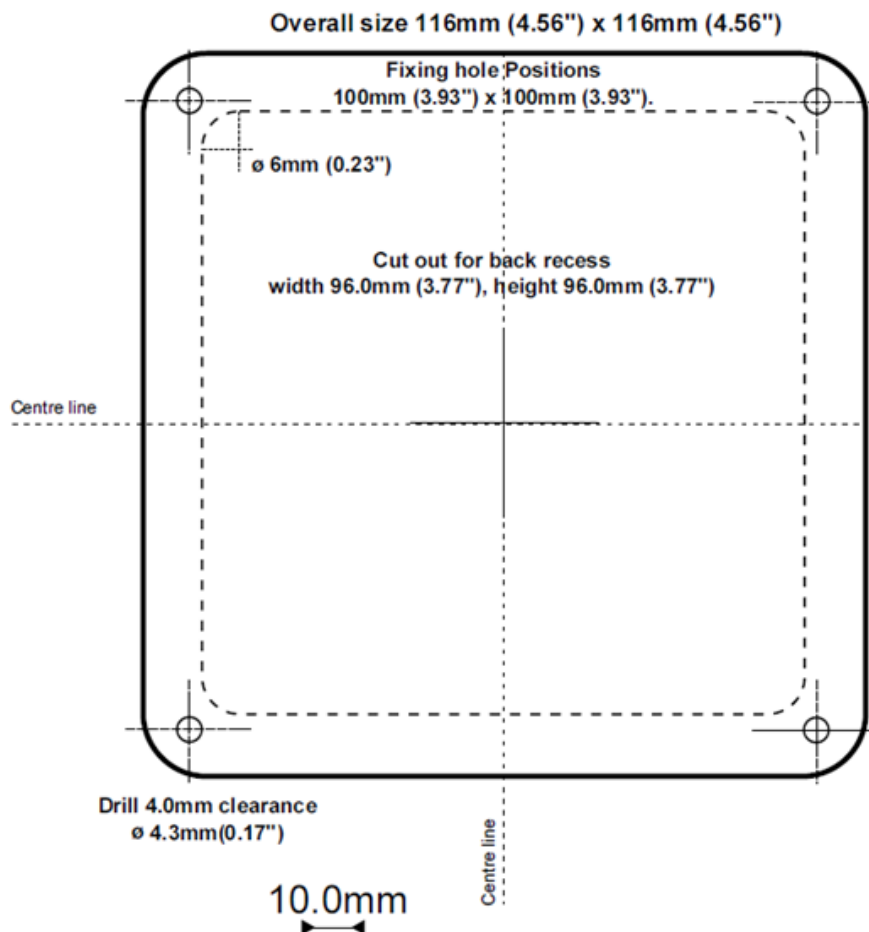
5. CONNECT 2ND OPERATOR STATION EQUIPMENT

- a. The 2nd Operator Station equipment is connected in accordance with the Cable Block Diagram, 90310.

Section 2: ELECTRICAL INSTALLATION

2.6 Display Installation Template

The following template is for mounting. Before using this template, measure to ensure that the shown size is actual.



DISPLAY MOUNTING TEMPLATE

Section 3: COOLING INSTALLATION

3.0 Introduction

The Seakeeper 26 is shipped with the cooling circuit filled and ready for use. Only a quick confirmation of glycol level is required.

Reference Drawings

90244 Seakeeper 26 Hardware Scope of Supply

90416 Seakeeper 20HD Hardware Scope of Supply

90310 Seakeeper 26/20HD Cable Block Diagram

90320 Seakeeper 26/20HD Cooling Water Schematic

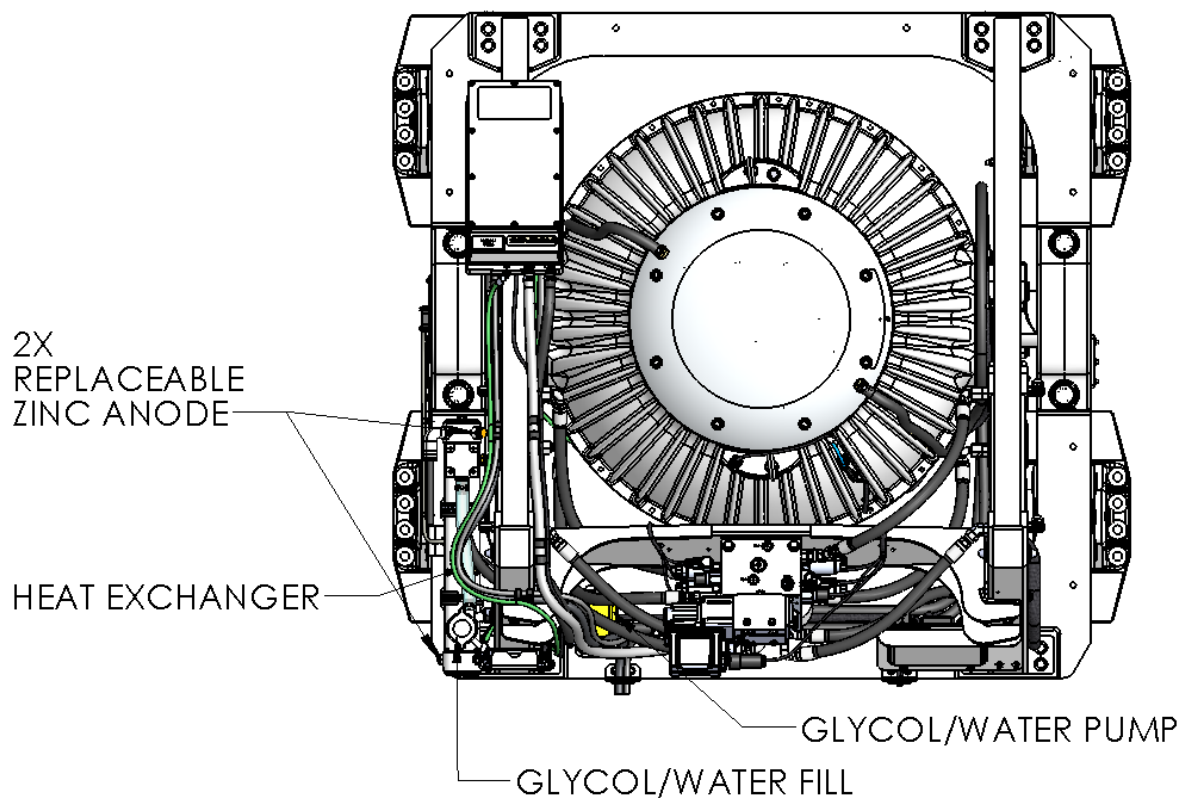


FIGURE 1 – SEAKEEPER 26

Section 3: COOLING INSTALLATION

3.1 Precautions

- Installer is responsible for supplying a dedicated sea water pump and associated plumbing. Sea water connections on the Seakeeper heat exchanger mate with ¾ inch (19 mm) hose.
- There is no need to disconnect hose from glycol pump except to replace the pump. In this case, provision will need to be made to catch draining glycol as plumbing is disconnected. Use caution to avoid breaking plastic hose connections on pump casing.
- An output is available from motor drive box to power and automatically control seawater pump. This pump must operate on 230 VAC single phase and consume less than 5 amps. Pumps requiring other voltages or higher current can still be controlled by using this supply from motor drive box to trigger an installer-supplied contactor but a separate source of power must be provided.
- Maximum sea water pressure in heat exchanger is 20 psi (1.4 bar)
- **Seawater flow requirement through heat exchanger is 4 GPM (15.1 LPM) minimum and 8 GPM (30.3 LPM) maximum under all operating conditions of the boat.** When sizing sea water pump, installer should factor in losses for raw water plumbing. In addition to initial operation at dock, new Seakeeper installations should be checked to be within the flow requirements while vessel is at speed. Flows higher than 8 GPM (30.3 LPM) could affect heat exchanger life.

3.2 Adding Coolant

- 1) Cooling system is filled to proper level when shipped, with a mixture of 50% ethylene glycol and 50% distilled water. Clear tube between thermostat housing and reservoir should be filled with green coolant mixture. If level has dropped, check for evidence of leaks at all connections before adding fluid as described below. If coolant is at the correct level, skip to sea water connection in section 3.3.

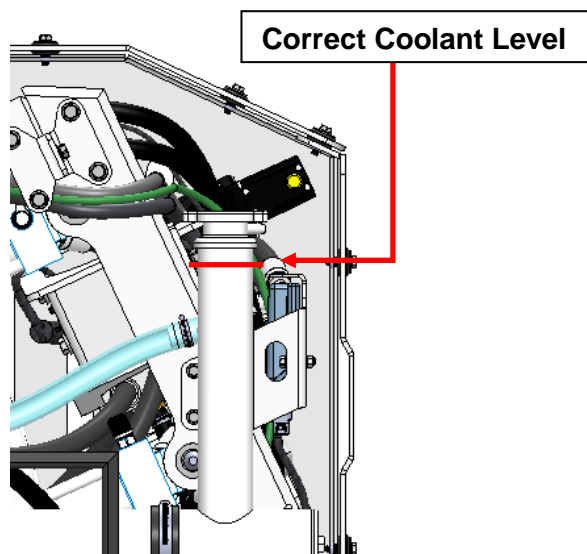


FIGURE 3 – SEAKEEPER 26 COOLANT LEVEL

Section 3: COOLING INSTALLATION

- 2) Mix 50% ethylene glycol with 50% distilled water in a clean container. Refer to Table 1 or glycol manufacturer's literature for freezing points.

| Table 1: Freezing Point | | | | | | | | |
|-------------------------------------------|------|----|----|----|-----|-----|-----|-----|
| Ethylene Glycol Solution (% by volume) | | 0 | 10 | 20 | 30 | 40 | 50 | 60 |
| Temperature | (°F) | 32 | 23 | 14 | 2 | -13 | -36 | -70 |
| | (°C) | 0 | -3 | -8 | -16 | -25 | -37 | -55 |

- 3) Remove pressure cap on top of reservoir. Pour mixture in until level reaches height shown in Figure 3. Filling reservoir above this level will not cause any damage but coolant may be expelled from pressure relief port below cap due to normal thermal expansion of coolant.
- 4) Connect 24 V to controller.
- At the Display check for any ALARMS



- Press the POWER ON/OFF button
- The flywheel will start to spin and the glycol pump will start.
- Recheck glycol level with fluid circulating in coolant circuit. Sight down inside reservoir and check that coolant level is above upper port on reservoir as shown in Figure 3. Replace cap.



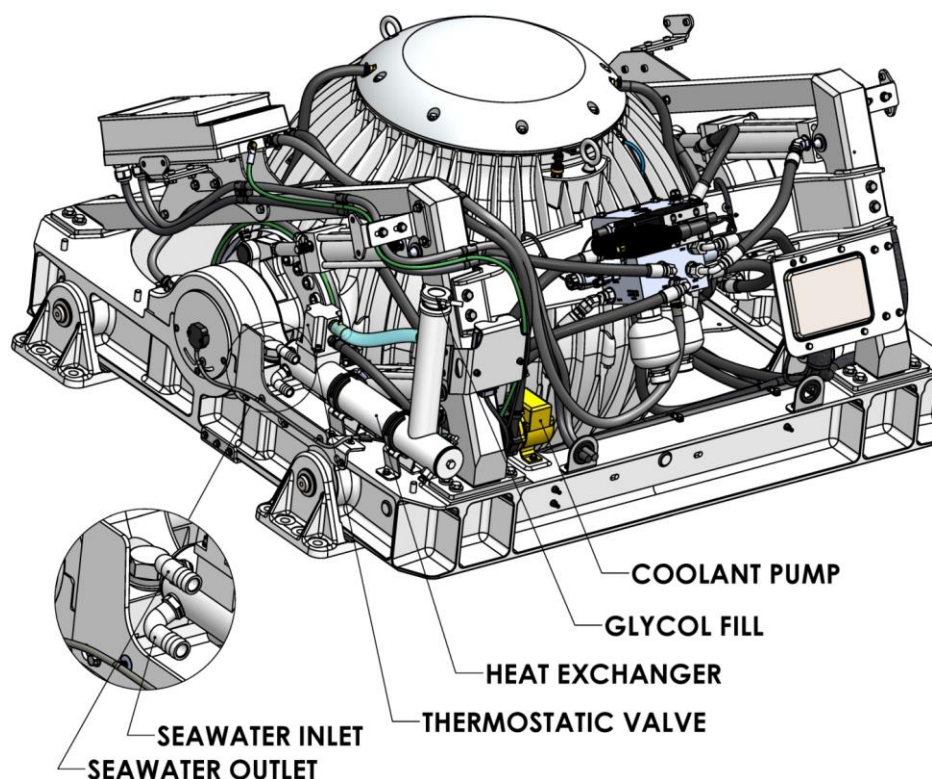
- After several minutes of running, press POWER ON/OFF button to turn power off to the flywheel and glycol pump. The glycol pump will stop and the flywheel will coast to a stop.

Section 3: COOLING INSTALLATION

- 5) The cooling system is self-purging. If small amounts of air are in the system, they will most likely be dislodged during the first sea trial. Recheck level after sea trial and add fluid if required.

3.3 Connecting Seawater to Heat Exchanger

- 1) Connect seawater from installer supplied pump to lower 3/4" (19 mm) hose barb on heat exchanger. Use the same practices as other below waterline seawater plumbing. Required flow rate is 4 GPM (16 LPM) minimum and 8 GPM (30.3 LPM) maximum. Refer to Figure 1.
- 2) Connect seawater discharge (upper hose barb) to overboard drain. Use the same practices as other below waterline seawater plumbing. Refer to Figure 1.
- 3) In addition to initial operation at dock, new Seakeeper installations should be checked for minimum 4 GPM (16 LPM) flow while vessel is at speed and when backing down. If no other method of confirming flow is available, discharge line may be temporarily diverted to a bucket. Flow is calculated from time to fill a known volume. A self-priming sea water pump (customer/installer supplied) may be required due to installation location to maintain water flow in all underway conditions where cavitation near the intake may occur and potentially cause an air-lock condition restricting sea water flow to the heat exchanger.
- 4) Inspect raw water plumbing after sea trial for any signs of leakage.
- 5) Heat exchanger contains removable end-caps to provide access for cleaning the tube bundle.



Section 4: STARTUP

4.0 Introduction


This section describes the first startup of the Seakeeper.

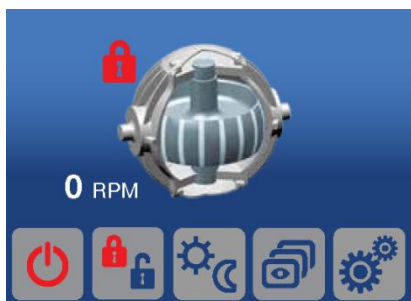
Also reference Seakeeper Document # 90266, Seakeeper 26/20HD Operation Manual.



- **Previous sections for mechanical, electrical and cooling installation must be completed before this startup sequence is initiated.**
- **Before continuing, covers must be installed unless the Seakeeper is inaccessible and there is no risk to injury. Also, the area around the Seakeeper must be clear of personnel and equipment.**


4.1 Startup Instructions

- 1) Energize 24 VDC supply at the customer supplied electrical disconnect.
- 2) Supply 220 VAC to Motor Drive Box at customer supplied electrical disconnect.
- 3) If sea water pump for the Seakeeper is not supplied though cable from Motor Drive Box, turn on the boat's AC or DC circuit breaker that supplies power to the sea water pump.
- 4) With system powered up check the display for any ALARMS. If there are any ALARMS present they must be corrected first.
- 5) Press the Seakeeper ON/OFF Button on Display.  The RED LOCK ICON and the PROGRESS BAR will appear and be RED until the Seakeeper is at speed, then stabilization can begin.





Section 4: STARTUP

- 6) The sea water pump should have started when the ON/OFF button on the display was depressed. Confirm pump operation and flow rate, if practical. Required flow is 4 GPM (15 LPM) minimum and 8 GPM (30 LPM) maximum.
- 7) Verify that there are no ALARMS present. If an ALARM is present it will be displayed.
- 8) When the PROGRESS BAR turns GREEN from RED the Seakeeper can be placed in

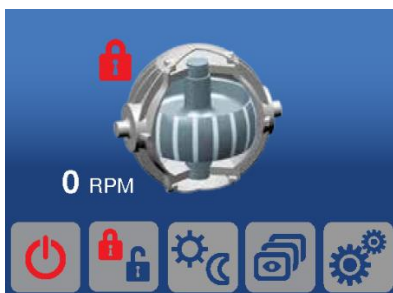
SEA mode. Depress the LOCK/UNLOCK Button  and the Seakeeper will be free to move and precession can occur.



- 9) Verify that there are no alarms. If an ALARM is present it will be displayed.

- 10) Press the LOCK/UNLOCK Button  to go from SEA to LOCK mode. Then press the Seakeeper ON/OFF Button  to power the Seakeeper down.

- 11) During normal operation, the Seakeeper should be stopped when stabilization is no longer required. This maximizes long term life as it allows the Seakeeper 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 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 the Seakeeper 26 will take 6+ hours to coast down to zero rpm from full speed. When the flywheel has stopped the display will indicate 0 RPM.



Section 5: INSTALLATION CHECKLIST AND SUPPLIES

Please Complete Checklist and E-mail to customerservice@seakeeper.com
or telefax to +1.410.326.1199

5.0 Installation Checklist

Mechanical Checklist (reference Installation Manual Section 1)

- ☐ **Seakeeper Foundation Installed in Hull**
- ☐ **Foundation bolts torqued to specification**

Electrical Checklist (reference Seakeeper Drawing 90310 & Installation Manual Sec. 2)

Mount Components

- ☐ **Display (near helm)**

Connect Customer Supplied Cables

- ☐ **Cable 1** – **Connect Cable 1 to 24 VDC power at customer supplied connection box or directly to circuit breaker**
- ☐ – **Plug connector of Cable 1 into mating connector on Seakeeper wire harness**
- ☐ **Cable 6 (customer supplied)** – **Install lugs on both ends of customer supplied 10 AWG ground cable**
- ☐ – **Connect one end of Cable 6 to nearest vessel ground and other end to Seakeeper rear brace**

Connect Seakeeper Supplied Cables

- ☐ **Cable 2 (Seakeeper supplied)–** **Connect Cable 2 from Drive Box to 230 VAC single phase at customer supplied connection box or directly to circuit breaker**
- ☐ **Cable 5 (Seakeeper supplied)–** **Connect Cable 5 from Drive Box to customer supplied 230 VAC seawater pump**

- ☐ **Cable 3 (Seakeeper supplied)–** **Connect female end of CAN communications Cable 3 to mating connector on Seakeeper wire harness**

Section 5: INSTALLATION CHECKLIST AND SUPPLIES

- ☐ – Route CAN communications Cable 3 from Seakeeper to helm (male end goes to helm)
- ☐ – Connect male end of CAN communications Cable 3 at helm to CAN Tee Adapter
- ☐ – Connect Display and Seakeeper supplied Cable 4 to CAN Tee Adapter with CAN Terminator

Cooling Checklist (reference Installation Manual Section 3)

- ☐ Verify coolant level in heat exchanger coolant reservoir.
- ☐ Connect sea water hoses / open sea cocks to heat exchanger and test sea water pump.
- ☐ Verify 4 GPM (15 LPM) minimum and 8 GPM (30 LPM) maximum sea water flow through heat exchanger under all operating conditions of the boat.

Startup Checklist (reference Installation Manual Section 4 & Operation Manual Sec. 2)

- ☐ Remove lifting bolts and replace with sealing screw/washers provided, Install cover panels
- ☐ Turn on 24 VDC circuit breaker
- ☐ Turn on 230 VAC circuit breaker
- ☐ Verify display works and no alarms are present
- ☐ Follow instructions in Section 4.1 of Installation Manual to turn on the Seakeeper
- ☐ Verify sea water pump turns on when the Seakeeper is turned ON
- ☐ Verify that no ALARMS are present
- ☐ Follow instruction in Section 4.1 of Installation Manual to turn off the Seakeeper
- ☐ AC & DC power and sea water pump may be turned off after the Seakeeper is turned off by placing the Seakeeper in LOCK mode and Turning the Seakeeper off
- ☐ Seakeeper 26 takes 6+ hours to coast down to zero rpm from full speed

Section 5: INSTALLATION CHECKLIST AND SUPPLIES

5.1 Required Supplies needed for Seakeeper Installation (not supplied with the Seakeeper)

| Item | Description | Qty | Installation Manual Reference Section | Other Reference | System |
|------|------------------------------------------------------------------------------------------|-----|---------------------------------------|-----------------|------------|
| 1 | Adhesive and cleaning supplies for bonding to hull | | 1 | | Mechanical |
| 2 | Soundproofing Considerations | | 1 | | Mechanical |
| 3 | Spreader bar for lifting the Seakeeper | | 1 | | Mechanical |
| 4 | Hose clamps for seawater plumbing to 3/4" (19 mm) hose barb (2 per hose barb) | 4 | 3 | | Cooling |
| 5 | M6 terminal lug for grounding Seakeeper at rear brace | 1 | 2.3.1 | | Electrical |
| 6 | Cable, 10 AWG, for grounding Seakeeper at rear brace to vessel ground (used with item 5) | AR | 2.3.1 | Dwg 90310 | Electrical |
| 7 | Sea water pump, 230V AC | 1 | 2.2.3 | | Electrical |
| 8 | Relay for sea water pump control (Not required if using 230V AC pump) | 1 | 2.2.3 | | Electrical |

AR = As Required

Dwg = Drawing

List of common tools that may be required for installation

| Item | Description | Use |
|------|--------------------------------------|---------------------------|
| 1 | Wire cutter | DC Power, AC Power cables |
| 2 | Wire stripper | DC Power, AC Power cables |
| 3 | 3 mm hex key | Gimbal sensor mount plate |
| 4 | 2.5 mm hex key | Gimbal angle sensor |
| 5 | 1/4 inch nut-driver | Hose clamps |
| 6 | Terminal or quick disconnect crimper | Power cables |
| 7 | Utility knife | Scoring cable jackets |