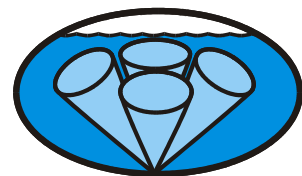


WorkHorse Maintenance Guide



P/N 957-6153-00 (August 2002)

RD Instruments
Acoustic Doppler Solutions

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WorkHorse Maintenance Guide

1 Introduction

This book explains how to prepare the Workhorse for deployment, how to do certain maintenance, repair, and equipment modification procedures, and how to prepare the Workhorse for storage or shipment.

Table 1, page 36 and Table 2, page 52 lists the items in the tools and spares parts kits. Use these kits when doing routine Workhorse maintenance.



NOTE. When an addition or correction to the manual is needed, an Interim Change Notice (ICN) will be posted to our web site on the Customer Service page (www.rdinstrument.com). Please check our web site often.

2 I/O Cable and Dummy Plug

The underwater connector (on the end-cap) and the I/O cable and dummy plug are molded wet-mate connectors. The end-cap connector is a factory-installed item. We do not recommend removing it for any routine maintenance.



NOTE. The dummy plug should be installed any time the I/O cable is removed. Use the dummy plug when the Workhorse is in storage or is being handled.

2.1 Disconnecting the I/O Cable or Dummy Plug

The cable should be disconnected with a straight outward motion only. Use the following procedure to disconnect the cable.



CAUTION. When disconnecting the WorkHorse I/O cable, do not apply any upward force on the connector as it is being pulled off. Applying an upward angle as the cable is disconnected puts stress on the end-cap connector. This may cause several serious problems: a) The end-cap connector or connector pins can crack. b) The O-ring on the bottom of the end-cap connector can be damaged. c) The molded urethane on the end-cap connector may separate from the brass insert. **If the end-cap connector is damaged in any of these ways, your ADCP will flood.**

- a. Release the retaining strap by pulling it over the connector.
- b. Grasp the cable close to the end-cap (see [Figure 1](#)). Your thumb should rest on top of the connector or against the edge of the end-cap. *Do not try to fit your hand under the cable as it passes over the end-cap.* This is what causes the upward force!
- c. Pull the cable straight out away from the end-cap with a gentle rocking motion. Do not apply any upward force on the connector as it is being disconnected.

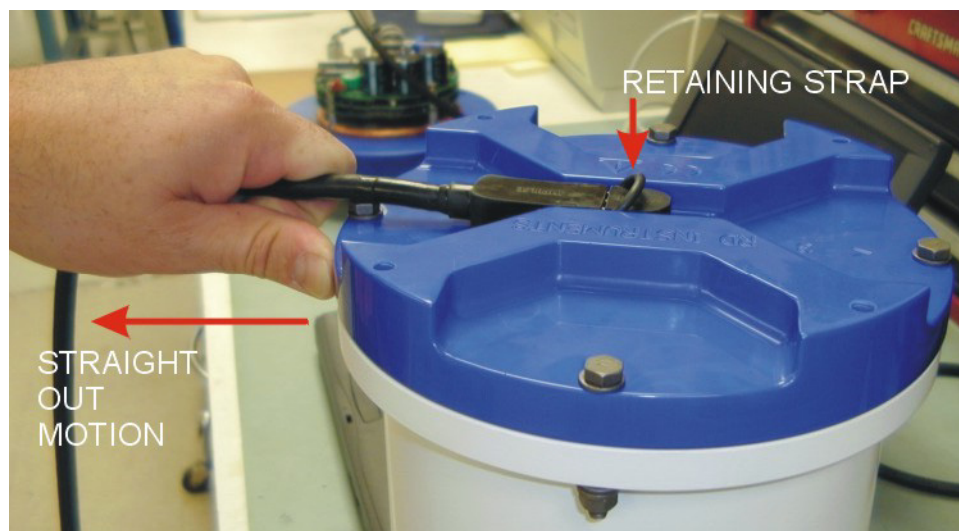


Figure 1. Removing the I/O Cable

2.2 Connecting the I/O Cable or Dummy Plug

The cable should be connected with a straight inward motion only. Use the following procedure to connect the cable.



CAUTION. When connecting the WorkHorse I/O cable, do not apply any upward force on the connector as it is being pushed on. Applying an upward angle as the cable is connected puts stress on the end-cap connector. This may cause several serious problems: a) The end-cap connector or connector pins can crack. b) The O-ring on the bottom of the end-cap connector can be damaged. c) The molded urethane on the end-cap connector may separate from the brass insert. **If the end-cap connector is damaged in any of these ways, your ADCP will flood.**

- a. Apply a light coat of DC-111 lubricant to the rubber portion of the end-cap connector pins. This will help seat the connector.
- b. Gently push the cable straight in toward the end-cap connector. Do not apply any upward force on the connector as it is being connected.
- c. Roll the retaining strap over the connector.

3 Workhorse Disassembly

This section explains how to remove and replace the end-cap or transducer head to gain access to the ADCP's electronics, batteries, and internal recorder. Read all instructions before doing the required actions.

3.1 End-Cap Removal Procedures

To remove the end-cap, do the following steps. Use [“Parts Location Drawings,” page 37](#) for parts identification.



NOTE. When you need access to the electronics, RDI recommends removing the transducer head assembly (see [“Transducer Head Assembly Removal,” page 4](#)).

- a. Dry the outside of the Workhorse.
- b. Stand the Workhorse on its transducer face on a soft pad.
- c. Remove all power to the Workhorse.
- d. Remove the I/O cable and place the dummy plug on the I/O cable connector (see [“I/O Cable and Dummy Plug,” page 1](#)).



CAUTION. If the ADCP flooded with batteries installed, there may be gas under pressure inside the housing. As a precaution, loosen the four end-cap bolts (6-mm) to vent the system.

- a. Loosen (do not remove) the four end-cap bolts to vent the system.

- b. Once all four end-cap bolts (6-mm) have been loosened, remove the bolts from the end-cap.



NOTE. Make sure you save all hardware removed during this procedure for re-assembly.

- e. Carefully pull the end-cap away from the housing until you can gain access to the connector jack on the common mode choke. Use care; the plastic mating surfaces scratch easily. Do not damage the mating surfaces.
- f. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap aside.
- g. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage (see [“O-ring Inspection and Replacement,” page 5](#)). Even small scratches can cause leakage around the O-ring seal.

3.2 Transducer Head Assembly Removal



NOTE. When you need access to the Sentinel internal battery, remove the end-cap assembly (see [“End-Cap Removal Procedures,” page 3](#)).

- a. Remove all power to the Workhorse.
- b. Remove the I/O cable and place the dummy plug on the I/O cable connector (see [“I/O Cable and Dummy Plug,” page 1](#)).
- c. Stand the Workhorse on its end-cap.



CAUTION. If the ADCP flooded with batteries installed, there may be gas under pressure inside the housing. As a precaution, loosen the four end-cap bolts (6-mm) to vent the system.

- a. Loosen (do not remove) the four titanium bolts (8-mm) bolts to vent the system.
- b. Once all four bolts have been loosened, remove the four bolts that attach the housing flange to the transducer head assembly.
- d. Carefully lift the transducer assembly straight up and away from the housing until you can gain access to the connector jack on the common mode choke. Use care; the plastic mating surfaces scratch easily. Do not damage the mating surfaces.



NOTE. The cable attached to the end cap is only long enough to disconnect the internal I/O cable. There is NOT enough cable to set the transducer down next to the Housing Assembly.

- e. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap assembly aside. Set the transducer assembly (transducer face down) on a soft pad.
- f. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage (see [“O-ring Inspection and Replacement,” page 5](#)).
- g. When you are ready to re-assemble the workhorse, see [“Workhorse Re-assembly,” page 5](#).

4 Workhorse Re-assembly

To replace the end-cap and transducer head, proceed as follows. Use [“Parts Location Drawings,” page 37](#) for parts identification.

- a. If you are sealing the Workhorse for a deployment, be sure you have done all appropriate maintenance items (see [“Sealing the Workhorse for a Deployment,” page 24](#)).
- b. Make sure all printed circuit boards, spacers, cables, and screws have been installed.
- c. Install two fresh bags of desiccant just before closing the Workhorse (see [“Desiccant Bags,” page 23](#)).

4.1 O-ring Inspection and Replacement

This section explains how to inspect/replace the Workhorse O-rings. A successful deployment depends on the condition of two O-rings and their retaining grooves. See [“Parts Location Drawings,” page 37](#) for the locations of the following O-rings. Read all instructions before doing the required actions.

- Transducer assembly, face, 2-260
- End-cap assembly, face, 2-260

We strongly recommend replacing these O-rings whenever you disassemble the Workhorse. Inspecting and replacing the O-rings should be the last maintenance task done before sealing the Workhorse.



NOTE. We recommend you use new O-rings if you are preparing for a deployment.

- a. Inspect the O-rings. When viewed with an unaided eye, the O-rings must be free of cuts, indentations, abrasions, foreign matter, and flow marks. The O-ring must be smooth and uniform in appearance. Defects must be less than 0.1 mm (0.004 in.).



CAUTION. If the O-ring appears compressed from prior use, replace it. **Weak or damaged O-rings will cause the ADCP to flood.**

- b. Clean and inspect the O-ring grooves. Be sure the grooves are free of foreign matter, scratches, indentations, corrosion, and pitting. Run your fingernail across damaged areas. If you cannot feel the defect, the damage may be minor; otherwise, the damage may need repair.



CAUTION. Check the O-ring groove thoroughly. **Any foreign matter in the O-ring groove will cause the ADCP to flood.**

- c. If a scratch is on the plastic housing flange O-ring groove, it may be gently sanded using 600-grit (wet) sandpaper. Use care not to cause further damage.
- d. Lubricate the O-ring with a thin coat of DC-111 lubricant ([Table 1, page 36](#), item 5). Apply the lubricant using latex gloves. Do not let loose fibers or lint stick to the O-ring. Fibers can provide a leakage path.



NOTE. RDI uses Dow Corning's silicone lube model number 111 but any type of silicone O-ring lube can be used.



CAUTION. Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

4.2 End-cap Replacement

- a. Stand the Workhorse on its transducer face on a soft pad.
- b. Inspect, clean, and lubricate the O-ring on the housing (see [“O-ring Inspection and Replacement,” page 5](#)). Apply a very thin coat of silicone lube on the O-ring.



NOTE. We recommend you use new O-rings if you are preparing for a deployment.



NOTE. RDI uses Dow Corning's silicone lube model number 111 but any type of silicone O-ring lube can be used.



CAUTION. Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

- c. Connect the internal I/O connector to the plug on the common mode choke.

- d. Place the end-cap on the housing, aligning the mating holes and the beam 3 number embossed on the end-cap with the beam 3 number embossed on the transducer head. When mating the end-cap with the housing flange, try to apply equal pressure to all parts of the O-rings. Make sure the face O-ring remains in its retaining groove.



CAUTION. Check that no wires or any other object is pinched between the end-cap and the housing. Use rubber bands to hold the wiring in place as necessary. **If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.**

- e. Examine the titanium end-cap assembly nuts, bolts, and washers (6-mm) for corrosion; replace if necessary. The [“Parts Location Drawings,” page 37](#) shows the assembly order of the end-cap mounting hardware. All the hardware items are needed to seal the Workhorse properly.
- f. Install all four sets of hardware until “finger-tight.”
- g. Tighten the bolts in small increments in a “cross” pattern until the split washer flattens out, and then tighten each bolt $\frac{1}{4}$ turn more to compress the face seal O-ring evenly. Tighten the bolts to the recommended torque value of 5.6 Newton-meters (50 pound-inches).



CAUTION. Apply equal pressure to the O-ring as you tighten the bolts. If one bolt is tightened more than the others, the O-ring can become pinched or torn. **A damaged O-ring will cause the system to flood.**



CAUTION. Do not over tighten the bolts that hold the transducer, housing, and end cap together. If you tighten too far, you can crack or break the plastic housing. On the other hand, leaving the bolts too loose can cause the system to flood. **Tighten the hardware to the recommended torque value.**



NOTE. The recommended torque value for the end-cap 6-mm bolts is 5.6 Newton-meters (50 pound-inches).

4.3 Transducer Head Assembly Replacement

- a. Stand the Workhorse on its end-cap.
- b. Inspect, clean, and lubricate the O-ring on the housing (see [“O-ring Inspection and Replacement,” page 5](#)). Apply a very thin coat of silicone lube on the O-ring.



NOTE. We recommend you use new O-rings if you are preparing for a deployment.



NOTE. RDI uses Dow Corning's silicone lube model number 111 but any type of silicone O-ring lube can be used.



CAUTION. Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

- c. Connect the internal I/O connector to the plug on the common mode choke.
- d. Gently lower the transducer head/electronics assembly into the housing, aligning the mating holes and the beam 3 number embossed on the transducer head with the beam 3 number embossed on the end-cap. When mating the housing with the transducer head flange try to apply equal pressure to all parts of the O-ring. Make sure the face O-ring remains in the retaining groove.



CAUTION. Check that no wires or any other object is pinched between the transducer head assembly and the housing. Use rubber bands to hold the wiring in place as necessary. **If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.**

- e. Examine the titanium transducer assembly nuts, bolts, and washers (8-mm) for corrosion; replace if necessary. The [“Parts Location Drawings,” page 37](#) shows the assembly order of the transducer mounting hardware. All hardware items are needed to seal the Workhorse properly.
- f. Install all four sets of hardware until “finger tight.”
- g. Tighten the bolts in small increments in a “cross” pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the face seal O-ring evenly. Tighten the bolts to the recommended torque value of 9.6 Newton-meters (85 pound-inches). Do not deform the plastic bushings.



CAUTION. Apply equal pressure to the O-ring as you tighten the bolts. If one bolt is tightened more than the others, the O-ring can become pinched or torn. **A damaged O-ring will cause the system to flood.**



CAUTION. Do not over tighten the bolts that hold the transducer, housing, and end cap together. If you tighten too far, you can crack or break the plastic housing. On the other hand, leaving the bolts too loose can cause the system to flood. **Tighten the hardware to the recommended torque value.**



NOTE. The recommended torque value for the transducer head 8-mm bolts is 9.6 Newton-meters (85 pound-inches).

5 Mariner Adapter Plate

The adapter plate helps mount the Mariner transducer head to a vessel. See the [Installation Guide](#) outline installation drawings for dimensions. The following procedure explains how to install and remove the Adapter Plate on a Workhorse Mariner ADCP.

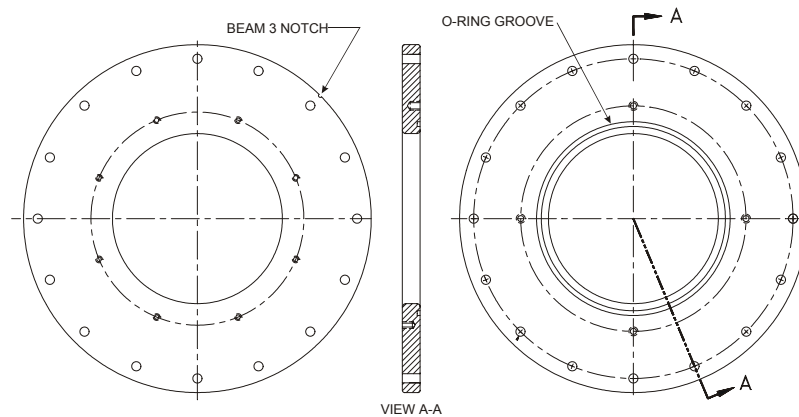


Figure 2. Mariner Adapter Plate

5.1 Installing the Adapter Plate

- a. Remove the Transducer Assembly (see [“Transducer Head Assembly Removal,”](#) page 4).
- b. Inspect and clean the O-ring groove of the Housing Assembly.
- c. Inspect, clean, and lubricate the O-ring (2-260) on the Housing Assembly where the Transducer Assembly was just mounted. Apply a very thin coat of silicone lube on the O-ring.



NOTE. RDI uses Dow Corning's silicone lube model number 111 but any type of silicone O-ring lube can be used.



CAUTION. Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

- d. Inspect and clean the Adapter Plate. Be sure no scratches, dents, or foreign matter is around the area that will be contact with the O-ring on the Housing Assembly.
- e. Place the adapter plate on the Housing Assembly, ensuring that the O-ring is not pinched or damaged. Rotate the plate such that the alignment notch in the plate is in alignment with the beam 3 arrow on the end cap.



CAUTION. Check that no wires or any other object is pinched between the adapter plate and the housing. Use rubber bands to hold the wiring in place as necessary. **If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.**

- f. Using four of the titanium 8-mm bolts supplied in the Adapter Plate Kit, secure the Adapter Plate to the Housing Assembly. Install the split lock washer next to the head of the bolt followed by a flat washer before installing the 8-mm bolts.
- g. Install all four sets of hardware until “finger-tight.”
- h. Tighten the bolts in small increments in a “cross” pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the O-ring evenly. Tighten the bolts to the recommended torque value of 9.6 Newton-meters (85 pound-inches).



CAUTION. Apply equal pressure to the O-ring as you tighten the bolts. If one bolt is tightened more than the others, the O-ring can become pinched or torn. **A Damaged O-ring will cause the system to flood.**



CAUTION. Do not over tighten the bolts that hold the transducer, housing, and end cap together. If you tighten too far, you can crack or break the plastic housing flange. On the other hand, leaving the bolts too loose can cause the system to flood. **Tighten the hardware to the recommended torque value.**



NOTE. The recommended torque value for the transducer 8-mm bolts is 9.6 Newton-meters (85 pound-inches).

- i. Install a new desiccant bag from the Adapter Plate Kit into the Housing Assembly.
- j. Inspect and clean the O-ring groove of the Adapter Plate.
- k. Inspect, clean, and lubricate the O-ring (2-260) from the Adapter Plate Kit and set this O-ring into the groove on the Adapter Plate.
- l. Connect the cable from the end cap assembly to the Power I/O board on the Transducer Assembly.
- m. Place the Transducer Assembly onto the Adapter Plate, ensuring that the O-ring is not pinched or damaged. Rotate the Transducer Assembly such that the beam-3 mark is aligned with both the alignment notch in the Adapter Plate and the beam-3 arrow on the end cap.



CAUTION. Check that no wires or any other object is pinched between the transducer head assembly and the adapter plate. Use rubber bands to hold the wiring in place as necessary. **If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.**

- n. Using the remaining four of the titanium 8-mm bolts supplied in the Adapter Plate Kit, secure the Transducer Assembly to the Housing Assembly. You should install the split lock washer next to the head of the bolt followed by a flat washer before installing the 8-mm bolts.
- o. Install all four sets of hardware until “finger-tight.”
- p. Tighten the bolts in small increments in a “cross” pattern until the split washer flattens out, and then tighten each bolt $\frac{1}{4}$ turn more to compress the O-ring evenly. Tighten the bolts to the recommended torque value of 9.6 Newton-meters (85 pound-inches).



CAUTION. Apply equal pressure to the O-ring as you tighten the bolts. If one bolt is tightened more than the others, the O-ring can become pinched or torn. **A Damaged O-ring will cause the system to flood.**



CAUTION. Do not over tighten the bolts that hold the transducer, housing, and end cap together. If you tighten too far, you can crack or break the plastic housing flange. On the other hand, leaving the bolts too loose can cause the system to flood. **Tighten the hardware to the recommended torque value.**



NOTE. The recommended torque value for the transducer 8-mm bolts is 9.6 Newton-meters (85 pound-inches).

5.2 Removing the Adapter Plate

- a. Remove the Transducer Assembly (see [“Transducer Head Assembly Removal,”](#) page 4).
- b. Remove the four titanium 8-mm bolts that secure the Adapter Plate to the Housing Assembly.
- c. Separate the Adapter Plate from the Housing Assembly.
- d. Install the Transducer Assembly (see [“Transducer Head Assembly Replacement,”](#) page 7).

6 Sentinel Battery Packs

The Sentinel system uses battery packs to provide power. Batteries should be replaced when the voltage falls below 30 VDC (measured across the battery connector under no-load conditions).



NOTE. Battery replacement induces both single and double cycle compass errors. The compass accuracy should be verified after replacing the battery pack. The compass does not have to be recalibrated if the compass verification passes specification.

These compass effects can be avoided by using an external battery pack. The external battery housing holds two batteries, and can easily be

replaced on-site. If properly used, no compass calibration will be required. The external battery pack provides an option for extended ADCP deployments.



NOTE. WorkHorse Sentinel batteries are shipped inside the ADCP but not connected. **Connect the battery and seal the ADCP before deployment.**

6.1 Sentinel Battery Replacement

To replace the battery pack, do the following steps.

- a. Remove the end-cap (see “[End-Cap Removal Procedures](#),” page 3).
- b. Disconnect the battery cable going to the common mode choke.
- c. Remove the four wing nuts, lock washers, and washers holding the battery pack onto the posts ([Figure 15](#), page 39).
- d. Remove the support plate.
- e. Slide out the used battery pack.
- f. Slide a new battery pack onto the four posts. Make sure the I/O cable is not pinched by the battery pack.
- g. Use the large rubber bands (supplied with each new pack) to hold the cables in place.
- h. Test the battery pack voltage by measuring across the battery connector under no-load conditions. The voltage should be +42 VDC for a new battery pack.



CAUTION. Older WorkHorse Battery Packs may not contain permanent internal sleeves that protect the battery pack from any accidental shorting against the four End Cap studs. If the battery pack shorts out, it will blow a protective fuse inside the battery pack. **The battery pack is then open and will read as zero volts DC.**

- i. Position the support plate over the four posts.
- j. Place a flat washer, lock washer, and wing nut on each of the four posts. Tighten the wing nuts firmly to hold the battery in place.
- k. Place a battery pack rubber band (two spare rubber bands are provided with each new battery) around all four wing nuts. This will prevent the wing nuts from backing off the post.



CAUTION. The Workhorse Sentinel battery packs are held in place by four sets of washers, lock washers, and wing nuts. If the wing nuts are not tight, the assembly of washers and wing nut can become loose and eventually fall onto the PIO board. **This has caused the PIO board to short out.**

- l. Connect the battery cable going to the common mode choke (see [Figure 17, page 41](#))
- m. Install the end-cap (see “[End-cap Replacement](#),” page 6).
- n. Align the compass (see “[Compass Calibration](#),” page 14).

6.2 External Battery Case Battery Replacement

The external battery case holds two battery packs to provide power. Batteries should be replaced when the voltage falls below +30 VDC (measured across the battery connector under no-load conditions). To replace the battery packs, do the following steps.



CAUTION. The external battery case should not be connected or disconnected underwater. The electrical output power will degrade the connector contacts and present a **potential electrical shock hazard to installation personnel** when the power connector is short-circuited in water. The external battery case output power cannot be enabled or disabled underwater.

- a. Remove one end-cap from the external battery pack (see [Figure 16, page 40](#)).
- b. Place the external battery case on its side and carefully pull out the battery pack (attached to the end-cap).
- c. Disconnect the battery power cable from the wiring harness.
- d. Remove the four wing nuts, lock washers, and washers holding the battery pack onto the posts (see [Figure 15, page 39](#)).
- e. Remove the support plate.
- f. Slide out the used battery pack.
- g. Slide a new battery pack onto the four posts. Make sure the wiring harness is not pinched by the battery pack. Use the large rubber bands (supplied with each new pack) to hold the cables in place.
- h. Position the support plate over the four posts.
- i. Place a flat washer, lock washer, and wing nut on each of the four posts. Tighten the nuts to hold the battery in place.
- j. Test the battery pack voltage by measuring across the battery connector under no-load conditions. The voltage should be +42 VDC for a new battery pack.



CAUTION. Older WorkHorse Battery Packs may not contain permanent internal sleeves that protect the battery pack from any accidental shorting against the four End Cap studs. If the battery pack shorts out, it will blow a protective fuse inside the battery pack. **The battery pack is then open and will read as zero volts DC.**

- k. Connect the battery power cable to the wiring harness.
- l. Install the end-cap/battery pack assembly (see [“End-cap Replacement,” page 6](#)).
- m. Repeat steps “a” through “l” to replace the other battery pack.
- n. Replace the desiccant bags on each battery just before sealing the external battery case (see [“Desiccant Bags,” page 23](#)).

7 Compass Calibration

The main reason for compass calibration is battery replacement. Each new battery carries a different magnetic signature. The compass calibration algorithm corrects for the distortions caused by the battery to give you an accurate measurement. You should be aware of the following items:

- We recommend against calibrating the Workhorse while on a ship. The ship’s motion and magnetic fields from the hull and engine will likely prevent successful calibration.
- If you think your mounting fixture or frame has some magnetic field or magnetic permeability, calibrate the Workhorse inside the fixture. Depending on the strength and complexity of the fixture’s field, the calibration procedure may be able to correct it.



NOTE. If only the battery modules were removed and replaced back in the same orientation, the compass does not require calibration. If the battery cores were replaced, you **must** verify the compass.

Battery replacement induces both single and double cycle compass errors. The compass accuracy should be verified after replacing the battery pack. The compass does not have to be recalibrated if the compass verification passes specification.

These compass effects can be avoided by using an external battery pack. The external battery housing holds two batteries, and can easily be replaced on-site. If properly used, no compass calibration will be required. The external battery pack provides an option for extended ADCP deployments.

7.1 Preparing for Calibration

- a. Place the Workhorse on a piece of strong cardboard on top of a smooth wooden (non-magnetic) table. If a wooden table is not available, place the Workhorse on the floor as far away from metal objects as possible. Use the cardboard to rotate the Workhorse during calibration—this way you will not scratch the Workhorse. Place the ADCP in the same orientation as it will be deployed.



NOTE. If you will deploy your Workhorse looking up, calibrate it looking up. If you will deploy it looking down, calibrate it looking down.



CAUTION. If you calibrate the compass in one direction (up or down) and deploy the ADCP in the opposite direction (i.e. calibrate it in a downward position and deploy it in an upward position) the compass calibration will be invalid. Compass errors in excess of 5 degrees may occur.

- b. Connect the Workhorse as shown in the appropriate [ADCP User's Guide](#).
- c. Start *BBTalk*. See the [RDI Tools User's Guide](#) for assistance on using *BBTalk*.

7.2 Compass Calibration Verification

Compass calibration verification is an automated built-in test that measures how well the compass is calibrated. The procedure measures compass parameters at every 5° of rotation for a full 360° rotation. When it has collected data for all required directions, the Workhorse computes and displays the results.



NOTE. Verify the compass if you have just replaced the memory module, or any ferrous metals is relocated inside or around the Workhorse housing. Calibrate the compass if the batteries have been replaced (see "Compass Calibration Procedure," page 16).

- a. Prepare the ADCP for calibration (see "[Preparing for Calibration](#)," page 15).
- b. Using *BBTalk*, send a Break to wake up the Workhorse.
- c. On the **Transfer** menu, click **Command History**. In the **Enter a Command** box, enter **AX** and click **OK**.

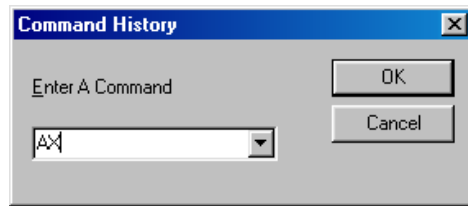


Figure 3. BBTalk Command History Box

- d. When prompted, rotate the Workhorse slowly 360 degrees (approximately 5 degrees per second). Pay particular attention to the Overall Error. For example;

HEADING ERROR ESTIMATE FOR THE CURRENT COMPASS CALIBRATION:

OVERALL ERROR:

Peak Double + Single Cycle Error (should be < 5): (1.55 (

DETAILED ERROR SUMMARY:

Single Cycle Error: (1.54 (

Double Cycle Error: (0.07 (

Largest Double plus Single Cycle Error: (1.61 (

RMS of 3rd Order and Higher + Random Error: (0.31 (

If the overall error is less than 2°, the compass does not require alignment. You can align the compass to reduce the overall error even more (if desired).

7.3 Compass Calibration Procedure

The built-in automated compass calibration procedure is similar to the alignment verification, but requires three rotations instead of one. The Workhorse uses the first two rotations to compute a new calibration matrix and the third to verify the calibration. It will not accept the new matrix unless the calibration was carried out properly, and it asks you to verify that you want to use the new calibration if it is not as good as the previous calibration. While you are turning the Workhorse for the two calibration rotations, the Workhorse checks the quality of the previous calibration and displays the results. It compares these results with the results of the third calibration rotation.

There are two compass calibrations to choose from; one only corrects for hard iron while the other corrects for both hard and soft iron characteristics for materials rotating with the ADCP. Hard iron effects are related to residual magnetic fields and cause single cycle errors while soft iron effects are related to magnetic permeability that distorts the earth's magnetic field and causes double cycle errors. In general, the hard iron calibration is recommended because the effect of hard iron dominates soft iron. If a large double cycle error exists, then use the combined hard and soft iron calibration.

- a. Prepare the ADCP for calibration (see [“Preparing for Calibration,”](#) page 15).
- b. Using *BBTalk*, send a Break to wake up the ADCP.

- c. On the **Transfer** menu, click **Command History**. In the **Enter a Command** box, enter **AF** and click **OK**. When the calibration procedure starts, choose the calibration type.
- d. Tilt the ADCP (see [Figure 4, page 18](#)). Tilt an upward-looking Workhorse with a block under one side of the end-cap. A 35-mm block will give you an 11-degree tilt. Check the on-screen instructions to see if the orientation is OK. Adjust as necessary.



NOTE. The tilts must remain constant during the rotations. The transducer beam is the center point of the rotation.

- e. When prompted, rotate the ADCP slowly 360 degrees (approximately 5 degrees per second).
- f. The second rotation requires the ADCP to be tilted 15 degrees in another direction than from the first rotation (see [Figure 4, page 18](#)). Follow the on-screen instructions to orient the ADCP correctly. When prompted, rotate the ADCP slowly 360 degrees (approximately 5 degrees per second).
- g. The third rotation requires the ADCP to be tilted 15 degrees in another direction than from the first and second rotations. Follow the on-screen instructions to orient the ADCP correctly.
- h. If the calibration procedure is successful, it records the new calibration matrix to nonvolatile memory. The ADCP will not change its matrix unless the calibration is properly carried out.
- i. If the calibration procedure is not successful, return your ADCP to the original factory calibration, by using the AR-command. Try using the AR-command if you have trouble calibrating your compass. In some circumstances, a defective compass calibration matrix can prevent proper calibration.

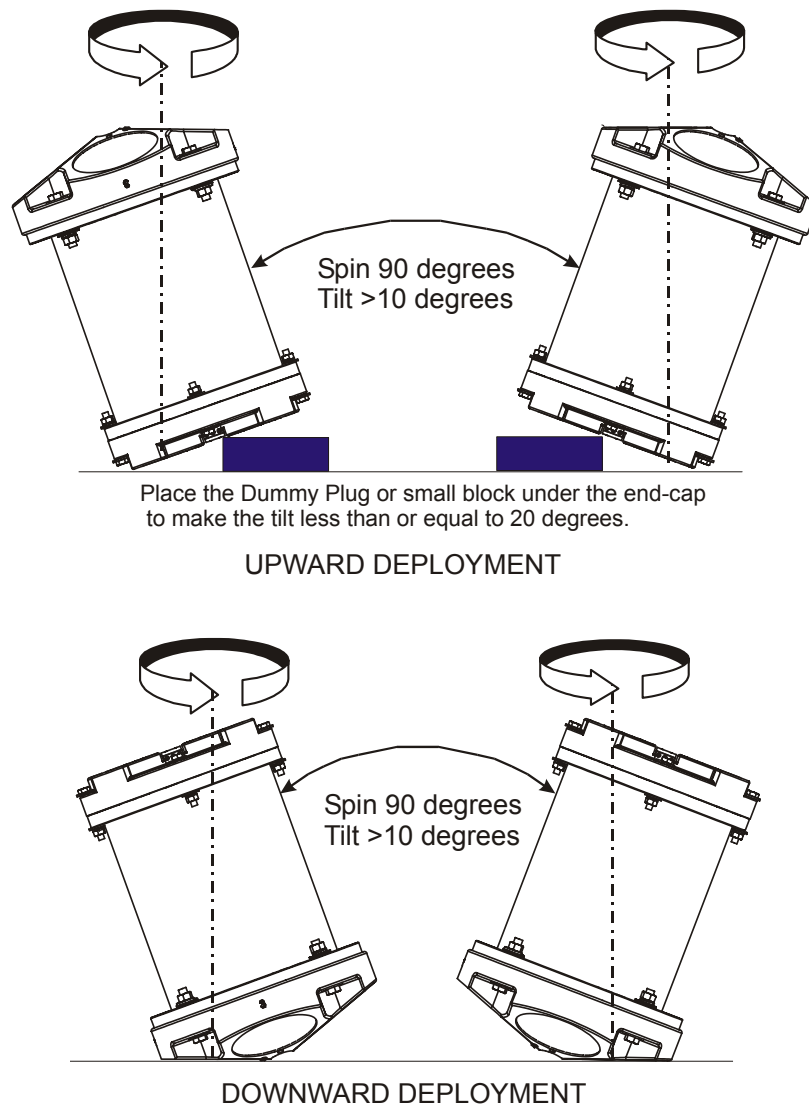


Figure 4. Compass Calibration

8 Fuse Replacement

PIO Board. There is one fuse on the PIO Board (see [Figure 5, page 20](#)) that protects the Workhorse from excessive incoming power. If this fuse continues to blow, check your input power before applying power again.

- Turn off the power.
- Remove the transducer head (see [“Transducer Head Assembly Removal,” page 4](#)).
- The PIO board fuse is located next to the internal I/O connector. Use a small flat-blade screwdriver to open the fuse housing. Turn the end 180° (counter-clockwise) to open the fuse housing.

- d. Gently pull the fuse housing out. Turn the housing to remove the fuse.
- e. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse ([Table 1, page 36](#) item 7).
- f. Install the transducer head (see [“Transducer Head Assembly Replacement,” page 7](#)).
- g. Test the system (see the [Test Guide](#)).

External Battery Pack. One fuse in the external battery pack protects the Workhorse from excessive incoming power. If this fuse continues to blow, check your battery packs before connecting the external battery case again.

- a. Remove one end-cap from the external battery pack (see [“End-Cap Removal Procedures,” page 3](#)).
- b. Carefully lift out the battery pack (attached to the end-cap).
- c. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse ([Table 1, page 36](#) item 7).
- d. Install the end-cap (see [“End-cap Replacement,” page 6](#)).
- e. Measure the voltage output of the external battery case across pin 3 (+) and pin 7 (-) on the external connector. If both battery packs are fresh, you should measure approximately +42 VDC.

Mariner Deck Box. The Deck Box back panel has three fuses.

- FUSE F1 $\downarrow$ 5 Amp, 250 V, slow-blow, 5x20mm, clip-mounted. This fuse protects Deck Box circuits from input overload on J25 (20-60 VDC power input).
 - FUSE F2 - 10 Amp, 250 V, slow-blow, 5x20mm, clip-mounted. This fuse protects Deck Box circuits from input overload on J26 (12 VDC power input).
 - FUSE F3 - 5 Amp, 250 V, slow-blow, 5x20mm, clip-mounted. This fuse protects Deck Box circuits from input overload on J27 (98 - 264 VAC power input).
- a. Turn off power to the deck box.
 - b. Press down gently on the top edge of the fuse holder.
 - c. Pull the fuse holder out and down. It will extend approximately one inch. Do not attempt to remove it completely.
 - d. The fuse closest to the inside of the deck box is the fuse in use. Check the fuse using an ohmmeter. There may be a spare fuse attached to the holder. Verify that the spare fuse is the correct voltage and amperage before using.

- e. Place the replacement fuse (and another spare as necessary) in the fuse holder.
- f. Gently push the fuse holder back in place.
- g. Turn on power and test the system (see the [Test Guide](#)).

Mariner Deck Box Power Supply. The Deck Box Power Supply has one fuse (F1 - 5 Amp, 250 V, fast-blow, clip-mounted). This fuse protects the Deck Box Power Supply circuits from input overload.

- a. Turn off power to the deck box.
- b. Remove the Deck Box top cover.
- c. Remove the fuse from the clips. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse.
- d. Replace the Deck Box top cover.
- e. Turn on power and test the system (see the [Test Guide](#)).

9 Communications Setting

A switch on the PIO board (see [Figure 5](#)) changes the communication settings between RS-232 and RS-422. Your computer and the Workhorse must both be set to the same communication setting. Use the RS-232-to-RS-422 converter if the Workhorse is using RS-422 communications and you computer only has an RS-232 COM port.

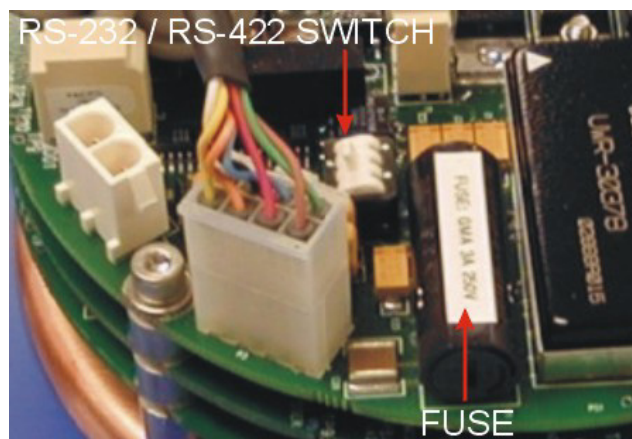


Figure 5. Communication Switch and Fuse

10 Firmware Upgrades

The firmware for Workhorse ADCPs is located on flash RAM chips on the CPU board. Firmware must be downloaded. Use the following procedure to download firmware to the Workhorse.

- a. Connect your ADCP to the computer as shown in the appropriate [ADCP User's Guide](#).
- b. Start the program *WHxxFW.exe* (where *xx* is the firmware number).
- c. Click **Setup**. Click the **View README.TXT** button to view the Readme.txt file for details on what is new in this version of the firmware.
- d. Click **Next** and follow the on-screen prompts.
- e. If you are not able to install the new firmware, contact Customer Service.
- f. After successfully upgrading the firmware, use *BBTalk* to test the ADCP (see the [Test Guide](#)).

11 Feature Upgrades

The feature upgrade installation program is used to install Bottom Tracking, Shallow Water Bottom Mode, Lowered ADCP (LADCP), Water Profiling (for Navigators), High-Resolution Water-Profiling mode, High Ping Rate, and Waves capabilities in a Workhorse ADCP.



NOTE. The upgrade disk is specific to the unit for which it was ordered. DO NOT attempt to install this feature for any other unit.



NOTE. Many feature upgrades require the latest firmware version to be installed in your ADCP. If you need to update the firmware, do this before installing the feature upgrade (see "Firmware Upgrades," page 21).

- a. Set up the Workhorse as shown in the appropriate [ADCP User's Guide](#).
- b. Place the feature upgrade disk in the disk drive (usually the "A" drive).
- c. Click the Windows **Start** button, and then select **Run**.
- d. In the **Open** box, type A:xxx.exe, where *xxx* is the ADCP's CPU serial number. The installation program will start (see [Figure 6, page 22](#)). The program is encoded with the ADCP's serial number and the requested feature upgrade.

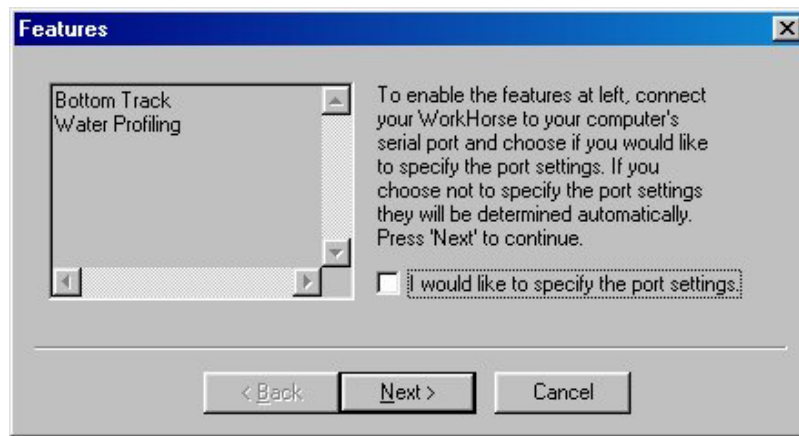


Figure 6. Installing Feature Upgrades

- e. To select the port settings, select the **I would like to specify the port setting** box and click **Next**.
- f. Select the **Serial Port** and **Baud Rate**.
- g. Click **Next** to install the feature upgrade. Click the **Finish** button to exit the program.

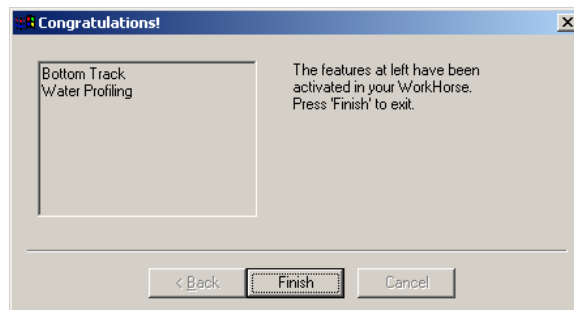


Figure 7. Feature Upgrade Completed

- h. Start *BBTalk* and use the OL command (see the [Workhorse Commands and Output Data Format guide](#)) to verify the feature upgrade has been installed.

12 PC Card Recorder

The PC Card recorder is located on the Digital Signal Processor (DSP) board inside the Workhorse's electronics (see [Figure 8, page 23](#)). To recover data, the card can be removed and used in a personal computer (PC), or left in the Workhorse, and accessed by using *WinSC* (see the [WinSC User's Guide](#)). To remove or install a PC card, do the following.

- a. Turn off power to the Workhorse.

- b. Remove the transducer head (see [“Transducer Head Assembly Removal,”](#) page 4).
- c. Remove the PC cards by pushing the button on the side of the PCMCIA card slot. The card should “pop” out of the connector. If you cannot reach the release button with your finger, use a plastic pen or non-conductive tool to depress the button. Do not try to force the card in or out of the connector. PC cards slide easily in or out when properly oriented.



Figure 8. PC Card Recorder

- d. When you are finished recovering the data, install the PC card back into the DSP board. PC cards install with the label side toward the face of the transducer.
- e. Install the transducer head (see [“Transducer Head Assembly Replacement,”](#) page 7).



NOTE. RDI uses true 16-bit PCMCIA/ATA, 5-volt, type 2 memory cards made by SANDISK (old name was SUNDISK). These cards must be formatted before using in the WorkHorse. Other cards may work but we have not had any success. You can use 16 to 220 MB cards (up to two cards).

The standard Workhorse Rio Grande, Mariner, and Monitor do not include memory cards, but have the same capacity for memory cards as a Sentinel.

13 Desiccant Bags

Desiccant bags are used to dehumidify the housing interior. Desiccant is essential in deployments with plastic housings. The factory-supplied desiccant lasts a year at specified Workhorse deployment depths and temperatures. Remember that desiccant rapidly absorbs moisture from normal room air.

The average dry weight of a new desiccant bag is 7.2 grams ((5%). The weight increases to 8.4 to 9 grams for a “used” desiccant bag. Used desiccant bags may be dried at 250° for 14 hours. As a minimum, replace the desiccant bags ([Table 1, page 36](#), item 6) whenever you are preparing to deploy or store the Workhorse for an extended time.



CAUTION. Do not open the desiccant bag. Contact with the silica gel can cause nose, throat, and skin irritation.



NOTE. Desiccant bags are shipped in an airtight aluminum bag to ensure maximum effectiveness. There is a moisture indicator inside the bag. If the moisture indicator is pink, do not use the desiccant bag until it has been dried. RDI recommends replacing the desiccant bag just before the deployment.

- a. Remove the transducer head (see [“Transducer Head Assembly Removal,” page 4](#)).
- b. Remove the new desiccant bags from the airtight aluminum bag.
- c. Remove the old desiccant bags and install two new ones. Place the desiccant bags ([Table 1, page 36](#), item 6) between the PIO board and the end-cap.
- d. Install the transducer head (see [“Transducer Head Assembly Replacement,” page 7](#)).

14 Sealing the Workhorse for a Deployment

Use the [“Parts Location Drawings,” page 37](#) and the following steps to seal the Workhorse for a deployment.

- a. Check the Workhorse electronics; there should be no loose screws or missing hardware.
- b. Install the PC card(s) (Sentinel ADCPs only, see [“PC Card Recorder,” page 22](#))
- c. Replace the battery pack or connect the battery cable (Sentinel ADCPs only, see [“Sentinel Battery Packs,” page 11](#))
- d. Add two fresh desiccant bags inside the Workhorse housing (see [“Desiccant Bags,” page 23](#)).
- e. Install the transducer head assembly and end-cap (see [“Workhorse Re-assembly,” page 5](#)).
- f. The Workhorse is now ready for deployment unless you want to take steps to prevent biofouling (see [“Prevention of Biofouling,” page 25](#)).
- g. Use the appropriate [ADCP User’s Guide](#) to connect the Workhorse system. Use the [Test Guide](#) to test the Workhorse before the deployment.

15 Prevention of Biofouling

This section explains how to prevent the buildup of organic sea life (biofouling) on the transducer faces. Objects deployed within about 100 meters (≈ 328 feet) of the surface are subject to biofouling, especially in warm, shallow water.

Deep Water Deployments. Biofouling is not usually a problem in deep water (more than 100 meters). Soft-bodied organisms usually cause no problems. Do not apply antifouling grease if deploying the WorkHorse in deep water.

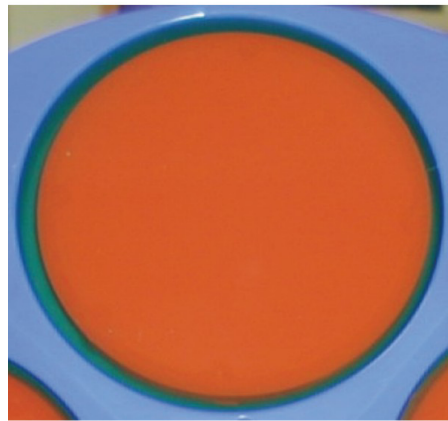
Shallow Water Deployments. Soft-bodied organisms usually cause no problems, but barnacles can cut through the urethane transducer face causing failure to the transducer and leakage into the WorkHorse (see [Figure 9, page 26](#)).

In shallow-water applications, the use of antifouling grease may be appropriate if you cannot clean the transducer faces often (weekly), and if the antifouling grease meets all of your local safety and environmental laws.

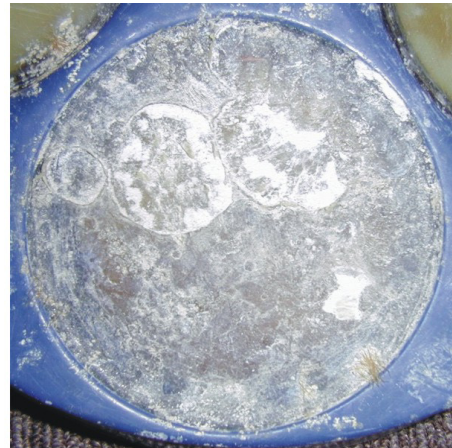
15.1 Controlling Biofouling

The best-known way to control biofouling is cleaning the WorkHorse transducer faces often. However, in many cases this is not possible. The following options can help reduce biofouling.

- Coat the entire WorkHorse with the recommended antifouling paint. Make sure that the paint is applied in an even coat over the transducer faces.
- Apply a thin coat (≈ 4 mm; ≈ 0.16 in.) of either a 50:50 mix of chili powder and petroleum jelly or chili powder and silicone grease to the transducer faces. The chili powder should be the hottest that can be found. Water flowing across the transducers will wash this mix away over time. The silicone mixture tends to last longer.



BEFORE



AFTER

Figure 9. Barnacle Damage



CAUTION. Barnacles can cut through the urethane transducer face causing failure to the transducer and leakage into the WorkHorse.

If using antifouling grease, remove the grease immediately after recovering the WorkHorse from its deployment. Remove the grease with soapy water. Be sure to wear protective gloves and a face shield.



CAUTION.

1. Do not arbitrarily use antifouling grease for deep-water applications. For shallow-water applications, barnacles are a threat to the transducer faces; using antifouling grease may be appropriate if you cannot clean the WorkHorse regularly (weekly). If using antifouling grease, remove it immediately after recovering the WorkHorse.
2. Antifouling grease is toxic. Read the product safety data sheet before using the grease. Wear gloves and a face shield when applying the grease. If the skin comes in contact with the grease, immediately wash the affected area with warm, soapy water.
3. All U.S. coastal states prohibit the use of tributyl-tins on boat hulls. The European Economic Commission has released a draft directive that would prohibit the use of many organo-tins after July 1989. We strongly recommend you obey your local laws.

15.2 Recommended Antifouling Paints

The plastic WorkHorse housing simplifies anti-fouling paint application. You can use almost any EPA approved anti-fouling paint on the housing or the urethane transducer faces. You do have to be extra careful with the urethane faces. We recommend the TRILUX II paint from Interlux.

Manufacturer	Contact
Courtalds Finishes	Telephone: 908-686-1300
Interlux brand paints	Web Page: www.interlux.com

15.3 Applying Antifouling Paints

Follow the urethane faces application instructions for TRILUX II. One thin coat can last for several months.



NOTE. If you have an optional WorkHorse pressure sensor, and you want pressure (depth) data, you cannot protect the pressure sensor from biofouling. The pressure sensor is located near the center of the transducer array, between the urethane-covered transducers. The sensor port is a small hole drilled through a screw (see “[Pressure Sensor Maintenance](#),” page 29). You should tape off the screw during anti-fouling paint application.

This means that the sensor port is not fully protected from bio fouling. The sensor port is surrounded by the antifouling paint, but bio fouling may build up on the screw, and eventually clog the sensor port. However, most organisms do not seem to find the small amount of unpainted surface attractive. If it is logistically possible to periodically inspect/clean the pressure sensor screw, it is highly recommended. This tradeoff situation must be analyzed for individual deployments. Unfortunately, the location of the deployment site usually dictates action in this regard.

Transducer Faces (urethane surfaces) and Plastic Housing

- a. Preparation - Lightly sand by hand with 120-grit paper.
- b. Application - Apply one or two coats of Trilux-2 at four mil/coat. If applying a second coat, wait at least 12 hours to allow the first coat to dry. One coat lasts one season (3-4 months); two coats might last one year.

Metal Surfaces (High Pressure Systems)

- a. Metal Surface Preparation
 1. On bare aluminum metal, use 353/354 Vinylux solvent wash (thin with 355). Perform the Metal Surface Application (Step (b), below) between 1 and 24 hours.
 2. On painted surfaces, use 120-grit sandpaper to remove gloss.
- b. Metal Surface Application
 1. Mask as necessary.
 2. Apply one or two coats of Trilux-2 (active ingredient is copper thiocyanate) at four mil/coat. If applying a second coat, wait at least 12

hours to allow the first coat to dry. One coat lasts one season (3-4 months); two coats might last one year.



NOTE. Do NOT use cuprous oxide on or near aluminum systems.



Figure 10. Antifouling Paint Applied to a WorkHorse Sentinel

16 Thermistor Maintenance

In order to respond quickly to changes in the water temperature, water must be able to flow over the sensor. Do not block the sensor or paint over it with antifouling paint. Remove any biofouling as soon as possible.



NOTE. The Thermistor is embedded in the transducer head. The sensor is under a titanium cover that is highly resistant to corrosion.

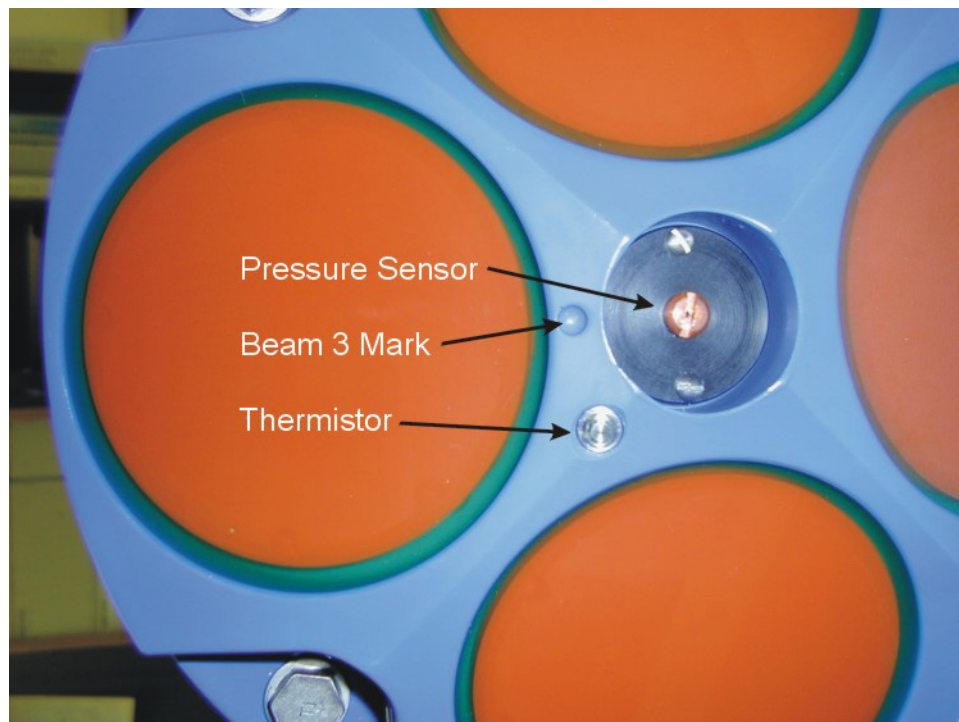


Figure 11. Thermistor and Pressure Sensor

17 Pressure Sensor Maintenance

In order to read the water pressure, water must be able to flow through the copper screw on the pressure sensor. The tiny hole in the copper screw may at times be blocked. Use the following procedure and [Figure 12, page 30](#) to clean the screw.



NOTE. The pressure sensor is optional. It may not be included on your system.

- a. Place the ADCP on its' end-cap. Use a soft pad to protect the ADCP.
- b. Use a straight-slot screwdriver to remove the copper screw.

- c. Gently clean out the hole in the copper screw with a needle. If the hole becomes enlarged or the screw is corroded, replace the screw. A replacement copper screw is included in the spare parts kit (part number 817-1067-00).
- d. Install the copper screw. Tighten the screw “finger tight” (2 in/lbs). Do not over tighten the screw or you may strip the threads on the plastic cover disc. If this happens, return the ADCP to RDI for repair.

CAUTION.



The pressure sensor is filled with silicone oil. Never poke a needle or other object through the copper screw while the screw is installed over the pressure sensor. You will perforate the sensor, causing it to fail.

Do not remove the cover disc or attempt to clean the surface of the pressure sensor. The diaphragm is very thin and easy to damage.

Do not remove the pressure sensor. It is not field replaceable.

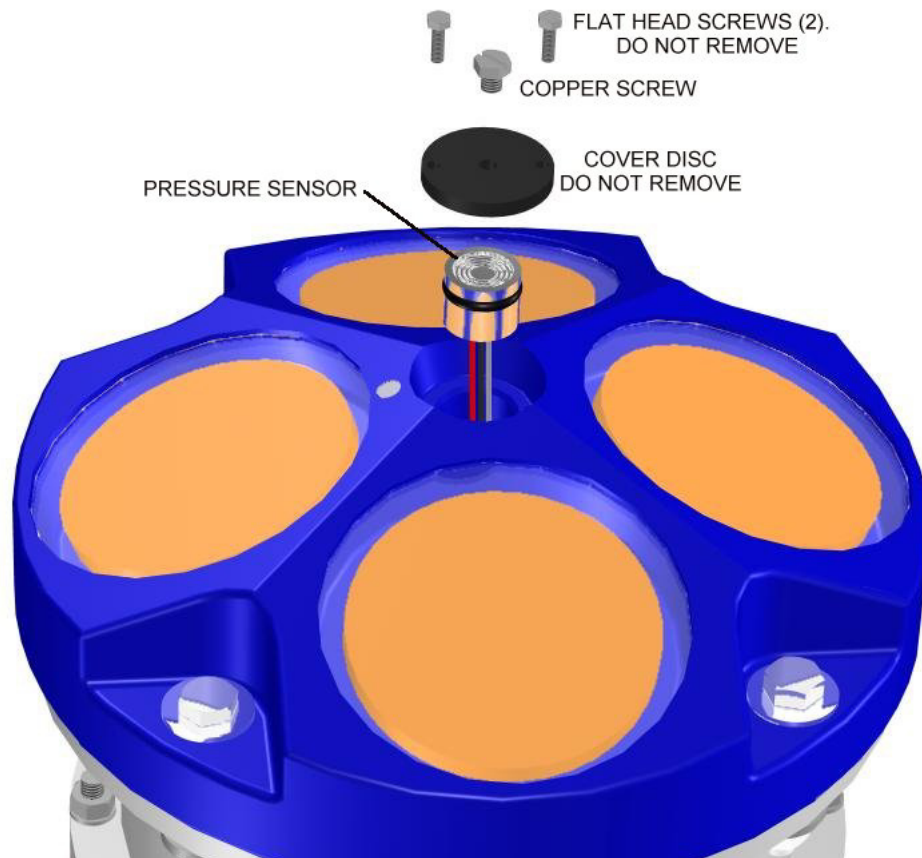


Figure 12. Workhorse Pressure Sensor (Exploded View)

18 Storage and Shipping Maintenance

This section lists the maintenance items to do before storing the Workhorse. These maintenance items include:

- Removing biofouling (see [“Removal of Biofouling,”](#) page 31).
- Inspecting the transducer head (see [“Transducer Head Inspection,”](#) page 31).
- Preparing the Workhorse for final storage or shipping (see [“Final Storage or Shipping Preparation,”](#) page 32).

18.1 Removal of Biofouling

Before storing or shipping the Workhorse, remove all foreign matter and biofouling. Remove soft-bodied marine growth or foreign matter with soapy water. Waterless hand cleaners remove most petroleum-based fouling. Rinse with fresh water to remove soap residue. Dry the transducer faces with low-pressure compressed air or soft lint-free towels.



CAUTION. The soft, thin urethane coating on the transducer faces is easily damaged. Do not use power scrubbers, abrasive cleansers, scouring pads, high-pressure marine cleaning systems, or brushes stiffer than hand cleaning brushes on the transducer faces.

If there is heavy fouling or marine growth, the transducer faces may need a thorough cleaning to restore acoustic performance. Barnacles do not usually affect Workhorse operation. We do however recommend removal of the barnacles to prevent water leakage through the transducer face. Lime dissolving liquids such as Lime-Away® break down the shell-like parts. Scrubbing with a medium stiffness brush usually removes the soft-bodied parts. Do NOT use a brush stiffer than a hand cleaning brush. Scrubbing, alternated with soaking in Lime-Away®, effectively removes large barnacles. After using Lime-Away®, rinse the Workhorse with fresh water to remove all residues. If barnacles have entered more than 1.0 to 1.5 mm (0.06 in.) into the transducer face urethane, you should send the Workhorse to RDI for repair (see [Figure 9, page 26](#)). If you do not think you can remove barnacles without damaging the transducer faces, contact RDI.

18.2 Transducer Head Inspection

The urethane coating on the transducer faces is important to Workhorse watertight integrity. Mishandling, chemicals, abrasive cleaners, and excessive depth pressures can damage the transducer ceramics or urethane coating. Inspect the transducer faces for dents, chipping, peeling, urethane shrinkage, hairline cracks, and damage that may affect watertight integrity or

transducer operation. Repair of the transducer faces should only be done by RDI.



CAUTION. Never set the transducer on a rough surface; always use foam padding to protect the transducers.

18.3 Final Storage or Shipping Preparation

This section explains how to store or ship the Workhorse. Clean and inspect the I/O connector for water or salt residue.



CAUTION. If you are shipping a Workhorse to RDI for repair or upgrade, remove all customer-applied coatings or provide certification that the coating is nontoxic. This certification must include the name of a contact person who is knowledgeable about the coating, the name, and manufacturer of the coating, and the appropriate telephone numbers. If you return the equipment without meeting these conditions, we have instructed our employees not to handle the equipment and to leave it in the original shipping container pending certification. If you cannot provide certification, we will return the equipment to you or to a customer-specified cleaning facility. All costs associated with customer-applied coatings will be at the customer's expense.

When shipping the Workhorse through a Customs facility, be sure to place the unit/s so identifying labels are not covered and can be seen easily by the Customs Inspector. Failure to do so could delay transit time.



NOTE. RDI strongly recommends using the original shipping crate whenever transporting the Workhorse.

If you need to ship or store the Workhorse, use the original shipping crate whenever possible. If the original packaging material is unavailable or unserviceable, additional material is available through RDI.

For repackaging with commercially available materials, use the following procedure:

- a. Use a strong shipping container made out of wood or plastic.
- b. Install a layer of shock-absorbing static-shielding material, 70-mm to 100-mm thick, around all sides of the instrument to firmly cushion and prevent movement inside the container.
- c. Seal the shipping container securely.
- d. Mark the container FRAGILE to ensure careful handling.
- e. In any correspondence, refer to the Workhorse by model and serial number.

19 Returning Workhorses to RDI for Service

When shipping the Workhorse to RDI from either inside or outside the United States, the following instructions will help ensure the Workhorse arrives with the minimum possible delay. Any deviation from these instructions increases the potential for delay.

19.1 Domestic Shipments

Step 1 - Get a Return Authorization

The best way to make sure RDI is aware of your intentions to ship equipment is to obtain a Return Authorization (RA) before sending the shipment. Return Authorizations are issued by Sales Administration or Customer Service and are used to notify us of your needs in advance of arrival so we can provide a faster turnaround. When requesting a Return Authorization, please give us the following information.

- What is being shipped (include the serial number)
- When you plan to send the shipment
- What problem(s) need correction
- When you need the instrument returned

When the Return Authorization is issued, we will tell you the RA number. Please include this number on all packages and correspondence.

Step 2 - Ship via air freight, prepaid



CAUTION. Never ship the Workhorse with lithium batteries inside. Lithium batteries must be packaged and shipped according to the hazardous materials regulations of the International Air Traffic Association (IATA) via Air Cargo only.

Urgent Shipments should be shipped direct to RDI via any of several overnight or priority air services. Do not send urgent airfreight as part of a consolidated shipment. If you ship consolidated, you will save money, but may lose up to three days in transit time.

Non-urgent shipments may be shipped as part of a consolidated cargo shipment to save money. In addition, some truck lines may offer equivalent delivery service at a lower cost, depending on the distance to San Diego.

Mark the Package(s)

To: RD Instruments, Inc. (RA Number)
9855 Businesspark Avenue
San Diego, CA 92131-1101

Step 3 - Urgent shipments

Send the following information by fax or telephone to RDI.

Attention: Sales Administration

Fax: (858) 695-1459

Phone: (858) 693-1178

- Detailed descriptions of what you are shipping (number of packages, sizes, weights, and contents).
- The name of the freight carrier
- Master Air bill number
- Carrier route and flight numbers for all flights the package will take

19.2 International Shipments

Step 1 - Get a Return Authorization

The best way to make sure RDI is aware of your intentions to ship equipment is to obtain a Return Authorization (RA) before sending the shipment. Return Authorizations are issued by Sales Administration or Customer Service and are used to notify us of your needs in advance of arrival so we can provide a faster turnaround. When requesting a Return Authorization, please give us the following information.

- What is being shipped (include the serial number)
- When you plan to send the shipment
- What problem(s) need correction
- When you need the instrument returned

When the Return Authorization is issued, we will tell you the RA number. Please include this number on all packages and correspondence.

Step 2 - Ship Via Air Freight, Prepaid



CAUTION. Never ship the Workhorse with lithium batteries inside. Lithium batteries must be packaged and shipped according to the hazardous materials regulations of the International Air Traffic Association (IATA) via Air Cargo only.

Urgent Shipments should be shipped direct. Do not send urgent airfreight as part of a consolidated shipment. If you ship consolidated, you will save money, but may lose up to five days in transit time.

Non-urgent shipments may be shipped as part of a consolidated cargo shipment to save money.

Mark the package(s) as follows:

To: RD Instruments, Inc. (RA Number)
9855 Businesspark Avenue
San Diego, CA 92131-1101 USA
C/O: Paxton, Shreve & Hays
Lindbergh Field, San Diego Airport
2361 Airline Drive, #D
San Diego, CA 92101

Notify upon arrival
Phone: 858-692-3113
Fax: 858-692-0539

Step 3 - Include Proper Customs Documentation

The Customs statement should be completed very carefully. It should accurately and truthfully contain the following information.

- Contents of the shipment
- Value
- Purpose of shipment (example: "American made goods returned for repair")
- Any discrepancy or inaccuracy in the Customs statement could cause the shipment to be delayed in Customs.

Step 4 - Send the Following Information by Fax or Telephone to RDI

Attention: Sales Administration
Fax: (858) 695-1459
Phone: (858) 693-1178

- Detailed descriptions of what you are shipping (number of packages, sizes, weights, and contents).
- The name of the freight carrier
- Master Air bill number
- Carrier route and flight numbers for all flights the package will take

20 Spare Parts

Table 1: Workhorse Spare Parts

Item #	Part #	Qty	Description
1.	2-260	4	O-Ring, Face Seal, Duro 70 EPDM
2.	717-3008-00	1	Jumper, GND, Main Electronics
3.	817-1067-00	1	Screw, Pressure Sensor, Workhorse
4.	817-3003-00	4	Washer, Felt Workhorse Electronics
5.	DC-111	1	Lubricant, Silicone1, 5.3oz Tube
6.	DES3	1	Desiccant, Sealed Bag
7.	GMA-3A	2	Fuse, 5mm X 20mm 3A 250V
8.	M6WASHSPLTI	2	Washer, 6mm Split Lock Titanium
9.	M6WASHSTDTI	4	Washer, Flat, Titanium 12.5mm OD
10.	M6X1.0NUTTI	2	Nut, Hex, Titanium 10mm
11.	M6X1.0X45HHTI	2	Screw, Hex Head, Titanium
12.	M8WASHSPLTI	2	Washer, Split Lock, Titanium
13.	M8WASHSTDTI	4	Washer, Flat, Titanium 12.5mm OD
14.	M8X1.25NUTTI	2	Nut, Hex, Titanium 13mm
15.	M8X1.25X65HHTI	2	Screw, Hex Head, Titanium
16.	SPR84-1LB	4	Rubber Band

21 Parts Location Drawings

Use the following figures to identify the parts used on your WorkHorse ADCP.

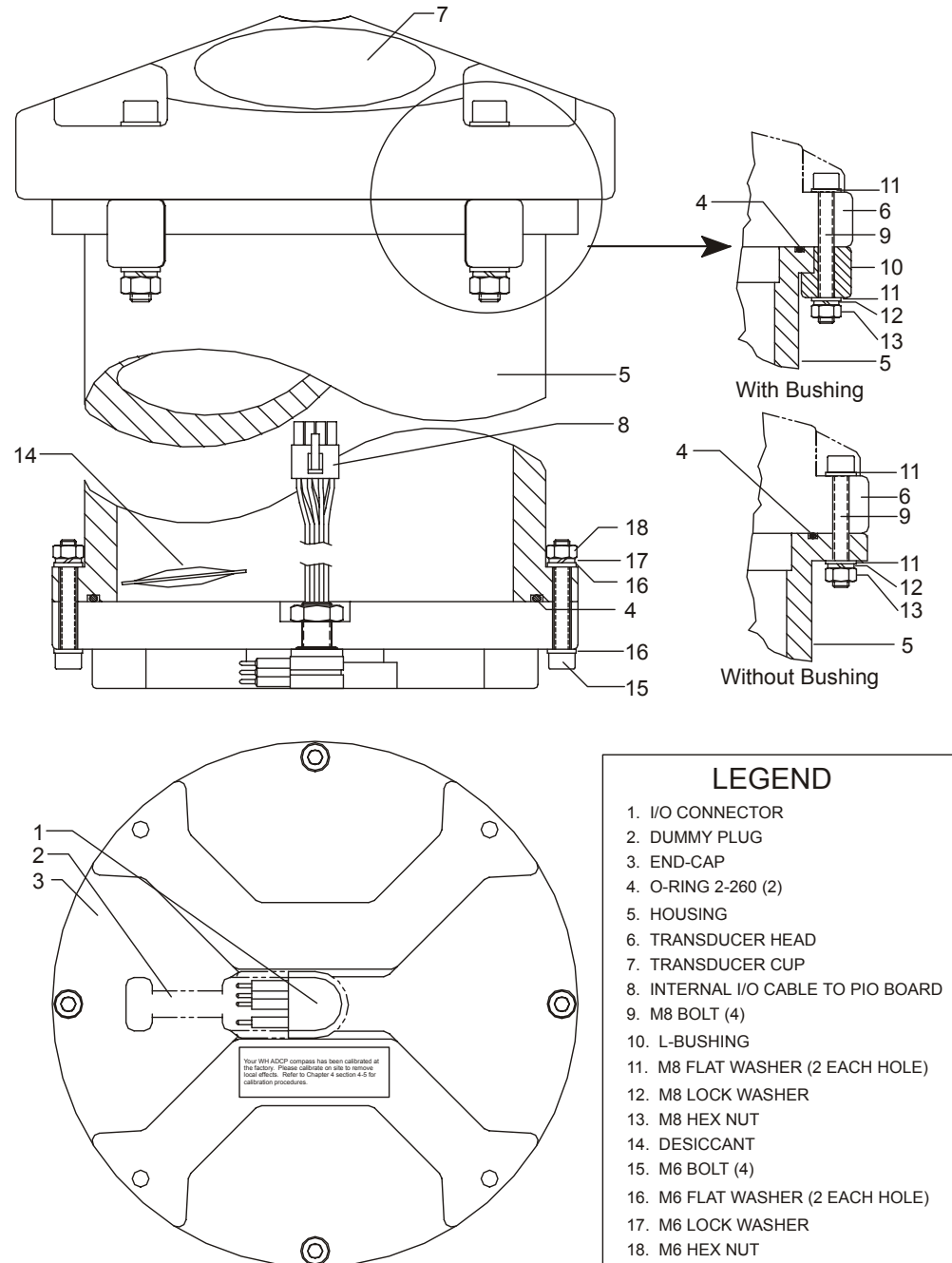


Figure 13. Mariner/Monitor and Rio Grande Parts Location (200 and 500 Meter Systems)

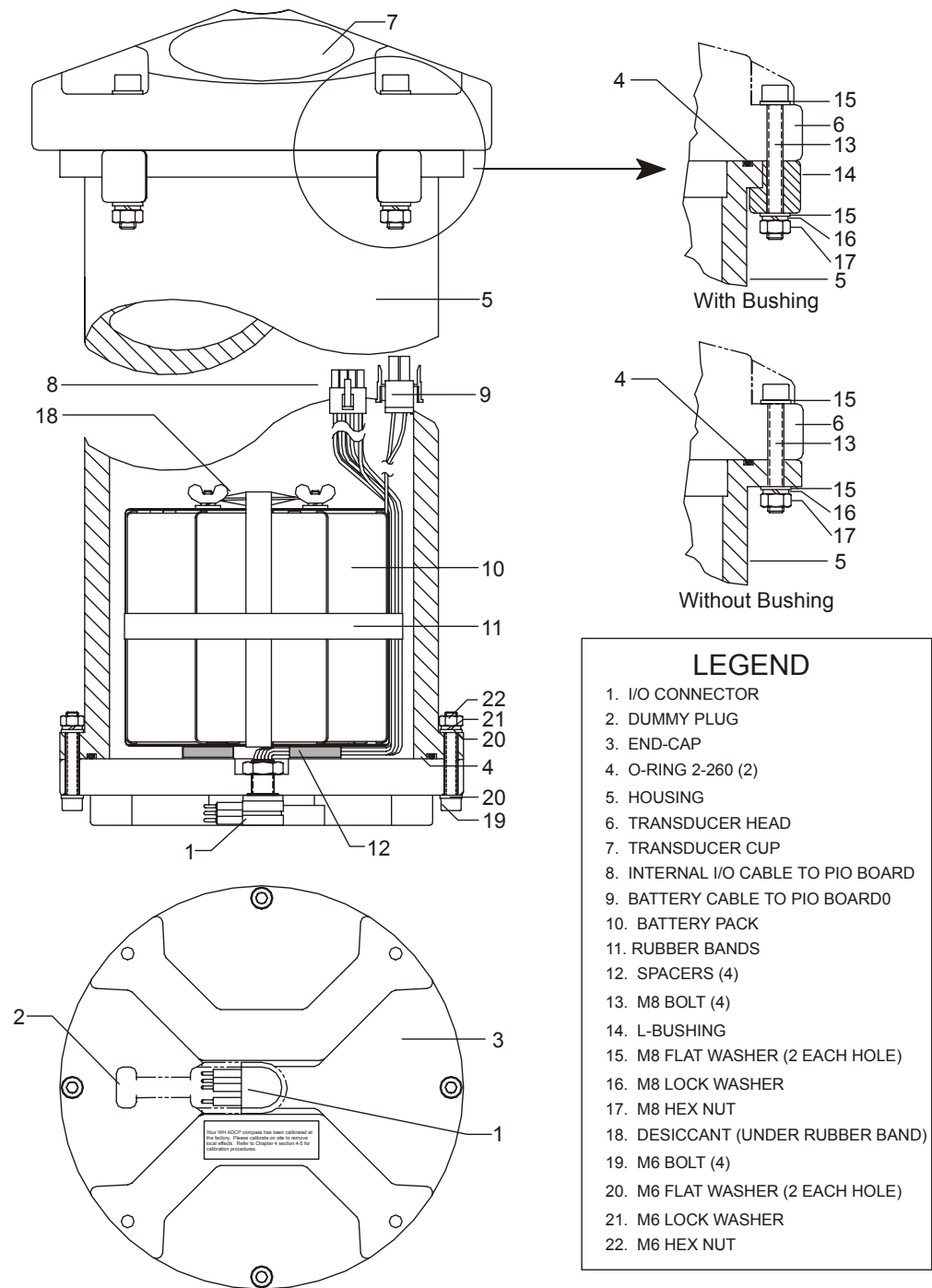


Figure 14. Sentinel Parts Location (200 and 500 Meter Systems)

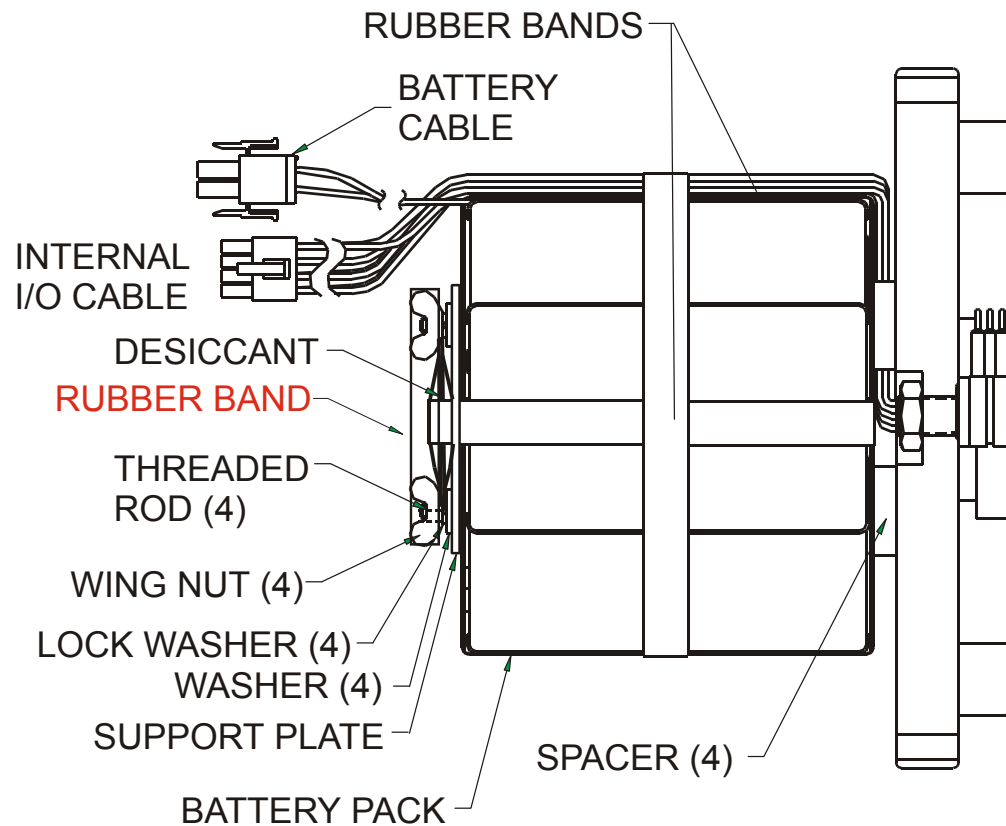


Figure 15. Sentinel End-cap and Battery Pack Parts Location



CAUTION. The Workhorse Sentinel battery packs are held in place by four sets of washers, lock washers, and wing nuts. If the wing nuts are not tight, the assembly of washers and wing nut can become loose and eventually fall onto the PIO board. **This has caused the PIO board to short out.** Place a rubber band around the four wing nuts to help hold them in place.

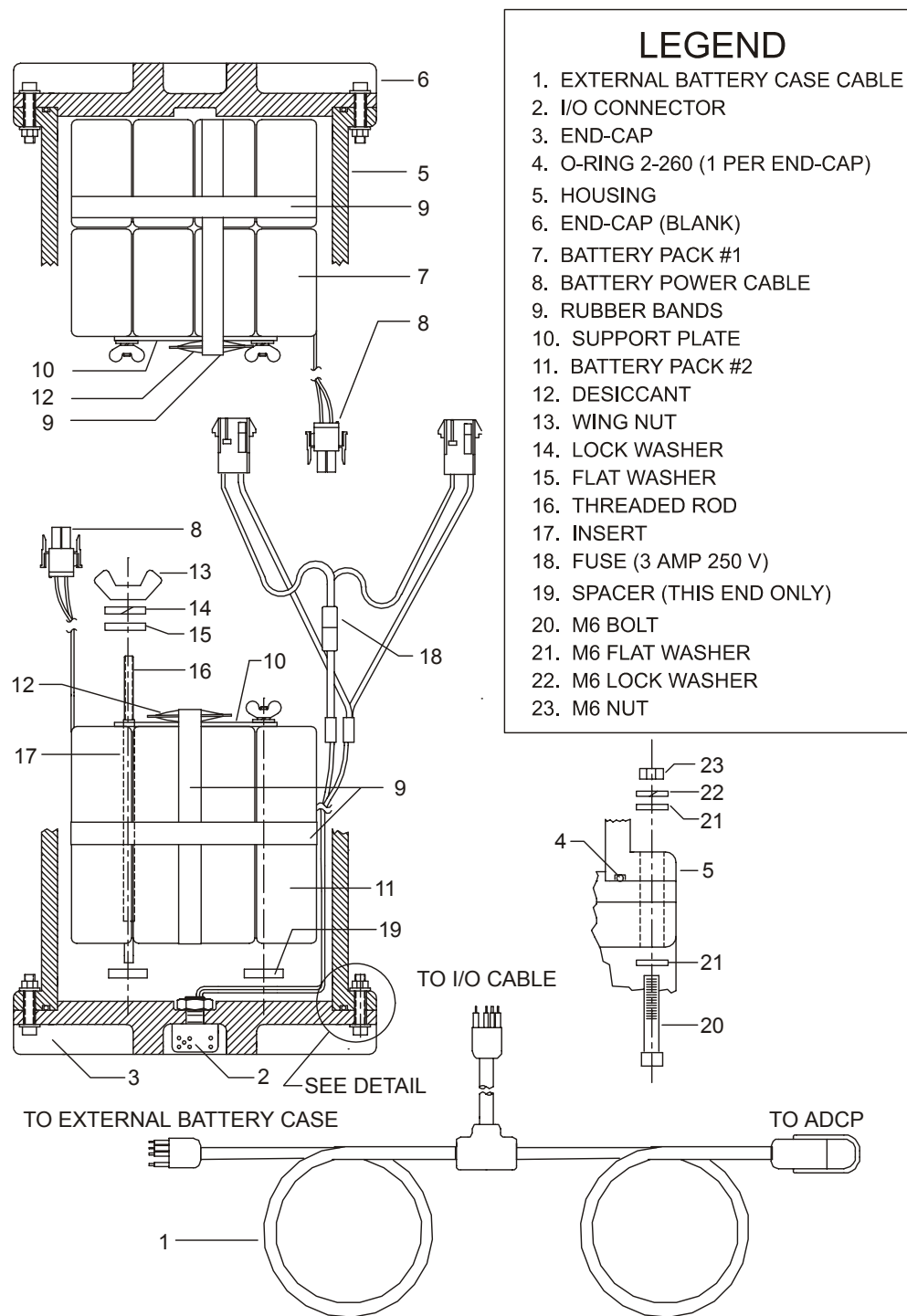


Figure 16. External Battery Pack Parts Location

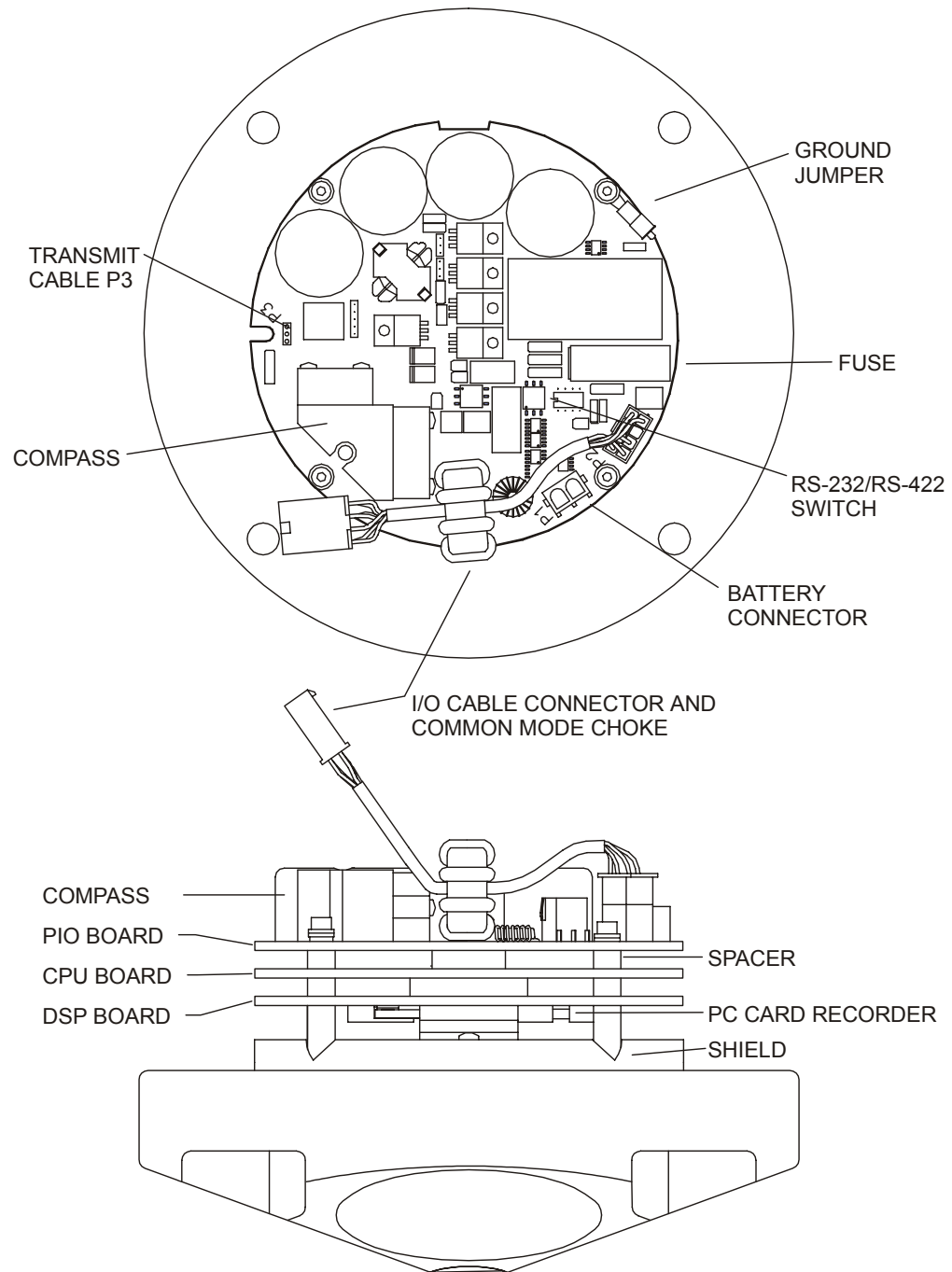


Figure 17. Workhorse Board Locations

22 High Pressure Housings

The high pressure housing upgrade allows you to deploy the ADCP in depths of 500, 1000, 3000, and 6000 meters. The [Installation Guide](#) (see the Outline Installation Drawings) shows the dimensions and weights for all of the systems.

This section includes information on installation, removal, and maintenance items for the high-pressure housing only.

22.1 High-Pressure Housing Disassembly

This section explains how to remove and replace the high-pressure end-cap or transducer head to gain access to the ADCP's electronics, batteries, and internal recorder. Read all instructions before doing the required actions.

22.1.1 High-Pressure End-Cap Removal Procedures

To remove the end-cap, do the following steps. Use [“High-Pressure Parts Location Drawings,”](#) page 52 for parts identification.



NOTE. When you need access to the electronics, RDI recommends removing the transducer head assembly (see [“High-Pressure End-Cap Removal Procedures,”](#) page 42).



NOTE. The 3000 and 6000 meter housing is one piece. Follow the [“High-Pressure Transducer Head Assembly Removal,”](#) page 43 to remove the housing.

- a. Dry the outside of the Workhorse.
- b. Stand the Workhorse on its transducer face on a soft pad.
- c. Remove all power to the Workhorse.
- d. Remove the I/O cable and place the dummy plug on the I/O cable connector (see [“I/O Cable and Dummy Plug,”](#) page 1).



CAUTION. If the ADCP flooded with batteries installed, there may be gas under pressure inside the housing. As a precaution, loosen the four end-cap bolts (6-mm) to vent the system.

- a. Loosen (do not remove) the four end-cap bolts to vent the system.
- b. Once all four end-cap bolts (6-mm) have been loosened, remove the bolts from the end-cap.



NOTE. Make sure you save all hardware removed during this procedure for re-assembly.

- e. Carefully pull the end-cap away from the housing until you can gain access to the connector jack on the common mode choke. Use care; the plastic mating surfaces scratch easily. Do not damage the mating surfaces.
- f. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap aside.
- g. Remove any water from the end-cap O-ring grooves with a soft, lint-free cloth. Clean the O-ring mating surfaces. Inspect the surfaces for damage. Even small scratches can cause leakage around the O-ring seal.

22.1.2 High-Pressure Transducer Head Assembly Removal

- a. Remove all power to the Workhorse.
- b. Remove the I/O cable and place the dummy plug on the I/O cable connector (see [“I/O Cable and Dummy Plug,”](#) page 1).
- c. Stand the Workhorse on its end-cap.



CAUTION. If the ADCP flooded with batteries installed, there may be gas under pressure inside the housing. As a precaution, loosen the four bolts (8-mm) to vent the system.

- a. Loosen (do not remove) the four bolts (8-mm) that attach the housing flange to the transducer head assembly to vent the system.
- b. Once all four bolts (8-mm) have been loosened, remove the bolts.
- d. Carefully lift the transducer assembly straight up and away from the housing until you can gain access to the connector jack on the common mode choke. Use care; the plastic mating surfaces scratch easily. Do not damage the mating surfaces.



NOTE. The cable attached to the end cap is only long enough to disconnect the internal I/O cable. There is NOT enough cable to set the transducer down next to the Housing Assembly.

- e. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap assembly aside. Set the transducer assembly (transducer face down) on a soft pad.
- f. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage.
- g. When you are ready to re-assemble the workhorse, see [“High-Pressure Workhorse Re-assembly,”](#) page 44.

22.2 High-Pressure Workhorse Re-assembly

To replace the end-cap and transducer head, proceed as follows. Use the [“High-Pressure Parts Location Drawings,”](#) page 52 for parts identification.

- a. If you are sealing the Workhorse for a deployment, be sure you have done all appropriate maintenance items (see [“Sealing the Workhorse for a Deployment,”](#) page 24).
- b. Make sure all printed circuit boards, spacers, cables, and screws have been installed.
- c. Install two fresh bags of desiccant just before closing the Workhorse (see [“Desiccant Bags,”](#) page 23).

22.3 High-Pressure O-ring Inspection & Replacement

This section explains how to inspect/replace the Workhorse O-rings. A successful deployment depends on the condition of two O-rings and their retaining grooves. See [“High-Pressure Parts Location Drawings,”](#) page 52 for the locations of the following O-rings. Read all instructions before doing the required actions.

500 meter housings

- Transducer assembly, face, 2-260
- End-cap assembly, face, 2-260

1000, 3000, and 6000 meter high pressure housings

- Transducer and end-cap assembly, bore 2-258
- Transducer and end-cap assembly, face 2-261
- Transducer assembly, backup O-ring, 8-258 N300-90



NOTE. The backup O-ring is installed on 1000, 3000, and 6000 meter high pressure housing systems in addition to the 2-258 bore o-ring on the transducer head assembly. Install the backup o-ring with the cupped side facing the 2-258 bore seal O-ring.

We strongly recommend replacing these O-rings whenever you disassemble the Workhorse. Inspecting and replacing the O-rings should be the last maintenance task done before sealing the Workhorse.



NOTE. We recommend you use new O-rings if you are preparing for a deployment.

- a. Inspect the O-rings. When viewed with an unaided eye, the O-rings must be free of cuts, indentations, abrasions, foreign matter, and flow

marks. The O-ring must be smooth and uniform in appearance. Defects must be less than 0.1 mm (0.004 in.).



CAUTION. If the O-ring appears compressed from prior use, replace it. **Weak or damaged O-rings will cause the ADCP to flood.**

- b. Clean and inspect the O-ring grooves. Be sure the grooves are free of foreign matter, scratches, indentations, corrosion, and pitting. Run your fingernail across damaged areas. If you cannot feel the defect, the damage may be minor; otherwise, the damage may need repair.



CAUTION. Check the O-ring grooves thoroughly. **Any foreign matter in the O-ring grooves will cause the ADCP to flood.**

- c. Lubricate the O-ring with a thin coat of DC-111 lubricant ([Table 1, page 36](#), item 5). Apply the lubricant using latex gloves. Do not let loose fibers or lint stick to the O-ring. Fibers can provide a leakage path.



NOTE. RDI uses Dow Corning's silicone lube model number 111 but any type of silicone O-ring lube can be used.



CAUTION. Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

- d. The backup O-ring (see [Figure 18, page 46](#)) is installed in addition to the 2-258 bore O-ring on the transducer head assembly for 1000, 3000, and 6000-meter high-pressure systems only. Install the backup O-ring with the cupped side facing the 2-258 bore seal O-ring.



NOTE. During installation, do not cut or twist the O-ring. Never force O-rings over sharp corners, screw threads, keyways, slots, or other sharp edges.

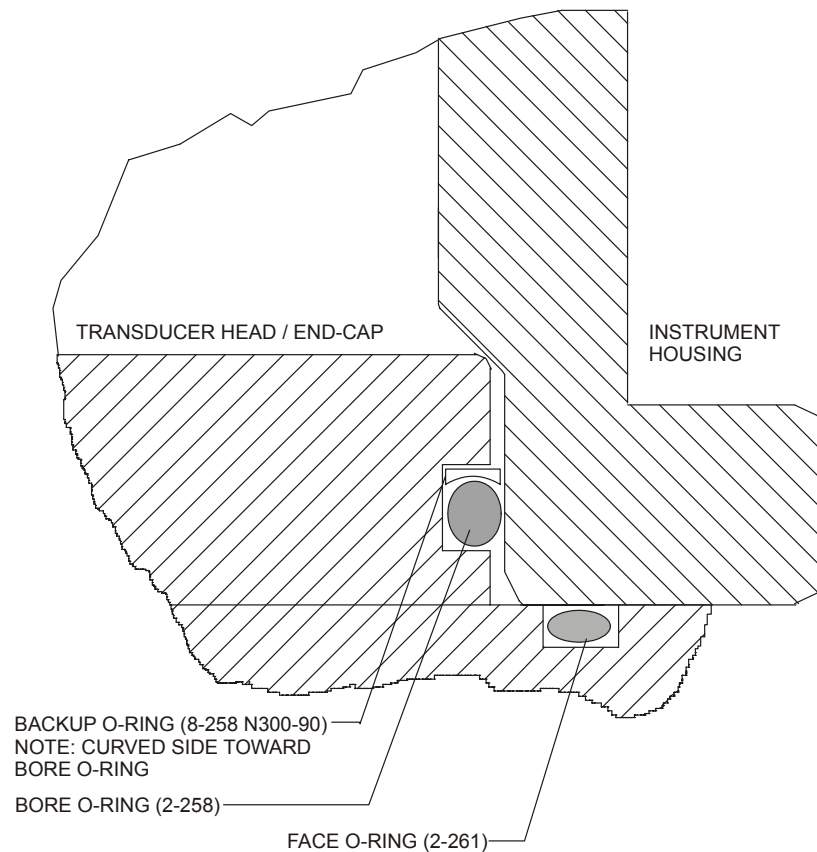


Figure 18. High Pressure O-Ring Detail View

22.3.1 High-Pressure End-cap Replacement

- a. Stand the Workhorse on its transducer face on a soft pad.
- b. Inspect, clean, and lubricate the face and bore O-rings on the end-cap.
Apply a very thin coat of silicone lube on the O-rings.



NOTE. We recommend you use new O-rings if you are preparing for a deployment.



NOTE. RDI uses Dow Corning's silicone lube model number 111 but any type of silicone O-ring lube can be used.



CAUTION. Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

- c. Connect the internal I/O connector to the plug on the common mode choke.

- d. Place the end-cap on the housing, aligning the mating holes and the beam 3 number embossed on the end-cap with the beam 3 number embossed on the transducer head. When mating the end-cap with the housing flange, try to apply equal pressure to all parts of the O-rings. Make sure the face and bore O-rings remain in the retaining groove.



CAUTION. Check that no wires or any other object is pinched between the end-cap and the housing. Use rubber bands to hold the wiring in place as necessary. **If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.**

- e. Examine the end-cap assembly nuts, bolts, and washers (6 mm) for corrosion; replace if necessary. The “[High-Pressure Parts Location Drawings](#),” page 52 shows the assembly order of the end-cap mounting hardware. All the hardware items are needed to seal the Workhorse properly.
- f. Install all four sets of hardware until “finger-tight.”
- g. Tighten the bolts in small increments in a “cross” pattern until the split washer flattens out, and then tighten each bolt $\frac{1}{4}$ turn more to compress the face seal O-ring evenly. Tighten the bolts to the recommended torque value of 5.6 Newton-meters (50 pound-inches).



CAUTION. Apply equal pressure to the O-rings as you tighten the bolts. If one bolt is tightened more than the others, the O-rings can become pinched or torn. **Damaged O-rings will cause the system to flood.**



CAUTION. Do not over tighten the bolts that hold the transducer, housing, and end cap together. If you tighten too far, you can crack or break the plastic bushing. On the other hand, leaving the bolts too loose can cause the system to flood. **Tighten the hardware to the recommended torque value.**



NOTE. The recommended torque value for the end-cap 6-mm bolts is 5.6 Newton-meters (50 pound-inches).

22.3.2 High-Pressure Transducer Head Replacement

- a. Stand the Workhorse on its end-cap.
- b. Inspect, clean, and lubricate the O-rings on the transducer head flange. Apply a very thin coat of silicone lube on the O-ring.



NOTE. We recommend you use new O-rings if you are preparing for a deployment.



NOTE. RDI uses Dow Corning's silicone lube model number 111 but any type of silicone O-ring lube can be used.



CAUTION. Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

- c. Connect the internal I/O connector to the plug on the common mode choke.
- d. Gently lower the transducer head/electronics assembly into the housing, aligning the mating holes and the beam 3 number embossed on the transducer head with the beam 3 number embossed on the end-cap. When mating the housing with the transducer head flange try to apply equal pressure to all parts of the O-rings. Make sure the face and bore O-rings remain in the retaining groove.



CAUTION. Check that no wires or any other object is pinched between the transducer head and the housing. Use rubber bands to hold the wiring in place as necessary. **If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.**

- e. Examine the transducer assembly nuts, bolts, and washers (8-mm) for corrosion; replace if necessary. The [“High-Pressure Parts Location Drawings,” page 52](#) shows the assembly order of the transducer mounting hardware. All hardware items are needed to seal the Workhorse properly.
- f. Install all four sets of hardware until “finger tight.”
- g. Tighten the bolts in small increments in a “cross” pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the face seal O-ring evenly. Tighten the bolts to the recommended torque value of 9.6 Newton-meters (85 pound-inches). Do not deform the plastic bushings.



CAUTION. Apply equal pressure to the O-rings as you tighten the bolts. If one bolt is tightened more than the others, the O-rings can become pinched or torn. **Damaged O-rings will cause the system to flood.**



CAUTION. Do not over tighten the bolts that hold the transducer, housing, and end cap together. If you tighten too far, you can crack or break the plastic bushing. On the other hand, leaving the bolts too loose can cause the system to flood. **Tighten the hardware to the recommended torque value.**



NOTE. The recommended torque value for the transducer head 8-mm bolts is 9.6 Newton-meters (85 pound-inches).

22.4 Zinc Anode Inspection and Replacement

High-pressure systems have up to twelve sacrificial zinc anodes. If the ADCP does not have exposed bare metal, properly installed anodes help protect the ADCP from corrosion while deployed. Read all instructions before doing the required actions.

22.4.1 Zinc Anode Inspection

The life of a zinc anode is not predictable. An anode may last as long as one year, but dynamic sea conditions may reduce its life. Use a six-month period as a guide. If the total deployment time for the anodes has been six months or more, replace the anodes. If you expect the next deployment to last six months or more, replace the anodes. Inspect the anodes as follows.

- a. Inspect the anodes on the transducer assembly, housing and end-cap for corrosion and pitting. If most of an anode still exists, you may not want to replace it.
- b. Inspect the RTV-covered screws that fasten each anode. If the RTV has decayed enough to let water enter between the screws and the anode, replace the RTV.
- c. If you have doubts about the condition of the anodes, remove and replace the anode.

22.4.2 Zinc Anode Electrical Continuity Check

Check electrical continuity using a digital multimeter (DMM). All measurements must be less than five ohms. If not, reinstall the affected anode.

End-Cap Anode. Measure the resistance between all four anodes. Scratch the surface of the anode with the DMM probe to make good contact if the anode is oxidized. The resistance should be less than five ohms.

Housing Anodes. Measure the resistance between all four anodes. Scratch the surface of the anode with the DMM probe to make good contact if the anode is oxidized. The resistance should be less than five ohms.

Transducer Anode. Remove the housing. Measure the resistance between the anode and any one of the four screws holding the PC boards to the transducer. The resistance should be less than five ohms.

22.4.3 Zinc Anode Replacement

The following steps explain how to remove and replace the zinc anode/s.

- a. Remove the RTV from the anode screw heads. Remove the screws.
- b. The anode may stick to the ADCP because of the RTV used during assembly. To break this bond, first place a block of wood on the edge of the anode to protect the housing anodizing and paint. Carefully strike the block to loosen the anode.
- c. Clean the bonding area under the anode. Remove all foreign matter and corrosion. Apply a continuous 1-2 mm bead (0.04-0.08 in.) of RTV around each screw hole.
- d. Set a new anode in place and fasten with new screws.
- e. Fill the counter bore above each screw head with RTV. The RTV protects the screw heads from water and prevents breaking the electrical continuity between the anode, screw, and housing.
- f. Check electrical continuity. If any measurement is greater than one ohm, reinstall the affected anode.

CAUTION.



1. Do not use zinc anodes with an iron content of more than 0.0015%. The major factor controlling the electrical current output characteristics of zinc in seawater is the corrosion film that forms on the surface of the zinc. Corrosion product films containing iron have a high electrical resistance. As little as 0.002% iron in zinc anodes degrades the performance of the anode.

2. Do not use magnesium anodes. Magnesium rapidly corrodes the aluminum housing.

3. Do not connect other metal to the ADCP. Other metals may cause corrosion damage. Use isolating bushings when mounting the ADCP to a metal structure.

22.5 Protective Coating Inspection and Repair

RDI uses paint on the housing for identification and corrosion protection. For more protection, the case and the transducer assembly are first anodized. Do not damage the surface coatings when handling the ADCP. Inspect and repair the protective coating as follows. Read all instructions before doing the required actions.



NOTE. The procedures contained in this section apply to our standard aluminum systems. For systems made of other materials, contact RDI.

- a. Inspect the end-cap, housing, and transducer assemblies for corrosion, scratches, cracks, abrasions, paint blisters, exposed metal (silver-colored

aluminum), exposed anodize (black or dark green), and exposed primer (yellow). Be critical in your judgment; the useful life of the WorkHorse depends on it.



CAUTION. The chemicals used in the following steps can be hazardous to your health. Read all material safety data sheets and manufacturer's instructions before handling these chemicals.

- b. If you are familiar with the repair of anodized coatings, proceed as follows; otherwise, send the WorkHorse to RDI for repair.
 1. Clean and prepare the damaged area using a fine-grade abrasive cloth or a fine-grade abrasive silicon carbide wheel. Remove all corrosion from the bare aluminum.
 2. Clean the area with trichlorethane or alcohol. Do not touch the area after cleaning.
 3. Anodize per MIL-A-8625, Type 3, Class 1.
 4. Seal with sodium dichromate only.
 5. Paint repaired area as described in step c below.
- c. Proceed as follows to repair or touch up the protective paint.
 1. Remove all loose paint without damaging the anodizing. Clean and prepare the damaged area using a fine-grade abrasive cloth. Feather the edges of the paint near the damaged area. Try to have a smooth transition between the paint and the damaged area. Do not sand the anodized area. If you damage the anodizing, see step b above for repair.
 2. Clean the area with trichlorethane or alcohol. Do not touch the area after cleaning.
 3. Paint with one coat of epoxy primer (manufacturer's part number 4500; see note below).
 4. Paint with one coat of orange or black paint (manufacturer's part number 4512-B (orange), 4511-B (black); see note below).



NOTE. RDI uses two-part epoxy type paint. This paint is manufactured by Pro-line Paint Manufacturing company, 2426 Main St., San Diego, CA, 92113, Telephone: (619) 231-2313; or 1168 Harbor, Long Beach, CA, 98813, Telephone: (213) 432-7961. Manufacturer's part numbers:
4500-A, Pro-thane Paint, Catalyst, Part A
4511-B, Pro-thane Paint, Black, Part B
4512-B, Pro-thane Paint, Orange, Part B

22.6 High-Pressure Systems Spare Parts

Table 2: High-Pressure Systems Spare Parts

Description	Vendor	Part #
O-ring, face seal, 2-261, EPDM, Duro	Cal State Seal (619-224-2007)	2-260, EPDM, Duro 70, Parker
O-ring, bore seal, 2-258, EPDM, Duro	Cal State Seal	2-258, EPDM, Duro 70, Parker
O-ring, 8-258 N300-90, PARBAK	Cal State Seal	2-258, PARBAK
Bushing, L	RDI	811-4007-00
M8 Bushing, plastic isolation	Use local vendor	

22.7 High-Pressure Parts Location Drawings

Use the following figures to identify parts used on your high-pressure WorkHorse ADCP.

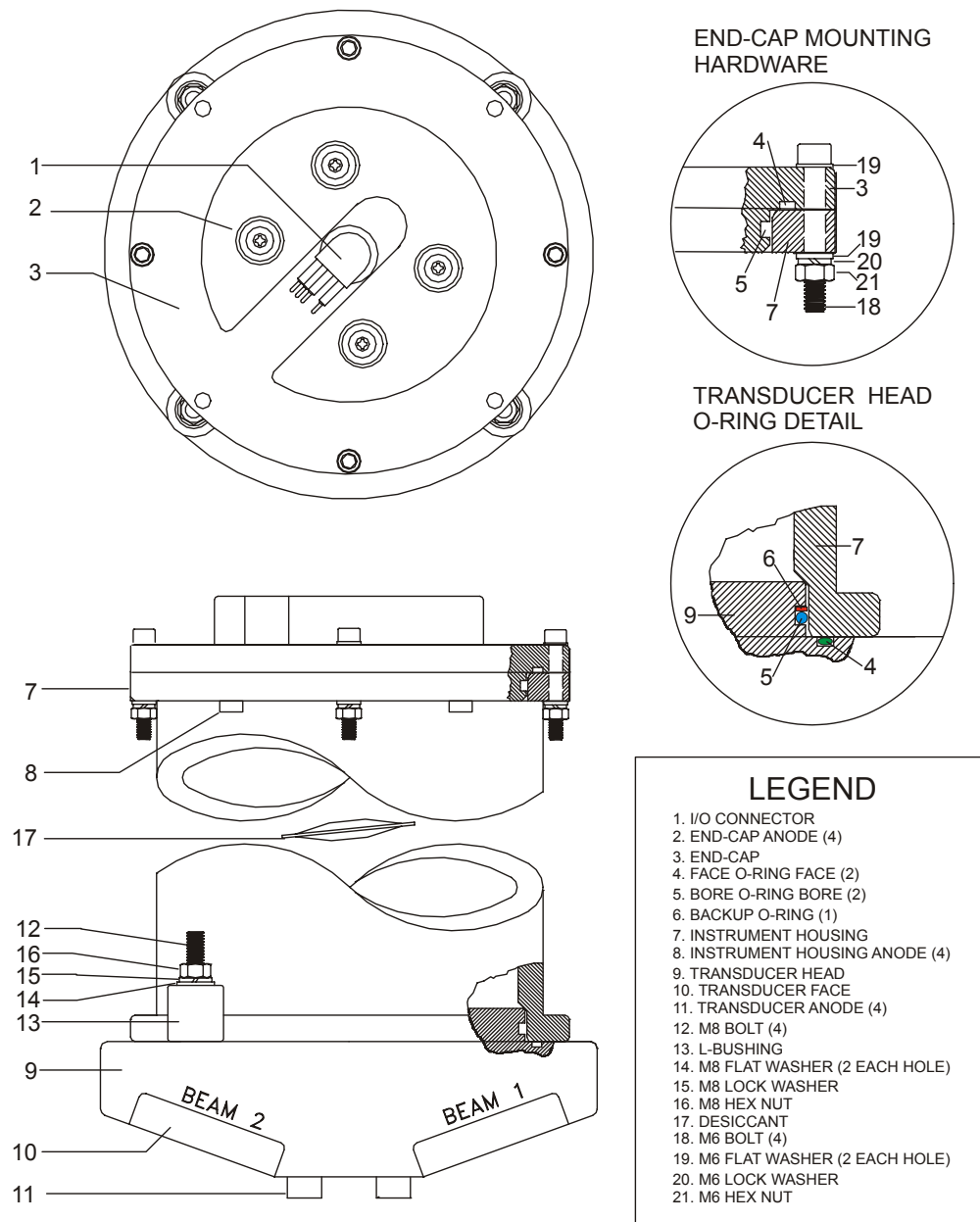


Figure 19. 1000 meter WorkHorse Parts Location

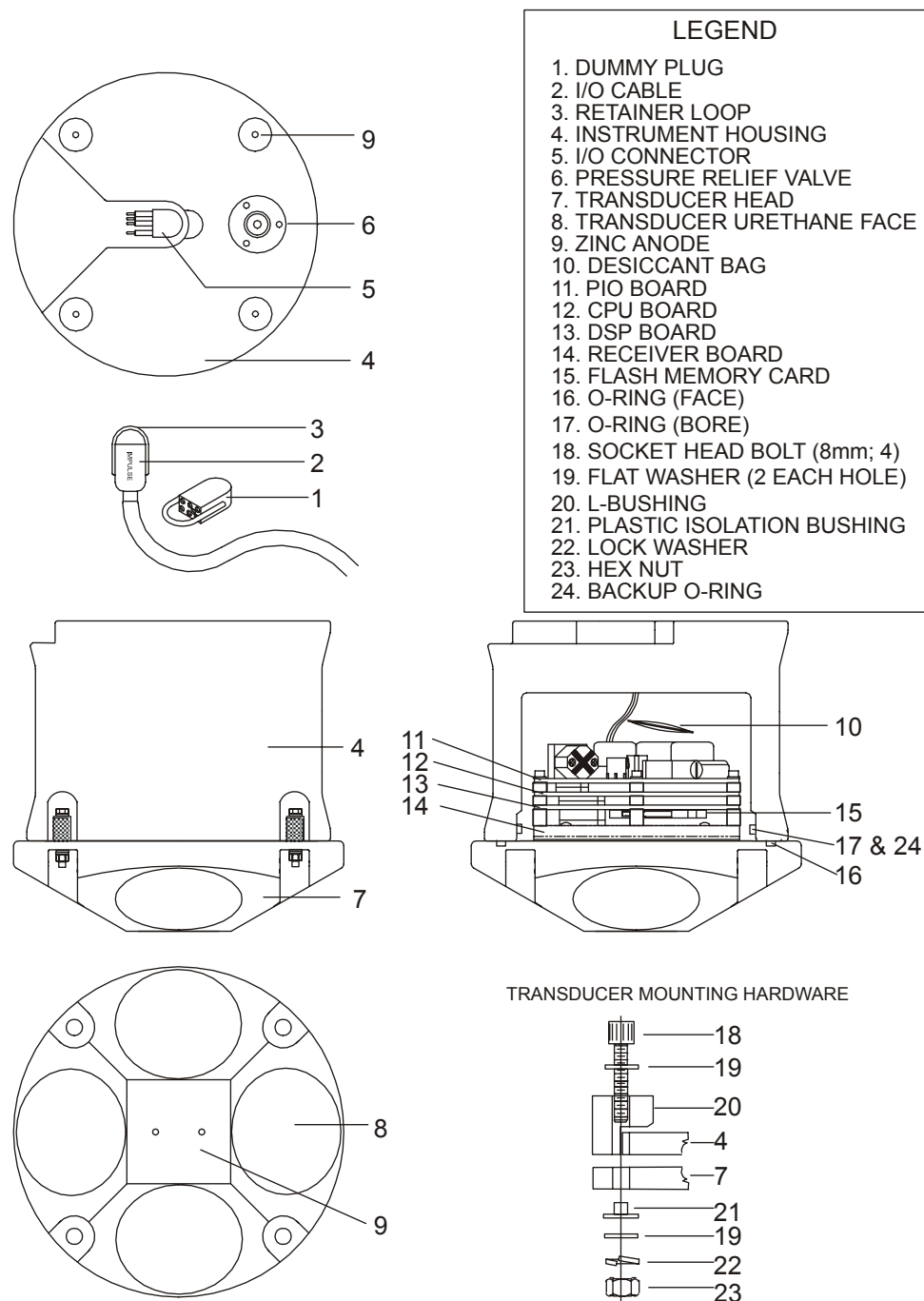


Figure 20. 3000 and 6000 meter WorkHorse Parts Location