WorkHorse

Sentinel, Monitor, & Mariner

Operation Manual

P/N 957-6150-00 (March 2014)

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Revision History

March 2014

- Updated the specifications in Table 33 and Table 34, page 190.
- Added the Transducer Alignment Test for Mariner systems to the Sea Acceptance Tests section.
- Corrected the 300 kHz acoustic window thickness recommendation from 0.5” to 3/8” (0.375”) on Table 3, page 40.
- Corrected the bullets under How to Determine the Maximum Range of the ADCP, page 153 from “The bin must have a percent good value above 25%” to “The bin must be > 25% of the sum of 3-beams Solutions (percent good 1) and 4-beams Solutions (percent good 4), [(PG1 + PG4) > 25%]”. Corrected the correlation threshold from 120 counts to 64 counts.
- Updated the script file names in the Installing the Spare Boards Kit section, page 124 and added instructions for installing the pressure sensor coefficients.

February 2013

- Combined Monitor/Sentinel and Mariner User’s Guide into the operation manual.
- Added corrections for ICN 145 I/O Connector Lubricant.
- Added 6000 meter outline installation drawings 967-6113, 967-6114, and 967-6115.
- Updated styles and fonts.
- Updated the maintenance procedures and parts location drawings.
- Updated Commands and Output Data Format guide to 5x.40 firmware.

August 2010

- Added corrections for ICNs 082, 100, 113, 116, 118, 120, 126, 127, and 130.
- Added information from FST-021.
- Updated Commands and Output Data Format guide to 5x.38 firmware.

November 2007

- Added corrections for the following ICNs: ICN063, RDI Tools Test Results File, ICN064, Corrections to WorkHorse Commands and Output Data Format, ICN065, WorkHorse Specifications, ICN077, Additions to the CP Command.
- Removed Rio Grande (now has its own manual).
- Updated Commands and Output Data Format guide to 16.30 firmware.

Exclusions and Omissions

1: None

Chapter 1

AT A GLANCE

In this chapter, you will learn:

- WorkHorse Models and Options
- System Overview
- Computer Considerations
- Power Overview
- Setting up the ADCP
- Caring for your Workhorse System

How to Contact Teledyne RD Instruments

If you have technical issues or questions involving a specific application or deployment with your instrument, contact our Field Service group:

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Phone +1 (858) 842-2600	Phone +33(0) 492-110-930
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Sales – rdisales@teledyne.com	Sales – rdie@teledyne.com
Field Service – rdifs@teledyne.com	Field Service – rdiefs@teledyne.com

Client Services Administration – rdicsadmin@teledyne.com

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Conventions Used in this Manual

Conventions used in the WorkHorse Acoustic Doppler Current Profiler (ADCP) Operation Manual have been established to help learn how to use the system quickly and easily.

Menu items are printed in bold: click **Collect Data**. Items that need to be typed by the user or keys to press will be shown as **<F1>**. If a key combination were joined with a plus sign **(<ALT+F>**), press and hold the first key while pressing the second key. Words printed in italics include program names (*BBTalk*) and file names (*TestWH.rds*).

Code or sample files are printed using a fixed font. Here is an example:

```
[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 50.40
Teledyne RD Instruments (c) 1996-2012
All Rights Reserved.
>
```

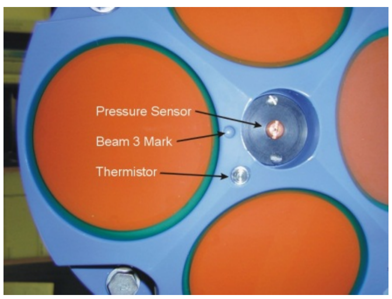
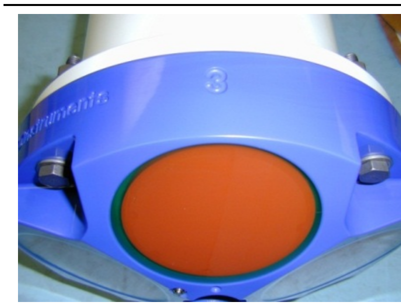
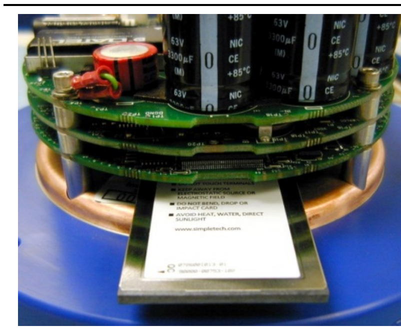
You will find two other visual aids that help you: Notes and Cautions.

This paragraph format indicates additional information that may help you avoid problems or that should be considered in using the described features.

This paragraph format warns the reader of hazardous procedures (for example, activities that may cause loss of data or damage to the WorkHorse ADCP).

System Overview

The ADCP transducer assembly contains the end-cap, housing, transducer ceramics, and electronics. The standard acoustic frequencies are 1200, 600, and 300 kHz. See the Outline Installation Drawings for dimensions and weights.

Picture	Description
	The Input/Output (I/O) cable connects the WorkHorse ADCP to the computer and external power supply. When the cable is not connected, use the dummy plug to protect the connector.
	The end-cap holds the I/O cable connector. When assembling the unit, match the Beam 3 mark on the end-cap with beam 3 number on the transducer.
	The Beam-3 mark shows the location of Beam-3 (Forward).
	The Thermistor measures the water temperature.
	The pressure sensor (standard 200 Bar) measures water pressure (depth).
	The orange urethane faces covers the transducer ceramics. Never set the transducer on a hard surface. The urethane faces may be damaged.
	The standard WorkHorse white plastic housing allows deployment depths to 200 meters.
	The WorkHorse electronics and transducer ceramics are mounted to the transducer head. The numbers embossed on the edge of the transducer indicate the beam number. When assembling the unit, match the transducer beam number 3 with the Beam 3 mark on the end-cap.
	The Sentinel ADCP includes a longer housing to hold an alkaline battery. The internal battery pack has 450 watt-hours (Wh) of usable energy at 0 C. When fresh, the voltage is +42 VDC. When depleted, the voltage drops to 30 VDC or less.
	WorkHorse Sentinel ADCPs come standard with one memory card. Two PCMCIA memory cards slots are available. The maximum memory for each slot is 2GB, with the total memory capacity not to exceed 4GB.

WorkHorse Models and Options

The following section explains the different models and options available for WorkHorse ADCPs.

WorkHorse Monitor

The WorkHorse Monitor is designed to measure real-time current profiles from temporary or permanent mounting in the ocean, near-shore, harbors, and lakes. The Monitor ADCP system consists of an ADCP, cables, RS-232-to-RS-422 converter, and software. The Monitor system requires the addition of a Windows® compatible computer to collect data.

Figure 1. WorkHorse Monitor ADCP

WorkHorse Sentinel

The WorkHorse Sentinel is designed for several-month autonomous current profile deployment from temporary or permanent mounting in the ocean, near-shore, harbors, and lakes. The Sentinel ADCP system consists of an ADCP, cables, battery pack, flash memory card, and software. Both battery capacity and memory can be increased with upgrades for longer deployments. The Sentinel can also be used for direct-reading current profile operation. The Sentinel system requires the addition of a Windows® compatible computer to configure the ADCP and replay collected data.

Figure 2. WorkHorse Sentinel ADCP

WorkHorse Mariner

The WorkHorse Mariner is designed to measure real-time current profiles from temporary or permanent mounting in a vessel. The Mariner ADCP system consists of a Monitor ADCP with Bottom Track mode, cables, Deck Box, Mounting Plate, and software.

The Deck Box converts AC power input or 12 VDC input into 48 VDC output for the Mariner input power. It can convert the computer serial interface from RS232 to RS422. As an option, it converts gyro analog input to a serial NMEA output (requires an optional gyro interface; must be purchased at time of order). The Mariner system requires the addition of a Windows® compatible computer to collect data.

Figure 3. WorkHorse Mariner ADCP

WorkHorse Options

- **Bottom Track** – You can use your WorkHorse ADCP from moving boats and ships with the Bottom Track Upgrade. Once the Bottom Track Upgrade is added, a WorkHorse ADCP can measure both water depth and boat velocity over the ground.
- **Shallow Water Bottom Track Mode 7** – You can use your WorkHorse 1200 kHz ZedHed™ ADCP in water as shallow as 30cm.
- **High-Resolution Water Profiling Modes** – This upgrade allows you to collect water profiles using Water Modes 1, 5, 8, and 11.
- **High Ping Rate Water Mode** – This upgrade allows you to collect water profiles using Water Mode 12.
- **Waves** – This upgrade allows you to use the ADCP as a wave gauge.
- ***VmDas* Software** – Controls the ADCP and displays profile data through a personal computer.
- ***WinRiver II* Software** – Controls the ADCP and displays discharge data and profile data through a personal computer.
- ***Waves* Software** – Controls the ADCP and displays waves data through a personal computer.
- **Memory** – The WorkHorse Sentinel ADCP includes one memory card. Two PCMCIA memory card slots are available for all WorkHorse ADCPs (see PC Card Recorder for memory card specifications). The maximum memory for each slot is 2GB, with the total memory capacity not to exceed 4GB.
- **Spare boards kit** – Contains a complete set of spare printed circuit boards for a WorkHorse ADCP. The set does not include boards purchased as options such as the gyro/synchro board or the receiver board (not field replaceable).

- **High-Pressure Housing** – The standard WorkHorse housing allows deployment depths to 200 meters. High-pressure housings are available in depth rating of 500 and 6000 meters. See the Outline Installation Drawings for dimensions and weights.
- **External Battery** – Adding external batteries can increase the deployment length for Sentinel ADCPs. Use an External Battery with a Monitor ADCP to provide backup power or for self-contained deployments.

Figure 4. WorkHorse External Battery Case Overview

Mariner Options

- **Gyrocompass (Gyro) Interface** – Connects the ship's gyro to the Deck Box (must be purchased at time of order).
- **Mounting Plate** – A bronze plate that helps mount the transducer head to a vessel. See the Outline Installation Drawings for dimensions.

Mariner Deck Box Overview

The deck Box contains all interfaces to/from the ADCP, computer/terminal, optional vessel gyrocompass, and power.

Power Switch – The power switch is a combination switch/circuit breaker. The **Power Status** LED next to the circuit breaker lights when power is applied to the Deck Box.

Reset Button – Pushing the **Reset** button sends a break to the ADCP.

Data In/Out LEDs – **Channel 1 In** indicates data transmission from the computer to the ADCP. **Channel 1 Out** indicates data transmission from the ADCP to the computer.

Gyro Display – The LCD Display shows the vessel's gyro heading.

The Gyro Interface is optional. If you do not have a Gyro Interface board installed, the LCD display will be blank.

Gyro Offset Controls – Use the **Up**/**Down**/**Set** buttons to set the Gyro Offset for systems with the optional Gyro Interface board installed. The Offset Control buttons are **Up**, **Set**, and **Down**, as depicted by the upward arrow, the square box, and the downward arrow respective.

For example, to set a heading offset for a multi-rate gyro, push the up or down button and set button simultaneously, using two small aids such as a pencil. When the desired offset is obtained, release the buttons. To prevent accidental re-adjustment, the buttons are recessed.

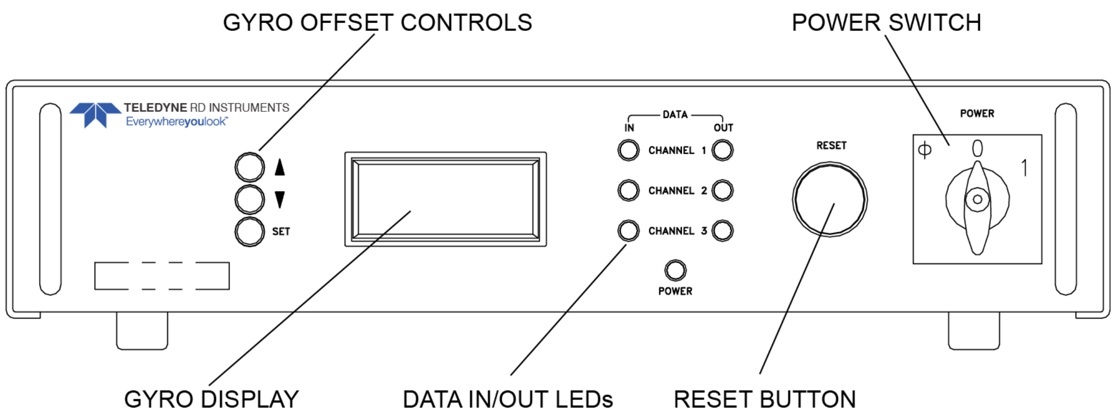


Figure 5. Deck Box (Front View)

ADCP (J17) – Connects the ADCP to the deck box.

Channel 1 RS 422 (J19) – Connects the computer's RS-422 port to the deck box. Use this only if your computer has a RS422 serial port. If your computer has a RS-232 serial port (standard), use J20.

Channel 1 RS 232 (J20) – Connects the computer RS-232 port to the deck box.

Gyro Synchro/Stepper (J22) – Optional Gyrocompass (gyro) interface connects the ship's gyro to the Deck Box. The WorkHorse Operation Manual lists gyro requirements.

Gyro Serial RS 232 (J28) – Supplies serial, ASCII navigation data to the computer via our *VmDas* program. See the *VmDas* help file for requirements. This is an option for some ADCP applications. When working in areas where bottom-track detection is not possible, you need this equipment to remove ADCP (Ship) motion from the data. The output from the J28 deck box connector is a serial data string of gyro heading, pitch, and roll. The format of this string is: *$PRDID,±ppp.pp,±rrr.rr,hhh.hh* (where *p* is pitch, *r* is roll, and *h* is heading; all scaled in decimal degrees).

AC Power Input – The deck box accepts input voltages of 98-264 VAC, 50-60Hz (J27). This input voltage will be converted to 48 VDC. This is the voltage supplied to the ADCP.

DC 12-Volt Input – Use a 12 VDC car battery (J26) when AC power is not available. The deck box converts the voltage to 48 VDC. This is the voltage supplied to the ADCP. Use the largest rated amp-hour battery as possible. A car battery should last one to two days powering a 1200 kHz ADCP.

DC 20 to 50 Volt Input – If you are using an external DC power supply connected to the deck box on J25 (20 to 50 VDC, 3.0 A), the voltage from the external power supply is sent *directly* to the ADCP. This is useful if you want to increase (higher voltage level) or decrease (lower voltage level) the range of the ADCP. The current requirement for the power supply is listed as a reference. Using a lesser-rated power supply can cause the voltage level to drop. The ADCP will draw only the current it needs.

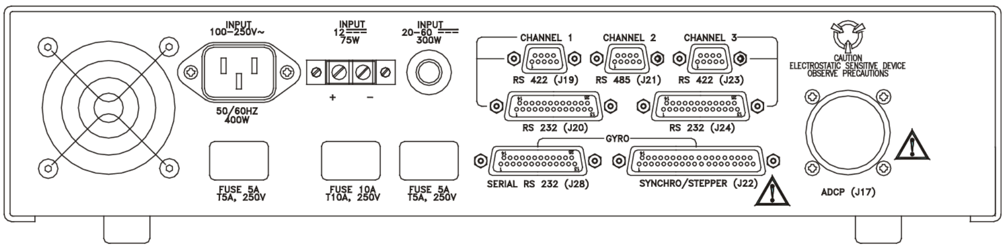


Figure 6. Deck Box (Rear View)

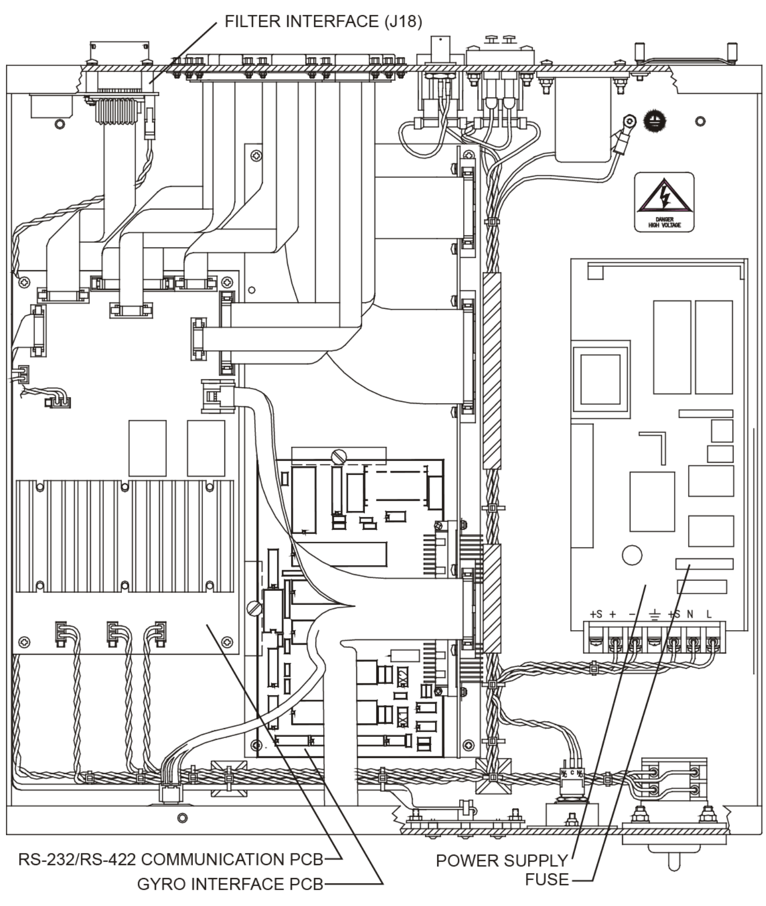


Figure 7. Deck Box (Top View)

Computer Considerations

TRDI designed the WorkHorse ADCP to use a Windows® compatible computer. The computer controls the ADCP and displays its data, usually through our *WinSC*, *WinADCP*, *VmDas* or *WinRiver II* programs. Table 1 lists the minimum computer requirements.

TRDI highly recommends that you download and install all of the critical updates, recommended updates, and the service releases for the version of Windows® that you are using prior to installing any TRDI software.

Table 1: Minimum Computer Hardware Requirements

Windows XP® or Windows 7®
Pentium III 600 MHz class PC (higher recommended)
1GB of RAM (2GB RAM recommended)
50 MB Free Disk Space plus space for data files (A large, fast hard disk is recommended
One Serial Port (two or more High Speed UART Serial Port recommended)
Minimum display resolution of 1024 x 768, 256 color (higher recommended)

VmDas has special requirements – see the VmDas User's Guide for detailed information on system requirements.

The computer configuration varies depending of the number of communication ports and the external data refresh rate. Serial communications require a lot of processor resources, and the minimum requirements can vary. A good quality video card is required to operate *VmDas* and *WinADCP* simultaneously. We do not use graphic card 3D functions; however, video memory is needed to display all graphics.

However, with experience we can recommend that:

- If you are using more than two communication ports, you should not use a Celeron processor.
- Intel Pentium III processors work best to operate the ADCP and give access to the display and keyboard without losing ensembles.

Power Overview

WorkHorse Monitor, Sentinel, and Mariner ADCPs require +20 to 50 VDC to operate.

Monitor/Sentinel Power Considerations

The AC Adapter runs on any standard AC power and supplies +48 VDC to run the WorkHorse when the batteries are not connected. The Sentinel's internal battery supplies +42 VDC.

The AC Adapter input voltage is sufficient to override the internal battery voltage (i.e. the ADCP will draw all power from the AC adapter even if the battery is installed and connected).

Transmitted power increases or decreases depending on the input voltage (within the voltage range of 20 to 50 VDC). A fresh battery provides +42 VDC. Batteries spend most of their life at a nominal voltage of +33 VDC.

The transmitted power is decreased 1 DB if the input voltage drops from 42 VDC to 33 VDC. For a 300 kHz WorkHorse ADCP, each DB will result in a decrease in range of one default depth cell.

Power on Cycle

The power supply must be able to handle the inrush current as well. Inrush current is the current required to fully charge up the capacitors when power is applied to the ADCP. The capacitors provide a store of energy for use during transmit. The inrush current is as high as 3 Amps rms. The ADCP will draw this amperage until its capacitors are fully charged.

If the power supply limits the current or the power drop on the cable is significant, then the power on cycle will take longer. It can take up to one minute. You do not want the power to shut down during the inrush current draw, as this may not allow the ADCP electronics to start.

AC Power Adapter

The AC power adapter is designed to maintain a 400-ma supply under the ADCP's inrush current. The adapters are 75-Watt supplies, with 48 VDC, 1.5 amp outputs. They will not fall back to 0 amps, 0 volts under a load. Customer provided power supplies might shut themselves down under such a load; when that occurs, the ADCP will not wakeup.

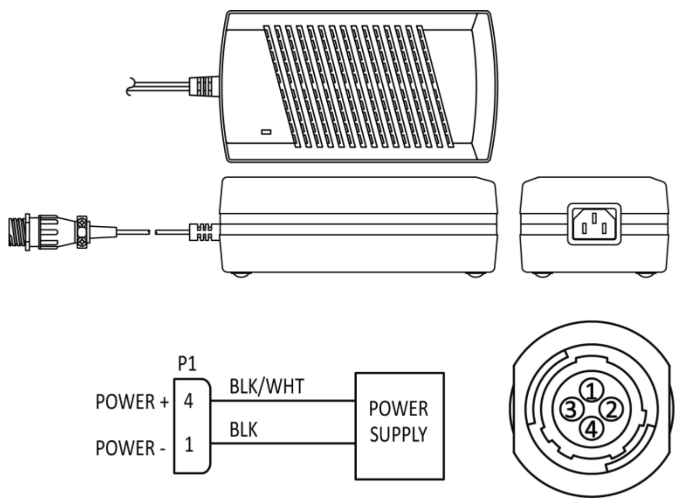


Figure 8. AC Power Adapter

Sentinel Internal Battery Power Overview

The WorkHorse Sentinel's internal battery supplies +42 VDC. The AC Adapter runs on any standard AC power and supplies +48 VDC to run the WorkHorse Sentinel when the batteries are not connected.

> The AC Adapter input voltage is sufficient to override the internal battery voltage (for example, the ADCP will draw all power from the AC adapter even if the battery is installed and connected). Always use the AC adapter when testing the ADCP to conserve the battery power.

Keep in mind the following about Sentinel battery packs:

- TRDI specifies its battery packs to have 450 Watt-hours (Wh) of usable energy at 0°C.
- A Standard WorkHorse battery packs hold 28 'D-cell' alkaline batteries with a voltage, when new, of approximately 42 VDC.
- When the capacity of a battery pack is 50% used, the voltage (measured across the battery connector) falls to approximately 32 to 35 volts. However, keep in mind that this voltage is not an accurate predictor of remaining capacity.

- Transmitted power increases or decreases depending on the input voltage (within the voltage range of 20 to 50 VDC). A fresh battery provides +42 VDC. Batteries spend most of their life at a nominal voltage of +33 VDC.

The transmitted power is decreased one DB if the input voltage drops from 42 VDC to 33 VDC. For a 600 kHz WorkHorse ADCP, each one DB drop will result in a decrease in range of one default depth cell.

- Batteries should be replaced when the voltage falls below 30 VDC (measured across the battery connector).
- Battery packs differ from one to another.
- Store batteries in a cool dry location (0 to 21 degrees C).
- Do not store batteries inside the ADCP for extended periods. The batteries may leak.
- Use batteries within one year of the manufacture date (use by warning date*).

Do not deploy the system with batteries that are older than the Warning date. It should be noted, that while a battery pack will not be dead after the Warning Date, the actual performance of the battery is in doubt, and TRDI does not warranty any deployment started with a battery pack that is past its Warning date.

TRDI batteries have four dates on them:

Manufacture Date is the date the battery was built and final tested.

TRDI Ship by Date provides the maximum duration that the battery will remain on our shelves before we will ship and is 6 months after our manufacture date.

Warning Date* provides the last date when the battery should be used to start a deployment and is 12 months from the manufacture date.

Expiration Date provides the date when the battery should no longer be considered useful and is 2 years from the manufacture date.

*A battery pack used to start a deployment prior to the Warning Date means that it will perform as expected and provide the required power for any deployment that was created using the TRDI planning module. For example, if your deployment is going to be 12 months long and the battery label shows it is nine months old, it is safe to use the battery.

Battery replacement induces both single and double cycle compass errors. The compass should be calibrated after replacing the battery pack.

These compass effects can be avoided by using an optional external battery pack. The optional external battery housing holds two batteries, and can easily be replaced on-site. If the optional external battery is placed a minimum of 30 cm away from the ADCP, no compass calibration will be required.

Mariner Power Overview

The Mariner deck box automatically scales the input voltage to the proper level. No special jumpers or switch settings are required to select the input voltage. If more than one power source is connected to the deck box, the highest voltage source will be used. Although this is not recommended, it will not damage the deck box.

AC Power. The deck box accepts input voltages of 90-264 VAC, 47-63 Hz (J27). This input voltage will be converted to 48 VDC. This is the voltage supplied to the ADCP.

Table 2. WorkHorse Mariner Deck Box Mains Input Power Specification

Parameter	Value Typical	Units
Input Voltage Range (typical):	90 – 132 180 – 264	Vac @auto-ranging, low range Vac @ auto-ranging, high range
Line Frequency (typical):	47 – 63	Hz
Inrush Current (typical):	23 47	A @ 115 Vac @ peak line A @ 230 Vac @ peak line
*Input Power (max):	80 380	W @ during awake or asleep W @ during transmit
Ride Through Time (min):	5 40	ms @ 90/180 Vac low line ms @ 90/180 Vac nominal line

*The 80 and 380 watts are maximum specifications. These have been derived from the maximum power supply rating and the specified minimum efficiency. Actual maximum input power may be lower than the one specified.

12 VDC Car Battery. Use a 12 VDC car battery (J26) when AC power is not available. The deck box converts the voltage to 48 VDC. This is the voltage supplied to the ADCP. Use the largest rated amp-hour battery as possible. A car battery should last one to two days powering a 1200 kHz ADCP.

DC Power Supply. If you are using an external DC power supply connected to the deck box on J25 (20 to 50 VDC, 3.0 A), the voltage from the external power supply is sent *directly* to the ADCP. This is useful if you want to increase (higher voltage level) or decrease (lower voltage level) the range of the ADCP. The current requirement for the power supply is listed as a reference. Using a lesser-rated power supply can cause the voltage level to drop. The ADCP will draw only the current it needs.

Transmitted power increases or decreases depending on the input voltage. Higher voltage to the ADCP (within the voltage range of 20 to 50 VDC) will increase the transmitted power. The transmitted power is increased 6 DB if you double the input voltage from 24 VDC to 48 VDC. For a 300 kHz WorkHorse ADCP, each additional DB will result in an increase in range of one default depth cell.

ADCP Internal Batteries. If you want the ADCP to use internal battery power (Sentinel Workhorse ADCP or external battery pack) rather than the deck box power:

1. Turn OFF or disconnect all power to all ADCP system equipment.
2. Remove the screws on the top cover of the deck box. Lift the cover off.
3. Locate the Filter Interface board (see Figure 7). Locate connector J18 and disconnect the twisted black and white cable plugged into this connector. The power from the deck box to the ADCP has now been disabled. Only the batteries are powering the ADCP.

Setting up the WorkHorse System

Use this section to connect the ADCP to a computer and establish communications. Install the *RDI Tools* or *WinSC* software in order to communicate with the ADCP.

Set Up the Monitor/Sentinel ADCP

To set up the WorkHorse ADCP:

1. Connect the I/O cable to the WorkHorse ADCP. Do so by pushing straight in against the connector. Roll the retaining strap over the connector.

Place a light amount of dry silicone lubricant spray on the connector pins (rubber portion only). This will make it easier to connect or remove the I/O cable and dummy plug. See I/O Cable and Dummy Plug for details.

2. Attach the I/O cable to your computer's communication port. The standard communications settings are RS-232, 9600-baud, no parity, 8 data bits and 1 stop bit.
3. Connect the AC power adapter to the I/O cable.

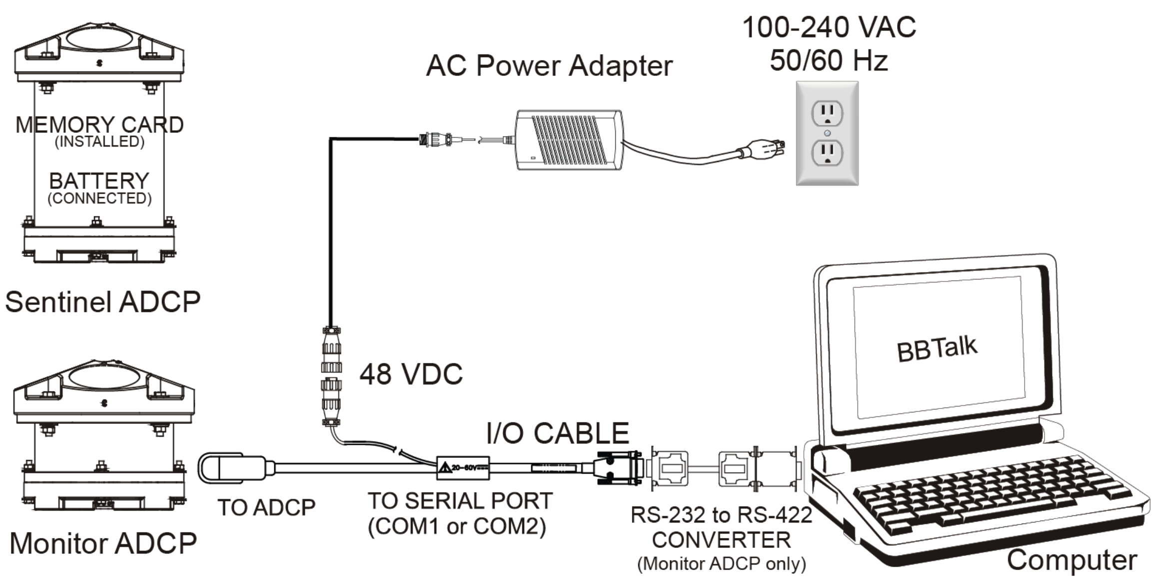


Figure 9. WorkHorse Monitor/Sentinel Connections

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

For testing, the battery can be disconnected to save battery power. If the battery is connected, use the AC power adapter to override the battery voltage to conserve the battery.

Set Up the Marnier ADCP

To set up the WorkHorse Mariner ADCP:

1. Connect the I/O cable (J17) to the WorkHorse ADCP. Do so by pushing straight in against the connector. Roll the retaining strap over the connector.

> Place a light amount of dry silicone lubricant spray on the connector pins (rubber portion only). This will make it easier to connect or remove the I/O cable and dummy plug. See I/O Cable and Dummy Plug for details.

2. Attach the I/O cable (J20) to your computer's communication port. The standard communications settings are RS-232, 9600-baud, no parity, 8 data bits and 1 stop bit.
3. Connect power to the deck box.

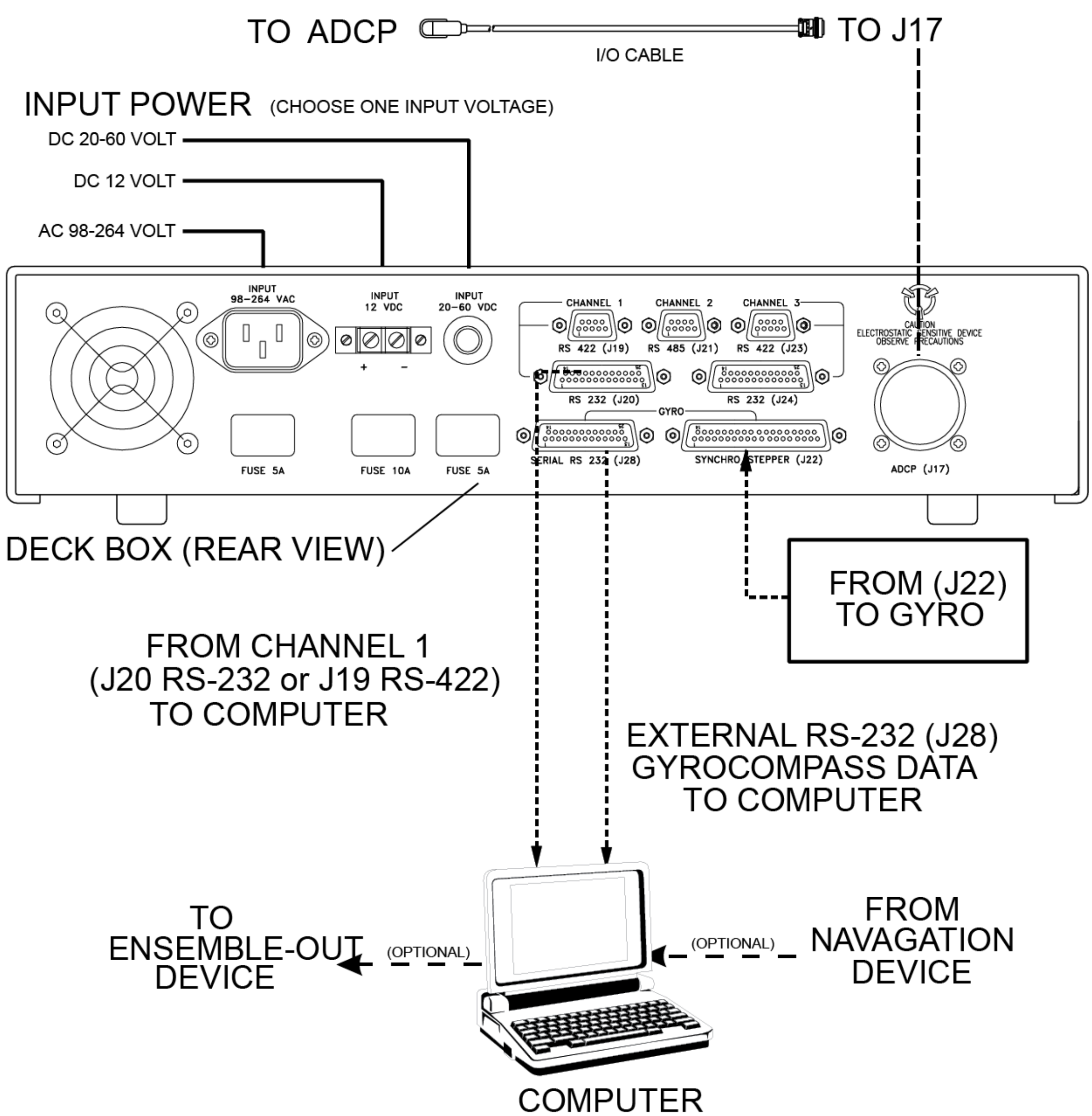
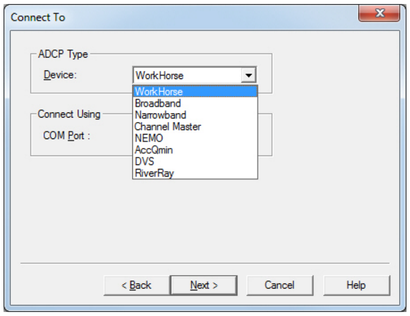


Figure 10. Mariner Connections

Connecting to the WorkHorse

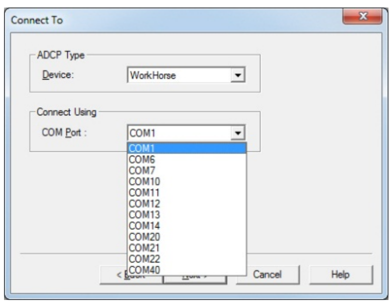
To connect to the WorkHorse ADCP:



Start BBTalk

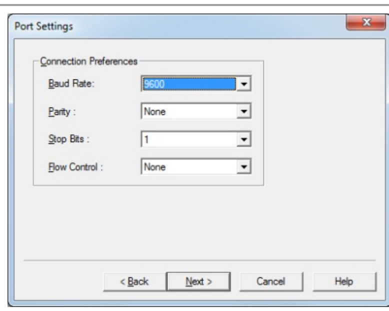
Start the *BBTalk* program (for help on using *BBTalk*, see the RDI Tools User's Guide).

On the **Connect To** screen, select **WorkHorse**.



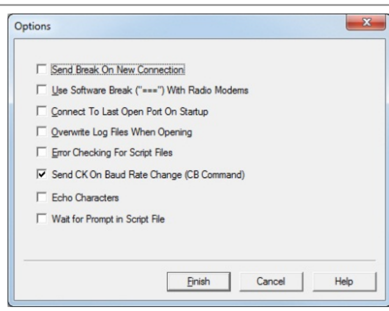
Select the COM port the WorkHorse ADCP cable is connected to.

Click **Next**.

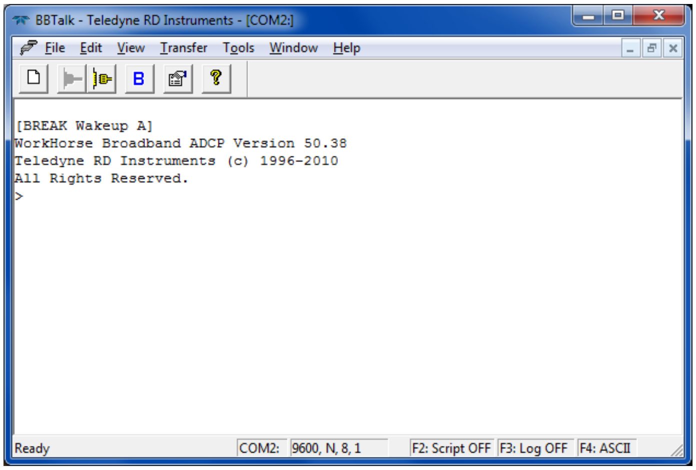


Enter the **Baud Rate**, **Parity**, **Stop Bits**, and **Flow Control**. If you are unsure of the settings, leave them at the default settings as shown.

Click **Next**.



Click **Finish**.



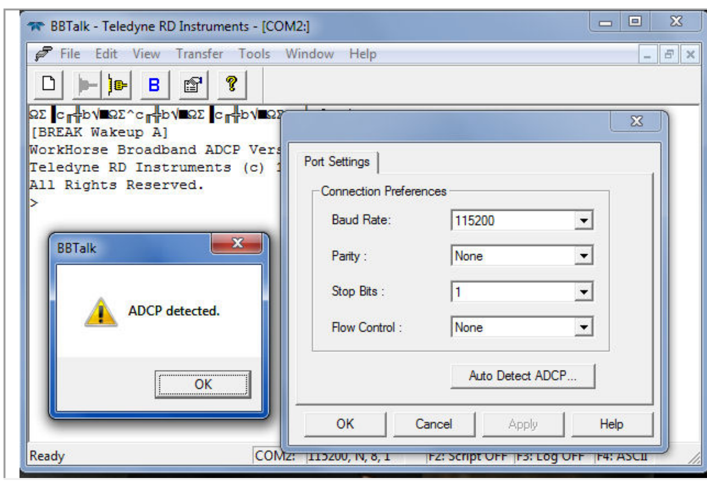
Wakeup

On the **File** menu, click **Break** (you can also press the **End** key to send a break or press the **B** button on the Toolbar).

You should see the wakeup message appear on the log file window.

If your WorkHorse ADCP does not respond, check the serial port, cables, AC power, and battery connection (Sentinel only). If necessary, refer to the Troubleshoot-ing section.

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



If the wakeup message is not readable or visible:

On the **File** menu, click **Properties**.

Click the **Auto Detect ADCP** button.

Click **OK** when the WorkHorse is detected. Try to wake up the WorkHorse again.

Both *BBTalk* and the ADCP must use the same Baud rate.

Changing the Baud Rate in the ADCPs

The ADCP can be set to communicate at baud rates from 300 to 115200. The factory default baud rate is always 9600 baud. The baud rate is controlled via the CB-command. The following procedure explains how to set the baud rate and save it in the ADCP. This procedure assumes that you will be using the program *BBTalk* that is supplied by Teledyne RD Instruments.

```
[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 50.38
Teledyne RD Instruments (c) 1996-2010
All Rights Reserved.
>cr1
[Parameters set to FACTORY defaults]
>
```

Connect the ADCP to the computer and apply power.

Start the *BBTalk* program and establish communications with the ADCP. Wakeup the ADCP by sending a break signal with the **End** key.

At the ">" prompt in the communication window, type **CR1** then press the Enter key. This will set the ADCP to the factory default settings.

BAUD RATE	CB-command
300	CB011
1200	CB111
2400	CB211
4800	CB311
9600	CB411 (Default)
19200	CB511
38400	CB611
57600	CB711
115200	CB811

Send the CB-command that selects the baud rate you wish. The table on the left shows the CB-command settings for different baud rates with no parity and 1 stop bit.

For example, to change the baud rate to 115200, at the ">" prompt in the communication window, type **cb811** then press the Enter key.

The **CB?** command will identify the communication setting.

```
>cb?
CB = 411 ----------------- Serial Port Control (Baud
[4=9600]; Par; Stop)
>cb811
>CK
[Parameters saved as USER defaults]
>cb?
CB = 811 ----------------- Serial Port Control (Baud
[8=115200]; Par; Stop)
>
```

BBTalk will send the command **CK** to save the new baud rate setting.

Exit *BBTalk*.

The ADCP is now set for the new baud rate. The baud rate will stay at this setting until you change it back with the CB command.

Exit *BBTalk* so the communication port is available for use with other programs.

Caring for your Workhorse System

This section contains a list of items you should be aware of every time you handle, use, or deploy your WorkHorse. *Please refer to this list often.*

General Handling Guidelines

- Never set the transducer on a hard or rough surface. **The urethane faces may be damaged.**
- Always remove the retaining strap on the underwater-connect cable and dummy plug when disconnecting them. **Failure to do so will break the retainer strap.**
- Do not apply any upward force on the end-cap connector as the I/O cable is being disconnected. **Stressing the connector may cause the ADCP to flood.** Read the Installation section for details on disconnecting the I/O cable.
- Do not expose the transducer faces to prolonged sunlight. **The urethane faces may develop cracks.** Cover the transducer faces on the WorkHorse if it will be exposed to sunlight.
- Do not expose the I/O connector to prolonged sunlight. **The plastic may become brittle.** Cover the connector on the WorkHorse if it will be exposed to sunlight.
- Do not store the ADCP in temperatures over 60 degrees C with the batteries removed. **The urethane faces may be damaged.**
- Store batteries in a **cool dry location** (0 to 21 degrees C). If the batteries are installed in the ADCP, do not store the ADCP in temperatures over 21 degrees C.
- Do not store batteries inside the ADCP for extended periods. **The batteries may leak.**
- **Use batteries within one year of the Manufacture date (use by Warning date)**. A battery pack used to start a deployment prior to the Warning Date means that it will perform as expected and provide the required power for any deployment that was created using the TRDI planning module. For example, if your deployment is going to be 12 months long and the battery label shows it is nine months old, it is safe to use the battery.
- Vent the system before opening by loosening the hardware on the housing. **If the ADCP flooded, there may be gas under pressure inside the housing.**
- Do not scratch or damage the O-ring surfaces or grooves. **If scratches or damage exists, they may provide a leakage path and cause the ADCP to flood.** Do not risk a deployment with damaged O-ring surfaces.
- Do not lift or support a WorkHorse by the external I/O cable. **The connector or cable will break.**

Assembly Guidelines

- Read the Maintenance section for details on WorkHorse re-assembly. Make sure the housing assembly O-ring stays in the groove when you re-assemble the WorkHorse. Tighten the hardware as specified. **Loose, missing, stripped hardware, or a damaged O-ring can cause the WorkHorse transducer to flood.**
- Use light amounts of silicone lubricant (such as 3M™ Silicone Lubricant (Dry Type) ID No: 62-4678-4930-3) on both the male pins and female socket to help seat the cable connectors. Wipe off excessive silicone spray from the metal portions of the pins. **Regular lubrication is required**: **Apply dry type silicone lubricant prior to each connection.**

- Do not connect or disconnect the I/O cable with power applied. When you connect the cable with power applied, you may see a small spark. **The connector pins may become pitted and worn.**
- The **WorkHorse** I/O cable may be connected while slightly wet; do not connect under water.

Deployment Guidelines

- Read the RDI Tools and WinSC Software User's Guides. **These guides have tutorials to help you learn how to use the ADCP.**
- WorkHorse Sentinel batteries are shipped inside the ADCP but not connected. **Connect the battery and seal** the ADCP before deployment.
- Align the compass whenever the batteries are replaced, the recorder module is replaced, or when any ferrous metals are relocated inside or around the WorkHorse housing. **Ferro-magnetic materials affect the compass.**

> When the batteries are replaced the compass must be calibrated with the AF command (see Compass Calibration).

- The AC power adapter is not designed to withstand water. **Use caution when using on decks in wet conditions.**
- Avoid using ferro-magnetic materials in the mounting fixtures or near the WorkHorse. **Ferro-magnetic materials affect the compass.**

NOTES

Chapter 2

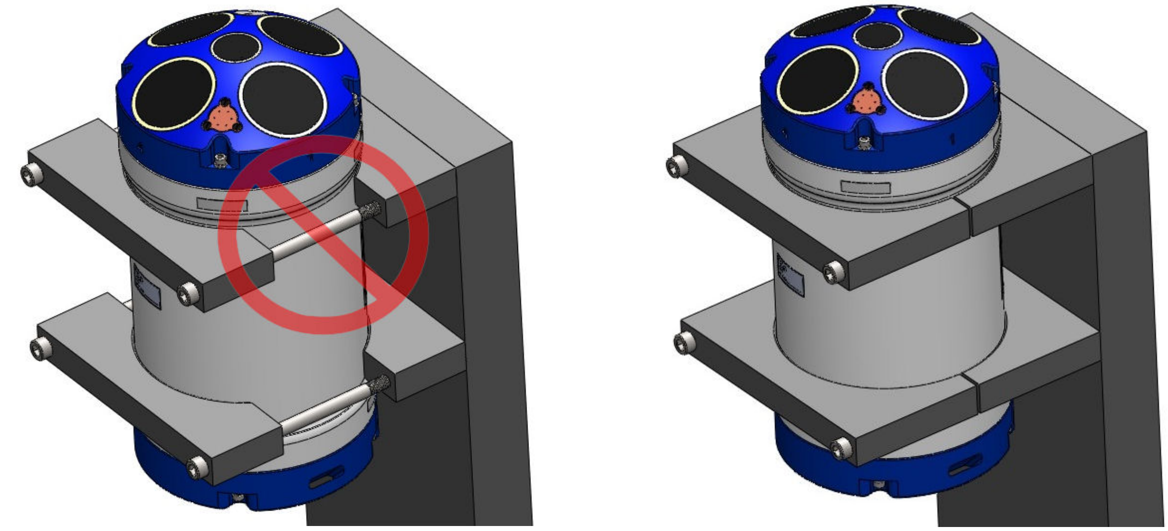
INSTALLATION

In this chapter, you will learn:

- How to connect/disconnect the I/O cable
- How to connect the optional external battery case
- Cable wiring diagrams
- Available mounts for the WorkHorse ADCP

Mounting the Instrument

The preferred method of mounting the WorkHorse is using clamps that grip the circumference of the housing. The fallback method of mounting the instrument is to use the holes on the end-cap. See the Outline Installation Drawings for dimensions.



Poor Design	Good Design
When clamping the WorkHorse to a mount, the clamp must not have a large gap between the front and rear clamp. Using this type of design can cause the housing to deform or even break if the clamps are over tightened. This will cause the ADCP to flood.	Design clamps that fully surround the housing. Design the gap as small as possible so that when the clamp is fully tightened it will not deform the housing or cause excessive pressure on the housing.

Figure 11. Mounting the Instrument with a Clamp Design

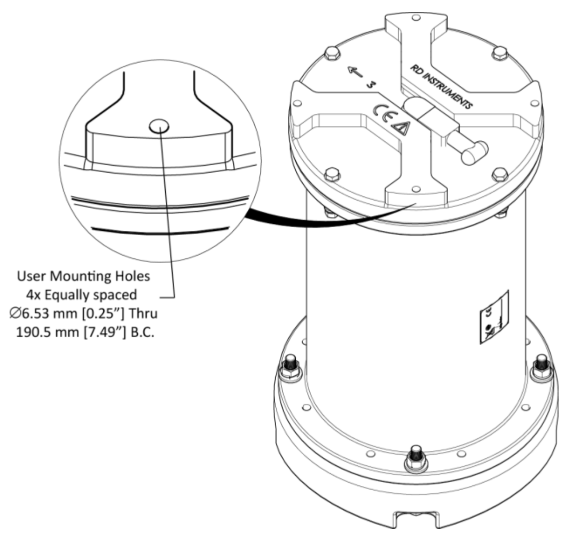


Figure 12. End-Cap User Mounting Holes

Only use stainless steel hardware.

I/O Cable and Dummy Plug

The underwater connector (on the housing) and the I/O cable and dummy plug are molded wet-mate connectors.

The dummy plugs should be installed any time the cable is removed. Use the dummy plug when the ADCP is in storage or is being handled.

When disconnecting or connecting the WorkHorse I/O cable, do not apply any upward force on the connector. Applying an upward angle as the cable is disconnected or connected puts stress on the connector. This may cause several serious problems:

a) The connector or connector pins can crack.

b) The O-ring on the bottom of the connector can be damaged.

c) The molded urethane on the connector may separate from the brass insert.

If the connector is damaged in any of these ways, your WorkHorse will flood.

Disconnecting the Cable

To disconnect the cable:

1. Release the retaining strap by pulling it over the connector.
2. Grasp the cable close to the housing (see Figure 13). Your thumb should rest on top of the connector or against the edge of the housing. *Do not try to fit your hand under the cable as it passes over the housing*. This is what causes the upward force!
3. Pull the cable straight out away from the housing with a gentle rocking motion. Do not apply any upward force on the connector as it is being disconnected.

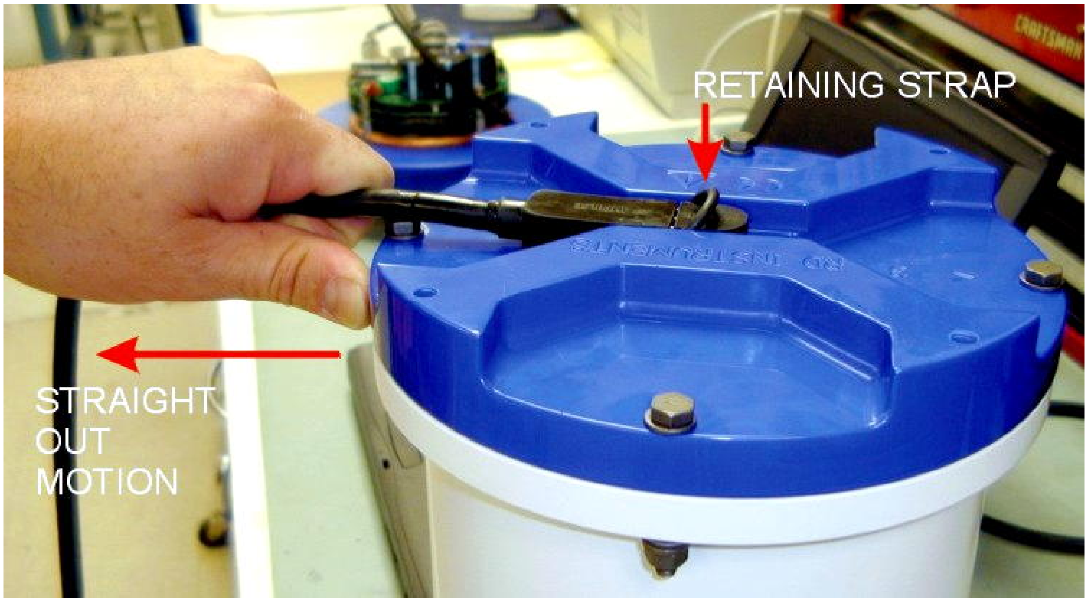
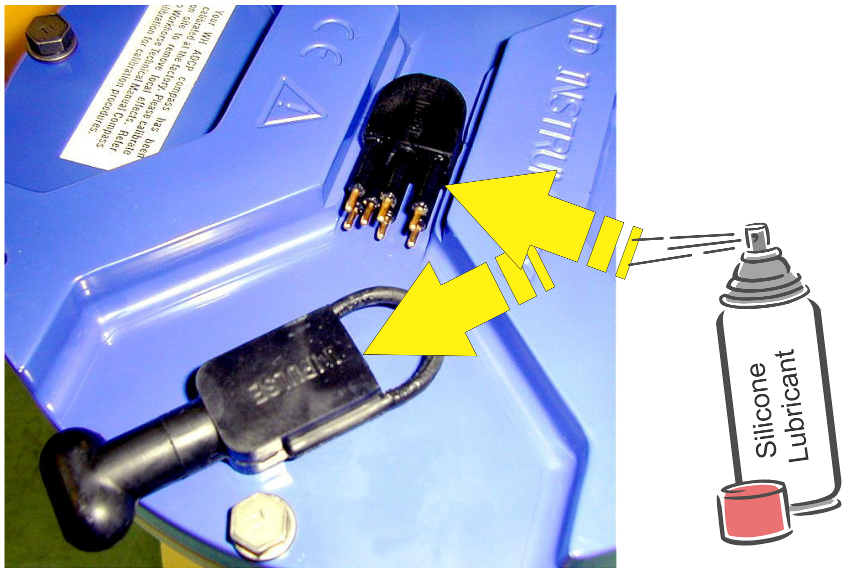


Figure 13. Removing the I/O Cable

Connecting the Cable

To connect the cable:

1. Check all pins for signs of corrosion (greenish oxidation, black deposits, or pitting).
2. Use light amounts of silicone lubricant (such as 3M™ Silicone Lubricant (Dry Type) ID No: 62-4678-4930-3) on both the male pins and female socket to help seat the cable connectors. Wipe off excessive silicone spray from the metal portions of the pins. **Regular lubrication is required**: Apply dry type silicone lubricant prior to each connection.



When the cable is connected without any lubricant, excessive force is needed to fully seat or remove the connector. This can cause several serious problems:

- The neoprene rubber portion of the contact pin may tear from the metal pin.
- Wiggling the cable side-to-side to overcome the friction as it is connected or disconnected may cause the neoprene rubber to tear or create pin-holes on the side of the connector.

As a result of any damage to the neoprene rubber, corrosion may occur on current carrying pins.

3. Gently push the cable straight in toward the connector. Do not apply any upward force on the connector as it is being connected.
4. Roll the retaining strap over the connector.

Connecting the External Battery Case

The optional External Battery Pack holds two 450 Watt-hours (Wh) batteries. To avoid affecting the compass, place the external battery case at least 30-cm away from the WorkHorse ADCP.

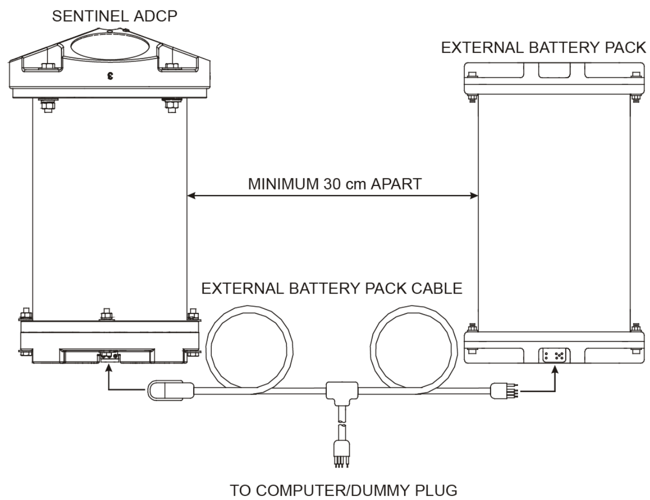


Figure 14. External Battery Pack Connection

> The optional external battery pack can be used with both the WorkHorse Monitor and Sentinel model ADCPs.

Routing Cables

Several cables connect to the Mariner ADCP system (see Figure 17). Use care when routing these cables through bulkheads, deck plates, cable runs, and watertight spaces. Make allowances in cable length and engineering design plans for cable routing. When necessary, use strain reliefs on the cables.

The input/output (I/O) cable connects the ADCP to the deck box (Mariner systems) or computer. We deliver the cable with both connectors attached. The transducer-end connector is molded on, so you can use it below the waterline. The cable is custom-made in lengths specified by the user. Route this cable so:

- You can install it with the connectors attached.

> You can order the cable with the deck box end connector removed. This allows easier cable routing, but requires you to solder the cable connections at your installation site. This is a difficult task (see Mariner I/O Cable Dry End Connector Assembly).

- It does not have kinks or sharp bends.
- Protect the cables with hose if zip-ties are used to secure them to structures (see Figure 15 and Figure 16).
- You can easily replace it if it fails.
- The Mariner dry-end connector OD is 5.02cm (1.530 inches) and is 3.89cm (1.976 inches) long. Model# Souriau 85106RC2024P50.
- The wet-end connector is 3.0cm (1.18 inches) long, 2.54cm (1.00 inches) wide, 1.27cm (0.5 inches) high. Model# Impulse LPMIL-7-FS.

Other cables that may need routing to the chassis include the computer interface, the navigation interface, and the gyro interface. You may also need to route External Battery case cables.

Figure 15. Do not use Zip-Ties Directly on Cables

When attaching the ADCP cables to your mount, do not zip-tie the cables directly to the structure. Zip-ties slowly cut through the cable's outer jacket and cause leaks.

Figure 16. Cables Protected with Abrasion Resistant Sleeving

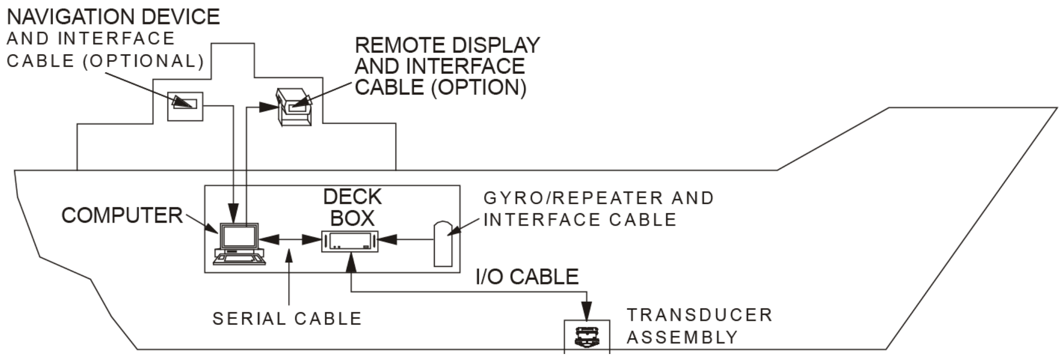


Figure 17. Typical Mariner Interface Cable Layout (Overview)

Cable Wiring Diagrams

This section has information on WorkHorse cabling. Special user-requests may cause changes to the basic wiring system and may not be shown here. If you feel there is a conflict, contact TRDI for specific information about your system. The following figures show various WorkHorse cable locations, connectors, and pin-outs.

Where shown, the color code is for reference only; your cable may be different.

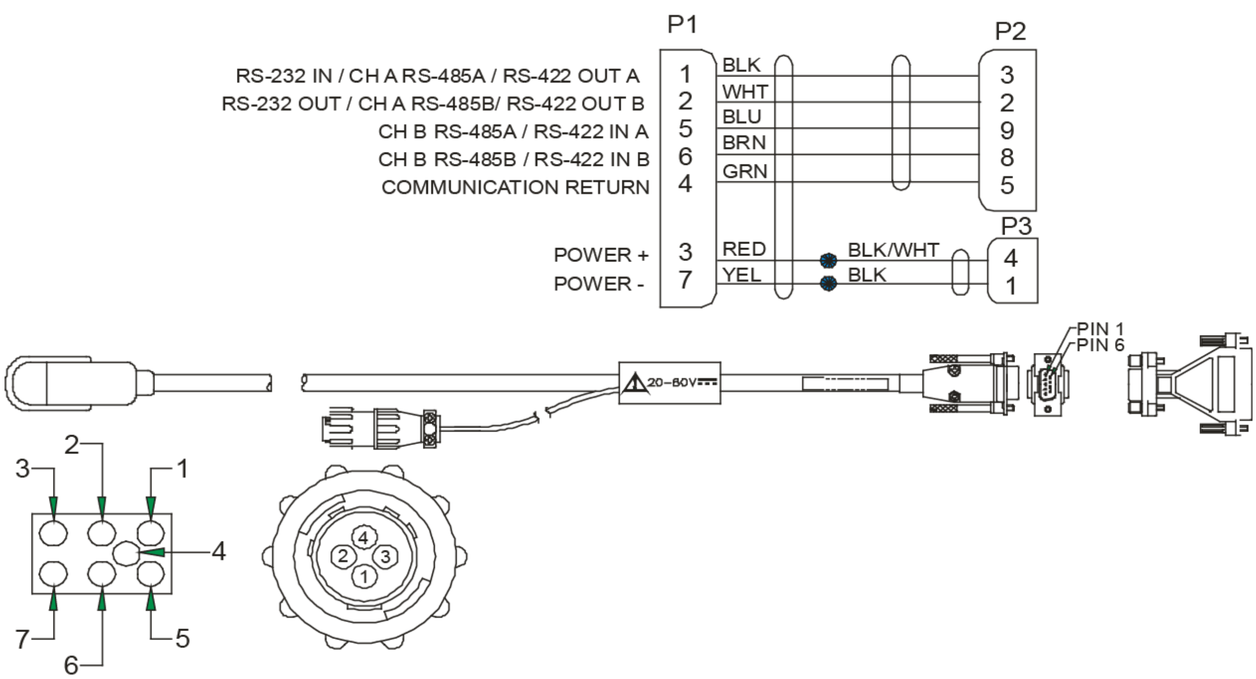


Figure 18. Monitor and Sentinel I/O Cable Wiring

Where shown, IN refers to signals going into the ADCP and OUT refers to signals coming out of the ADCP.

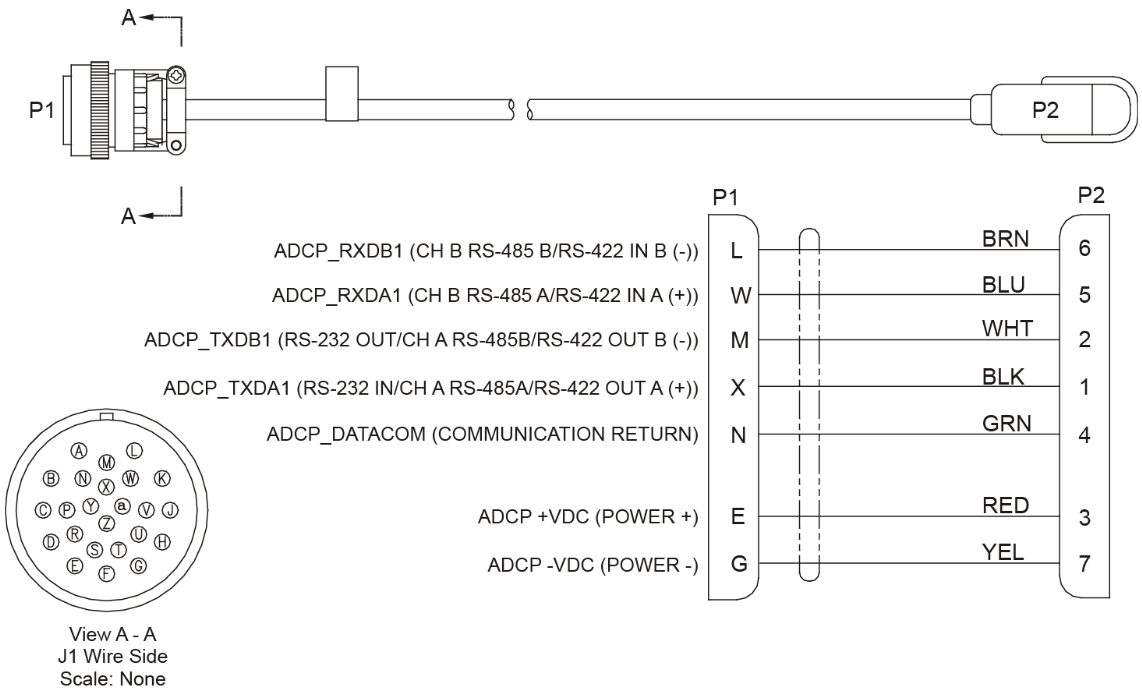
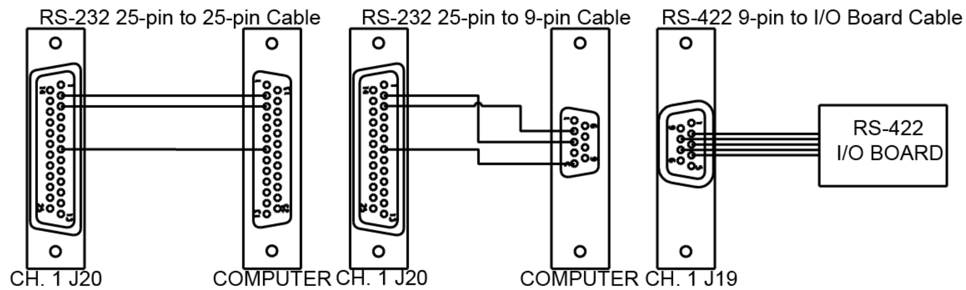


Figure 19. Mariner I/O Cable Wiring

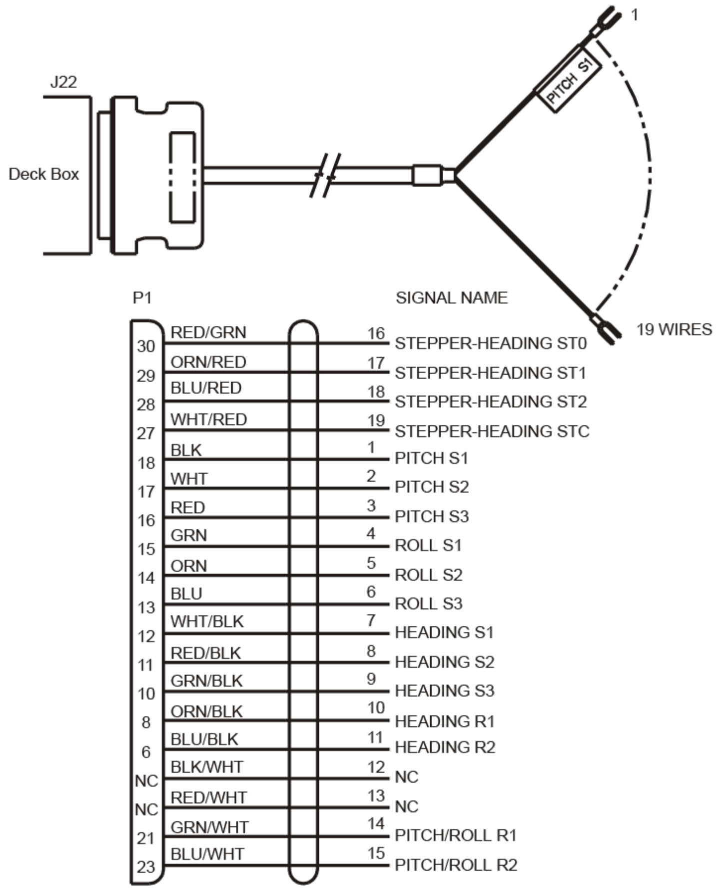


Cable Type	ADCP Signal	Chassis	Computer	Computer Signal
RS-232 25-pin to 25-pin	DATA IN DATA OUT GND	2 3 7	2 3 7	DATA OUT DATA IN GND
RS-232 25-pin to 9-pin	DATA IN DATA OUT GND	2 3 7	3 2 5	DATA OUT DATA IN GND
RS-422 9-pin to I/O board	DATA IN A DATA OUT A COMMON DATA IN B DATA OUT B	2 4 3 7 8	- - - - -	DATA OUT A (+) DATA IN A (+) COMMON DATA OUT B (-) DATA IN B (-)

NOTE: These cables provides RS-232 or RS-422 communications. Two cables are provided with the instrument: (1) 25-pin to 25-pin RS-232 cable, and (1) 25-pin to 9-pin RS-232 cable. Each cable is about 2-meters long and has a diameter of 8 mm (0.31 in.).

For cable lengths longer than 15 meters, we recommend you use RS-422 communications. The cable for RS-422 communication is not provided with the equipment.

Figure 20. Mariner Deck Box to Computer Serial Cable



NOTE: This cable provides synchro/stepped heading signals and/or synchro tilt from an external gyrocompass to the deck box. This cable is provided with the instrument (length specified by user). Cable specifications: 26 conductors, cable OD = 8 mm (0.31 in.), terminated at one end with a 37-pin connector (deck box side), terminated at the other end (gyro side) with 19 spade (or forked) lugs for connecting to the gyro's terminal strip.

Figure 21. Mariner Gyro Cable

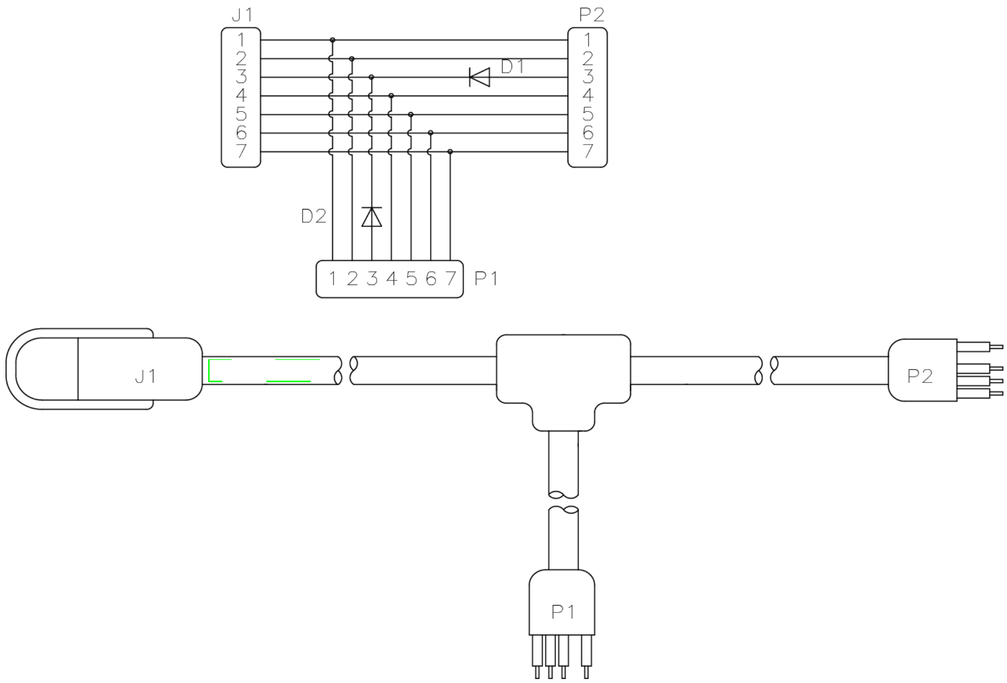


Figure 22. External Battery Pack "Y" Cable

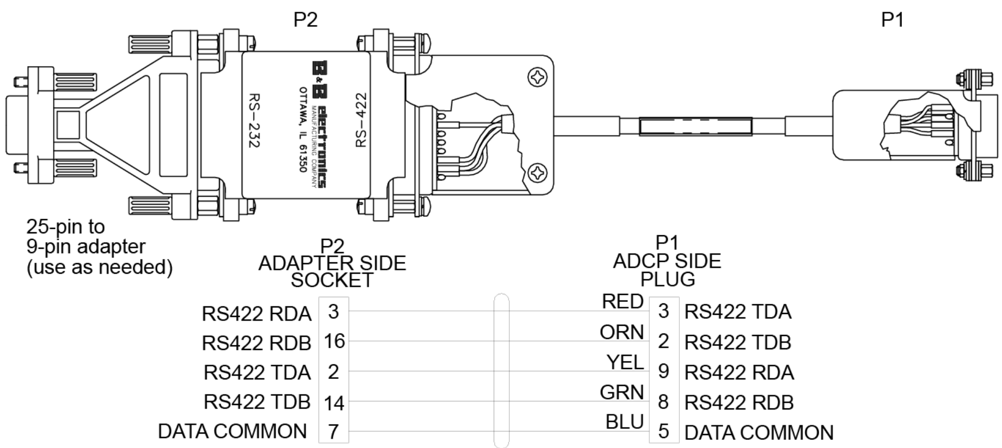


Figure 23. RS232-to-RS422 Converter Wiring (25-Pin to 9-Pin)

Bottom Mounts

Bottom mounts can range from simple PVC frames to Trawl Resistant Bottom Mounts. Below is a sample of some of the types of bottom mounts available for WorkHorse ADCPs.

Figure 24. Teledyne RD Instruments Bottom Mount

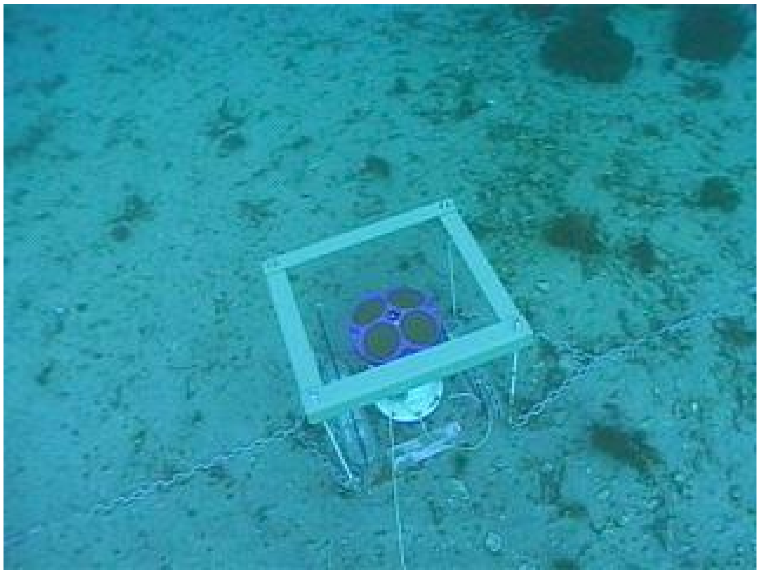


Figure 25. View from the Bottom

Photo courtesy of John Skadberg, US Navy SPAWAR System Center in San Diego, CA. Sent to TRDI by Steve Monismith.

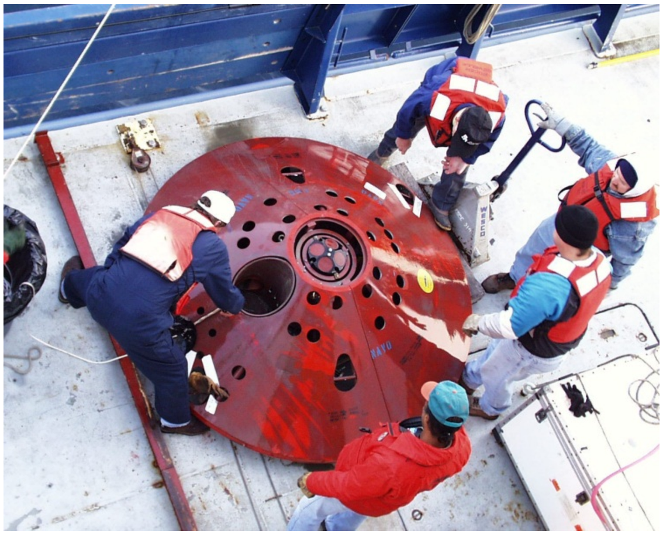


Figure 26. Trawl Resistant Bottom Mount

Photo courtesy of Maureen Wieler, Mooring Systems.

Buoy Mounts and Load Cages

Buoy mounts and load cage frames are designed to allow the WorkHorse to profile unobstructed by the mooring hardware. Below is a sample of some the types of buoy and load cage mounts available for WorkHorse ADCPs.

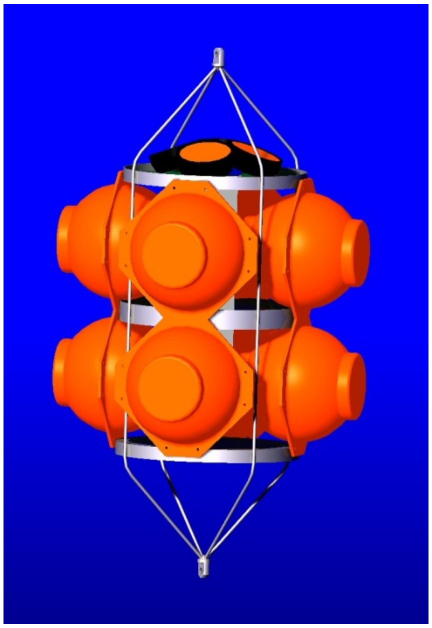


Figure 27. Deep-Water Mount

Photo courtesy of the Oceanscience Group.

Figure 28. Buoy Mount with External Battery

Photo courtesy of Maureen Wieler, Mooring Systems.

Figure 29. Subsurface Buoy

Photo courtesy of Patrick Lefeuvre, Technicap. The Subsurface buoy was developed by BMTI and Technicap.

Figure 30. Buoy Mount

Photo courtesy of Flotation Technologies.

Figure 31. Load Cage

Photo courtesy of Angela Cates, UNM.

Over-the-Side Mounting

The over-the-side mount is common if you want the ability to move the ADCP from one platform to another. You must make the mount as rigid as possible to limit the amount of pitch and roll applied to the ADCP. Although the tilt sensor can measure a ±20° influence, anything beyond 15° will cause bias to the data that cannot be removed. No matter what mounting type used, the ADCP must be below the bubble layer. Bubbles will cling to the urethane faces of the ADCP and reduce the range to almost nothing. Usually a mount somewhere aft of amidship is used. A stern mount will cause all sorts of problems due to propeller wake, bubbles, and turbulent water conditions.

Our transducer assembly is sturdy, but TRDI did not design it to withstand collisions with all floating objects. TRDI strongly suggests you protect the Sentinel V ADCP if this is a possibility.

Avoid using ferro-magnetic materials in the mounting fixtures or near the ADCP. They affect the compass. Use titanium or 316 stainless steel hardware.

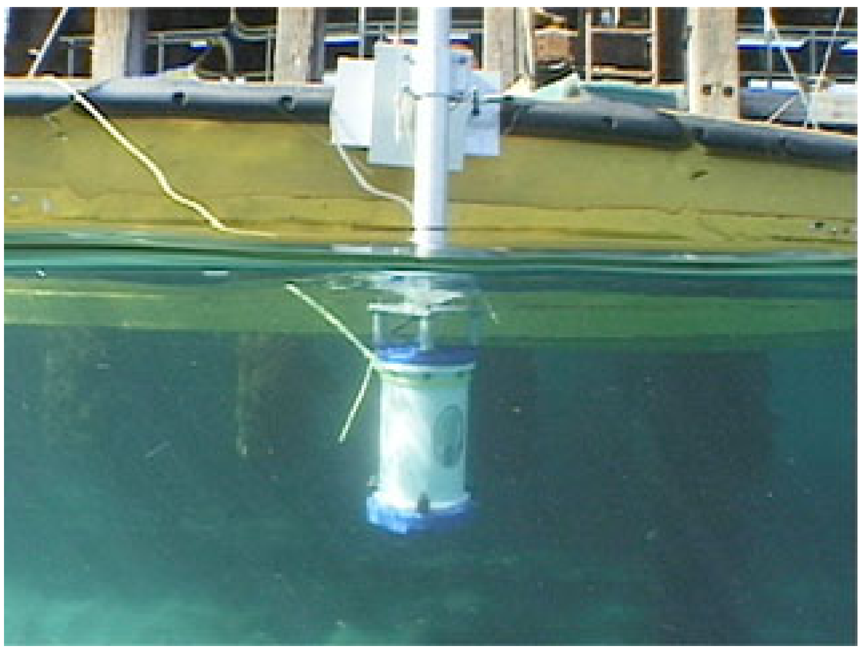


Figure 32. Over-the-Side Mount

Photo courtesy of John Skadberg, US Navy SPAWAR System Center in San Diego, CA. Sent to TRDI by Steve Monismith.

Example of an Over-the-Side Mount

When mounting the ADCP to a platform, use the following sequence.

- Test the ADCP
- Align the compass
- Mount to the platform (see Figure 33).

1. Hand winch with cable or rope.
2. Boat cleat to tie off the lower end of the channel.
3. Rotating arm. The rotating arm has to be strong to prevent vibration of the instrument which can cause false data readings and it must be non-magnetic to avoid interference with the compass.
4. Pivot housing.
5. Instrument clamps (see Mounting the Instrument).

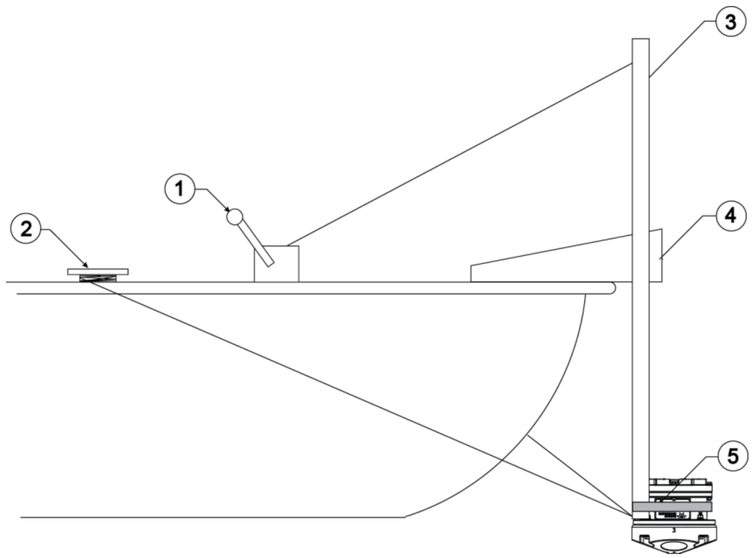


Figure 33. Mounting an ADCP to a Platform

Over-the-Side Mounting Special Considerations

Use the following suggestions when mounting the ADCP to a platform:

- It is desirable to rigidly mount the ADCP to the platform. You want to avoid the free spinning of the ADCP in this application. The ADCP must stay in the water at all times.
- The ADCP must be mounted deep enough so that turbulence caused by its movement through the water does not allow air bubbles to be attached to the transducer faces.
- Avoid mounting the ADCP near motors and thrusters. They cause air bubbles and will cause bias to the internal compass.
- Avoid mountings that will cause the ADCP to see severe accelerations.

In-Hull Mounting

The in-hull mounted ADCP is common when it is intended to keep the system on a single vessel or when over-the-side mounting is not practical for your vessel. For this type of mounting, there are issues of beam clearance and access.

Transducer Head Mounting Considerations

You must consider several potential problems before installing the transducer head assembly. Read this section before deciding where to install the transducer assembly. See the outline installation drawings for specifications on our standard ADCP transducer heads.

Mounting Plate Overview

The Mariner mounting plate is a bronze plate that helps mount the transducer head to a vessel. The overall dimension of the mounting plate is ∅311.1 (12.25 inches) and the bolt hole pattern is 16 equally spaced ∅8.20 through holes on a ∅285.75 bolt circle.

See the outline installation drawings for the exact dimensions and weights.

Location

Ideally, you want to install the transducer head:

- Where it is accessible both internally (for access to transducer electronics) and externally (to remove biofouling).
- Away from shipboard protrusions that reflect ADCP energy. Allow for a reflection-free clearance of 15° around each beam (see the outline installation drawings).
- Away from other acoustic/sonar devices, especially those operating at the same frequency (or harmonic) of the ADCP.
- Close to the ship's fore-to-aft centerline. As distance from the centerline increases, vertical accelerations caused by the roll of the ship also increase. These accelerations can cause additional uncertainties in ADCP velocity measurements.

Other considerations may be:

- Ease of installation.
- Portability (wanting to move the instrument from vessel to vessel).
- Permanent installation.

With all of these choices there are good and bad points. We will show you several options for installation and then go through specific concerns that you may have to deal with once you install or mount the ADCP.

Sea Chest In-Hull Mounting

A sea chest (Figure 34 and Figure 35) is a fixture that surrounds and holds the transducer head, protecting it from debris in the water. The bottom of the sea chest must be open to seawater to allow the acoustic beams to pass through freely. If using a sea chest interests you, call TRDI for the latest information.

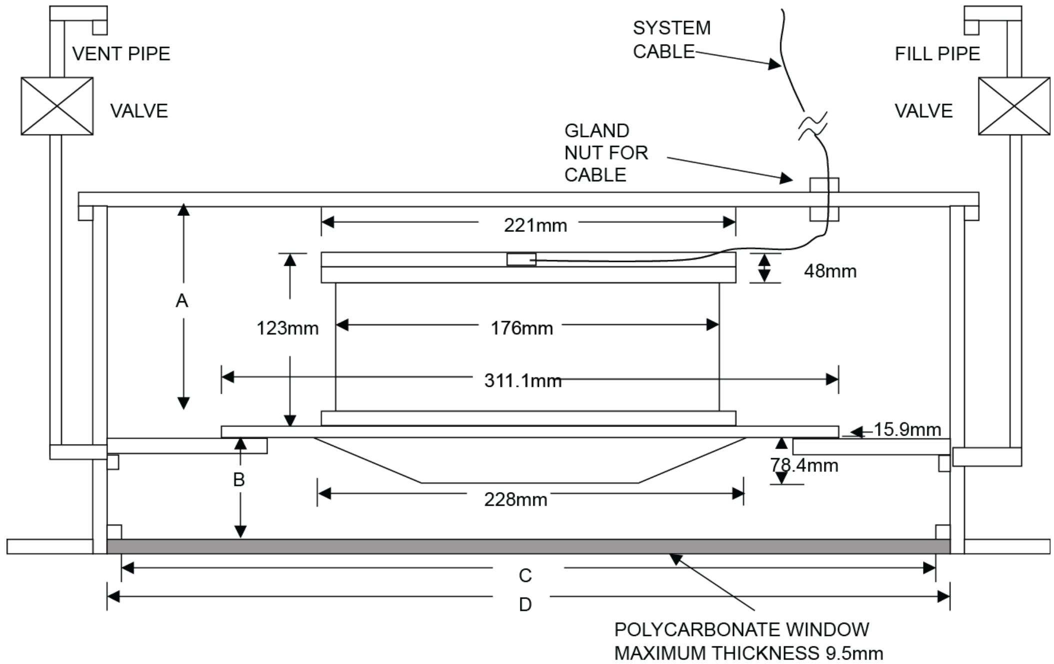


Figure 34. Inside Vessel Mounting of a WorkHorse Mariner 300 kHz Transducer

Dimension Letter	Option 1 Minimum Dimension	Option 2 Maximum Dimension
A	275.4mm	275.4mm
B	84.7mm	91.1mm
C	362mm	362mm
D	412mm	412mm

Special Notes:

1. No liability is assumed by Teledyne RD Instruments for users using this conceptual well drawing. Users realize that this drawing is provided as a basis for the user to construct their own well. It is expected that the user will have their well design inspected and approved by a naval architect.
2. The top plate of the well is intended as the primary seal for the vessel. The window and transducer can provide additional seal but should not be considered the primary sealing mechanism for the vessel.
3. This conceptual well drawing is designed such that it would be possible to remove the transducer from inside the vessel. For safety, it is strongly recommended that divers fit a steel plate either over the window or in place of the window before installing or removing the transducer.
4. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.
5. The gasket material between the transducer housing and the vessel flange should be used that will both seal and provide electrical isolation between the transducer housing and the vessel flange. Typical gasket material used is silicone rubber 3-6.35mm thick.
6. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.
7. The walls of the well should be coated with a material to absorb reflected sound in the well. Material such as 3mm wet suit material glued to the inside well walls is satisfactory for this purpose.
8. Vent and fill pipes should be above the water line of the vessel and it is recommended that a gate valve be installed to seal off these pipes.
9. Window thickness should not exceed 9.5 mm of Polycarbonate material. Thinner Polycarbonate window is OK.
10. Window faces should be parallel to the transducer face to within 2 degree for best performance; angle should never exceed 5 degrees.

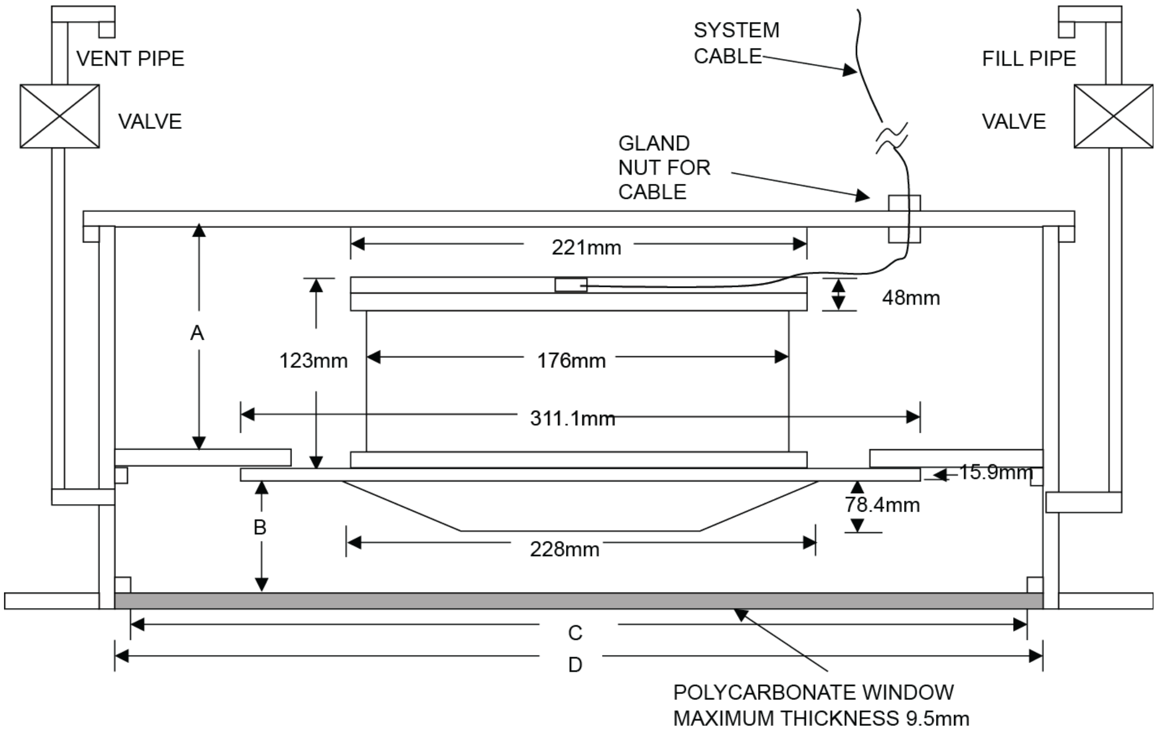


Figure 35. Underneath Vessel Mounting of a WorkHorse Mariner 300 kHz Transducer

Dimension Letter	Option 1 Minimum Dimension	Option 2 Maximum Dimension
A	275.4mm	275.4mm
B	84.7mm	91.1mm
C	362mm	362mm
D	412mm	412mm

Special Notes:

1. No liability is assumed by Teledyne RD Instruments for users using this conceptual well drawing. Users realize that this drawing is provided as a basis for the user to construct their own well. It is expected that the user will have their well design inspected and approved by a naval architect.
2. The top plate of the well is intended as the primary seal for the vessel. The window and transducer can provide additional seal but should not be considered the primary sealing mechanism for the vessel.
3. This conceptual well drawing is designed such that it would be possible to remove the transducer from beneath the vessel while in dry dock.
4. The listed minimum and maximum dimensions are recommendations based on maintaining the clearance for the transducer as well as providing the smallest well possible.
5. The gasket material between the transducer housing and the vessel flange should be used that will both seal and provide electrical isolation between the transducer housing and the vessel flange. Typical gasket material used is silicone rubber 3-6.35mm thick.
6. Inserts in the transducer housing mounting holes may be used to provide additional isolation from vessel.
7. The walls of the well should be coated with a material to absorb reflected sound in the well. Material such as 3mm wet suit material glued to the inside well walls is satisfactory for this purpose.
8. Vent and fill pipes should be above the water line of the vessel and it is recommended that a gate valve be installed to seal off these pipes.
9. Window thickness should not exceed 9.5 mm of Polycarbonate material. Thinner Polycarbonate window is OK.
10. Window faces should be parallel to the transducer face to within 2 degree for best performance; angle should never exceed 5 degrees.

Mounting Considerations

Now that we have shown you the main methods of mounting the ADCP, you must be aware of issues that may cause reduction in range, biased data, fouling, and other performance related considerations.

Orientation

We recommend you mount the transducer head with Beam 3 rotated to a ship-relative angle of 45° (Figure 38 shows beam orientation). This causes the magnitude of the signal in each beam to be about the same. This improves error rejection, reduces the effect of ringing (see Acoustic Isolation), and increases the ADCP's effective velocity range by a factor of 1.4. If you align Beam 3 at an angle other than zero, you must nullify this offset. You can do this using a direct command (see the WorkHorse Operation Manual) or through our *VmDas* program.

Use the ship's roll and pitch reference to mount the transducer head as level as possible. If the head is not level, depth cell (bin) mapping will be incorrect. Large misalignments can cause large velocity measurement errors. If you cannot mechanically make the transducer head level, you can use *VmDas* to enter offset values for roll and pitch.

Fairing

Fairings are structures that produces a smooth outline and reduces drag or water resistance. The fairing also diverts floating objects away from the transducer. A fairing that is shaped like a teardrop, sloped such that the leading edge (closer to the bow) is higher than the back edge, and extends below the hull (typically 12 inches) will divert the air bubbles away from the transducer faces.

Acoustic Window

While we do not fully understand windows, we do believe that windows can be used to produce overall performance improvements in vessel-mounted ADCPs. Additionally, if the ship operates where there is danger of barnacle damage or a high density of ice or other floating objects, then the use of an acoustic window is the only option.

It is theoretically possible to use a window successfully; however there are several advantages and disadvantages to consider before using an acoustic window.

Advantages

- Well will not fill with air bubbles caused by the ship moving through the surface water, see Sea Chest In-Hull Mounting.
- Flow noise is reduced, see Flow Noise.
- The well can be filled with fresh water to limit corrosion.
- Barnacles cannot grow on the transducer faces. Barnacle growth is the number one cause of failure of the transducer beams.
- The transducer is protected from debris floating in the water.

Disadvantages

- The range of the ADCP will be reduced because the window can and will absorb some of the transmit and receive energy.
- The transmit signal could be reflected into the well, causing the well to "ring" like a bell. This will cause the data being collected during the ringing to be biased. Some ships have reported a loss in range as great as 50 meters. The ringing may be dampened by applying sound absorbing material on the well walls (TRDI does not have any recommendations for sound absorbing material), see Ringing.
- The transmit signal could be reflected off the window and back into the other beams.

Our experience has allowed us to put together some minimum specific recommendations:

Window orientation. The acoustic window should be flat and parallel to the transducer mounting plate. Note this is not an absolute requirement. However, if the water temperatures inside the window and outside the window are not the same, all four beams will be refracted and actual velocity components will be rotated into a new coordinate system. In particular, some of the horizontal velocity will appear as a vertical velocity.

Window material. Important acoustic properties of the window include acoustic refractive index (which should be as close as possible to that of water), insertion loss (which should be as small as possible) and speed of sound. There are two acoustic refractive indices: one for shear waves and one for plane waves. The acoustic refractive indices are simply the ratios of speed of sound in water to speed of sounds in the material. Insertion loss combines absorption and reflection of sound, and it depends on both the thickness and the material properties of the window. In particular, you should avoid using window thickness equal to odd multiples of shear mode quarter-waves (Dubbelday and Rittenmeyer, 1987; Dubbleday, 1986). Refer to Selfridge (1985) and Thompson (1990) for more information. Note that the speeds of sound in plastics decrease with increasing temperature and that causes the resonant frequencies to shift. This can be a large effect. Neither Selfridge nor Thompson has much information on the temperature coefficients of sound speeds.

Our experience has shown that Polycarbonate windows are very good for the Ocean Surveyor/Observer (OS), WorkHorse (WH), and Broadband (BB) ADCPs. The thickness of the materials depends on the frequency you intend to use. Table 3 will help to choose the maximum thickness you should use.

One concern with window selection is that it be able to support the weight of the water inside the well once the ship is dry-docked. TRDI recommends that you always fill/drain the well at the same time that you are either filling/draining the dry dock area.

Table 3: Window Thickness

Frequency	Recommended Thickness	Maximum Thickness
75	1 inch	2 inches
300	0.375 inches	1 inch
600	0.25 inches	0.5 inches
1200	0.25 inches	0.5 inches

Spacing between window and transducer. The primary geometrical factor in design of windows is the reflection of one beam into another beam, causing crosstalk between the beams. The distance from the window should be at least 0.25 inches and no more than 0.5 inches for optimal set up.

Window aperture. The window aperture must be sufficient to pass the beams without causing diffraction. If the window is placed next to the transducer, then the aperture diameter should be the same as the distance between transducer cup corners. If the window is placed away from the transducer, then the aperture should be larger than all four beams plus about one transducer ceramic diameter.

Free Flow and Windows

If filling and draining the well is an issue, then you may want to use a window but allow the water to freely exchange from outside the well to inside the well.

Our Japanese representative uses 0.25 inch thick Low Density Polethylene (LDPE). He then drills two 30mm holes in the window along the edges. The inside walls are painted with anti-fouling paint. This allows the water to be full of anti-foulant during the time the ship is docked, which is when the barnacle growth occurs. The holes allow the water to exchange when the ship is in motion and allows for draining when the ship is dry-docked (a 0.25” window will not support the weight of the water). He has never had a failure with the window, and has seen only a minimal loss in range (5-30 meters).

It is best if the window is parallel to the bottom edge of the transducer cups. The transducer cups are at a 30° angle. If the window is at an angle to the transducer, it will change the absorption. We do not have experience with different angles, but we have had customers use domes or have the window follow the contour of the ship bottom without real problems.

The optimum distance for the bottom of the transducer assembly from the window is 0.25 inches ±0.125 inches. Never allow the transducer to touch the window. The farther away the transducer cups are from the window, the more the sound is reflected off of one beam and then reflected into another beam.

Acoustically-absorbing sea chest liner. A sound absorbing material should be used inside the sea chest to minimize the effects of sound ringing within the sea chest. The material should be a minimum of one wavelength thick (include the sound speed of the absorbing material when calculating the size of a wavelength). Approximate wavelengths of sound in seawater are given below in Table 4. We do not have sufficient experience to recommend a specific absorbing material.

Table 4: Wavelength of sound in seawater (1500 m/s sound speed)

FREQUENCY (kHz)	WAVELENGTH (mm)
75	20
300	5
600	2.5
1200	1.25

Fluid in the sea chest. The sea chest should be filled with fresh water. Seawater can be used, but at the cost of increased corrosion. Seawater should not be circulated through the sea chest because it will encourage growth of biofouling organisms. The pressure within the sea chest should be adjusted to keep the window from bowing in and out, and thereafter, the volume should be kept constant.

Transducer calibration. The factor used to correct velocity for speed of sound variations should be based on the speed of sound of the fluid inside the sea chest. Changes of speed of sound resulting from temperature changes may be computed from the temperature sensor on the transducer.

Air Bubbles

Design your installation to minimize the volume of air bubbles in the path of the acoustic beams. Air bubbles attenuate (weaken) the signal strength and reduce the ADCP profiling range. Ships with a deep draft or a non-flat bottom have fewer problems with bubbles. Ways to reduce bubble flow vary with ship characteristics, but two options are available. Mount the transducers below or away from the bubble layer.

- The flow layer is usually within the first two feet below the hull. Bubbles can get trapped in this layer. Mounting the transducer head amidship on the fore-to-aft centerline may help. For ships with propulsion systems that make large amounts of bubbles, use a mounting technique that lets you lower the transducer head below the hull while underway.

> If you use locally made or existing extension hardware instead of the hardware available from TRDI, you may need to make an adapter plate to connect your hardware to our transducer head. Please call us for the exact dimensions and layout of our transducer head bolt holes for your system.

- Divert the bubble layer so it flows around the transducers - You can use fairings to alter the bubble flow. An acoustic window (see Acoustic Window) may help reduce the bubble problem, but can cause ringing (see Acoustic Isolation) and attenuation problems.

Flow Noise

Water flowing over the transducer faces increases the acoustic noise level, which decreases the profiling range of the ADCP. You can reduce the flow across the transducer faces with a sea chest, fairing, or acoustic window.

Corrosion and Cathodic Disbondment

Your ADCP is made of plastic and uses titanium bolts. The adapter plate (if used) may be naval bronze, aluminum, or other materials. Although the plastic ADCP will not corrode, the bolts and adapter plate may corrode.

Never attach anodes directly to the transducer head. Standard anode protection used for the ship should be installed outside of the well of the transducer head. Mounting of ship's standard anode protection outside of the transducer well will typically protect the parts that may corrode. However, you should plan regular inspections of mounting hardware and the adapter plate for signs of corrosion. Replace and parts that are questionable (corrosion can be further reduced if the well is covered with a window and then filled with fresh water).

Ringing

The ADCP transmits an acoustic pulse into the water. The main lobe of this pulse bounces off particles in the water and the signals returned from these particles are used to calculate the velocity of the water.

As stated, the main lobe of the transmitted pulse is what we are using to process and calculate a velocity. The transmitted pulse, however, is made up of many side lobes off the main lobe. These side lobes will come in contact with transducer beam itself and other items in either the water or the well.

The energy from the side lobes will excite the transducer and anything bolted to the transducer. This causes the transducer and anything attached to it to resonate at the system's transmit frequency. We refer to this as "ringing."

If the ADCP is in its receive mode while the transducer is ringing then it will receive both the return signals from the water and the "ringing." Both of these signals are then processed by the ADCP. The ringing causes bias to the velocity data.

All ADCPs "ring" for some amount of time. Therefore, each ADCP requires a blanking period (time of no data processing) to keep from processing the ringing energy. Each ADCP frequency has a different typical ringing duration. The typical ringing period for each ADCP frequency is as follows; 75kHz is 8 meters, 300kHz ADCPs is 2 meters, 600kHz ADCPs is 1.5 meters, and 1200kHz ADCPs is 0.8 meters. These typical ringing values are recommended as the minimum setting for all ADCPs using default set ups.

It should be noted, on some installations the effects of ringing will last longer than the recommended settings above. For example, the effects of ringing will last longer if the transmit signal becomes trapped inside the transducer well. This can occur because the well itself is ringing with the transducer or when windows covering the opening of the well reflect the signal back inside the well.

The window causes the transmit signal to reflect back into the well due to the difference in impedance between the window and the water. When the transmit signal is reflected in the well it becomes trapped and this results in longer ringing periods. To keep from processing this signal, the blanking period must be increased.

Lining the inside walls of the well with a sound absorbing material aid in dampening the ringing effect.

Acoustic Isolation

Try to minimize the acoustic coupling between the transducer head and the ship. Without adequate acoustic isolation, the transducer output will "ring" throughout the ship and feeds back into the ADCP receive circuits. Ringing causes bias errors in water-track velocities and results in the loss of data in the closest depth cells (bins). Reflections inside a sea chest with an acoustic window also can cause ringing.

You can attain acoustic isolation several ways. At a minimum, use gaskets to isolate all contact points between the ship and the transducer head. Design your installation for:

- A minimum number of contact points between the transducer head and the ship.
- Minimal contact area.
- Single points of contact for positioning and support (when possible).

You also should try to separate the transducer head from the ship using intermediate connections. This is because direct connections transfer the most acoustic energy. Texas A & M used the following installation technique and had minimal ringing problems.

- Transducer mounted to a thin steel plate
- Steel plate positioned with three pins set into mounting holes on the hull; pins isolated with gaskets
- Steel plate held in place with four I-beams welded to a frame
- Frame bolted to another frame and separated by gaskets
- Second frame bolted to the ship and separated by gaskets

Acoustic isolation from other acoustic devices on the ship is also necessary. You can do this using the following techniques.

- Mount the other acoustic devices as far apart as possible.
- Make sure neither the main lobes nor the side lobes of the acoustic devices point at the transducers, including acoustic reflections.
- Try not to operate devices that use the same frequency or a harmonic of the ADCP's frequency.

Maintenance

The Maintenance section explains routine maintenance procedures. You rarely need access to the electronics inside the transducer head. However, one external maintenance item is important enough to mention here as it may affect how you install the transducer head.

Objects deployed within about 100 meters (328 feet) of the surface are subject to the buildup of organic sea life (biofouling). This means WorkHorse ADCPs are subject to biofouling. Soft-bodied organisms usually cause no problems, but hard barnacle shells can cut through the urethane transducer face causing transducer failure and leakage into the ADCP (see Figure 36).

Figure 36. Barnacle Damage to Urethane Face

The best-known way to control biofouling is cleaning the ADCP transducer faces often. However, in many cases this is not possible. The other alternatives include the use of a window or some sort of anti-foulant protection.

Some of our users have had success applying a thin coat (≈4 mm; ≈0.16 in.) of either a 50:50 mix of chili powder and Vaseline 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.

Some organizations may decide to use antifouling grease. However, most antifouling greases are toxic and may cause problems. Recent tests suggest antifouling grease may cause the urethane on the transducer faces to develop cracks. Warmer temperatures accelerate this effect.

The other method is to use antifoulant paint (see Applying Antifouling Paints).

1. Read the Material Safety Data Sheet before using any of the listed solvents and paints.
2. Some antifouling coatings may not be legal for use in all areas. Check with your local environmental agency before using the antifouling paint.
3. Do not arbitrarily use antifouling paints. Be aware that antifouling paints can accelerate the dezincification corrosion of brass. Once initiated, dezincificatioin will rapidly destroy the brass.
4. TRDI no longer recommends the use of Nopcocide for the prevention of biofouling. If using antifouling grease, remove it immediately after recovering the ADCP.
5. 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.
6. When possible, do not coat the transducer faces with cuprous oxide or related paints that contain chemicals such as copper, chrome, or arsenic. These paints advance the corrosion of the transducer assembly and will cause the urethane to separate from the transducer cups.
7. All US 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.

Mariner Deck Box Mounting Considerations

Place the Mariner Deck Box (see Outline Installation Drawings) where there is access to the I/O cable, host computer, gyro interface cable, and navigation interface cable. The chassis needs an input voltage of 90 to 260 VAC or 12 VDC to operate (see Power Considerations). Allow enough room around the Deck Box for access, ventilation, and isolation from electronic and magnetic interference.

Gyrocompass Interface Considerations

The Gyrocompass Interface is available only for Mariner ADCPs using the Deck Box. If you are using a NMEA external device, see Navigation Interface Considerations.

There are two ways to interface sensor data such as heading, pitch, and roll information with the ADCP data, either by analog signal input or by a serial ASCII input.

- Single- or multi-turn synchro heading outputs and single-turn synchro tilt sensor outputs for pitch and roll or
- Stepper heading outputs and single-turn synchro tilt sensor outputs for pitch and roll.
- Serial ASCII data input to the host computer running the TRDI ADCP software that conforms to one of the following NMEA standards.
- $_ _ HDT (NMEA 0183 standard of true heading only)
- $_ _ HDG (NMEA 0183 standard of magnetic heading only)
- $PRDID (TRDI proprietary NMEA string supporting heading, pitch, and roll)

The analog input is read by the Gyro Interface board in the Mariner Deck Box, and converted to a serial NMEA string to be used by the *VmDas* program at one of the COM ports. The advantage to these options is that gyro outputs can be used on vessels where flux-gate heading sensors and pendulums cannot. This is due to the effects from the hull on a flux gate compass and the accelerations of the ship on pendulum pitch and roll sensors. Table 5 lists the gyro interface options.

Use the RD-SIC-0 option when only stepper heading is available. Use the RD-SIC-1 option when either synchro or stepper heading is available. This option supports single-turn (1:1), multi-turn (36:1, 90:1, 360:1), and stepper voltage outputs from a ship's gyro or portable gyro. Use the RD-SIC-3 option with a gyro capable of resolving motion across the vertical plane (i.e., tilt synchro gyro). With the RD-SIC-3 option, you can use:

The Gyro Interface board uses up to three synchro-to-digital converter chips, a resistor network is used to configure the board for the input synchro stator voltages, and a DIP switch is used to configure the board for the turns ratio of a specific gyro. The Gyro Interface board supports a wide range of input synchro frequencies (50, 60, and 400 Hz).

We usually configure the Gyro Interface board at the factory to customer specifications for synchro stator voltage and gyro turns ratio. Table 6 lists the acceptable standard configurations. For us to configure the board you must provide us with either the Stepper

Sometimes, though, the customer chooses to use a gyro other than the one originally specified. Because of the need to change the gyro interface configuration "in the field," we provide technical information below.

Table 5: Gyro Interface Options by Model

Inputs allowed	Natel chips	Typical use
1 (RD-SIC-0)	0	Stepper heading only
1 (RD-SIC-1)	1	Synchro/Stepper heading only
3 (RD-SIC-3)	3	Synchro/Stepper heading, AND Synchro-only pitch and roll

Table 6: Acceptable Gyro Interface Configurations

Gyro Heading Input (Synchro)	
Frequency Input	50Hz, 60Hz, or 400Hz
Stator Voltages	Through a variable scaling resistor package, the stator voltage can vary. Starting with a minimum voltage of 11.6 volts RMS, the most common voltages are 11.8, 26, 50, and 90 volts RMS.
Reference Voltages	20 to 150 VAC
Turns Ratios supported	Through a selectable DIP switch, the turns ratio can be 1:1, 36:1, 90:1, and 360:1
Gyro Heading Input (Stepper)	
Input Voltages	Most common ranges are from 35 to 70 VDC, with a positive or negative common. On special request, other voltages may be possible.

Stepper Ratio	Only a 6-step gyro can be used, where each step stands for 1/6 of a degree. See table below.
	`ST0 ST1 ST2  DEGREE`
	`1   1   0   (0/6) 0.000`
	`1   0   0   (1/6) 0.167`
	`1   0   1   (2/6) 0.333`
	`0   0   1   (3/6) 0.500`
	`0   1   1   (4/6) 0.667`
	`0   1   0   (5/6) 0.833`

Gyro Tilt Input (Synchro Only)	
Input Frequency	50Hz, 60Hz, or 400Hz
Stator Voltages	Through a variable scaling resistor package, the stator voltage can vary. Starting with a minimum voltage of 11.6 volts RMS, the most common voltages are 11.8, 26, 50, and 90 volts RMS.
Reference Voltages	20 to 150 VAC
Turns Ratio	1:1 only
Output Types (ASCII Only)	
Baud Rate	9600
Parity	None
Data Bits	8
Stop Bits	1
String Format	$PRDID,±PPP.PP, ±RRR.RR,HHH.HH (where P is for pitch, R is for roll, H is for heading. All are in decimal degrees.

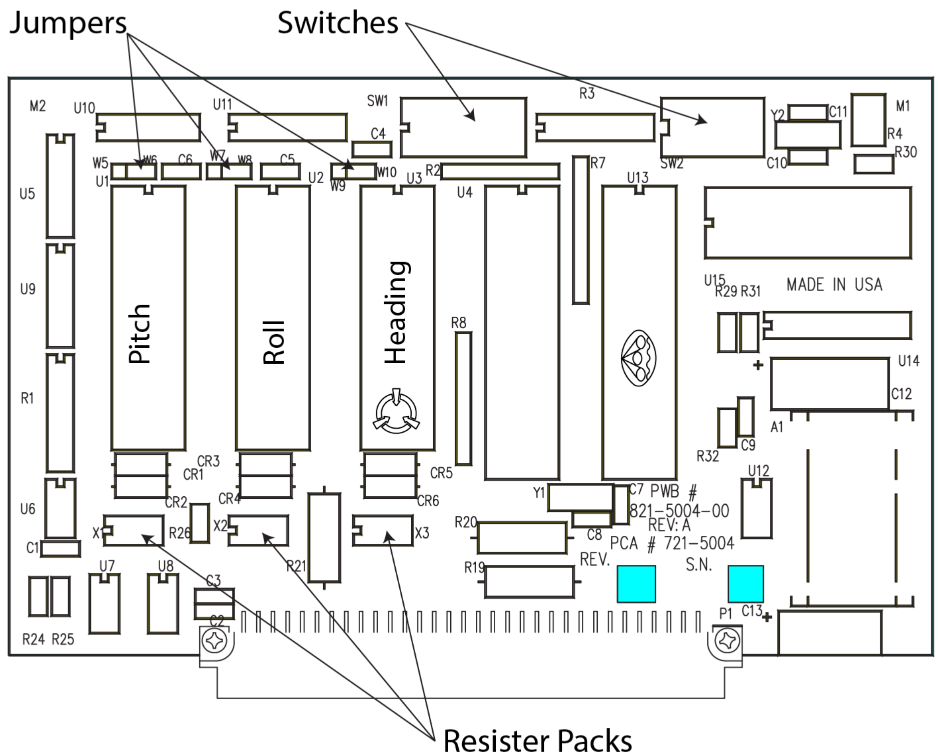


Figure 37. Gyro Interface Board

Determining the Synchro Stator Voltage

The best way to find the synchro stator voltage is to use the value listed in the gyro manual. If the manual does not list this value, you can determine the stator voltage by using an AC voltmeter and doing some calculations. After finding the stator voltage requirements, you will install one or more scaling-resistor packs on the Gyro Interface board. If you already know the stator voltage requirements, skip the rest of this section and go to Determining the Size of the Scaling-Resistor Pack to find the size of the scaling-resistor pack.

1. With the gyro synchro at a constant angle, measure the AC voltage across the following sets of leads. You must maintain this constant angle during your readings.

1. S1 to S2:_____ VAC = S_{12}
2. S2 to S3:_____ VAC = S_{23}
3. S3 to S1:_____ VAC = S_{31}

2. Calculate the RMS stator voltage, V_S:

$$V_S = \left[\frac{S_{12}^2 + S_{23}^2 + S_{31}^2}{1.5} \right]^{1/2} = RMS\ stator\ voltage$$

Usually, V_S will be a common stator voltage (11.8, 26.0, 50.0, or 90.0). If V_S is about equal to one of these values, you can probably assume your gyro is using a common value. If you are unsure of your readings, retake them at a different gyro angle and re-compute V_S. If you know your gyro is using an *uncommon* stator voltage value, you can still modify the scaling-resistor pack value for use with the Gyro Interface board (see Determining the Size of the Scaling-Resistor Pack).

Verify the synchro stator voltages are within acceptable limits.

Each stator-pair voltage (S_{12}, S_{23}, and S_{31}) must be less than or equal to V_S.

All pairs of synchro stator voltages must be within the limits given below. For example, the check for one such pair is

$$0.7071 \leq \frac{(S_{12}^{2} + S_{23}^{2})^{1/2}}{V_S} \leq 1.2247$$

If these voltage checks are not within acceptable limits, then the synchro output is bad, the voltage measurements were incorrect, or the synchro angle was not constant during readings.

Determining the Size of the Scaling-Resistor Pack

As explained earlier, most synchros use one of the standard synchro stator voltages (V_S) listed in Table 7. The Gyro Interface board will work with any of these voltages by using the associated scaling-resistor pack to adjust the stator voltage input rating to 11.8 VAC.

Table 7: Standard Synchro Stator Voltages and Scaling Resistance

Common synchro stator reference voltages	Scaling resistance
11.8 VAC	0.0 kΩ (jumper)
26.0 VAC	39.2 kΩ, 1/8 W
50.0 VAC	100.0 kΩ, 1/8 W
90.0 VAC	221.0 kΩ, 1/8 W

If the gyro is using non-standard stator voltages, you can find the scaling resistance with the following equation.

$$R = (V_S - 11.8\ VAC)\ x\ (2.76\ k\Omega)$$

The tolerance for this can be as large as 10%, but the four resistors in the scaling-resistor pack must be within 0.1% *of one another*. For example, the exact scaling-resistance value for a V_S of 50.0 VAC is 105.4 kΩ. However, resistor values of 100 kΩ are more common. Because this value is within 10% of the calculated value, you can use four 100-kΩ resistors for the scaling-resistor pack if they are within 0.1% of one another.

If you configure the gyro interface board for a lower voltage than the actual synchro stator voltage, you could damage the board or the ADCP.

Installing the Scaling-Resistor Pack and W-Jumpers

After calculating the size of the scaling-resistor pack, you are ready to install the pack on the Gyro Interface board (Figure 37). Before you can install the scaling-resistor pack, you may have to change the resistors now in the pack. To do so, pull the resistor pack out of its socket on the Gyro Interface board, unsolder the old resistors, and install the new resistors. When the scaling-resistor pack has the correct resistors soldered in place, re-install the pack in its socket. Also, make sure the appropriate W-jumpers are installed. Table 8 lists the associated resistor sockets and W-jumpers.

Table 8: Natel Chip, Resistor Pack, and W-jumper Sockets

Function	Natel chip socket	Resistor pack socket	W-jumper socket
Pitch	U1	X1	W5
Roll	U2	X2	W7
Heading	U3	X3	W9

Determining and Setting the Synchro Turns Ratio

The best way to find the synchro turns ratio is to use the value listed in the gyro manual. If the manual does not list this value, you may have to experiment by trying the various settings on the Gyro Interface board. Table 9 lists the available turns ratios and their switch settings. To set the turns ratio, set the poles of switch S1 on the Gyro Interface board (Figure 37) to the appropriate position.

If you are guessing, try a 1:1 turns ratio first. The reason you want to use a 1:1 turns ratio is so you do not have to enter a heading bias (or initialization) value in any software program or adjustment on the front panel you are using. That is, whenever you use a *non-1:1 turns ratio* or a *stepper* voltage, it is possible for the Gyro Interface board to be out of alignment with the heading synchro. For example, if the ship's heading is 027° when you initialize the ADCP, the misalignment between the gyro and the Gyro Interface board will be 27°. When a misalignment condition occurs, you must account for the misalignment either by the front panel set Up/Down buttons, or in the software program you are using. You can use the EB-command (Heading Bias) to align the Gyro Interface board to the gyro if you do not have the ability to initialize the WorkHorse ADCP through the front panel or in the software. Once set, the heading bias value is valid until you turn off the ADCP or gyro.

Table 9: Gyro Interface Switch 1 Settings

Turns ratio	P1	P2	P3	P4	P5	P6	P7	P8
1:1	C	O	C	O	O	C	C	C
36:1	C	O	C	O	O	O	C	C
90:1	C	O	C	O	O	C	O	C
360:1	C	O	C	O	O	O	O	C
Stepper enable	O	C	O	C	O	O	O	O

C = CLOSED O = OPEN

Table 10: Gyro Interface Switch 2 Settings

Pole	Setting	Function		
P1	C	Enables pitch and roll on the synchro board		
	O	Disabled pitch and roll on the synchro board		
P2-3	Baud rate	Baud rate	P2	P3
		2400	O	O
		4800	O	C
		9600	C	O
		19200	C	C
P4-5	Display rate	Display rate	P4	P5
		Continuous	O	O
		10 times per second	O	C
		2 times per second	C	O
		Once per second	C	C
P6	Not used			

Stepper Interface

If you are using a *stepper* voltage instead of a synchro voltage, remove the Synchro to Digital chip in socket U3 on the Gyro Interface board. Be sure to protect the Synchro to Digital chip from static discharge.

Synchro-to-Digital converter chips are expensive, so handle them with care.

Remember the following items when using the stepper interface

- Only a 6-step gyro can be used, where each step stands for 1/6 of a degree (see Table 6).
- If you are using roll and pitch inputs from a vertical gyro, the turns ratios for these inputs ***must*** be 1:1.
- Most common stepper voltage ranges are from 35 to 70 VDC, with a positive or negative common and this is what the gyro interface board is set up for from the factory. On special request, other voltages may be possible. The gyro Interface board uses resistors R19, R20, and R21 to set the current for the opto isolators on the stepper interface. Use Table 11 to determine the correct value of these resistors.

Table 11: Stepper Interface Resistor Values

Stepper Voltage	Resistor Value	Watt
35 to 70 VDC	8.2kΩ	1
20 to 35 VDC	4.0kΩ	1
70 to 110 VDC	16.0KΩ	2

Testing the Gyro Interface

You can use the front LCD display on the Deck Box to test the gyro interface. Turn on the Deck Box. If the LCD heading readout agrees with the gyro at several angles, you can assume the settings are correct. You also should have the gyro make a complete turn through 360°. Some lag may appear, but the LCD readout should change smoothly and in the same direction as the gyro.

If you do *not* have a 1:1 turns-ratio synchro input, and the LCD readout follows in the same direction but with a constant offset from the gyro value, you must use the initializing ↑, ↓, and SET buttons on the front of the deck box. If you do not have the initializing buttons, then you can set the offset in the *VmDas* **Transforms** page. If you are not using TRDI's *VmDas* program you can set the offset through the EB-command. This entry will align the two values when properly set; or one of two problems can exist.

- Incorrect turns-ratio value - If you are *not* sure of the turns ratio, try selecting the other turns-ratio values and retest the configuration.

> Be sure to power down the Deck Box *before* changing the switch settings. You also should secure the gyro signals to the Deck Box, as these signals are still "live" at the Gyro Interface board terminals.

- Incorrect wiring hookup to gyro - If you *are* sure of the turns-ratio (i.e., found in gyro manual), the problem must be incorrect wiring. That is, the stator lines (S1, S2, S3) or reference lines (RH, RL) may be connected to the wrong gyro terminals. Use Table 12 or systematically swap pairs of stator or reference leads to correct wiring problems.

Table 12: Gyro Interface Troubleshooting Guide

"A" Gyro angle	"B" Angle displayed by heading readout (Shaded areas indicate reverse rotation)											
000	000	120	240	240	000	120	180	300	060	060	180	300
060	060	180	300	180	300	060	240	000	120	000	120	240
120	120	240	000	120	240	000	300	060	180	300	060	180
180	180	300	060	060	180	300	000	120	240	240	000	120
240	240	000	120	000	120	240	060	180	300	180	300	060
300	300	060	180	300	060	180	120	240	000	120	240	000
Gyro conn.	"C" Possible ADCP Connector Configurations											
	1	2	3	4	5	6	7	8	9	10	11	12
RH	RH	RH	RH	RH	RH	RH	RL	RL	RL	RL	RL	RL
RL	RL	RL	RL	RL	RL	RL	RH	RH	RH	RH	RH	RH
S1	S1	S2	S3	S2	S3	S1	S1	S2	S3	S2	S3	S1
S2	S2	S3	S1	S1	S2	S3	S2	S3	S1	S1	S2	S3
S3	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2

NOTE

1. With a gyro angle of "a," the heading readout will show an angle of "b" if the gyro interface cable wires are connected as shown in "c." For example - if the gyro is at an angle of 120° ("a"), and the heading readout is showing a value of 300° ("b"), the interface is wired in either configuration #7 or #10 ("c"). If the heading readings rotate in the same direction as the gyro, the interface is wired as #7; if the rotation is in the reverse direction, the interface is wired as #10.
2. As shown above, only configuration #1 in "c" is correct for gyro interface wiring.
3. Configurations 7-12 occurs when reference wires RH and RL are reversed, producing errors of 180°.
4. Configurations 2, 3, 8, and 9 occur when the S1-S2-S3 wires are rotated, producing errors of 120°.
5. Switching any two of the S1-S2-S3 wires, as in configurations 4, 5, 6, 10, 11, and 12 (shaded in table), cause synchro rotation to be reversed and result in errors of varying degrees.
6. Setting the gyro to 000° will produce an offset that is a multiple of 60° for all possible wiring configurations.
7. Leaving any of the S1-S2-S3 connections "open" will give unpredictable results.

Navigation Interface Considerations

VmDas can read in, decode, and record ensembles from an ADCP and NMEA data from some specific (i.e. GPS and attitude sensors) external devices. *VmDas* stores this data in both raw data files (leaving all original data input in its original format) and in a combined, averaged data file. *VmDas* uses all of this data to create different displays for the user.

VmDas looks for, and utilizes the following strings if transmitted: standard GGA (position), HDG/HDT (Heading), VTG (speed and track) messages, and a proprietary PRDID (pitch and roll) message.

As well as being able to input NMEA strings to *VmDas*, it can produce NMEA output strings of speed log information. The speed log contains VDVBW (ground/water speed) and VDDBT (depth).

For more information about NMEA data, see the VmDas and WinRiver II User's Guides.

Installation Procedures (Overview)

Read these steps before doing them. In general, follow them in the order listed. Some may differ for your installation, so modify them as necessary. Some can be done simultaneously (e.g., hardware installation and software loading). If you have problems or questions, call us.

The following procedure applies to WorkHorse Mariner ADCPs. Some parts may apply to WorkHorse Monitor/Sentinel ADCPs if they are being mounted to a vessel.

1. On receipt of the system, read the WorkHorse Operation Manual.
2. Before installing the system, test the transducer and deck box right out of the shipping container. Do the following.
   a. All power to the system DISCONNECTED.
   b. Review Power Considerations.
   c. Connect the I/O cable from the deck box to the ADCP.
   d. Connect the serial I/O cable from the computer to the deck box.
   e. Connect the power cable to the deck box and apply power to the system (the Routing Cables section shows all cable connections).
   f. Follow testing procedures in Testing the WorkHorse. Test the system. If errors occur, use Troubleshooting.
3. Prepare the system for shipboard installation. Disconnect all power to the system. Disconnect all interface cables.
4. Review Transducer Head Mounting Considerations. Install the transducer head. Mechanically align the system (see Alignment Procedures (Overview)).

Take steps to prevent leaks through the hull and gate valves.

5. Review section Mariner Deck Box Mounting Considerations. As necessary, do the following.
   a. Install the Synchro Interface board in the chassis (see Gyrocompass Interface Considerations).
   b. Check all switch settings on the gyro board.
   c. Install the deck box.

6. Review Computer Considerations. Install the computer.
7. Review Cabling Considerations. As necessary, route and connect the following cables:
   - Transducer to deck box (J17) interface cable.
   - Gyro to deck box (J22) cable.

Signals may be present.

   - Navigation to computer cable.

Signals may be present.

8. As necessary, load the software on the computer's hard drive. See the Software User's Guide and the Help files for each program.
9. Configure *VmDas* or *WinRiver II*. See the software's help file and the *VmDas* or *WinRiver II* User's Guide for help on configuring the program.
10. Do the Dock Side Tests (see Dock Side Tests). If errors occur, use Troubleshooting.
11. Do the Sea Acceptance testing (see Sea Acceptance Tests). The Sea Acceptance tests include the following checks.
    - Interference
    - Water Profile Range
    - Ringing and (cross-coupling, other pingers, noise)
    - Water Profile Reasonableness (transducer alignment)
    - Bottom-track (range, accuracy)

Alignment Procedures (Overview)

This section does not apply to stationary systems (such as bottom mounted Sentinels). These systems use an internal compass by default.

The mechanical alignment of the transducer head is important to ADCP data accuracy. Mechanically mount the head as close as possible to your reference point. This is usually with the Beam 3 mark at 0° or 45° relative to the ship's fore-to-aft centerline. You also must mount the transducer head as level as possible using the ship's roll and pitch references. Review the Transducer Head Mounting Considerations for alignment considerations.

VmDas uses the **Heading Correction Parameters** on the **Transforms** tab to align the ADCP's north reference (Beam 3 mark) to the north reference of an external gyro/compass. Ships use the bow as the north reference.

When the WorkHorse is aboard a vessel, the mechanical alignment of the transducer head (Beam 3 mark) is usually aligned with the ship's fore-to-aft centerline (0°) or rotated 45° clockwise. To conceptually determine the misalignment angle, visually hold the ADCP still and turn the ship gyro's north reference to match the ADCP's north reference. For example, if the Beam 3 mark is pointing at the bow (Figure 38), the misalignment angle is zero. If the Beam 3 mark is pointing 45° to starboard (Figure 38), you must turn the ship a +45° to align the two north reference points. Conversely, if the Beam 3 mark is pointing 45° to port, you must turn the ship a -45° to align the two reference points.

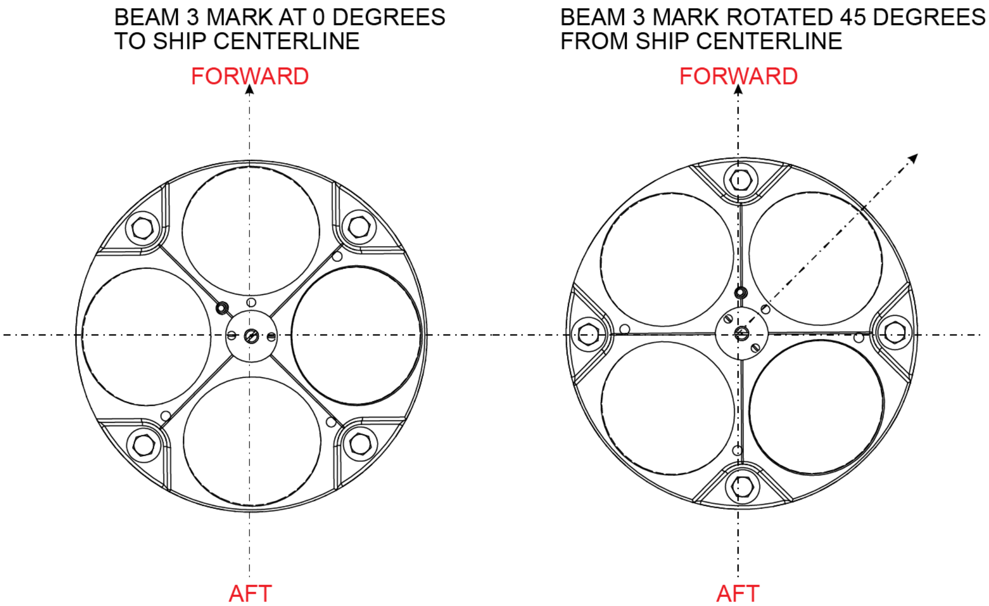


Figure 38. Transducer Misalignment Reference Points

The alignment of the transducer installation holes on the Mariner Adapter Plate to the centerline of the transducer is within 0.15 degrees. We recommend you choose a bolt (or stud) that fills the installation holes as close as possible to limit any additional misalignment.

Chapter 3

COLLECTING DATA

In this chapter, you will learn:

- Deployment checklist
- How to collect Self-Contained data
- How to collect Real-Time data

Getting Ready for a Deployment

Use the Parts Location Drawings and the following checks to ready the WorkHorse for a deployment:

Deployment Checklist

- ❑ **Visually inspect the WorkHorse**
  - ❑ Check the I/O Cable and connector pins for damage.
  - ❑ Check the housing condition for damage.
  - ❑ Check the transducer faces are clean and free from defects.
- ❑ **Seal the WorkHorse for deployment**
  - ❑ Install and connect the battery (WorkHorse Sentinel ADCP only).
  - ❑ Check Recorder PC card is installed (WorkHorse Sentinel ADCP only).
  - ❑ Use fresh desiccant inside WorkHorse ADCP.
  - ❑ Install new O-rings; use silicone lubricant.
  - ❑ Check all mounting hardware is installed and free of corrosion.
- ❑ **Bench Tests**
  - ❑ Test the WorkHorse using *BBTalk*.
  - ❑ Verify the compass alignment using *BBTalk*; if necessary, re-calibrate.
  - ❑ Check the recorder status using *BBTalk* (WorkHorse Sentinel ADCP only).
- ❑ **Final Preparation for Deployment**
  - ❑ Are biofouling precautions needed?
  - ❑ Clean the optional pressure sensor port copper screw.
  - ❑ Zero the pressure sensor (optional) at deployment site with AZ-command.
  - ❑ Install I/O cable or Dummy Plug. Regular lubrication of the I/O connector is required: Apply dry type silicone lubricant prior to each connection.

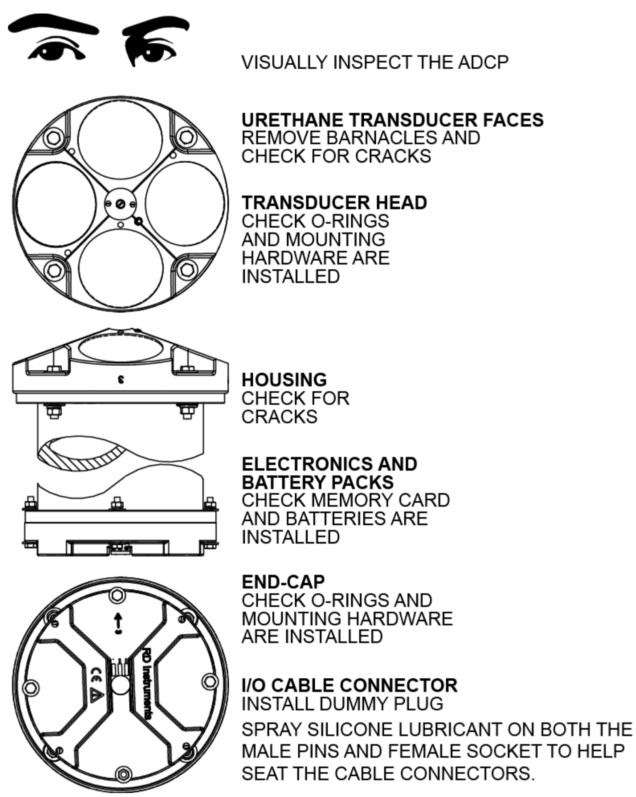
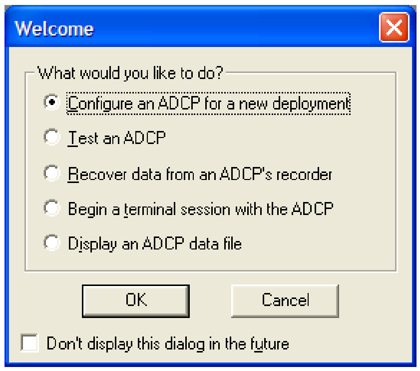


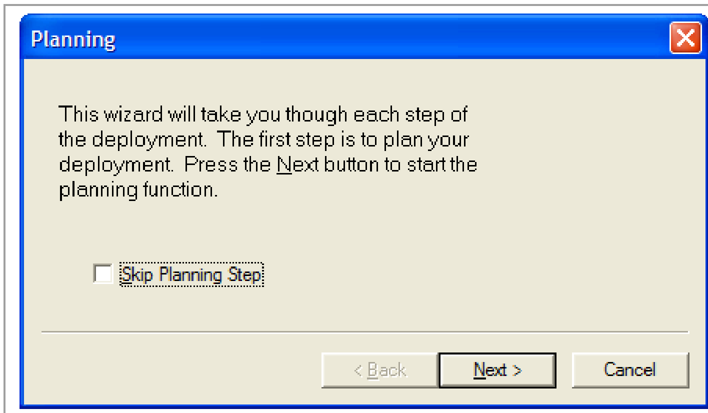
Figure 39. Visual Inspection Checklist

Collecting Self-Contained Data

WinSC works as a shell program to launch the *PlanADCP* program. *PlanADCP* is designed to create a command file that will be used to set up a WorkHorse ADCP for collecting data. In this example we will start *WinSC*, use *PlanADCP* to develop the command file, and then go back to the *WinSC* program to continue with the testing, deployment, and recovery of data.



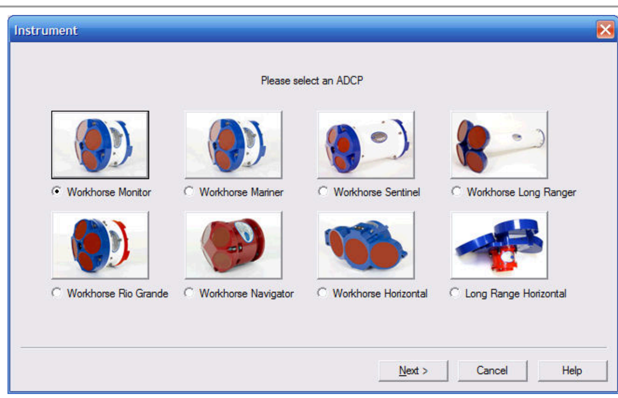
Start *WinSC*. Select **Configure an WorkHorse for a new deployment** and click **OK**.



Planning

The first step of the deployment wizard will start *PlanADCP*.

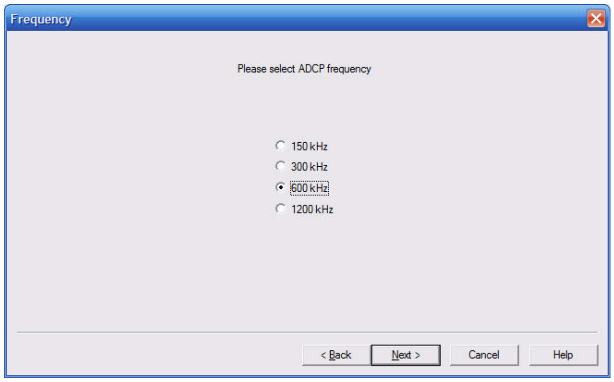
Click **Next** to continue.



Instrument

Select the type of WorkHorse ADCP you want to create a command file for.

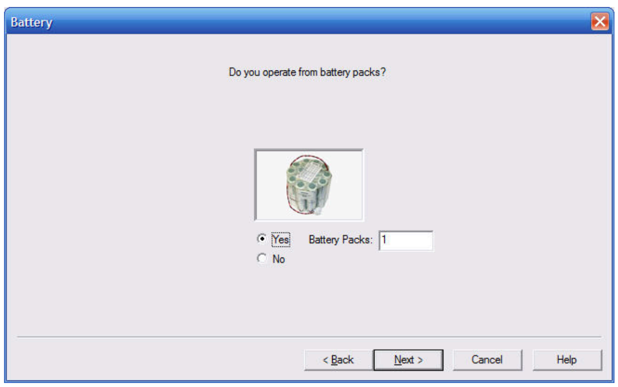
Click **Next** to continue.



Frequency

Select the frequency of your WorkHorse. The default settings and consequences are based upon the Work-Horse frequency.

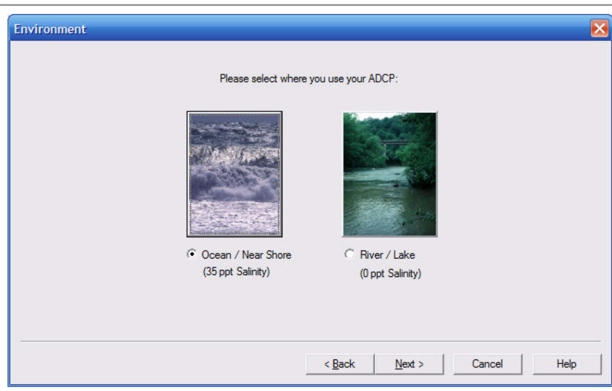
Click **Next** to continue.



Battery

Select if the WorkHorse has internal batteries. If you select **Yes**, then enter the number of battery packs you are going to use.

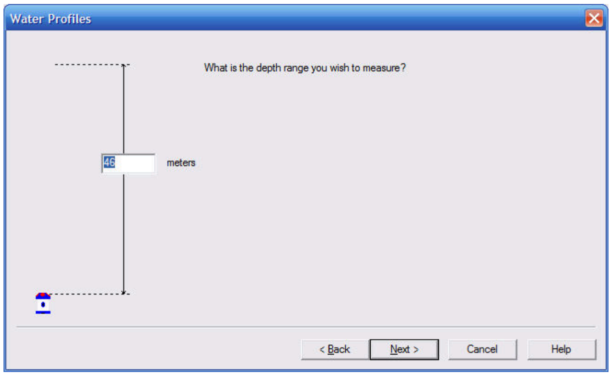
Click **Next** to continue.



Environment

Select **Ocean/Near Shore** or **River/Lake** to set the salinity. Water salinity affects the maximum range. Salt water is typically 35 ppt, fresh water is 0 ppt.

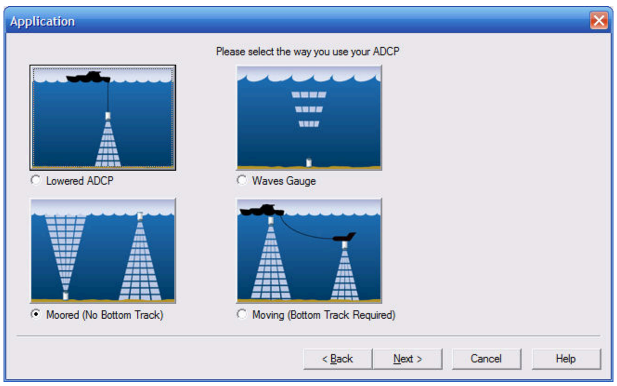
Click **Next** to continue.



Water Profiles

Select the depth range you wish to measure. The maximum depth range is dependent on the WorkHorse frequency, water salinity, water temperature, and the depth of the WorkHorse.

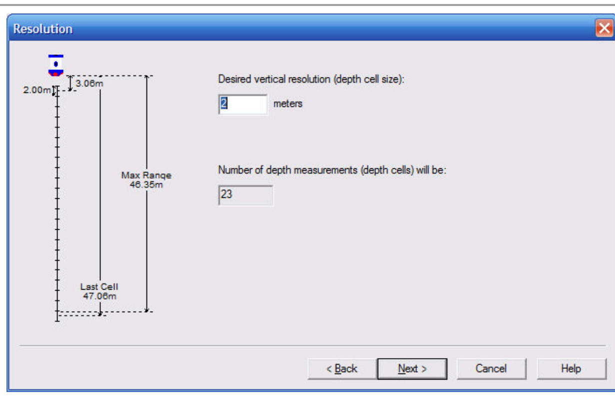
Click **Next** to continue.



Application

Select **Moored (No Bottom Track)** for a self-contained deployment.

Click **Next** to continue.

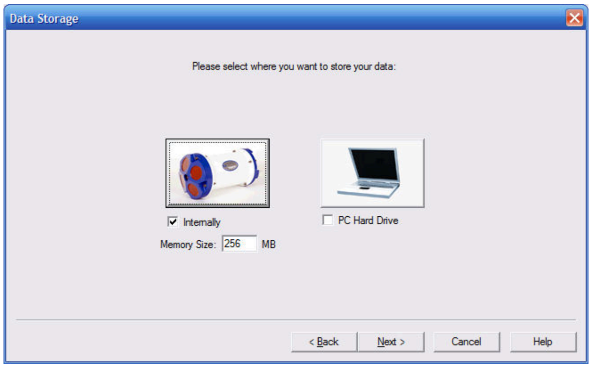


Resolution

Set the depth cell (bin) size. Adjust the depth cell (bin) size as necessary to get at least 10 depth cells (bins). A larger depth cell (bin) size decreases the standard deviation, but shallow water situations may need to use small depth cells (bins) to get more data points.

PlanADCP will set the number of depth cells (bins) so that the consequence *last depth cell (bin) range* is approximately 10% greater than the depth range set in the previous step.

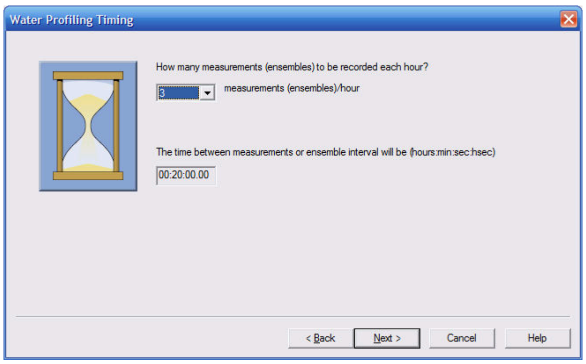
Click **Next** to continue.



Data Storage

Select where to store the data. Data can be stored internally, sent out the serial port, or both. If you selected **Internally**, enter the amount of memory installed.

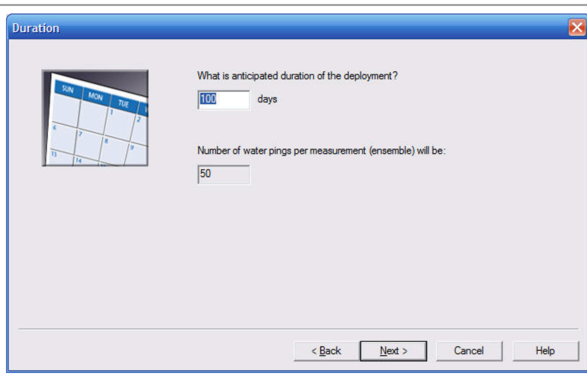
Click **Next** to continue.



Water Profiling Timing

Select how many ensembles per hour you want to record.

Click **Next** to continue.

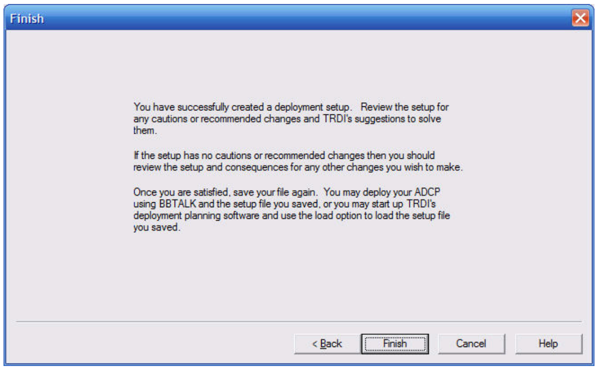


Duration

Enter the expected duration of the WorkHorse deployment from the time of the first water profiling ping (either immediately or first ping date/time). This duration *does not* produce a command to instruct the WorkHorse to stop data collection; it is for estimating consequences only. This duration is used to estimate the following *consequences*:

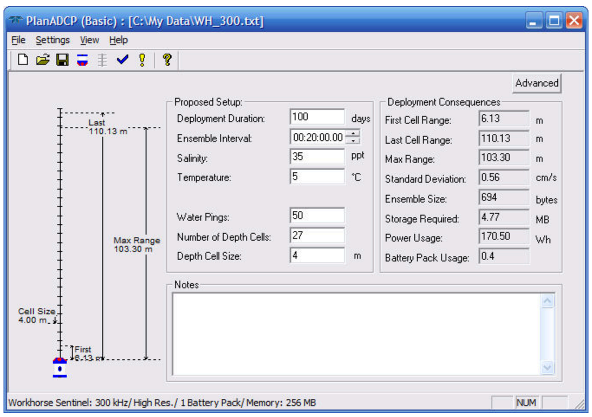
- Battery usage
- Ensembles
- Storage required

Click **Next** to continue.



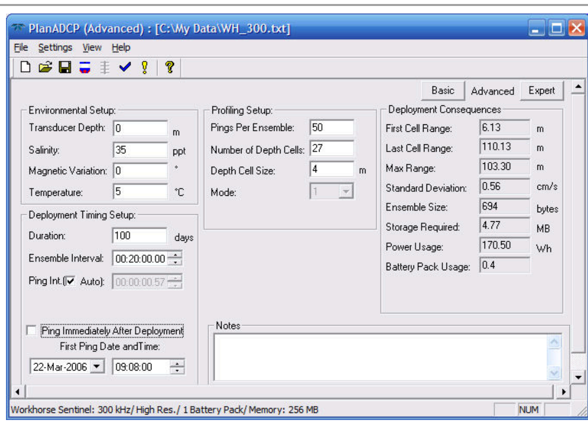
The wizard is now finished.

Click **Finish**.



The *PlanADCP* (Basic) Screen opens using the settings you selected with the wizard. Review the consequences (see the WinSC and PlanADCP User's Guide for details).

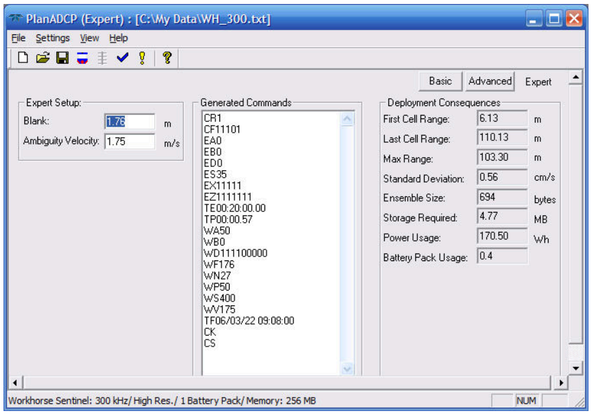
On the *PlanADCP* (Basic) Screen click the **Advanced** button to bring up the **Advanced** setting screen.



Advanced Screen

Uncheck the **Ping Immediately After Deployment** box and enter a date and time you want the WorkHorse to begin pinging.

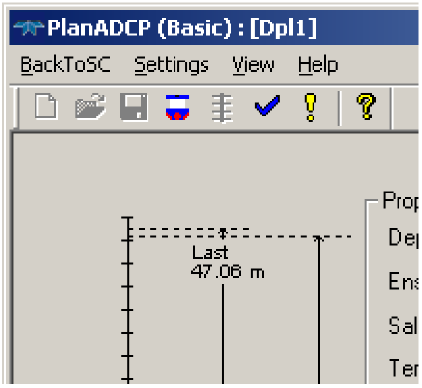
Start sample intervals on the minute by using a delayed start up. Instead of having your 10-minute sample intervals start at 12:36:47, delay startup a few minutes to have samples start at 13:00:00.



Expert Screen

On the *PlanADCP* (Advanced) Screen click the **Expert** button to bring up the **Expert** setting screen.

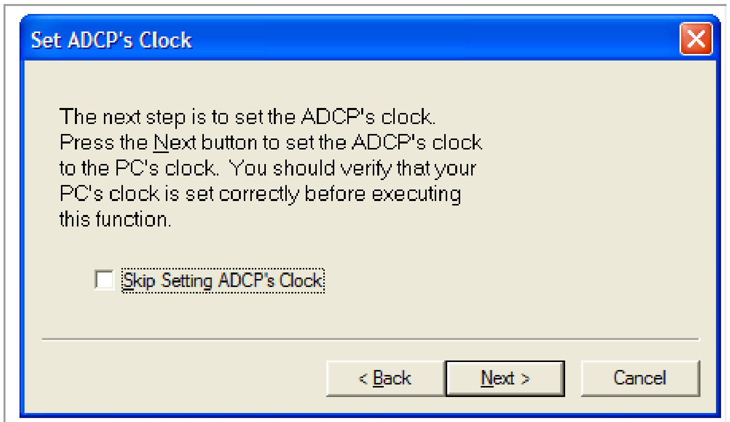
You can view the commands that will be sent to the WorkHorse.



Back to WinSC

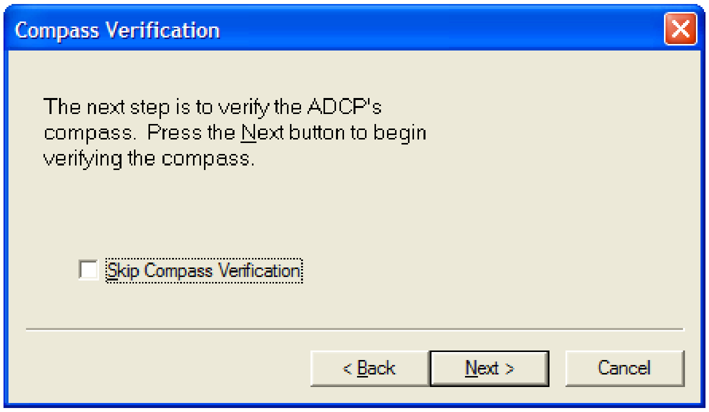
Click the **BackToSC** menu to return to *WinSC*.

At this point, the WorkHorse ADCP should be prepared for deployment, using battery power, and sealed.



The second step will set the WorkHorse ADCP's clock to the computer's time and date using the TS-command.

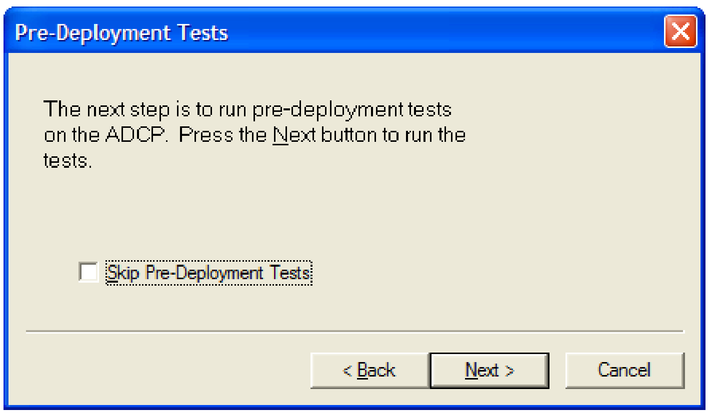
Click **Next** to continue.



The third step will verify the compass using the AX-command.

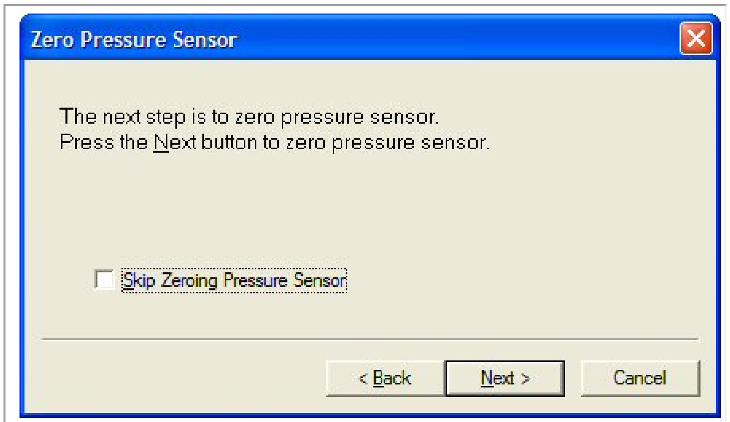
If the internal batteries were replaced, this step will only *verify* the compass; you must *align* the compass prior to using the *WinSC* wizard.

Click **Next** to continue.



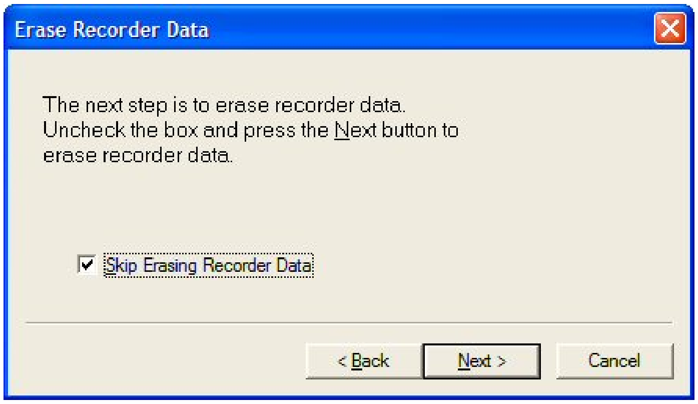
The fourth step will run the pre-deployment tests Deploy?, System?, TS?, PS0, PA, PC2, RS, and PC1-commands.

Click **Next** to continue.



The fifth step will zero the pressure sensor using the AZ-command.

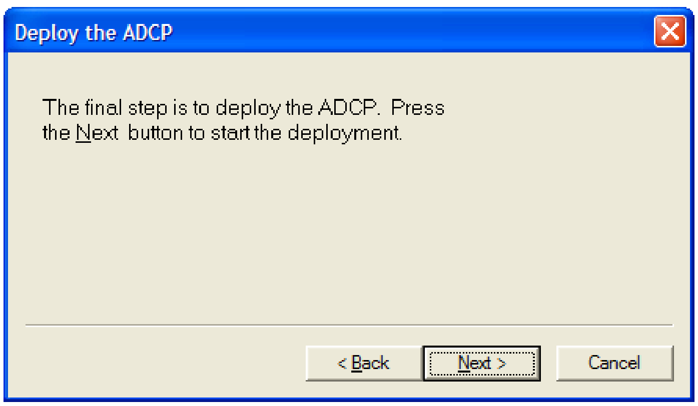
Click **Next** to continue.



The sixth step will erase the recorder using the RE-command. Uncheck the **Skip Erasing Recorder Data** box if you want to erase the data.

Once erased, the data is not recoverable.

Click **Next** to continue.



The seventh and final step in the Deployment Wizard will send the commands from the command file to the WorkHorse.

Click **Next** to send the commands. When the commands have been sent to the WorkHorse, you should see a message "*You have successfully deployed the ADCP*."

Click **OK**.

NOTE. The WorkHorse must be powered with the batteries, sealed, and ready to deploy before you click Next.

Save Deployment File

If you have not already saved the deployment file, you will be prompted to name the deployment. Choose and use Deployment Names carefully: they help you identify and organize all the data and log files associated with each deployment.

The command file and deployment log file will be saved when the deployment file is saved. For example, if you save the deployment file as *Dpl1_.dpl*, then the command file will be saved as *Dpl1_.whp* and the log file will be saved as *Dpl1_.scl.*

Before deploying the WorkHorse ADCP, scroll through the deployment log file and look for error messages. Correct as needed and re-send the commands.

Photo courtesy of J. Bornhoeft.

Deploy and Recover the WorkHorse

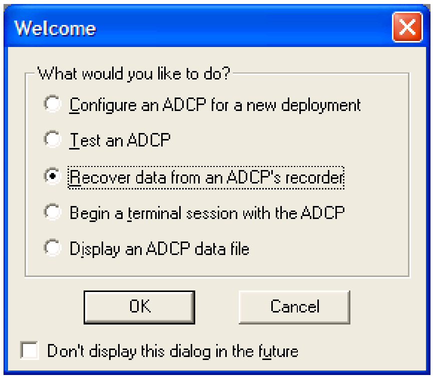
Once the commands have been sent to the WorkHorse, proceed as follows.

- Disconnect the I/O cable and install the dummy plug on the WorkHorse ADCP's end-cap.
- Deploy the WorkHorse ADCP.

Do not send a break, any other command, or run any other programs once the commands have been sent to the WorkHorse ADCP or your commands will be over-written.

Disconnect the I/O cable before turning off power to the computer. Some computers may send a break signal out the serial ports when shutting down.

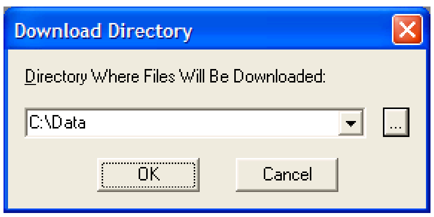
Recover Data with WinSC



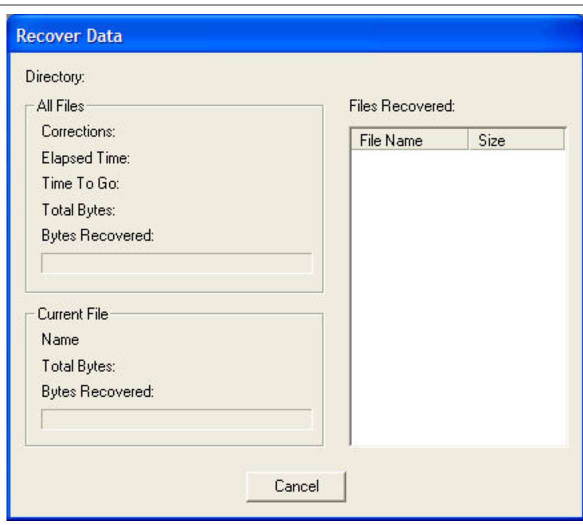
Connect and power up the WorkHorse ADCP.

Start *WinSC*.

At the **Welcome Screen** select **Recover Data from an ADCP's Recorder** or from the **File** menu, select **Recover Recorder Data**.

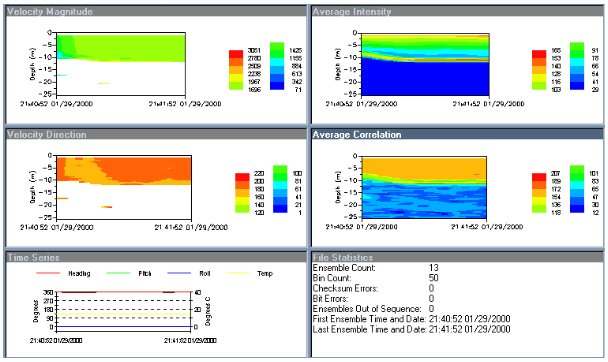


Select the directory where the data will be written.



WinSC will increase the baud rate set in the **Com Settings** window to 115200 BAUD to reduce the download time.

Viewing Data with *WinSC*

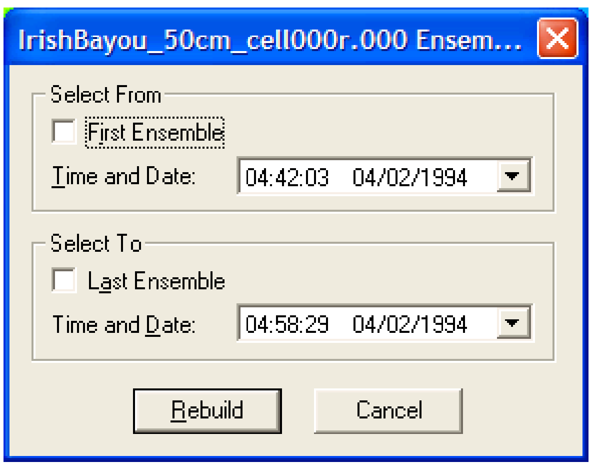


On the **File** menu, click **Open**.

On the **Files of Type** box, select **ADCP Data** (*.0*).

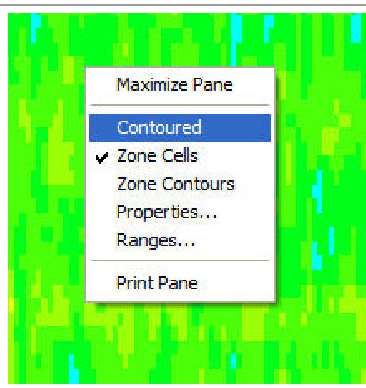
Select the file and click **Open**.

The data file will display all of the ensembles.



To select a subsection of the data file, use the **View** menu, **Ensemble Selection**.

To quickly select a section, hold the **Control** key while dragging the mouse over the area to be selected.



Display Controls.

Right-click inside any window to bring up the display menu.

To increase the size of a window, click **Maximize Pane** button.

To increase the contrast of the contoured plot, select **Contoured**.

You can increase the contrast between cells and contours by using the **Zone Cells** or **Zone Contours**.

To change the colors of the plot or other plot controls, click **Properties**.

To select the range of a contoured plot, click **Ranges**.

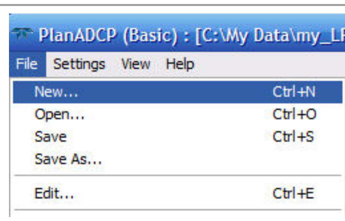
Collecting Real-Time Data

Mariner ADCPs – *WinRiver II* is the most often used software package for Mariner ADCPs. *WinRiver II* is TRDI's river and coastal data acquisition software package where the primary use is for discharge calculation. Although this is its primary function, it can be used for general coastal survey applications.

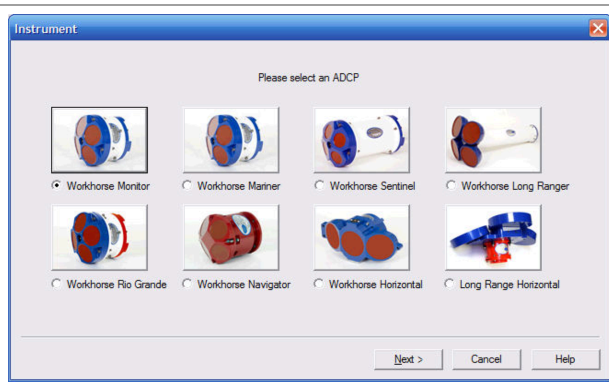
TRDI also offers the *VmDas* program. *VmDas* is designed for real-time data collection and processing of data gathered by an ADCP on a moving vessel. The displays are designed to make evaluation of the currents at a glance.

For information on using WinRiver II or VmDas, see the respective User's Guide included with the software.

Monitor and Sentinel ADCPs – *PlanADCP* is designed to create a command file that will be used to set up a WorkHorse ADCP for collecting data. In this example we will use *PlanADCP* to develop the command file, and *BBTalk* to send the commands to the WorkHorse. Then we will use the *WinADCP* program to view the data in real-time.



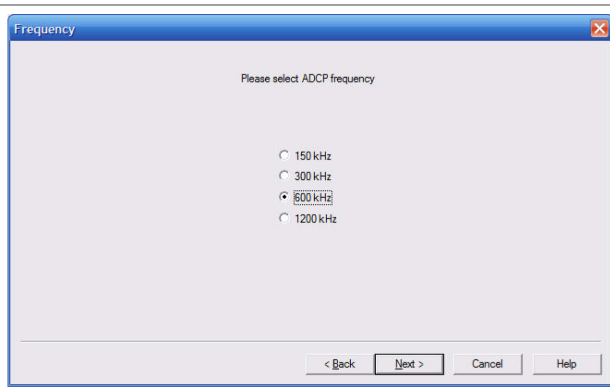
Start *PlanADCP*. On the **File** menu, click **New**.



Instrument

Select the type of WorkHorse ADCP you want to create a command file for.

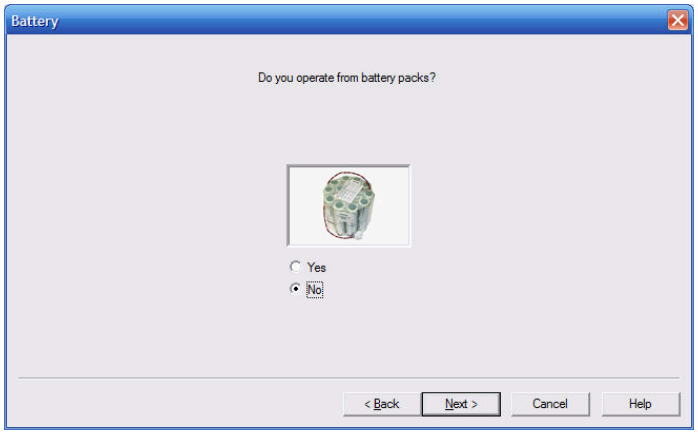
Click **Next** to continue.



Frequency

Select the frequency of your WorkHorse ADCP. The default settings and consequences are based upon the WorkHorse frequency.

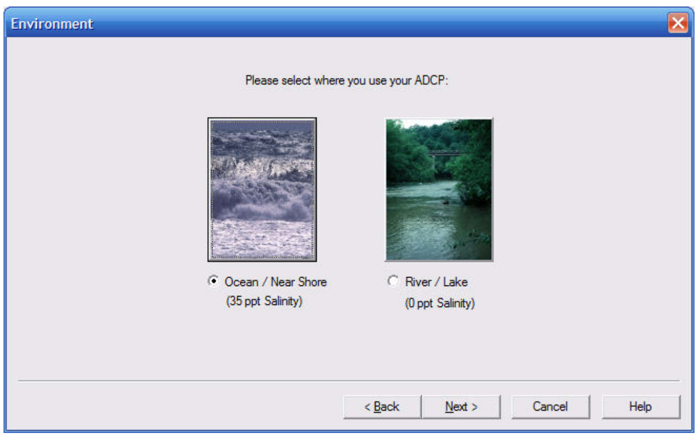
Click **Next** to continue.



Battery

Select if the WorkHorse has internal batteries. If you select **Yes**, then enter the number of battery packs you are going to use.

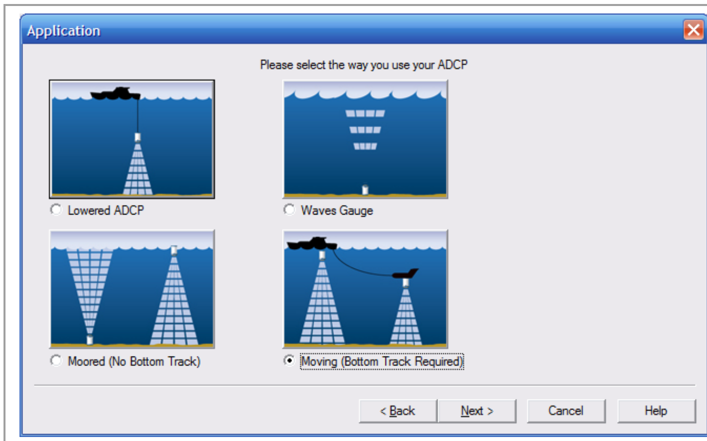
Click **Next** to continue.



Environment

Select **Ocean/Near Shore** or **River/Lake** to set the salinity. Water salinity affects the maximum range. Salt water is typically 35 ppt, fresh water is 0 ppt.

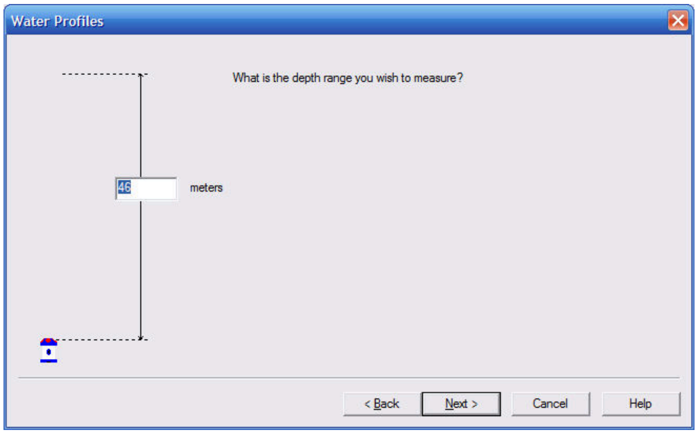
Click **Next** to continue.



Application

Select **Moored (No Bottom Track)** for a self-contained deployment.

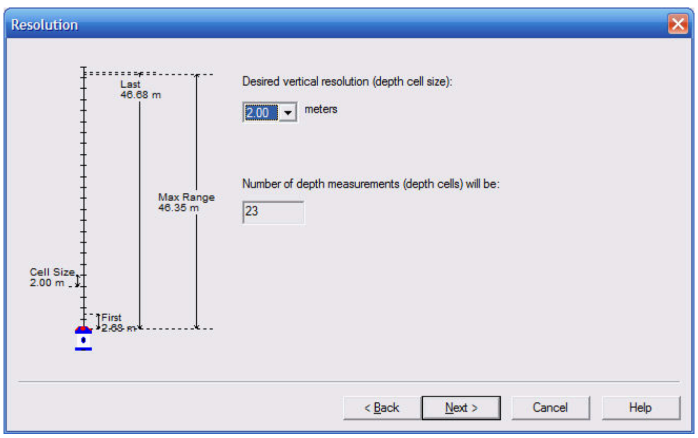
Click **Next** to continue.



Water Profiles

Select the depth range you wish to measure. The maximum depth range is dependent on the WorkHorse frequency, water salinity, water temperature, and the depth of the WorkHorse.

Click **Next** to continue.

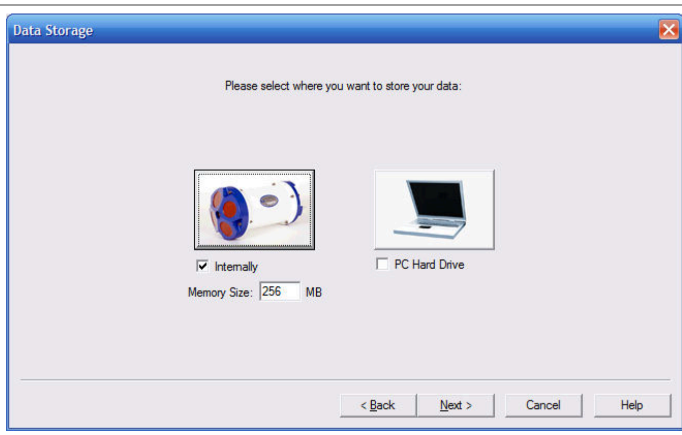


Resolution

Set the depth cell (bin) size. Adjust the depth cell (bin) size as necessary to get at least 10 depth cells (bins). A larger depth cell (bin) size decreases the standard deviation, but shallow water situations may need to use small depth cells (bins) to get more data points.

PlanADCP will set the number of depth cells (bins) so that the consequence *last depth cell (bin) range* is approximately 10% greater than the depth range set in the previous step.

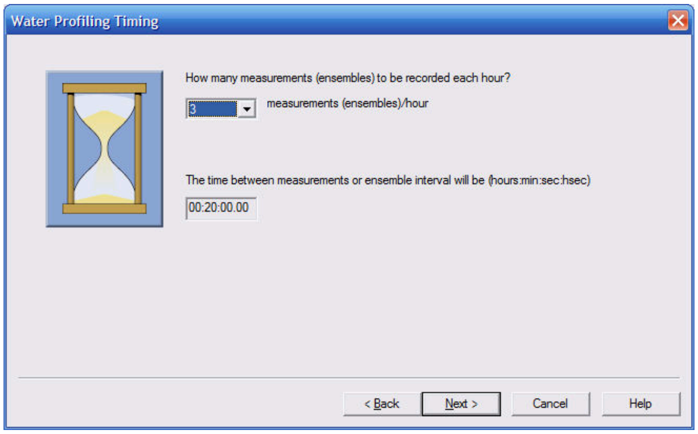
Click **Next** to continue.



Data Storage

Select where to store the data. Data can be stored internally, sent out the serial port, or both. If you selected **Internally**, enter the amount of memory installed.

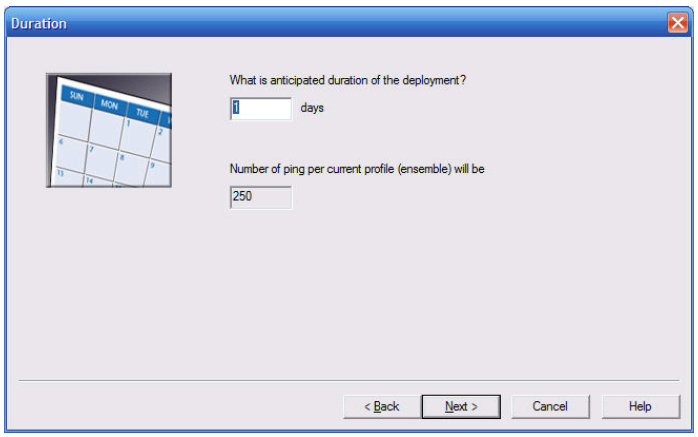
Click **Next** to continue.



Water Profiling Timing

Select how many ensembles per hour you want to record.

Click **Next** to continue.

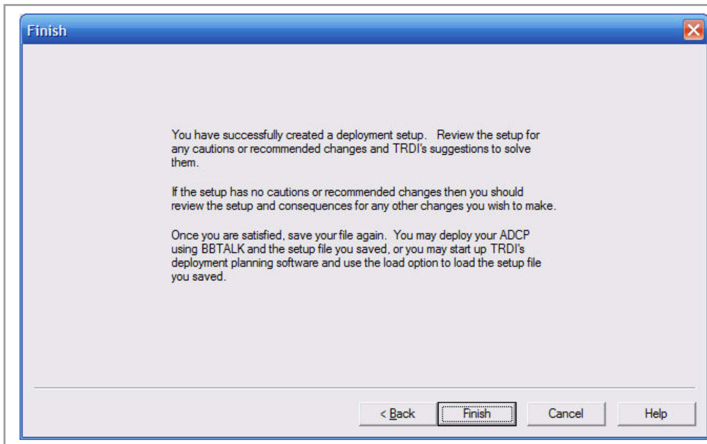


Duration

Enter the expected duration of the WorkHorse deployment from the time of the first water profiling ping (either immediately or first ping date/time). This duration *does not* produce a command to instruct the WorkHorse to stop data collection; it is for estimating consequences only. This duration is used to estimate the following *consequences*:

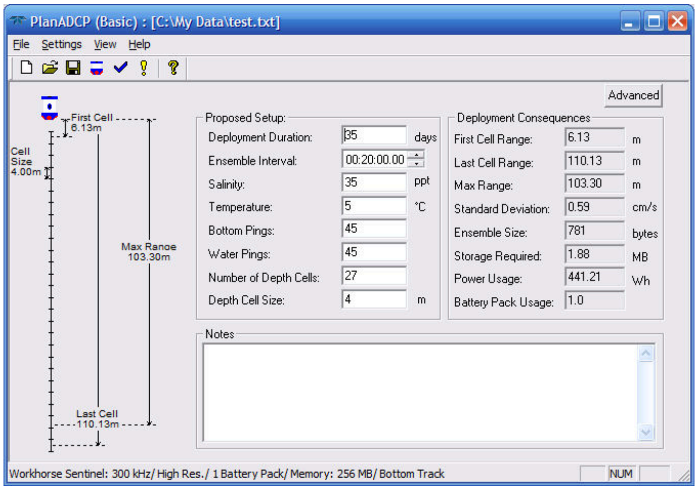
- Power requirements
- Ensembles
- Storage required

Click **Next** to continue.



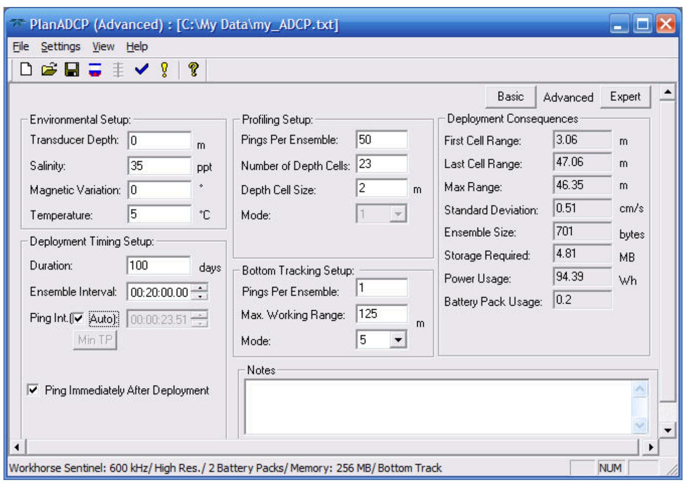
The wizard is now finished.

Click **Finish**.



The *PlanADCP* (Basic) Screen opens using the settings you selected with the wizard. Review the consequences (see the WinSC and PlanADCP User's Guide for details).

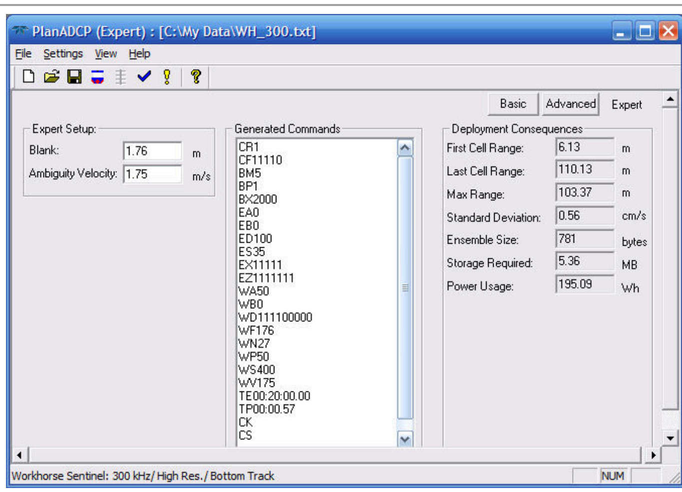
On the *PlanADCP* (Basic) Screen click the **Advanced** button to bring up the **Advanced** setting screen.



Advanced Screen

Uncheck the **Ping Immediately After Deployment** box and enter a date and time you want the WorkHorse ADCP to begin pinging.

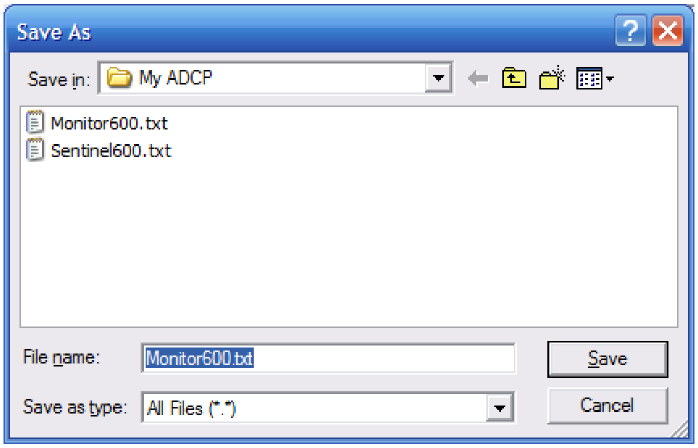
Start sample intervals on the minute by using a delayed start up. Instead of having your 10-minute sample intervals start at 12:36:47, delay startup a few minutes to have samples start at 13:00:00.



Setup Advanced Screen

On the *PlanADCP* (Advanced) Screen click the **Expert** button to bring up the **Expert** setting screen.

You can view the commands that will be sent to the WorkHorse.



Save the Command File

On the **File** menu, click **Save**. Name the command file and click **Save**.

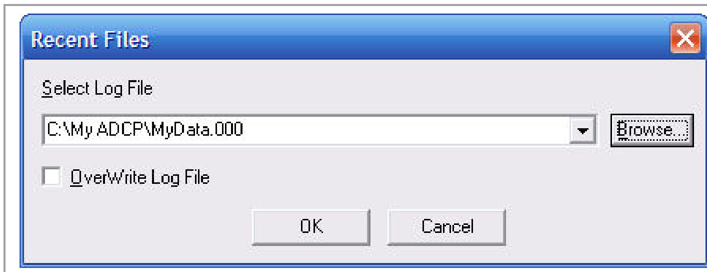
Sending the Commands to the WorkHorse ADCP

```
[BREAK Wakeup A]
WorkHorse ADCP 43.xx
Teledyne RD Instruments (c) 1996-2013
All Rights Reserved.
>
```

Wakeup the WorkHorse

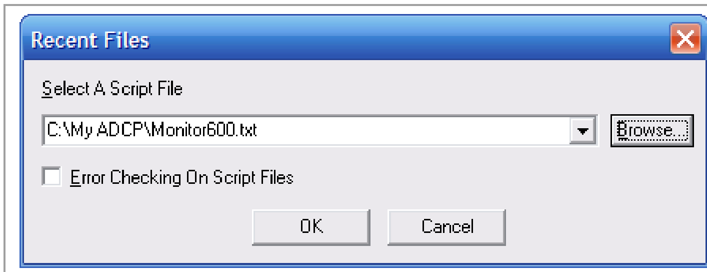
Start *BBTalk*. On the **File** menu, click **Break** (you can also press the **End** key to send a break or and press the **B** button on the Toolbar).

You should see the wakeup message appear on the log file window.



Create a Log File

Press **F3** and create a log file. Name the file and use **.000* for the file extension.



Send the Commands to the WorkHorse

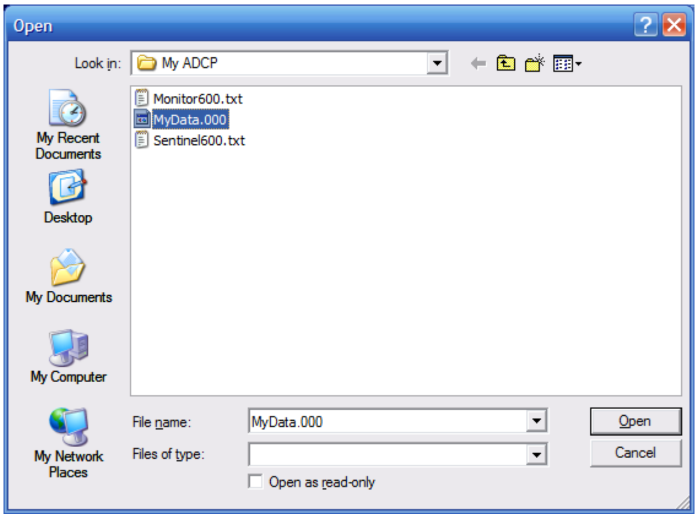
Press **F2** and use the **Browse** button to locate the command file.

You should see the commands appear on the log file window and the WorkHorse ADCP's response.

Carefully review the log file window and make sure that no command created an error message.

Viewing Data in Real-Time

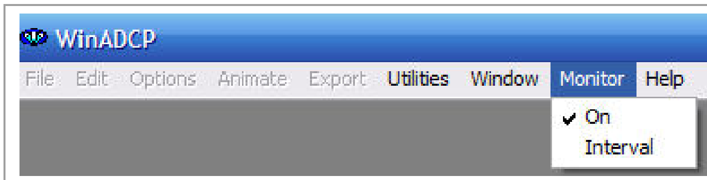
WinADCP has the ability to automatically update the reading of a file as real-time data collection is occurring. When the file size increases, (due to real-time data collection) **Monitor** will automatically reread the file at selected intervals and display the contents. When **Monitor** is enabled and the file size is changing, all menu items except **Monitor** will be unavailable.



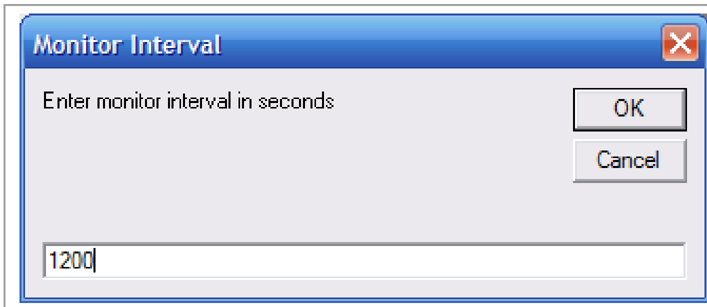
Start WinADCP

Start *WinADCP*. On the **File** menu, click **Open**.

Select the log file created with *BBTalk* (see Sending the Commands to the WorkHorse ADCP).

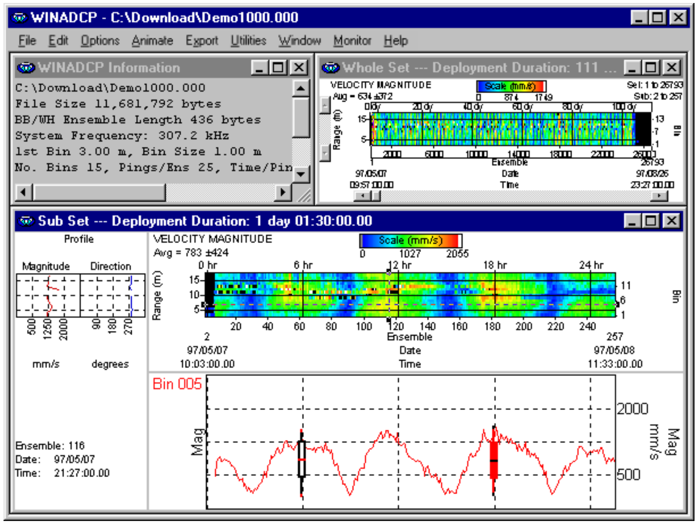


On the **Monitor** menu, select **ON**.

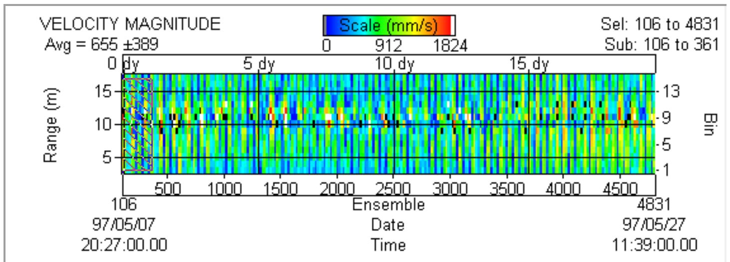


You can change the interval by clicking **Monitor**, **Interval**.

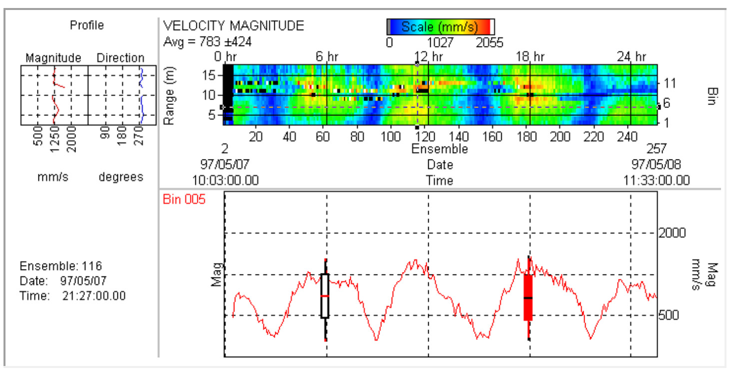
Enter the monitor interval in seconds. For example, a 20 minute ensemble would be 1200 seconds.



WinADCP has two main graphic display forms. The form located in the upper right portion of the screen is called the **Whole Set**. The form located across the bottom half of the display is called the **Sub Set**. Each of these forms displays a portion of the entire data set as a color contour. In addition to the color contour, **Sub Set** displays the user selected **Profile**, **Series**, and **Ancillary** data.



The **Whole Set** form is displayed in the upper right-hand portion of *WinADCP*. When a file containing a Binary Output Data Format is opened, the entire set of the selected data type is displayed as a color contour located within the **Whole Set** form.



By holding down the **Spacebar** and then pressing the **Left** mouse button, the user can drag the mouse to select a portion of the entire data set. When the mouse button is released, the selected portion of the **Whole Set** is marked by a blinking box outline. The blinking box outlines a set of data called the **Selected Set**.

NOTES

Chapter 4

MAINTENANCE

In this chapter, you will learn:

- Where parts are located on the ADCP
- How to spot problems
- How to take the ADCP apart and put it back together
- How to replace the batteries
- How to do periodic maintenance items on the ADCP

Parts Location Drawings

This section is a visual overview of the inside and outside parts of the WorkHorse ADCP. Use the following figures to identify the parts used on your system.

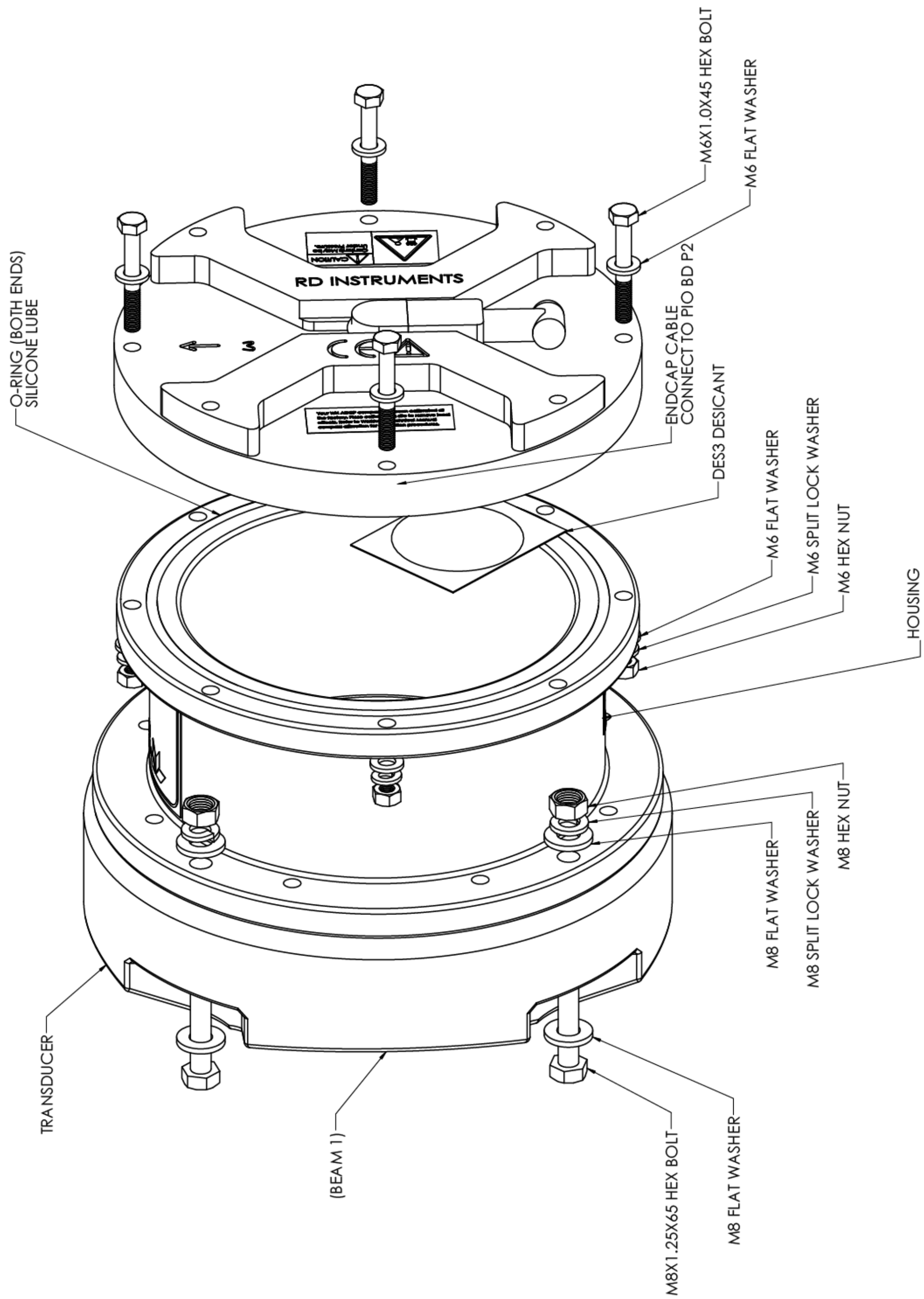


Figure 40. Mariner/Monitor Parts Location (200 Meter Systems)

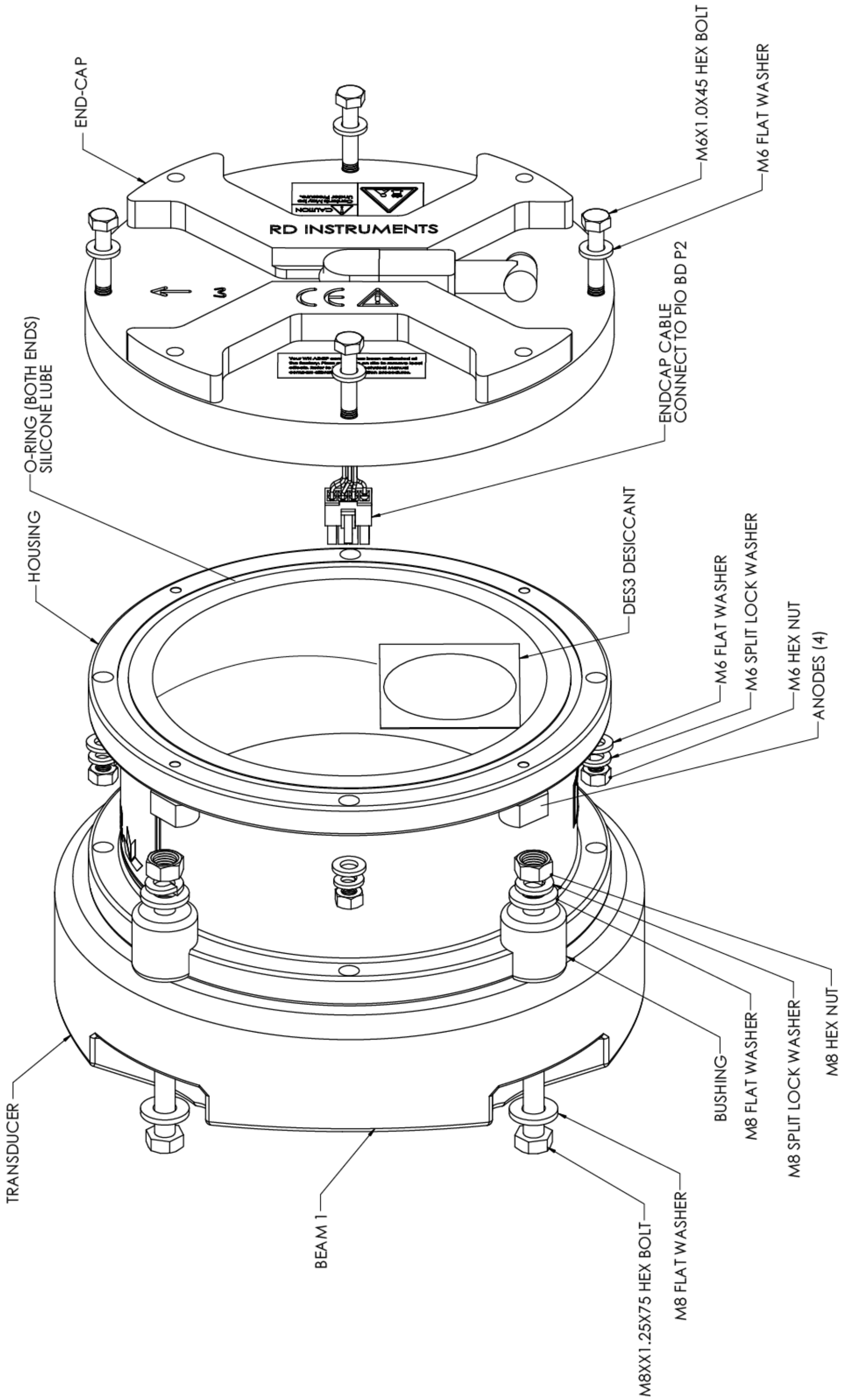


Figure 41. Mariner/Monitor Parts Location (500 Meter Systems)

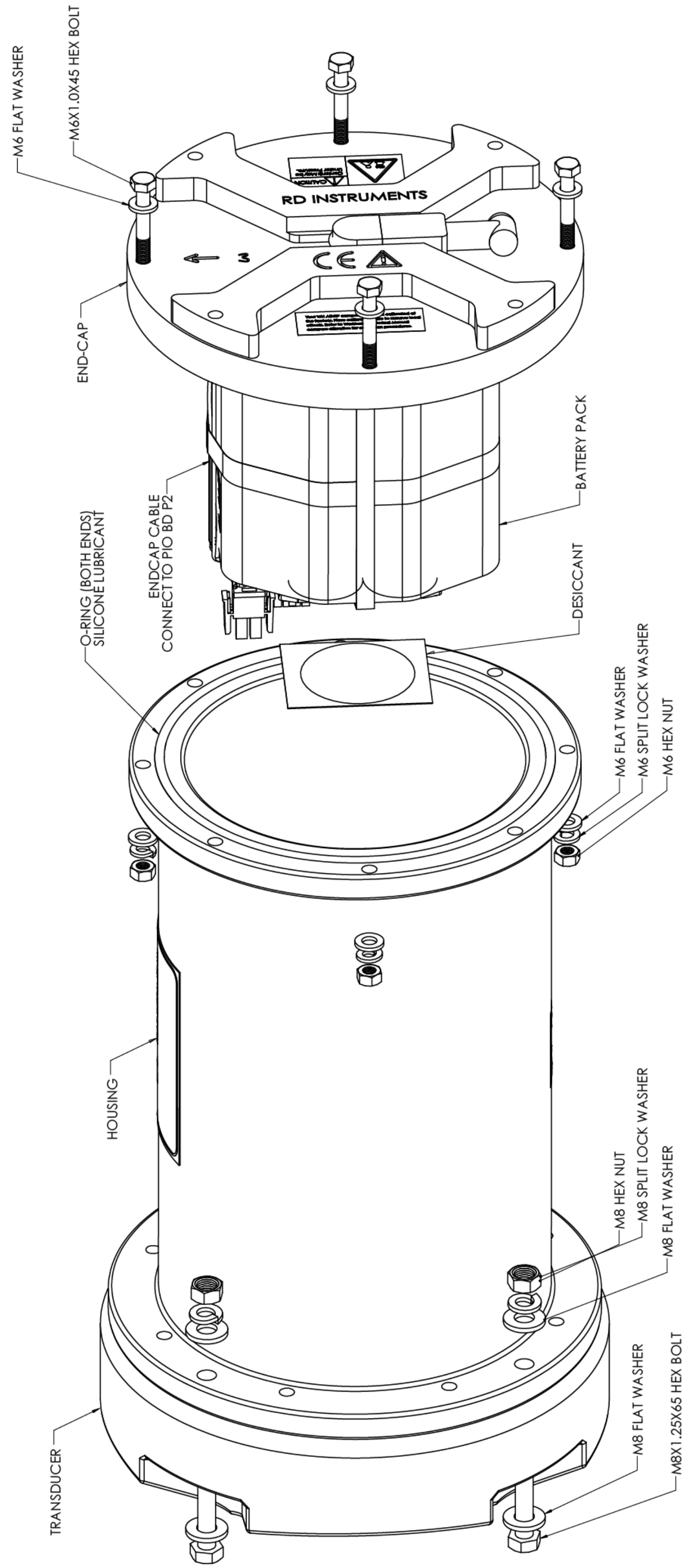


Figure 42. Sentinel Parts Location (200 Meter Systems)

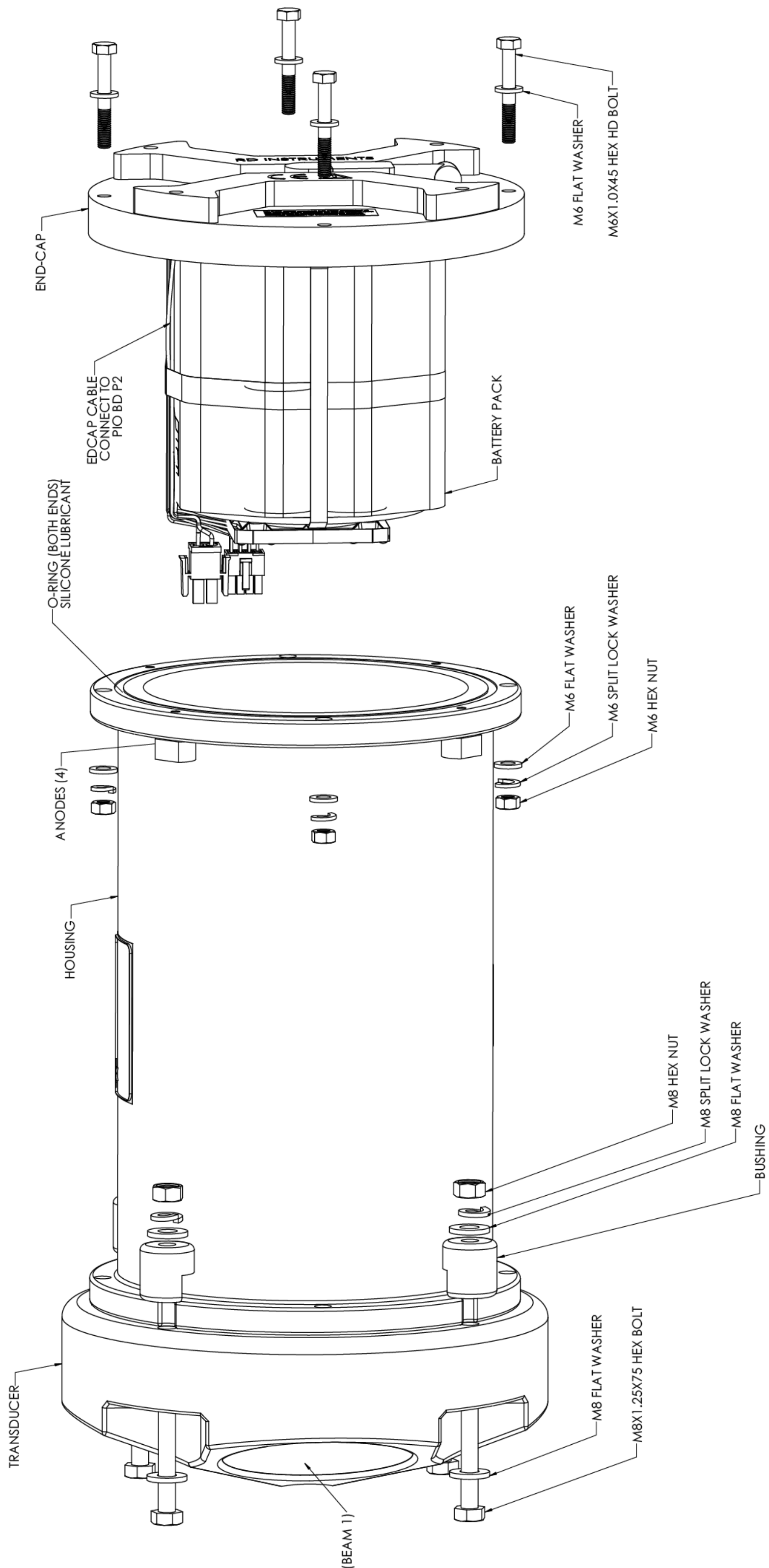


Figure 43. Sentinel Parts Location (500 Meter Systems)

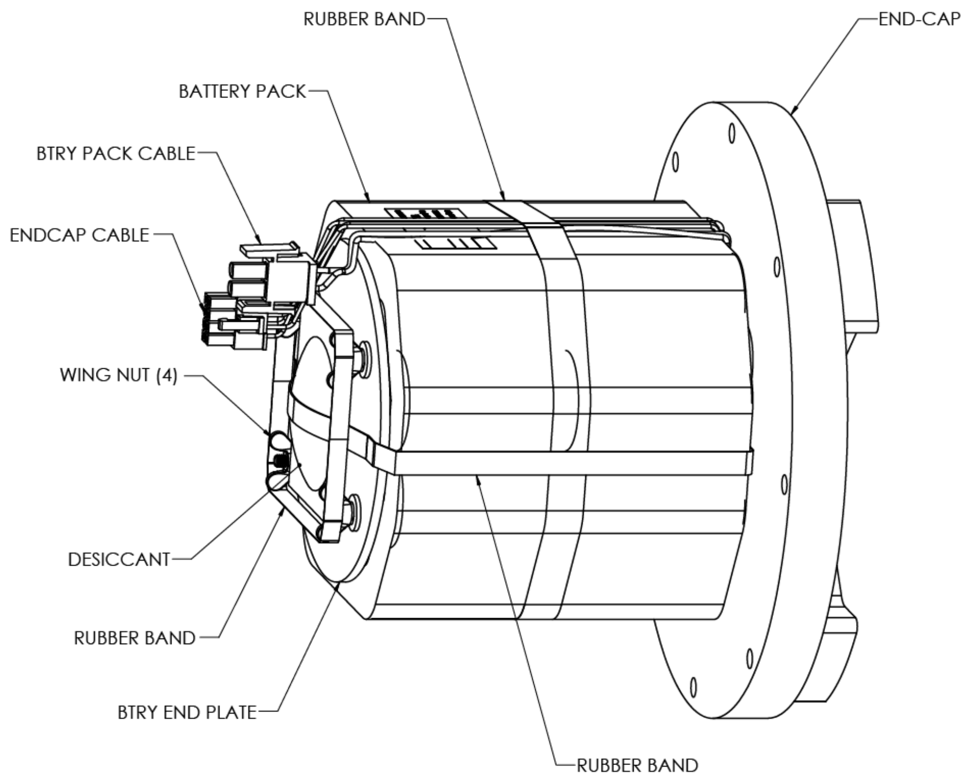


Figure 44. Sentinel End-cap and Battery Pack Parts Location

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.

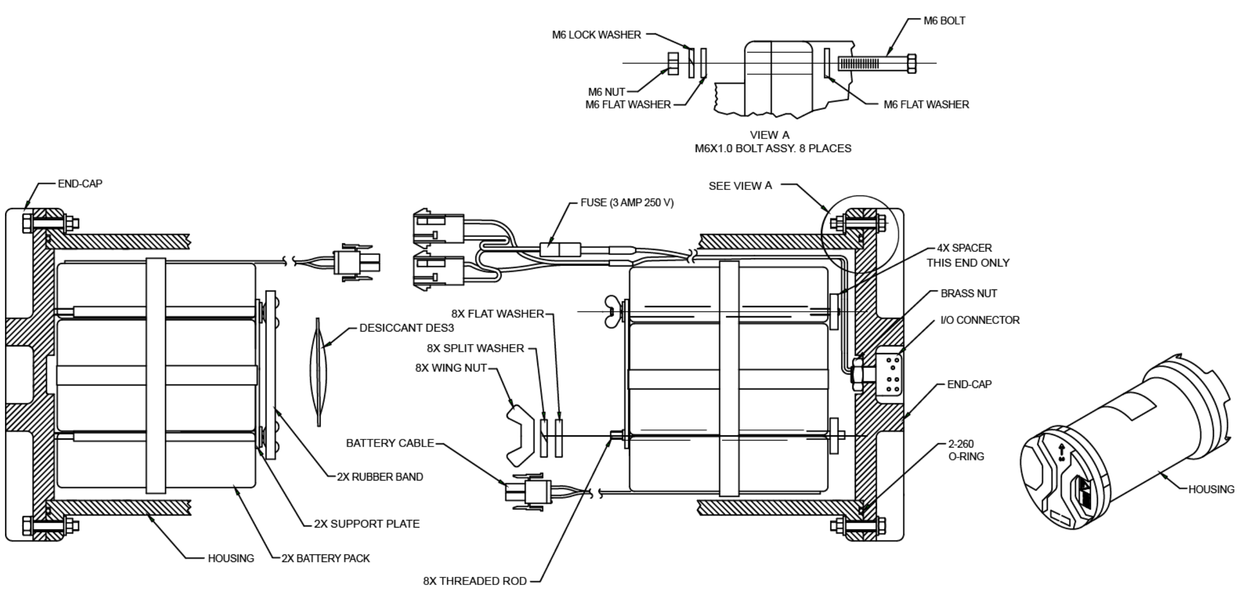


Figure 45. External Battery Pack Parts Location

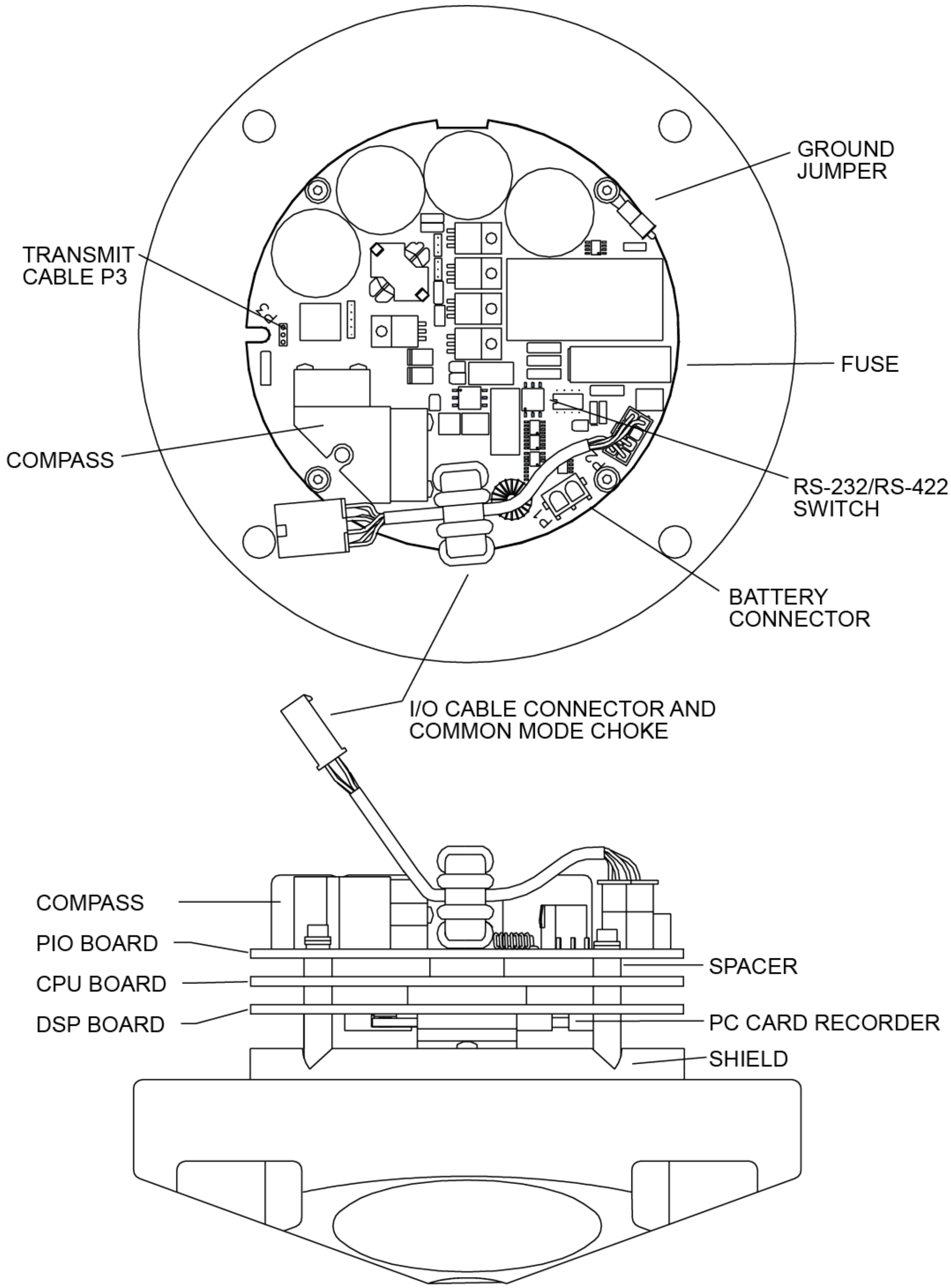


Figure 46. WorkHorse Board Locations

High-Pressure Parts Location Drawings

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

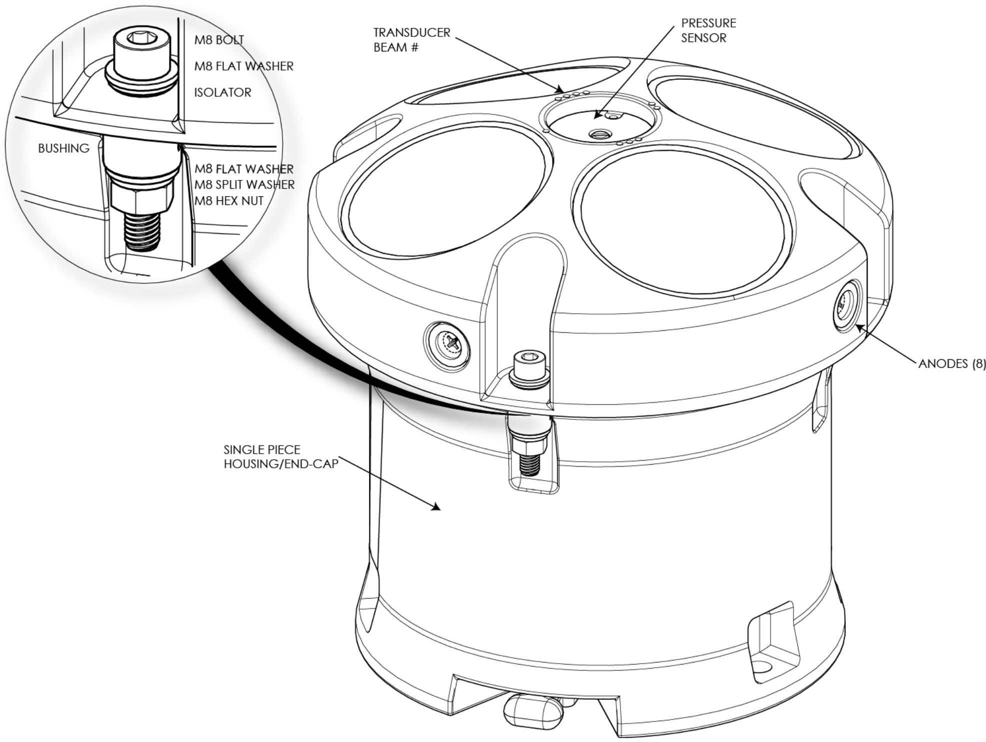


Figure 47. 6000 meter WorkHorse Monitor Parts Location

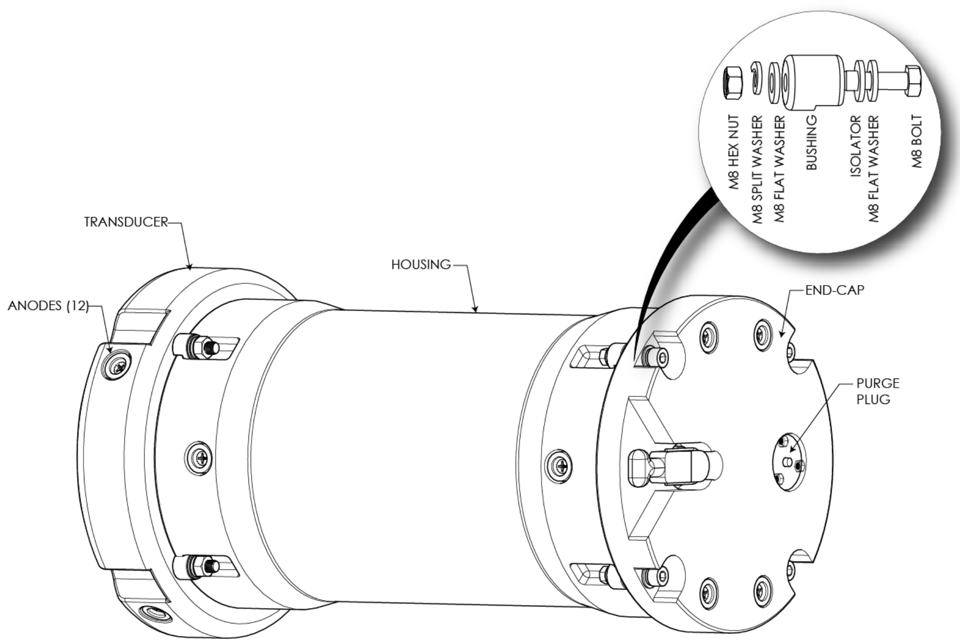


Figure 48. 6000 meter WorkHorse Sentinel Parts Location

Maintenance Schedule

To ensure that you continue to receive optimal results from your Teledyne RD Instruments product(s), TRDI recommends that every ADCP be returned to our factory for an inspection every two to three years. We'll provide your unit with a thorough multi-point inspection, and let you know if any refurbishment services are required to properly maintain the unit. To learn more about this service, please contact field service.

Calibration Items

Use the following calibration schedule:

Item	TRDI Recommended Period
Transducer Beam Angle	TRDI recommends return every two to three years for verification of velocity accuracy
Pitch & Roll (Tilt)	
Temperature (Factory)	TRDI recommends return every two to three years for Factory calibration
Pressure Sensor (Factory)	
Heading (Factory)	
Heading (Field Pre-Deploy)	Field Compass Calibration (AF) performed prior to each deployment (see Compass Calibration)
Heading (Field Post-Deploy)	Field Compass Verification (AX) performed post each deployment (see Compass Calibration Verification)

Pressure sensor and compass drift effects will accumulate over time. TRDI recommends a factory calibration be done every two to three years. The longer you wait between factory calibrations, the more error (due to drift) you can expect to have.

For example, the pressure sensor has an initial accuracy spec of ±0.25%, and a long-term drift spec of ±0.11%. Most of the 0.11% drift will occur in the first 12 months of operation. The fluxgate compasses accumulate an error of approximately 1% over a year.

Maintenance Items

Inspect the ADCP to spot problems:

Item	TRDI Recommended Period
Transducer Beams	The urethane coating is important to ADCP watertight integrity. Many users are not familiar with the early signs of urethane failure. The primary damage to the urethane is from bio-fouling and long exposure to the water and sun. Damage occurs on the surface of the urethane and at the edge where the urethane bonds to the cups. Mishandling, chemicals, abrasive cleaners and excessive depth pressures can also damage the transducer ceramics or urethane coating. Before each deployment, check the urethane coating on the transducer faces for dents, chipping, peeling, urethane shrinkage, hairline cracks and damage that may affect watertight integrity or transducer operation (see Figure 49). Based on experience, TRDI knows that most systems need to have the urethane inspected after three to five years of field use; shorter periods may be required depending on marine growth.
O-rings	O-rings should be replaced whenever the system is opened and BEFORE they are showing any signs of wear and tear. For example, when replacing the Sentinel battery, the end-cap is removed. Replace the end-cap O-ring each time the end-cap is removed. All O-rings should be replaced every one to two years maximum.

Item	TRDI Recommended Period
Housing and End Cap	Inspect for damage and replace as needed before each deployment. Inspect the paint (high pressure systems only) on 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.** See Protective Coating Inspection and Repair for details.
Hardware (bolts, etc.)	Check all bolts, washers and split washers for signs of corrosion before each deployment. TRDI recommends replacement after every deployment or every year whichever is longer. Damaged hardware should never be used.
Zinc Anodes	Inspect the anodes (available on aluminum systems only) before each deployment for wear around the mounting bolts. Cover bolts with silicone sealant prior to deployment. Replace anodes whenever the mounting bolt is in less than 75% in contact with the bolt. Replace all anodes every one to two years maximum.
Cables and Connectors	Check the end-cap I/O connector for cracks or bent pins (see Figure 50) before each deployment. Replace the end-cap I/O connector every five years as a normal maintenance item (see Table 15. Replacement Kits to order parts). Check the cable connectors for cracks or bent pins. Inspect the full length of the cable for cuts, nicks in the insulation, and exposed conductors before each deployment. Check the Deck Box (Mariner) connectors on the rear panel for cracks or bent pins. Repair of the Deck Box connectors should only be done by TRDI.
CPU Lithium Coin-Cell Battery	TRDI recommends replacing the lithium coin-cell battery every five years.

Figure 49. Transducer View

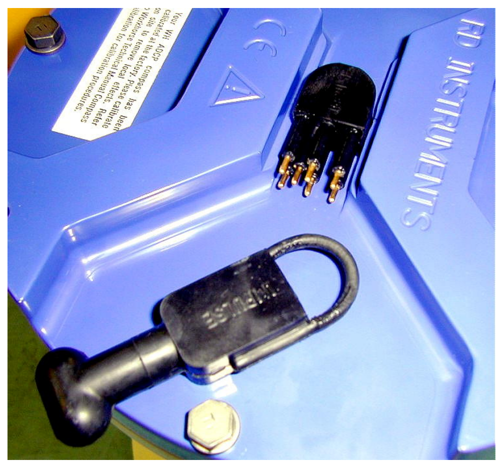


Figure 50. End-Cap View

Spare Parts

Periodic maintenance helps maintain the ADCP so it is ready for a deployment. Use the following tables if you need to order replacement parts.

Table 13: WorkHorse 200 and 500 meters Spare Parts

Part Number	Item Name	Where Used
206062-1	Clamp, Cable, Plastic Shell	AC Power Adapter
206430-2	Receptacle, 4 Pin, Free Hang	
66101-4	Socket, Crimp, 18-16awg	
SPR84-1LB	Rubber Band	Battery pack
5020	Silicone Lubricant, 4-Pack	Housing
97Z-6052-00	O-Ring, 2-260 (200 meter housing)	
97Z-6053-00	O-Ring, 2-261 (500 meter housing)	
M10COMBINATION	Wrench, 10MM COMB.	
M13COMBINATION	Wrench, 13MM COMB.	
M6WASHSPLTI	Washer, 6MM Split Lock, Titanium	
M6WASHSTDTI	Washer, Flat, Titanium 12.5MM OD	
M6X1.0NUTTI	Nut, Hex, Titanium 10MM	
M6X1.0X45HHTI	Screw, Hex Head, Titanium	
M8WASHSPLTI	Washer, Split Lock, Titanium	
M8WASHSTDTI	Washer, Flat, Titanium 22.9MM OD	
M8X1.25NUTTI	Nut, Hex, Titanium 13MM	
M8X1.25X65HHTI	Screw, Hex Head, Titanium Full Threads Length	
717-3008-00	Jumper, GND	Main Electronics
817-3003-00	Washer, Felt	
GMA-3A	Fuse, 5MM X 20MM 3R 250V	
DES3	Desiccant, Sealed Bag	Inside Housing
817-1067-00	Screw, Pressure Sensor	Pressure Sensor

Table 14: High-Pressure Systems Spare Parts

Part Number	Item Name	Where Used
206062-1	Clamp, Cable, Plastic Shell	AC Power Adapter
206430-2	Receptacle, 4 Pin, Free Hang	
66101-4	SOCKET, CRIMP, 18-16AWG	
SPR84-1LB	Rubber Band	Battery pack
5020	Silicone Lubricant, 4-Pack	Housing
97Z-6008-00	O-Ring, 2-013, DURO 70, EPDM	
97Z-6050-00	O-Ring, 2-258, 70 DURO, EPDM	
97Z-6053-00	O-Ring, 2-261 DURO 70, EDPM	
97Z-6068-00	O-Ring, Back-Up Ring Bore Seal, DURO 90	
M13COMBINATION	Wrench, 13mm Comb.	
7289A16	Key, Hex, 5m	
7289A17	Key, Hex, 6m	
811-4007-00	Bushing	
M8WASHSPL	Washer, Split Lock,SST316	
M8WASHSTD	Washer, Flat16mmod,SST316	
M8X1.25NUT	Nut, Hex, SST316	
M8X1.25X45SH	Screw, SKT HD.SST 316	
810-4006-00	ANODE, Housing FLANGE, 3000/6000M	
RTV162	Sealant, Silicone 2.8 OZ	
GMA-3A	Fuse, 5mm X 20mm 3R 250V	Main Electronics
717-3008-00	Jumper, GND	
817-3003-00	Washer, Felt	
DES3	Desiccant, Sealed Bag	Inside Housing
817-1067-00	Screw, Pressure Sensor	Pressure Sensor

Table 15. Replacement Kits

Part Number	Description	Where Used
757K6122-00	WorkHorse End-Cap Tools Kit	Replacing the End Cap Connector
757K6123-00 (200 and 500 meter systems)	End Cap Connector Replacement Kit (requires the WorkHorse End-Cap Tools Kit)	
757K6125-00 (6000 meter systems)		
757K6149-00 (WorkHorse External Battery case)		
757K6023-00	WorkHorse Sentinel Battery Pack Kit (includes 1 battery, desiccant, and 2 rubber bands)	Replacing the Sentinel Battery Packs Replacing the External Battery Case Packs
717-3009-00	WorkHorse Sentinel Battery Packs (10-pack)	
757K6152-00	Anode Kit, 500 Meter WorkHorse	Zinc Anode Inspection and Replacement
757K6035-02	1200 kHz Spare Boards Kit	Installing the Spare Boards Kit
757K6035-03	600 kHz Spare Boards Kit	
757K6035-04	300 kHz Spare Boards Kit	
757K6037-00	WorkHorse 200 meter Monitor/Sentinel Spare Parts Kit	Replacement spare parts kit (see Table 13 and Table 14 for list of included parts.
757K6068-00	WorkHorse 500 meter Monitor/Sentinel Spare Parts Kit	
757K6057-00	WorkHorse Mariner Spare Parts Kit	
757K6072-00	WorkHorse 6000 meter Monitor/Sentinel Spare Parts Kit	
757K6036-00	WorkHorse 200 meter Close-up kit	Includes needed hardware, O-rings, and desiccant to seal the ADCP.
757K6069-00	WorkHorse 500 meter Close-up kit	
757K6113-00	WorkHorse Mariner Close-up kit	
757K6011-00	WorkHorse 6000 meter Close-up kit	

Disassembly and Assembly Procedures

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.

Standard 200 meter and 500 meter housings

- End-Cap Removal Procedures
- Transducer Head Assembly Removal
- O-ring Inspection and Replacement
- End-cap Replacement
- Transducer Head Replacement

High Pressure systems

- High-Pressure End-Cap Removal Procedures
- High-Pressure Transducer Head Assembly Removal
- High-Pressure O-ring Inspection and Replacement
- High-Pressure End-cap Replacement
- High-Pressure Transducer Head Replacement

End-Cap Removal Procedures

Caution label on End-Cap

Wear safety glasses and keep head and body clear of the end-cap while opening.

Any system that was deployed may have pressure inside the housing.

When you need access to the electronics, TRDI recommends removing the transducer head assembly (see Transducer Head Assembly Removal).

Use Parts Location Drawings for parts identification.

To remove the end-cap:

1. Dry the outside of the ADCP.
2. Disconnect the I/O cable and install the dummy plug.
3. Stand the ADCP on its transducer faces on a soft pad.
4. Inspect the housing and end cap bolts for any signs of damage such as bending, stretched bolts, crushed or deformed bushings, etc. These signs may indicate that there is internal pressure inside the system.
5. To avoid any possible injury it is ALWAYS recommended that you loosen but do not remove the four end-cap bolts to allow any internal pressure to be vented from the system. **Loosen the end-cap bolts two turns each in a cross-pattern. Repeat until the face seal O-ring is not compressed and the system has the opportunity to vent.** If you note that the end cap moves as you loosen the bolts then this may indicate that internal pressure is present. Be sure to only loosen the bolts far enough to allow the system to vent.
6. Once all four end-cap bolts have been loosened and you are sure that there is no internal pressure, remove the bolts from the end-cap.

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

7. 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.
8. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap aside.
9. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage (see O-ring Inspection and Replacement). Even small scratches can cause leakage around the O-ring seal.

Transducer Head Assembly Removal

When you need access to the Sentinel internal battery, remove the end-cap assembly (see End-Cap Removal Procedures).

1. Remove all power to the WorkHorse.
2. Remove the I/O cable and place the dummy plug on the I/O cable connector (see I/O Cable and Dummy Plug).
3. Stand the WorkHorse on its end-cap.

Wear safety glasses and keep head and body clear of the transducer while opening.

Any system that was deployed may have pressure inside the housing.

4. Inspect the transducer bolts for any signs of damage such as bending, stretched bolts, crushed or deformed bushings, etc. These signs may indicate that there is internal pressure inside the system.
5. To avoid any possible injury it is ALWAYS recommended that you loosen but do not remove the four transducer bolts to allow any internal pressure to be vented from the system. **Loosen the transducer bolts two turns each in a cross-pattern. Repeat until the face seal O-ring is not compressed and the system has the opportunity to vent.** If you note that the transducer moves as you loosen the bolts then this may indicate that internal pressure is present. Be sure to only loosen the bolts far enough to allow the system to vent.
6. Once all four bolts have been loosened and you are sure that there is no internal pressure, remove the bolts from the transducer.
7. 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.

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.

8. 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.
9. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage (see O-ring Inspection and Replacement).
10. When you are ready to re-assemble the WorkHorse, see WorkHorse Re-assembly.

WorkHorse Re-assembly

To replace the end-cap and transducer head, proceed as follows. Use Parts Location Drawings for parts identification.

1. 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).
2. Make sure all printed circuit boards, spacers, cables, and screws have been installed.
3. Install two fresh bags of desiccant just before closing the WorkHorse (see Desiccant Bags).

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 for the locations of the following O-rings. Read all instructions before doing the required actions.

200 meter housings

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

500 meter housings

- Transducer assembly, face, 2-261
- End-cap assembly, face, 2-261

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.

TRDI recommends you use new O-rings if you are preparing for a deployment.

To replace the O-Ring:

1. 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.).

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

2. 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.

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

3. 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.
4. Lubricate the O-ring with a thin coat of silicone lubricant (Table 13, 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.

   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.

End-Cap Replacement

To replace the end-cap:

1. Stand the WorkHorse on its transducer face on a soft pad.
2. Inspect, clean, and lubricate the O-ring on the housing (see O-ring Inspection and Replacement). Apply a very thin coat of silicone lube on the O-ring.

TRDI recommends you use new O-rings if you are preparing for a deployment.

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.

3. Connect the internal I/O connector to the plug on the common mode choke.
4. 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.

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.

5. Examine the titanium end-cap assembly nuts, bolts, and washers (6-mm) for corrosion; replace if necessary. The Parts Location Drawings shows the assembly order of the end-cap mounting hardware. All the hardware items are needed to seal the WorkHorse properly.
6. Install all four sets of hardware until "finger-tight."
7. 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 5.6 Newton-meters (50 pound-inches).

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.

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.

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

Transducer Head Assembly Replacement

To replace the transducer head:

1. Stand the WorkHorse on its end-cap.
2. Inspect, clean, and lubricate the O-ring on the housing (see O-ring Inspection and Replacement). Apply a very thin coat of silicone lube on the O-ring.

TRDI recommends you use new O-rings if you are preparing for a deployment.

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.

3. Connect the internal I/O connector to the plug on the common mode choke.
4. 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.

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.

5. Examine the titanium transducer assembly nuts, bolts, and washers (8-mm) for corrosion; replace if necessary. The Parts Location Drawings shows the assembly order of the transducer mounting hardware. All hardware items are needed to seal the WorkHorse properly.
6. Install all four sets of hardware until “finger tight.”
7. 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.

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.

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.

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

High Pressure Housings

The high pressure housing upgrade allows you to deploy the ADCP in depths up to 6000 meters. 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.

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.

High-Pressure End-Cap Removal Procedures

Caution label on End-Cap

Wear safety glasses and keep head and body clear of the end-cap while opening.

Any system that was deployed may have pressure inside the housing.

When you need access to the electronics, TRDI recommends removing the transducer head assembly (see High-Pressure End-Cap Removal Procedures).

The Monitor 6000 meter housing is one piece. Follow the High-Pressure Transducer Head Assembly Removal to remove the housing. Use High-Pressure Parts Location Drawings for parts identification.

To remove the end-cap:

1. Dry the outside of the ADCP.
2. Disconnect the I/O cable and install the dummy plug.
3. Stand the ADCP on its transducer faces on a soft pad.
4. Inspect the housing and end cap bolts for any signs of damage such as bending, stretched bolts, crushed or deformed bushings, etc. These signs may indicate that there is internal pressure inside the system.
5. To avoid any possible injury it is ALWAYS recommended that you loosen but do not remove the four end-cap bolts to allow any internal pressure to be vented from the system. **Loosen the end-cap bolts two turns each in a cross-pattern. Repeat until the face seal O-ring is not compressed and the system has the opportunity to vent.** If you note that the end cap moves as you loosen the bolts then this may indicate that internal pressure is present. Be sure to only loosen the bolts far enough to allow the system to vent.
6. Once all four end-cap bolts have been loosened and you are sure that there is no internal pressure, remove the bolts from the end-cap.

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

7. 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.
8. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap aside.
9. 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.

High-Pressure Transducer Head Assembly Removal

1. Remove all power to the WorkHorse.
2. Remove the I/O cable and place the dummy plug on the I/O cable connector (see I/O Cable and Dummy Plug).
3. Stand the WorkHorse on its end-cap.

> Wear safety glasses and keep head and body clear of the end-cap while opening.
>
> Any system that was deployed may have pressure inside the housing.

4. Inspect the transducer bolts for any signs of damage such as bending, stretched bolts, crushed or deformed bushings, etc. These signs may indicate that there is internal pressure inside the system.
5. To avoid any possible injury it is ALWAYS recommended that you loosen but do not remove the four transducer bolts to allow any internal pressure to be vented from the system. **Loosen the transducer bolts two turns each in a cross-pattern. Repeat until the face seal O-ring is not compressed and the system has the opportunity to vent.** If you note that the transducer moves as you loosen the bolts then this may indicate that internal pressure is present. Be sure to only loosen the bolts far enough to allow the system to vent.
6. Once all four bolts have been loosened and you are sure that there is no internal pressure, remove the bolts from the transducer.
7. 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.

> 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.

8. 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.
9. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage.
10. When you are ready to re-assemble the WorkHorse, see High-Pressure WorkHorse Re-assembly.

High-Pressure WorkHorse Re-assembly

Use the High-Pressure Parts Location Drawings for parts identification.

1. 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).
2. Make sure all printed circuit boards, spacers, cables, and screws have been installed.
3. Install two fresh bags of desiccant just before closing the WorkHorse (see Desiccant Bags).

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 for the locations of the following O-rings. Read all instructions before doing the required actions.

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

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.

TRDI strongly recommends 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.

To replace the O-rings:

1. 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.).

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

2. 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.

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

3. Lubricate the O-ring with a thin coat of DC-111 lubricant (Table 13, 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.

   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. The backup O-ring (see Figure 51) 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.

   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.

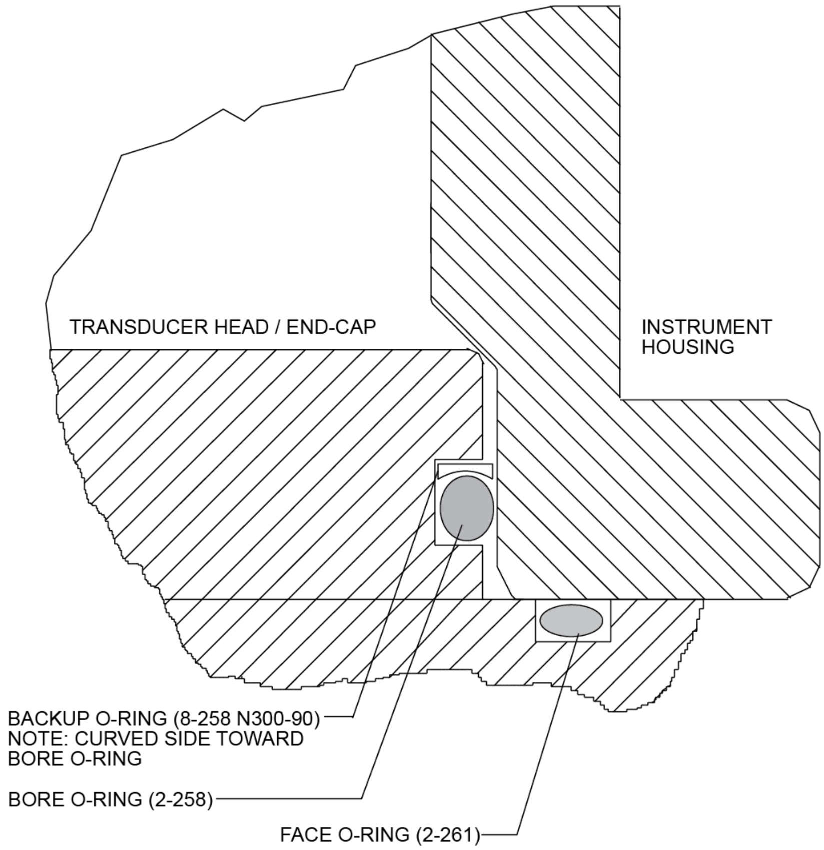


Figure 51. High Pressure O-Ring Detail View

High-Pressure End-Cap Replacement

To replace the end-cap:

1. Stand the WorkHorse on its transducer face on a soft pad.
2. 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.

> TRDI recommends you use new O-rings if you are preparing for a deployment.

> 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.

3. Connect the internal I/O connector to the plug on the common mode choke.
4. 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.

> 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.

5. Examine the end-cap assembly nuts, bolts, and washers (6 mm) for corrosion; replace if necessary. The High-Pressure Parts Location Drawings shows the assembly order of the end-cap mounting hardware. All the hardware items are needed to seal the WorkHorse properly.
6. Install all four sets of hardware until “finger-tight.”
7. 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 5.6 Newton-meters (50 pound-inches).

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.

Do not over tighten the bolts that hold the transducer, housing, and end cap together. If you tighten too much, 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.

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

High-Pressure Transducer Head Replacement

To replace the transducer head:

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

TRDI recommends you use new O-rings if you are preparing for a deployment.

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.

3. Connect the internal I/O connector to the plug on the common mode choke.
4. 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.

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.

5. Examine the transducer assembly nuts, bolts, and washers (8-mm) for corrosion; replace if necessary. The High-Pressure Parts Location Drawings shows the assembly order of the transducer mounting hardware. All hardware items are needed to seal the WorkHorse properly.
6. Install all four sets of hardware until “finger tight.”

7. 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.

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.

Do not over tighten the bolts that hold the transducer, housing, and end cap together. If you tighten too much, 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.

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

Mariner Adapter Plate

The adapter plate helps mount the Mariner transducer head to a vessel. See the Outline Installation Drawings for dimensions. The following procedure explains how to install and remove the Adapter Plate on a WorkHorse Mariner ADCP.

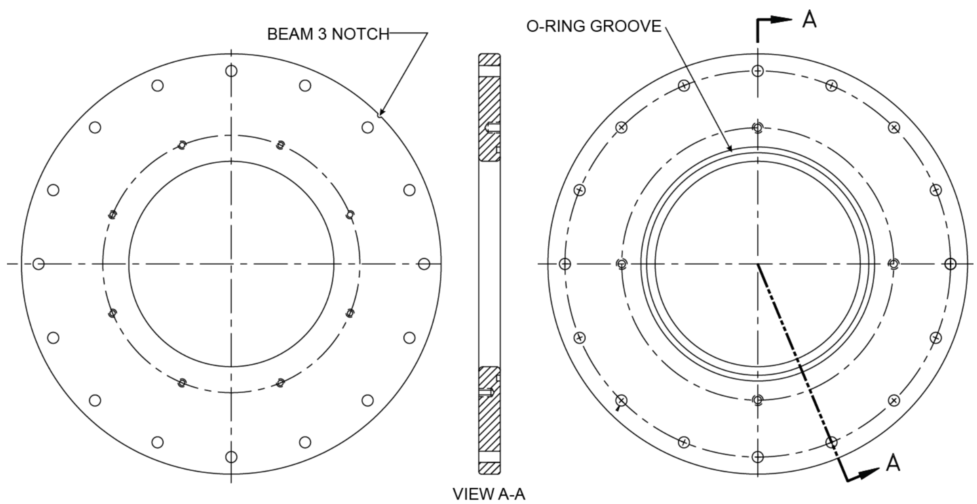


Figure 52. Mariner Adapter Plate

Installing the Adapter Plate

To install the adapter plate:

1. Remove the Transducer Assembly (see Transducer Head Assembly Removal).
2. Inspect and clean the O-ring groove of the Housing Assembly.
3. 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.

> 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. 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.
5. 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.

> 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.

6. 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.
7. Install all four sets of hardware until "finger-tight."

8. 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).

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.

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.

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

9. Install a new desiccant bag from the Adapter Plate Kit into the Housing Assembly.
10. Inspect and clean the O-ring groove of the Adapter Plate.
11. 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.
12. Connect the cable from the end cap assembly to the Power I/O board on the Transducer Assembly.
13. 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.

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.

14. 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.
15. Install all four sets of hardware until "finger-tight."
16. 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).

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.

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.

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

Removing the Adapter Plate

To remove the adapter plate:

1. Remove the Transducer Assembly (see Transducer Head Assembly Removal).
2. Remove the four titanium 8-mm bolts that secure the Adapter Plate to the Housing Assembly.
3. Separate the Adapter Plate from the Housing Assembly.
4. Install the Transducer Assembly (see Transducer Head Assembly Replacement).

Replacing the 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).

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.

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

To replace the battery pack:

1. Remove the end-cap (see End-Cap Removal Procedures).
2. Disconnect the battery cable going to the common mode choke.
3. Remove the four wing nuts, lock washers, and washers holding the battery pack onto the posts (Figure 44).
4. Remove the support plate.
5. Slide out the used battery pack.
6. Slide a new battery pack onto the four posts. Make sure the I/O cable is not pinched by the battery pack.
7. Use the large rubber bands (supplied with each new pack) to hold the cables in place.
8. Test the battery pack voltage by measuring across the battery connector. The voltage should be +42 VDC for a new battery pack.

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.

9. Position the support plate over the four posts.
10. 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.
11. 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.

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.

12. Connect the battery cable going to the common mode choke (see Figure 46)
13. Install the end-cap (see End-cap Replacement).
14. Align the compass (see Compass Calibration).

Replacing the External Battery Case Packs

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). To replace the battery packs, do the following steps.

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.

To replace the external battery case battery packs:

1. Remove one end-cap from the external battery pack (see Figure 45).
2. Place the external battery case on its side and carefully pull out the battery pack (attached to the end-cap).
3. Disconnect the battery power cable from the wiring harness.
4. Remove the four wing nuts, lock washers, and washers holding the battery pack onto the posts (see Figure 44).
5. Remove the support plate.
6. Slide out the used battery pack.
7. 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.
8. Position the support plate over the four posts.
9. Place a flat washer, lock washer, and wing nut on each of the four posts. Tighten the nuts to hold the battery in place.
10. Test the battery pack voltage by measuring across the battery connector. The voltage should be +42 VDC for a new battery pack.

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.

11. Connect the battery power cable to the wiring harness.
12. Install the end-cap/battery pack assembly (see End-cap Replacement).
13. Repeat steps 1 through 12 to replace the other battery pack.
14. Replace the desiccant bags on each battery just before sealing the external battery case (see Desiccant Bags).

Calibrating the Compass

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:

- TRDI recommends **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 or **will provide an improper calibration for the heading sensor once the ADCP operates away from the ship.**
- 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.
- A good compass calibration requires slow, smooth movement to allow the compass to collect data at each point.
- Calibrate the compass as close to the location that it will be deployed and as far away as possible from objects that have magnetic fields that could result in a poor calibration. **Common objects to avoid calibrating the compass near include steel reinforced concrete, buildings, and automobiles.**
- **Completing the calibration rotation(s) does not guarantee an acceptable compass error.** Compass error is based not only on the quantity of measurements made during the calibration but also the quality of the magnetic environment. Attempting to calibrate the compass in a poor environment, e.g., near fixed ferrous objects, will likely result in an unacceptable compass error regardless of how well the calibration is performed.
- The Single-tilt calibration is intended for applications where tilting the unit is not practical. **This calibration is only applicable to the tilt orientation the unit is rotated about during the calibration**.

Compass Background

The compass calibration algorithm collects magnetic field vector information for various measured headings during the calibration. Hard and soft iron effects rotating with the compass are made observable during the calibration by causing the local field to be perturbed as the compass is spun during the calibration. That is, each component of the hard and soft iron has to alternately increase the local field for some orientations and decrease for orientations 180 degrees (or 90 degrees for soft iron) from those orientations for the algorithm to "notice" it. Tilting and rotating the compass about the vertical axis is sufficient to do this.

There are three compass calibrations to choose from; one only corrects for hard iron while the second corrects for both hard and soft iron characteristics for materials rotating with the ADCP. The third method provides calibration for a single tilt orientation. 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.

Preparing for Calibration

To prepare for compass calibration:

1. 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.

   If you are using a calibration stand, place the ADCP in the stand in the same orientation as it will be deployed.

The WH-1 is shown with a Teledyne RD Instruments Workhorse loaded for a UPWARD Looking Profile Calibration (Center) and loaded a for DOWNWARD Looking Profile Calibration (Right).

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

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.

2. Connect the WorkHorse as shown in [Setting up the WorkHorse System](#).
3. Start *BBTalk*. See the RDI Tools User's Guide for assistance on using *BBTalk*.

Compass calibration stands are not required to calibrate the WorkHorse compass, but they do make it much easier and increase the calibration accuracy. Calib Designs is one source for calibration stands. Contacting this company is done with the knowledge that Teledyne RD Instruments is not recommending them, but only offering this as a source for the stand.

http://www.calibdesigns.com/index.html

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 5º of rotation for a full 360º rotation. When it has collected data for all required directions, the WorkHorse computes and displays the results.

> 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).

To verify the compass calibration:

1. Prepare the ADCP for calibration (see Preparing for Calibration).
2. Using *BBTalk,* send a Break to wake up the WorkHorse.
3. At the > prompt, type **AX** and press the **Return** key.
4. 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).

Compass Calibration

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.

To calibrate the compass:

1. Prepare the ADCP for calibration (see Preparing for Calibration).
2. Using *BBTalk,* send a Break to wake up the ADCP.
3. At the > prompt, type **AR** and press the **Return** key. This will return the compass to the factory calibration matrix.
4. At the > prompt, type **AF** and press the **Return** key. Choose option "a" or "b" to start the calibration procedure.

```
Field Calibration Procedure
Choose calibration method:
     a. Remove hard iron error (single cycle) only.
     b. Remove hard and soft iron error (single + double cycle).
     c. Calibration for a single tilt orientation (single + double cycle).
     d. Help.
     e. Quit.
```

> In general, the hard iron calibration is recommended for Monitor and Mariner systems because the effect of hard iron dominates soft iron.
>
> For Sentinel systems that have just replaced the battery, then use the combined hard and soft iron calibration. Changing the WorkHorse Sentinel batteries should only change the hard-iron signature of the ADCP, but can induce both single and double cycle compass errors.

5. Tilt the ADCP (see Figure 53). 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.

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

6. When prompted, rotate the ADCP slowly 360 degrees (approximately 5 degrees per second).
7. The second rotation requires the ADCP to be tilted 15 degrees in another direction than from the first rotation (see Figure 53). Follow the on-screen instructions to orient the ADCP correctly. When prompted, rotate the ADCP slowly 360 degrees (approximately 5 degrees per second).
8. 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.
9. 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.
10. 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.

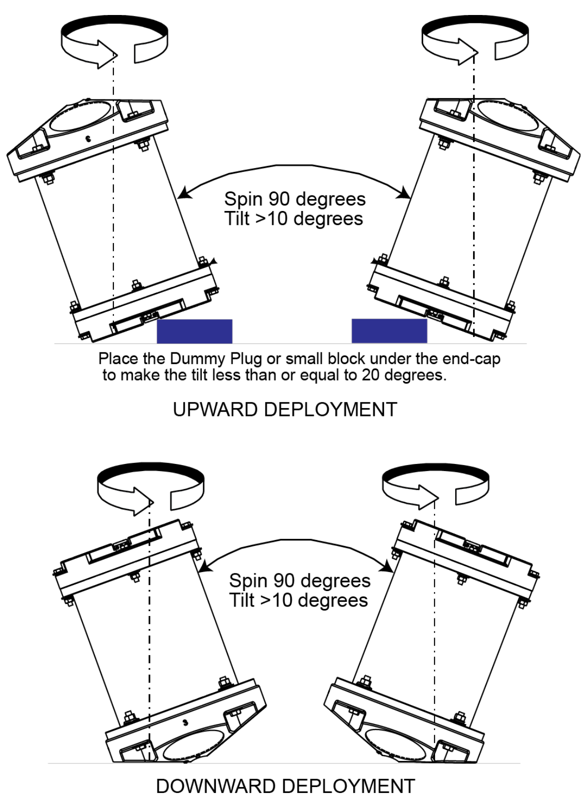


Figure 53. Compass Calibration

Single-Tilt Compass Calibration Procedure

This procedure is used to correct the ADCP's internal flux-gate compass for one-cycle deviation errors. The compass correction procedure given here can be used in place of the Compass Calibration procedures if you are using a WorkHorse ADCP with firmware version 16.30 or higher.

During this procedure, the ADCP must be rotated in a complete 360 circle no faster than 5 degrees per second. This calibration can be done in the water (recommended) or on shore. It is important to reduce any pitch and roll effects during the turn and avoid any acceleration.

This calibration is intended for applications where tilting the unit is not practical. This calibration is only applicable to the tilt orientation the unit is rotated about during the calibration.

Single tilt calibration does a hard-iron correction only. Changing the WorkHorse Sentinel batteries should only change the hard-iron signature of the ADCP, but can induce both single and double cycle compass errors. A single-tilt calibration should suffice, but performing a full hard and soft iron calibration is always a safer route whenever possible.

To calibrate the compass:

1. Mount the ADCP in the boat as it will be used to acquire data.
2. Start *BBTalk*.
3. At the ">" prompt, type **AR** and press the **Return** key. Type **Y** to return the Fluxgate Calibration Matrices with the factory original values.

```
>AR
Do you really want to write over the active fluxgate calibration
   data [y or n]?Y

Fluxgate Calibration Matrices Updated with Factory Original Values.

>
```

4. At the ">" prompt, type **AF** and press the **Return** key. Select option "c" Calibration for a single tilt orientation (single + double cycle).

```
Field Calibration Procedure
Choose calibration method:
     a. Remove hard iron error (single cycle) only.
     b. Remove hard and soft iron error (single + double cycle).
     c. Calibration for a single tilt orientation (single + double cycle).
     d. Help.
     e. Quit.
c
```

5. During the calibration, drive the boat in a continuous small circle. You can accomplish this by adjusting the throttle to just above idle and steering either hard left or hard right. You will want to reduce any pitch and roll effects during the turn. Do not move about the boat as this may cause the boat to change how it sits in the water. Avoid any accelerations during the calibration. If you are working on a river, you will find that you drift downstream as you perform the circles. This will not affect the calibration.
6. While you continue to drive the boat in circles, press any key to start the compass calibration. Follow the on screen prompts.
7. Press **D** for details.

```
HEADING ERROR ESTIMATE FOR THE CURRENT COMPASS CALIBRATION:
   OVERALL ERROR:
      Peak Double + Single Cycle Error (should be < 5ø):  ñ 1.73ø
   DETAILED ERROR SUMMARY:
      Single Cycle Error:                                 ñ 1.70ø
```

```
      Double Cycle Error:                               ñ 0.42ø
      Largest Double plus Single Cycle Error:           ñ 2.12ø
      RMS of 3rd Order and Higher + Random Error:       ñ 0.77ø
      Orientation:    Down
      Average Pitch:  -0.18ø         Pitch Standard Dev:    0.37ø
      Average Roll:    0.35ø         Roll Standard Dev:     0.45ø

Successfully evaluated compass performance for the current compass calibration.

Press C to display Percent Horizontal Field Components
     Relative to Calibration or any other key to continue....
Calibration parameters have been updated in NRAM.

>
```

8. You can now use the ADCP with its corrected compass.

Periodic Maintenance Items

Replacing the 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 13, item 6) whenever you are preparing to deploy or store the WorkHorse for an extended time.

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

Do not puncture or tear the desiccant bag. Do not use desiccant bags that are torn or open.

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. TRDI recommends replacing the desiccant bag just before the deployment.

To replace the desiccant:

1. Remove the transducer head (see Transducer Head Assembly Removal).
2. Remove the new desiccant bags from the airtight aluminum bag.
3. Remove the old desiccant bags and install two new ones. For Monitor and Mariner systems, place the desiccant bags (Table 13, item 6) between the PIO board and the end-cap. For Sentinel systems, place the desiccant under one of the rubber bands on the battery pack (see Parts Location Drawings).
4. Install the transducer head (see Transducer Head Assembly Replacement).

Cleaning the Thermistor Cover

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.

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

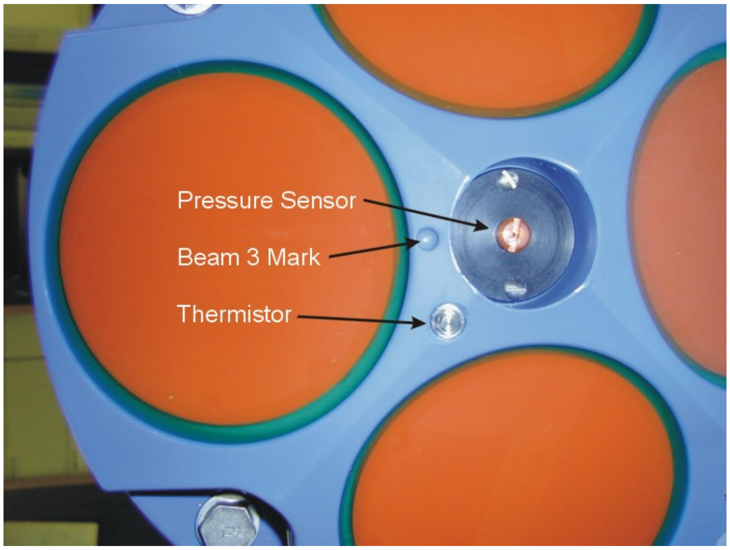


Figure 54. Thermistor and Pressure Sensor

Cleaning the Pressure Sensor Port

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 55 to clean the screw.

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

To clean the pressure sensor port:

1. Place the ADCP on its' end-cap. Use a soft pad to protect the ADCP.
2. Use a straight-slot screwdriver to remove the copper pressure sensor port screw.
3. 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).
4. 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 TRDI for repair.

The pressure sensor installed on the high pressure WorkHorse systems is installed in an anodized aluminum cavity that includes a plastic protective cover to hold the copper screw. This cover is held into place with two M3 screws. The holes where the M3 screws are inserted in the 6000 meter pressure sensor housing are anodized aluminum.

TRDI knows from our experience that it is difficult to anodize sharp edges on threaded holes such as these. In marine and fresh water environments, poor anodizing on aluminum will lead to corrosion problems. **Always inspect for corrosion in this (and all) areas between deployments.**

On 6000 meter WorkHorse systems:

1. Remove the M3 screws and cover disk. Look for signs of corrosion such as white deposits. If corrosion caused part of the pressure sensor housing to be visibly damaged, do not redeploy your system. Send it back to TRDI for inspection (see Returning Systems to TRDI for Service).
2. Clean both M3 screw mounting holes with a thin brush and lime based product. Flush the holes with the lime based product if you do not have a brush available. Be sure to clean and remove any signs of corrosion.
3. Brush the M3 screws with marine environment grease such as Aqua Shield® grease. Use gloves as the grease tends to stick to your skin. Note that the grease is incompressible and therefore apply a thin layer to the screws to avoid binding or difficulty in the installation of the screws in the mounting holes. Place the cover disk over the pressure sensor and tighten the screws "finger tight" (2 in/lbs).
4. 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).
5. 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 TRDI for repair.

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 attempt to clean the surface of the pressure sensor. The diaphragm is very thin and easy to damage.

If the pressure sensor surface looks corroded or is bowed outward, then contact TRDI for servicing. Do not attempt to remove the pressure sensor. It is not replaceable in the field.

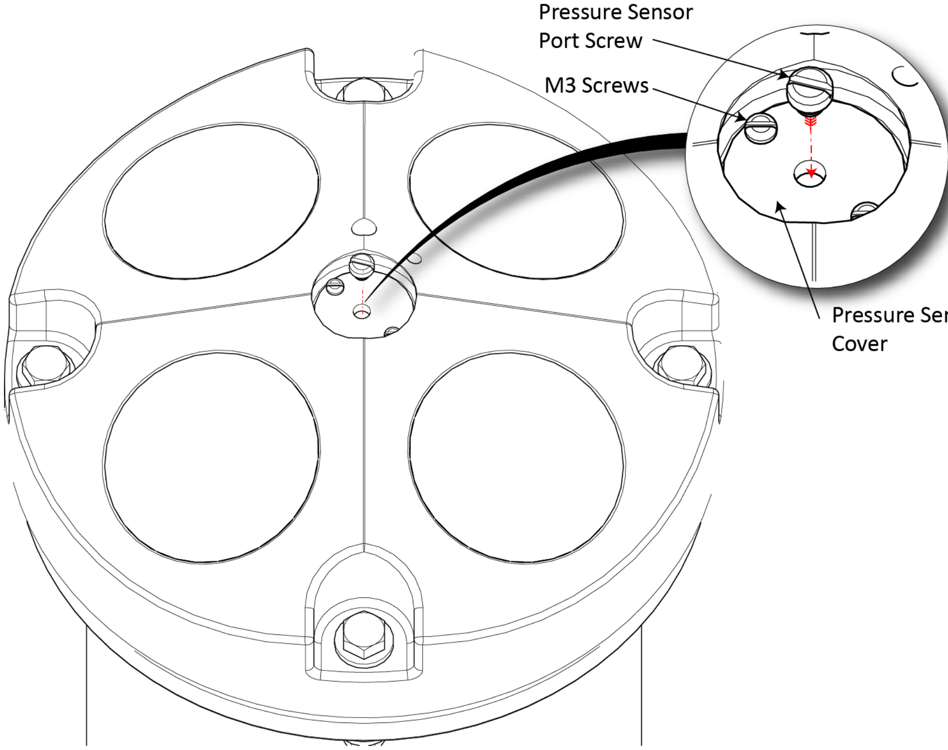


Figure 55. WorkHorse Pressure Sensor

Replacing the PC Card Recorder

The PC Card recorder is located on the Digital Signal Processor (DSP) board inside the WorkHorse's electronics (see Figure 56). 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:

1. Turn off power to the WorkHorse.
2. Remove the transducer head (see Transducer Head Assembly Removal).
3. 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.

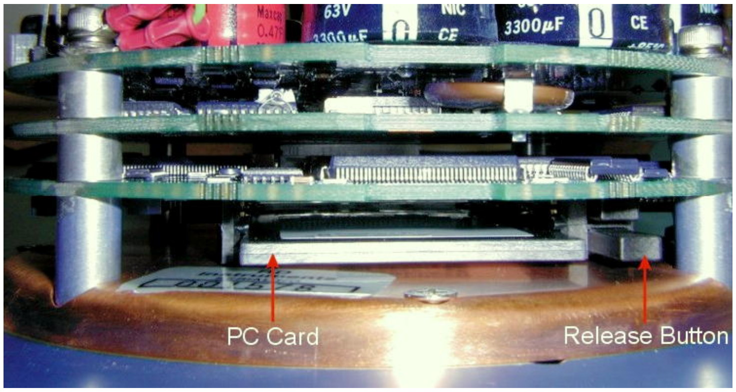


Figure 56. PC Card Recorder

4. 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.
5. Install the transducer head (see Transducer Head Assembly Replacement).

Do not use a PCMCIA adapter for compact flash cards. These do not work.

Do not delete files from the PC card using Windows®. This may leave hidden files on the card. Always use the ADCP's erase command to delete data from the PC card recorder.

Installing Firmware Upgrades

The firmware for WorkHorse ADCPs in located on flash RAM chips on the CPU board. Firmware upgrades can be downloaded from TRDI's website support page (www.rdinstruments.com). If the firmware upgrade is not available via the web, then please contact Field Service (rdifs@teledyne.com) to request a copy.

To install a firmware upgrade:

1. Connect your ADCP to the computer as shown in Setting up the WorkHorse System.
2. Start the program *WHMSLxxx.exe* (where *xxx* is the firmware number).
3. 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.
4. Click **Next** and follow the on-screen prompts.
5. If you are not able to install the new firmware, contact Customer Service.
6. After successfully upgrading the firmware, use *BBTalk* to test the ADCP (see Testing the WorkHorse).

Installing Feature Upgrades

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

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

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**).

To install a feature upgrade:

1. Set up the WorkHorse as shown in Setting up the WorkHorse System.
2. Start the program *Activate_WH_xxxx.exe* (where *xxxx* is the ADCP's serial number).
3. The installation program will start (see Figure 57). The program is encoded with the ADCP's serial number and the requested feature upgrade.

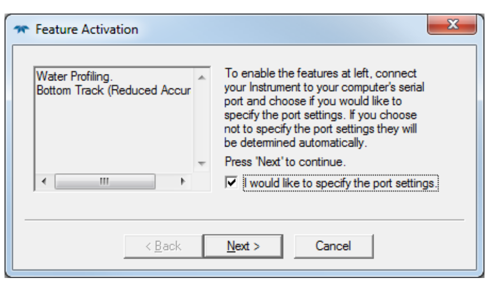
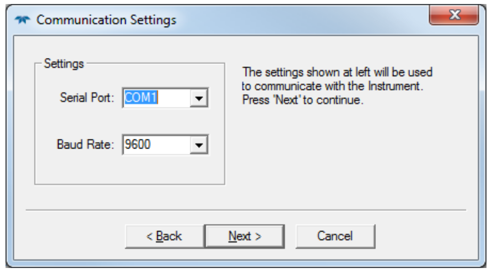


Figure 57. Installing Feature Upgrades

4. To select the port settings, select the **I would like to specify the port setting** box and click **Next**.



5. Select the **Serial Port** and **Baud Rate**.
6. Click **Next** to install the feature upgrade.
7. Click the **Finish** button to exit the program.
8. Start *BBTalk* and use the OL command (see the WorkHorse Commands and Output Data Format guide) to verify the feature upgrade has been installed.

Replacing Fuses

PIO Board. There is one fuse on the PIO Board (see Figure 46) that protects the WorkHorse from excessive incoming power. If this fuse continues to blow, check your input power before applying power again.

To replace the fuse:

1. Turn off the power.
2. Remove the transducer head (see Transducer Head Assembly Removal).
3. 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.
4. Gently pull the fuse housing out. Turn the housing to remove the fuse.
5. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse (Table 13 item 7).
6. Install the transducer head (see Transducer Head Assembly Replacement).
7. Test the system (see Testing the WorkHorse).

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.

To replace the fuse:

1. Remove one end-cap from the external battery pack (see End-Cap Removal Procedures).
2. Carefully lift out the battery pack (attached to the end-cap).
3. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse (Table 13 item 7).
4. Install the end-cap (see End-cap Replacement).
5. 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 - 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).

To replace the fuse:

1. Turn off power to the deck box.
2. Press down gently on the top edge of the fuse holder.
3. Pull the fuse holder out and down. It will extend approximately one inch. Do not attempt to remove it completely.
4. 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.
5. Place the replacement fuse (and another spare as necessary) in the fuse holder.
6. Gently push the fuse holder back in place.
7. Turn on power and test the system (see Testing the WorkHorse).

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.

To replace the fuse:

1. Turn off power to the deck box.
2. Remove the Deck Box top cover.
3. Remove the fuse from the clips. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse.
4. Replace the Deck Box top cover.
5. Turn on power and test the system (see Testing the WorkHorse).

Changing Communications Setting

A switch on the PIO board (see Figure 58) 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 your computer only has an RS-232 COM port.

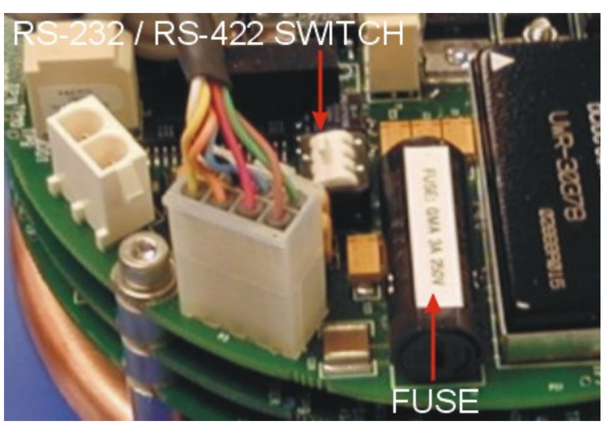


Figure 58. Communication Switch and Fuse

Preventing 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 water. This means WorkHorse ADCP systems are subject to biofouling. 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 ADCP. Therefore, you should take steps to prevent biofouling during shallow water deployments.

Some organizations may decide to use antifouling grease. However, most antifouling greases are toxic and may cause problems. Recent tests suggest antifouling grease may cause the urethane on the transducer faces to develop cracks. Warmer temperatures accelerate this effect. If using antifouling grease, remove the grease immediately after recovering the ADCP from its deployment. Remove the grease with soapy water because cleaning solvents may also cause the urethane to crack. Be sure to wear protective gloves and a face shield.

The best-known way to control biofouling is cleaning the ADCP transducer faces often. However, in many cases this is not possible.

The following options can help reduce biofouling:

- Coat the entire ADCP with antifouling paint. Make sure that the paint is applied in an even coat over the transducer faces and inductive modem (see Applying Antifouling Paints).
- Apply a thin coat (1 mm, 0.039 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.
- If using antifouling grease, remove the grease immediately after recovering the ADCP from its deployment. Remove the grease with soapy water. Be sure to wear protective gloves and a face shield.

If using antifouling grease, remove it immediately after recovering the ADCP.

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.

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.

Antifouling Paints

You can use almost any EPA approved anti-fouling paint on the housing or the urethane transducer faces. Contact the antifouling paint manufacturer for preparation and application procedures for this and other antifoulant paints. Interlux is one source of antifouling paint. Contacting this company is done with the knowledge that Teledyne RD Instruments is not recommending them, but only offering this as a source for the anti-fouling paint.

Manufacturer	Contact
Courtalds Finishes	Telephone: +1 (800) 468-7589
Interlux brand paints	Web Page : http://www.yachtpaint.com/usa/

Do not use antifouling paints that contain cuprous oxide on aluminum housings as it will cause galvanic corrosion.

Applying Antifouling Paints

The following tips are only general recommendations. Always follow the anti-fouling paint manufacturer's instructions on how to apply the anti-fouling paint.

TRDI recommends that any antifouling coating should be applied in as thin a layer as possible. It should be understood that applying a coating may reduce the measurement range of the ADCP (though it will not affect its accuracy in the measurable range).

As originally manufactured, the transducer faces have a smooth surface which makes it inhospitable for most biofouling to develop. Preserving this smooth surface is an effective way to prevent heavy biogrowth on the transducer faces. However, if an antifouling coating is desired on the transducer faces, then the faces must be lightly abraded to allow for the antifouling coating to adhere. **As a rule, the surface must be kept smooth unless an antifouling coating will be applied.**

1. Transducer Face Surface Preparation and high pressure painted housings - Lightly abrade the surface using Scotch Brite® to remove gloss. Thoroughly clean the areas to be painted with soapy water and dry.
2. Surface Application:
   - Mask as necessary. Do not paint over mounting hardware, anodes, pressure sensors, etc.
   - Apply an even, thin layer (0.1mm, 4mil per coat) of antifouling paint. If more than one coat is needed to reach the maximum thickness, allow each coat to dry for 16 hours.
   - When applying paint to the urethane faces, use extra caution to apply a smooth, thin coat of paint.

If the ADCP includes the optional pressure sensor, do not block the sensor port. The sensor port is a small hole in the center of the copper screw (see Pressure Sensor Maintenance). During anti-fouling paint application, tape off the screw. Once the anti-fouling paint has cured, remove the tape.

This means that the sensor port is not fully protected from bio fouling. Even though the sensor port is surrounded by the antifouling paint, bio fouling may still build up on the copper 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 port, 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.

Figure 59. Antifouling Paint Applied to a WorkHorse Sentinel

Removing Biofouling

To remove foreign matter and biofouling:

1. Remove soft-bodied marine growth or foreign matter with soapy water. Waterless hand cleaners remove most petroleum-based fouling.

> 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. The urethane coating on the transducer faces could be damaged.

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 ADCP operation, but TRDI does 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.

> If barnacles have entered more than 1.0 to 1.5 mm (0.06 in.) into the transducer face urethane, you should send the ADCP to TRDI for repair. If you do not think you can remove barnacles without damaging the transducer faces, contact TRDI.

2. Rinse with fresh water to remove soap or Lime-Away® residue.
3. Dry the transducer faces with low-pressure compressed air or soft lint-free towels.

> Always dry the ADCP before placing it in the storage case to avoid fungus or mold growth. Do not store the ADCP in wet or damp locations.

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.

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.

To inspect the anodes:

1. 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.
2. 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.
3. If you have doubts about the condition of the anodes, remove and replace the anode.

Zinc Anode Electrical Continuity Check

Check electrical continuity using a digital multi-meter (DMM). Scratch the surface of the anode with the DMM probe to make good contact if the anode is oxidized. All measurements must be less than five ohms. If not, reinstall the affected anode.

End-Cap Anode. Measure the resistance between all four anodes.

Housing Anodes. Measure the resistance between all four anodes.

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.

Zinc Anode Replacement

To remove and replace the zinc anode/s:

1. Remove the RTV from the anode screw heads. Remove the screws.
2. 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.
3. Clean the bonding area under the anode. Remove all foreign matter and corrosion. Apply a continuous 1 to 2 mm bead (0.04-0.08 in.) of RTV around each screw hole.
4. Set a new anode in place and fasten with new screws.
5. 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.
6. Check the electrical continuity. If any measurement is greater than one ohm, reinstall the affected anode.

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.

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.

Do not use magnesium anodes. Magnesium rapidly corrodes aluminum housings.

Protective Coating Inspection and Repair

TRDI uses paint on the high pressure housing for identification and corrosion protection. For more protection, the case and the transducer assembly are first anodized per MIL-A-8625, Type 3, Class 1 and sealed with sodium dichromate. Do not damage the surface coatings when handling the ADCP.

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 (light blue or yellow for 6000 meter systems). Be critical in your judgment; the useful life of the ADCP depends on it.

The procedures contained in this section apply to our standard aluminum systems. For systems made of other materials, contact TRDI. Read all instructions before doing the required actions.

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.

If there is any damage to the paint near the edges of the urethane transducer cups or the I/O connector, DO NOT DEPLOY THE ADCP. Return the WorkHorse to TRDI for repair.

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 there is damage to the anodizing, return the ADCP to TRDI for repair.
2. Clean the area with alcohol. Do not touch the area after cleaning.
3. Mix the epoxy primer Part A and Part B using a 1:1 mix. Paint one coat of epoxy primer (see note below). Allow the primer to dry thoroughly before continuing.
4. Mix the colored paint using two parts color and 1 part catalyst. Paint with one coat of colored paint (see note below).

The catalyst (hardener) will rapidly harden in air. Mix only the amount of paint you need and work quickly.

TRDI uses two-part epoxy type paint. This paint is manufactured by Sherwin –Williams Proline Paint Store, 2426 Main St., San Diego, CA, 92113-3613, Telephone: +1 (619) 231-2313.

Primer Manufacturer's part numbers:
F-158 for 6000 meter systems (part A and part B)
3061 for all other systems (part A and part B)

Colored paint Manufacturer's part numbers:
4800HS, Catalyst,
4800-19, Yellow
4800-28, Orange
4800-01, Snow White
4800-25, Bright Blue

Contact the paint manufacturer for preparation and application procedures for this and other paints. Contacting this company is done with the knowledge that Teledyne RD Instruments is not recommending them, but only offering this as a source for the paint.

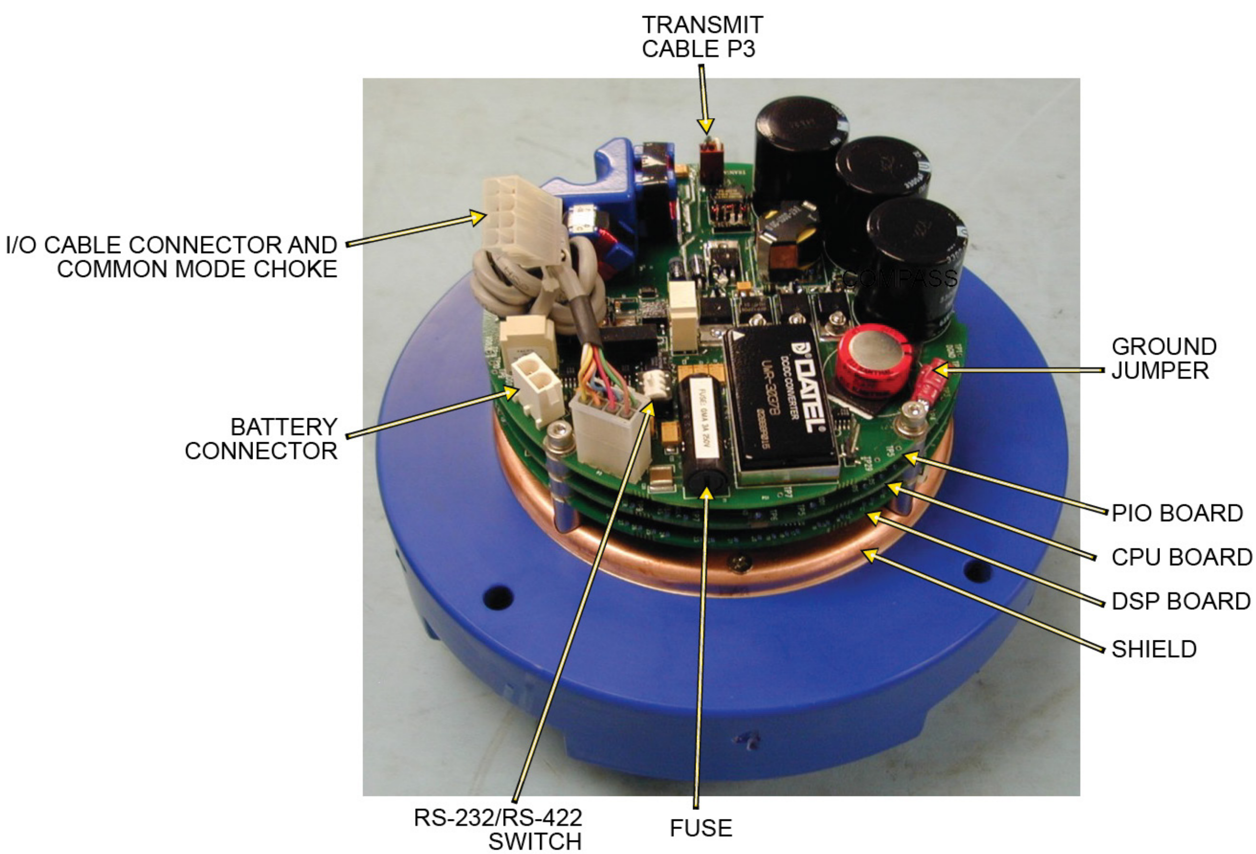
Installing the Spare Boards Kit

The Spare Boards Kit has been set up so that you will replace all three of the WorkHorse boards at once. This is done so that you do not have to risk damaging the individual boards while swapping in individual boards. The heading, pitch, and roll sensors have all been calibrated (the temperature sensor is an independent calibration and not changed by these new boards). Once you have replaced the original boards, place them back in the Spare Board Kit box and contact Teledyne RD Instruments Customer Service Department so that you can return them for repair.

Before handling either the Spare Board Kit or the original Board Set, always wear an earth-grounding static protection strap. The electronics in the WorkHorse are very sensitive to static discharge. Static discharge can cause damage that will not be seen immediately and will result in early failure of electronic components.

TRDI assumes that a qualified technician or equivalent will perform all of the following work.

The Spare Boards Set will allow your system to perform to the same velocity specifications as your original set. However, there is an offset error in the compass that can be as great as ±1.5 degrees. This error CANNOT be removed by doing the Field Calibration procedure (AF command) even though you MUST do this as part of the installation. The additional ±1.5 degrees can only be removed by TRDI at the factory. In most cases, the total compass error will still be within our original specification of ±5.0 degrees. The only way to be sure that you have smaller errors than this specification is to perform your own local compass verification and correct any errors you find during post processing of the data.



Remove the Original Set of Boards

To remove the original boards:

1. Remove the Transducer assembly from the pressure case. Use Transducer Head Assembly Removal for instructions.
2. With your earth-ground static protection strap on, use a 3mm Allen wrench, to remove the four bolts that secure the three original WorkHorse boards to the Transducer assembly.
3. Note the orientation of the transmit cable connector as it is plugged into the PIO board and to the Receiver board (see Figure 60).

   This cable must be removed and it has a very tight fit. To remove this cable, lift straight up on the three boards and tilt slightly (no more than 2 cm) toward the cable. This should allow you enough slack to unplug the cable from the PIO board. If this is not possible you may unplug the cable from the Receiver board. Be sure to note its orientation before unplugging.

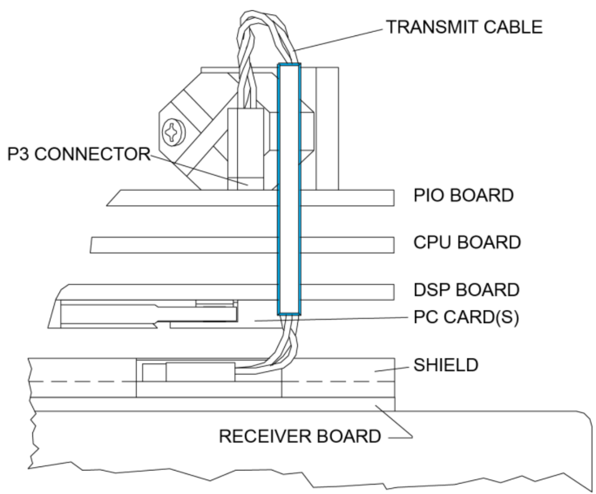


Figure 60. Transmit Cable

4. Once the transmit cable has been disconnected you may now remove the top three boards as a set by lifting the set straight up.

   These top three boards are connected to each other via connectors and will remain as one piece (see Figure 61). The DSP board connects to the Receiver board through a 26-pin header. The 26-pin header is a series of male pins. The 26-pin header may or may not stay connected to the DSP board when you remove the top three boards. If you see that there are male pins sticking out of the DSP board when you finish removing the board set then the header has remained attached to the DSP board. If this happens remove it and place it into the Receiver board. To remove it, gently rock it back and forth while pulling it away from the DSP board. Once removed, align it with the connector on the Receiver board and press it into place.

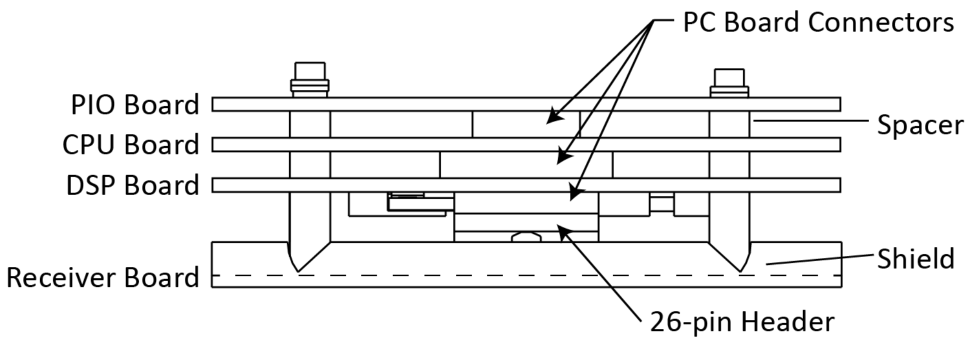


Figure 61. PC Board Connectors

5. Remove all PCMCIA card(s) from the original set of boards. These PCMCIA cards will be used again once you install your Spare Boards Set. The Spare Board set does NOT contain a PCMCIA card(s). The PCMCIA card(s) are located on the bottom of the DSP board. To remove the PCMCIA card(s) press the button(s) on the side of the PCMCIA card slot. As you press this button the PCMCIA card will slide out. You will have to pull the card(s) out the rest of the way once the button is depressed all the way in.
6. Set the original board set to the side for now.

Installing the Spare Board Kit

To install the spare boards kit:

1. With your earth-ground static protection strap on, remove the Spare Board Kit from the anti-static bag.
2. Using a 3 mm Allen wrench and a 7mm wrench remove the nuts from the bolts that secure the Spare Boards together. You will be using these bolts to secure the spare set in your system. DO NOT change the position of any of the bolts. The bolt containing the felt washers and ground jumper must remain in the same position (see Figure 62).

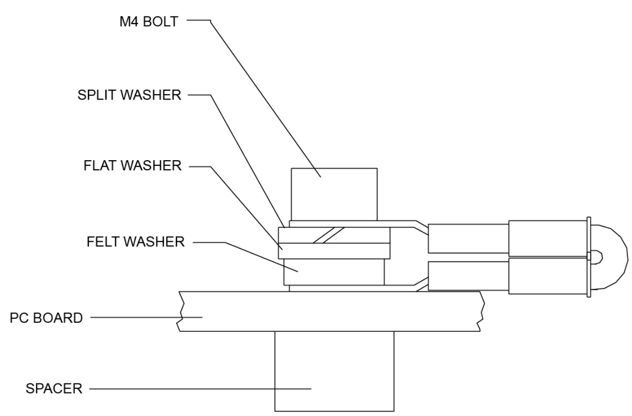


Figure 62. Ground Jumper

3. Place the nuts (just removed) on the four bolts of your original set of boards and place them into the anti-static bag. You will use the new set of bolts included in the Spare Board kit to secure them to the Transducer assembly.
4. Install all PCMCIA cards removed in Remove the Original Set of Boards step e into the PCMCIA card slots. The PCMCIA card is keyed and will only connect when it has been aligned correctly and slid all the way in. The PCMCIA card is installed with the label side pointing away from the DSP board.

5. Connect the Spare Board set to the Receiver board. Align the Spare Board set to the 26-pin header connected to the Receiver board. As you connect the Spare Board set, connect the transmit cable you removed in Remove the Original Set of Boards step c. Be sure to connect the cable in the same orientation as was installed on the original board set.

   To test that the transmit cable is connected properly, start *BBTalk* and run the PT4 test. The test failure example shown below is what you would see for a missing or improperly attached transmit cable.

```
[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 16.21
Teledyne RD Instruments (c) 1996-2002
All Rights Reserved.
>pt4

IXMT    =      0.0 Amps rms  [Data= 0h]
VXMT    =     19.3 Volts rms [Data=4ch]
   Z    =    999.9 Ohms
Transmit Test Results = $C0 ... FAIL
>
```

6. Insert the four new bolts and tighten to 4 Newton-meters.
7. Install the Transducer into the Pressure Case. See WorkHorse Re-assembly for instructions.

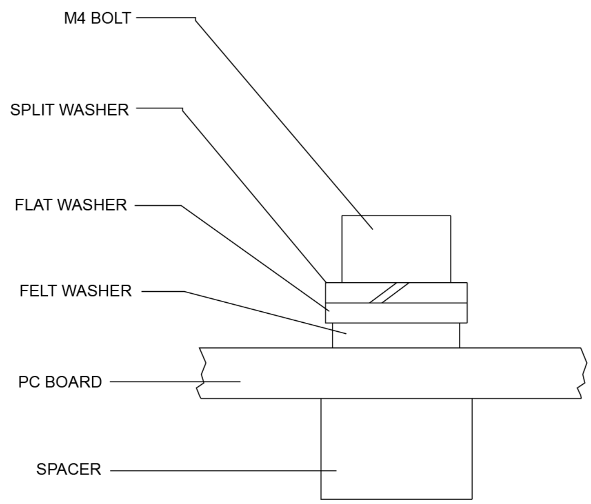


Figure 63. Mounting Hardware

Installing the Beam Cosine Matrix

The beam cosine matrix table corrects small transducer beam misalignment angles that occur during manufacturing.

To install the beam cosine matrix:

1. Connect your WorkHorse ADCP as you would normally and apply power.
2. Start *BBTalk* and confirm that the WorkHorse ADCP is communicating normally and which communication port you are using (COM 1 or COM 2).
3. Place the Beam Cosine Matrix CD into your computer's disk drive.
4. Run the script file *xxxx BEAM COSINE MATRIX.rds* (where xxxx is your system serial number).

   Your Beam Cosine Matrix table will automatically be updated in your ADCP. You can view the contents of this file to confirm that the data entered during the &V portion matches the contents in the PS3 results under the label Q14.

Installing the Pressure Sensor Coefficients

If the ADCP included a pressure sensor, the pressure sensor coefficients must be loaded.

To install the pressure sensor coefficients:

1. Connect your WorkHorse ADCP as you would normally and apply power.
2. Start *BBTalk* and confirm that the WorkHorse ADCP is communicating normally and which communication port you are using (COM 1 or COM 2).
3. Place the CD into your computer's disk drive.
4. Run *xxxxx PRESSURE SENSOR COEFFICIENTS.rds* (where xxxx is your system serial number) to install the pressure sensor coefficients appropriate to the system.

   The Pressure coefficients will automatically be updated in your ADCP. You can verify the pressure sensor coefficients loaded by viewing the PS0 results.

Testing the System

To test the system after replace any board(s):

1. Install the Transducer in the Pressure Case.
2. Connect the cable and power as you normally do and test the ADCP as shown in Testing the WorkHorse. All PA tests should pass when run in water and the PC tests should pass with the ADCP out of water.
3. Perform a field calibration of your compass. Use Compass Calibration for instructions on running the AF command. Remember that there will be up to 1.5 degrees of offset error in the compass measurement. This error is not removed by the field calibration.

You have completed the WorkHorse Spare Board Installation. The original boards can be returned to TRDI for repair. Please contact the Teledyne RD Instruments Customer Service Department for return shipping instructions and repair costs (see Technical Support).

If the ADCP included optional feature upgrades, these features must be re-installed. See Installing Feature Upgrades for instructions

Replacing the End Cap Connector

This section explains how to replace the 7-pin end-cap connector on a Workhorse or external battery.

> Some older WorkHorse end-caps may have the connector brass lock nut glued into place. If this is the case for your end-cap assembly, TRDI recommends that you purchase a new end cap assembly.

Equipment Provided

The WorkHorse End-Cap Tools Kit (P/N 757K6122-00) includes the following:

- Socket, lock nut removal
- Extracting wrench
- Plug, dummy, modified

The End Cap Replacement Kit P/N 757K6123-00 (200 and 500 meter systems), 757K6125-00 (6000 meter systems), and 757K6149-00 (WorkHorse External Battery case) includes the following:

- 7-pin end-cap connector with cable and 2-014 O-ring
- Isolation bushing and 2-017 O-ring (metal end-caps only)
- Connector, header, 8-pin Molex or 2-pin as needed
- Fuses and fuse holders, wire, shrink tube (External Battery kit only)
- Nut, brass
- End-cap O-ring(s)
- Desiccant
- Silicon lubricant, 4-pack
- Loctite® 242
- Cord, lacing, black

Customer Supplied Additional Equipment

- Soft pad (ESD Safe) to rest WorkHorse on while dissembling and reassembly
- Socket wrench handle
- Torque Wrench (35 Inch/pound / 4 N-M)
- Multi-Meter

Removing the End-Cap Connector

To remove the end-cap connector:

1. Remove the end-cap from the housing.
2. Insert the modified dummy plug into the connector.

Figure 64. Modified Dummy Plug

3. Place the Extracting Wrench over the connector and dummy plug. The wrench will fit into the End Cap slot.

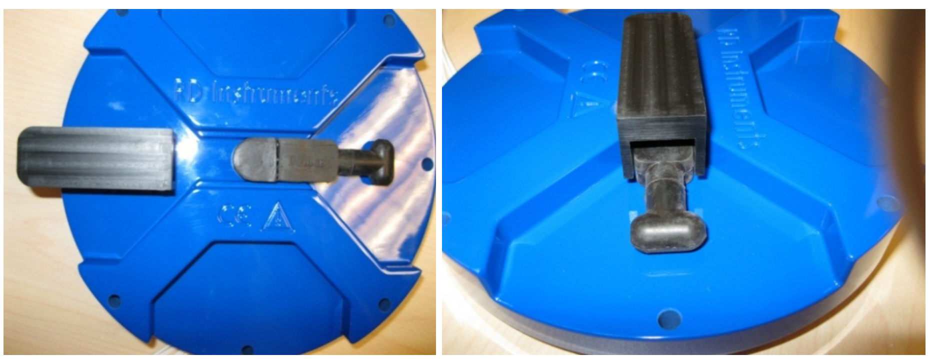


Figure 65. Extracting Wrench

4. Flip the end-cap assembly over and insert the socket onto the lock nut. Slide the cable wires into the socket's clearance slot.

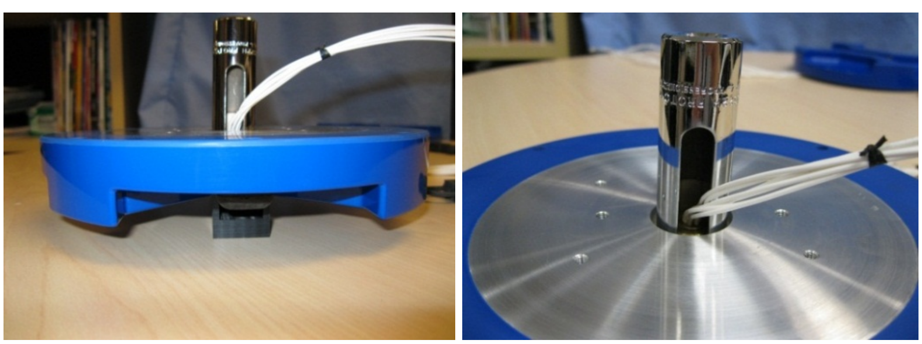


Figure 66. Lock Nut Removal Socket

5. Attach a ratchet wrench to the socket and remove the lock nut.

Figure 67. Removing the Connector

6. Remove the Molex 8-pin header connector by cutting the wires approximately 3-inches from the connector. Remove the connector from the end-cap.

> USE CAUTION – do not score or scratch the O-ring seal bore.

7. Remove all the tools and clean the end-cap thoroughly with Flux-Off® cleaner (or similar product). The O-ring pocket must be free of dirt, burrs and divots.

> Replace the end cap if any burrs or divots are found. These could provide a leakage path into the ADCP housing.

Installing the New End-Cap Connector

To install the new connector:

1. Clean the connector threads with Flux-Off® cleaner (or similar product).
2. Apply a **light** coat of silicon lubricant onto the O-rings (P/N 2-014 and 2-017).

> Do not over lube the O-rings.

3. Systems with a metal end-cap use an isolation bushing and 2-017 O-ring between the end-cap and the 7-pin connector. Press the new bushing and O-ring onto the end-cap as shown in Figure 68.

> Carefully check metal end-caps for signs of corrosion such as white deposits. If corrosion caused part of the end-cap to be visibly damaged, do not redeploy your system. Send it back to TRDI for inspection.

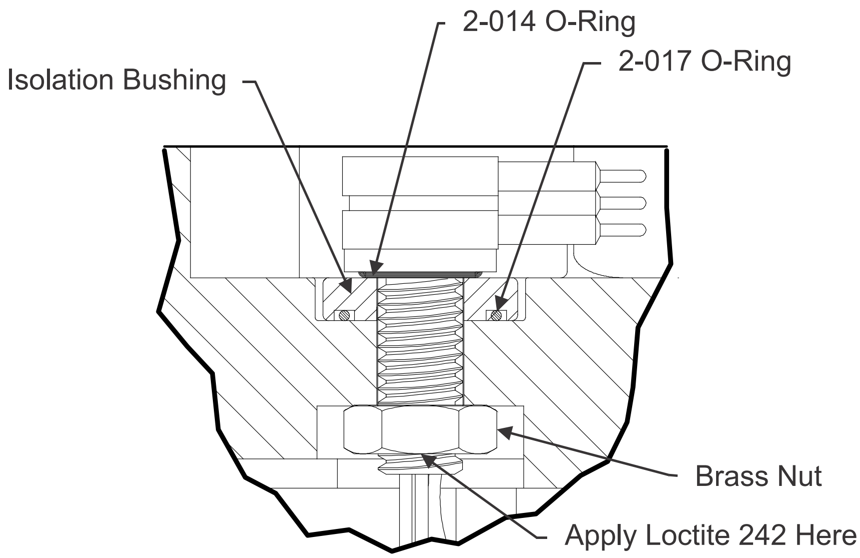


Figure 68. End-Cap Connector with Isolation Bushing

The isolation bushing and 2-017 O-ring are required for metal end-caps only.

4. Install the O-ring onto the face seal groove located at the bottom of the threads on the connector.

Do not scratch or mar the O-ring surface as you feed it over the threads of the connector.

5. Install the modified dummy plug. Pay attention to the pin orientation. **Do not bend the pins**.
6. Apply one drop of Loctite® 242 on the top starting threads of the connector.
7. Install the connector into the end cap by feeding the 7 wires and pins through the end-cap from the outside face (see Figure 64. Modified Dummy Plug).

The connector pins should point away from beam 3.

8. Push the connector down so that it fully bottoms out in the O-ring pocket.

Do not score or scratch the bore or the O-ring pocket sealing face.

9. Feed the brass nut through the wires and pins and hand tighten onto the connector threads.
10. Place the Extracting Wrench over the connector and dummy plug. The wrench will fit into the End Cap slot between the 2 rails (see Figure 65. Extracting Wrench).
11. Flip the End-Cap assembly over and insert the slotted socket onto the lock nut. Fit the cable wires into the socket's clearance slot (see Figure 66. Lock Nut Removal Socket).
12. Attach a torque ratchet wrench to the socket and tighten the nut to 35 in/lbs., (4 NM). **Make sure that the connector is aligned straight and is parallel to the rails**.
13. Remove the assembly tools and the dummy plug.
14. Follow the wiring schematic in order to assemble the Molex 8-pin header connector or external battery case wiring (see Wiring Diagrams). Insert the pins into the connector. As the pin is pushed into the connector, the tabs on the pin will lock it into place.

Use the old cut-off Molex connector as a reference in addition to the schematic diagram when installing the new Molex connector. Each wire should have a corresponding J1 pin number tag.

15. After all the pins for the connector are installed, use a multi-meter to confirm that the connector has been wired properly by performing an end-to-end continuity check.
16. Use the black lacing cord to bind the connector wires together. The lacing is applied by wrapping it around the wire bundle approximately four times and then tying it securely with a square knot. Each wrap on the wire bundle should be spaced approximately 3-inches apart. This will prevent the wires from “bird caging” out and getting caught between the end-cap and pressure case O-ring.
17. For the WorkHorse External Battery Case, cut the wires on pins 1, 2, 4, 5, and 6 to 6mm long. Shrink wrap the bare ends of the wires. Place shrink wrap around the splices on pins 3 and 7 (see Figure 70. WorkHorse External Battery Case Wiring).

Wiring Diagrams

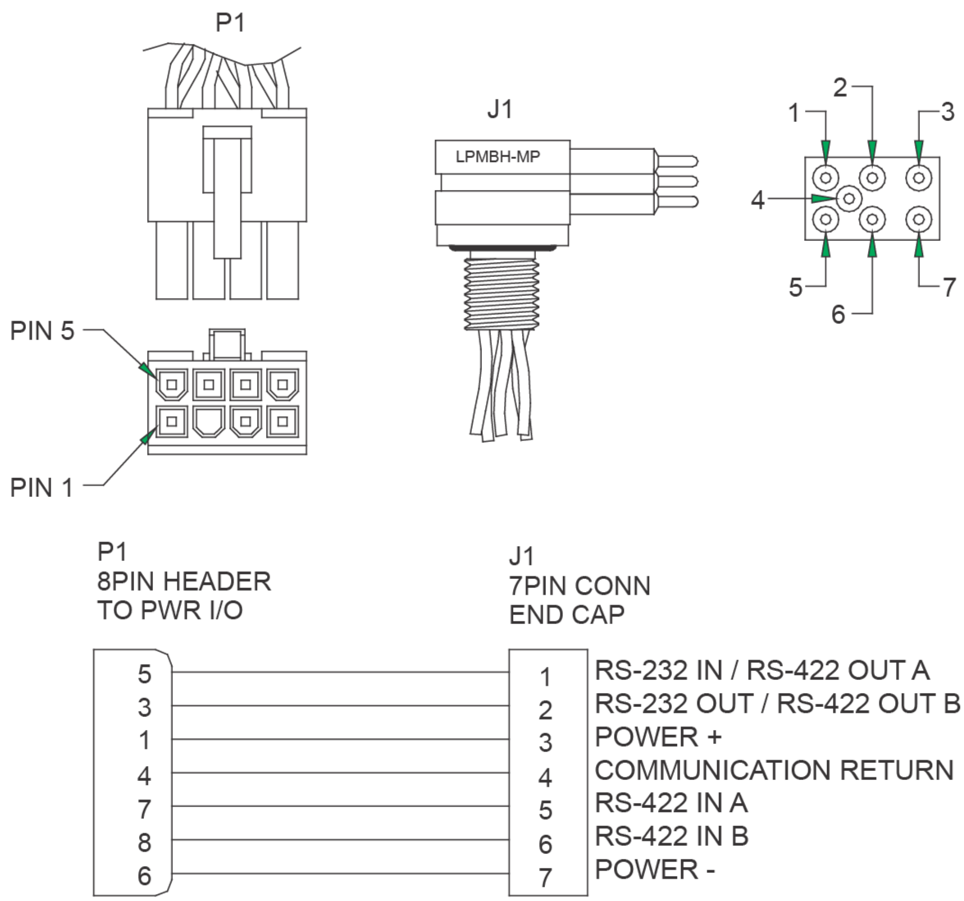


Figure 69. End-Cap Connector Wiring – WorkHorse ADCP

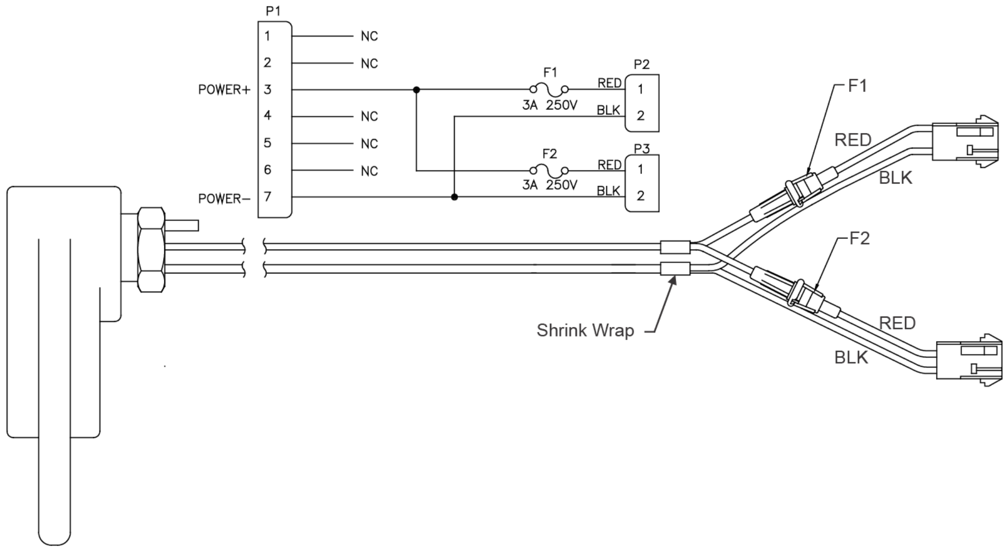


Figure 70. WorkHorse External Battery Case Wiring

Cut the wires on pins 1, 2, 4, 5, and 6 to 6mm long. Shrink wrap the bare ends of the wires. Place shrink wrap around the splices on pins 3 and 7.

Replacing the WorkHorse Lithium Battery

This section explains how to replace the rechargeable lithium coin-cell battery in a WorkHorse system. The battery is located on the CPU board just below the PIO board transmit capacitors. The battery will recharge itself as soon as power is applied to the ADCP. Over time, the battery loses the ability to recharge and the voltage capacity drops. Therefore, TRDI recommends replacing the battery every five years.

The battery keeps the Real-Time Clock (RTC) running in case power is removed temporarily. The RTC drifts independently from the battery voltage by approximately 12 minutes/year. Clock drift does NOT indicate problems with the battery.

Equipment Required

- ESD safe work space
- Soft pad (ESD Safe) to rest WorkHorse on while dissembling and reassembly
- Anti-static ground strap
- Hex wrenches
- O-rings and desiccant for ADCP
- Soldering iron
- Digital multi-meter
- Lithium battery VL2330

Testing the Lithium Battery Voltage

To verify that the lithium battery is working:

1. Remove the transducer head assembly.
2. Measure the voltage on the CPU board between TP17 (BAT+) and TP20 (GND). While power is not applied to the ADCP, TP17 should read approximately 3 VDC and the voltage should remain stable (see Figure 71).
3. If the voltage is below 3 VDC and visibly decreasing, then reapply power to the ADCP. While re-charging, TP17 should read approximately 5 VDC. This only takes a few seconds.
4. When the battery is done recharging, the voltage should read slightly above 3 VDC with power still applied.
5. After recharging the battery, disconnect the power and test the voltage. The voltage should hold stable at approximately 3 VDC for several hours at least, but for best results it should hold at 3 VDC for several days.
6. If the voltage is not holding for more than a week, then the battery may be defective. Before con-tinuing, review your options:
   - Replace the Lithium battery yourself.
   - If you are uncomfortable with replacing the battery, please contact TRDI Customer Service Administration to schedule a replacement of the battery or request a Return Merchandise Au-thorization (RMA) directly from our website <here>.

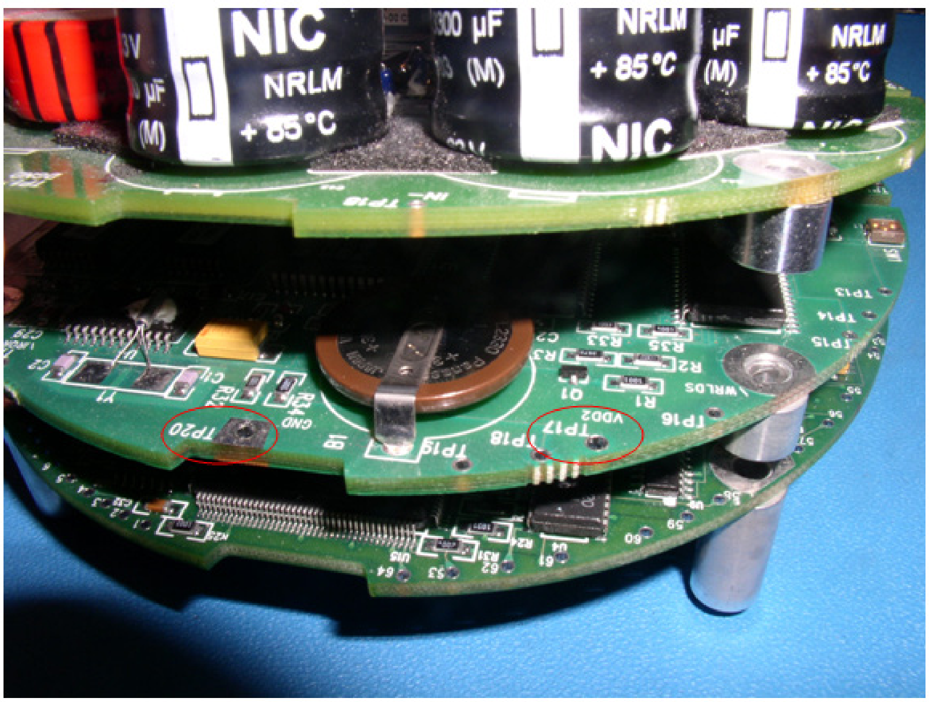


Figure 71. Lithium Battery Test Points on the CPU Board

Replacing the Lithium Battery

To replace the battery:

1. Attach an earth-grounded wrist strap.

> Before handling any of the WorkHorse boards, you must be sure that you always wear an earth-grounding static protection strap. The electronics in the WorkHorse are very sensitive to electro-static discharge (ESD). **ESD can cause damage that will not be seen immediately and will result in early failure of electronic components.**

2. Remove all power from the ADCP.

> Wait a few minutes after turning the power off before removing the electronics stack. This allows the transmit capacitors on the PIO board time to discharge.

3. Remove the transducer head assembly.
4. Remove the CPU board from the main electronic stack (see Installing the Spare Boards Kit).
5. Locate the lithium battery B1 (on the top side of the CPU board).
6. De-solder the two associated pins for B1 which are located on the underside of the CPU board.
7. Install the new battery assembly (VL2330). Please note the battery pins; the battery can only be installed one way.

Figure 72. Lithium Battery

8. Verify the voltage holds stable at approximately 3 VDC (see Testing the Lithium Battery Voltage, step 2).
9. Replace the transducer head assembly. Make sure to use new O-rings and desiccant.

Mariner I/O Cable Dry End Connector Assembly

The Mariner I/O cable connects the transducer assembly to the deck box. This cable is typically pulled through the vessel inside of conduits that may be unable to accommodate the dry end connector. To facilitate installation through conduits, the cable is provided without the dry end connector installed. Once the cable has been pulled through the vessel, the dry end connector is installed. The following procedure explains the steps required to install the dry end connector.

Tools and Equipment Requirements

- WorkHorse Mariner ADCP I/O cable pigtail kit (dry end in bag)
- 24-pin dry end cable connector (Part Number 85106RC2024P50) with pins

Tools and Equipment Requirements (User Supplied)

- Standard wire strippers for 18 - 22 awg wire.
- Heat Gun
- 6 inches of 0.500 inch (12.7 mm) general purpose heat shrink tubing
- Wire cutters
- Multi-meter

The following items can be purchased from:

Daniels Manufacturing Corporation
526 Thorpe Road
Orlando, FL 32824
Phone: (407) 855-6161
Fax: (407) 855-6884
Web Site: www.dmctools.com

- Crimping tool: AF8 M22520/1-01
- Turret Head TH1A: M22520/1-02

May be purchased as a pair AF8-TH1A Crimp Tool with TH1A Turret Head.

- Extraction Tool: MS24256R20 (DRK20)
- Insertion Tool: MS24256A20 (DAK20)

Installation Instructions

To install the dry end cable connector:

1. Strip the black polyurethane jacket back approximately 40 mm (1.5 inch).
2. Slide on a 76.2 mm (3 inch) length of heat shrink tubing. Using a heat gun, shrink the tubing around the end of the cable. Add a second layer of heat shrink tubing to strengthen the cable.
3. Remove the cable clamp and rubber grommet from the connector. Slide the grommet onto the cable.
4. Strip back the insulation on the wires approximately 6 mm (0.25 in.).
5. Insert the wire into the pin's crimp barrel and ensure that it has penetrated correctly by checking that it may be seen through the lateral hole in the barrel. Using the crimping tool, crimp a pin on each wire. Squeeze the crimp tool handles firmly until a click is heard. The crimp tool should spring open when released.

Do not solder the wires as this will cause the pin to be deformed and it will not fit into the connector.

6. Repeat step 5 for each of the wires.
7. Insert the pins in the connector using the insertion tool (MS24256A20 (DAK20)). The pin out configuration is shown in Figure 19, page 28.

Insert the pins from the center of the connector and work your way out. This makes it less likely to bend or break the wires off of the pins.

8. Slide the rubber grommet over the heat shrink tubing and onto the cable clamp. Insure the cable clamp and rubber grommet will grip the cable's black polyurethane jacket (covered with the two layers of heat shrink tubing), not the single wires.
9. Attach the loose half of the cable clamp over the rubber grommet using the two screws.

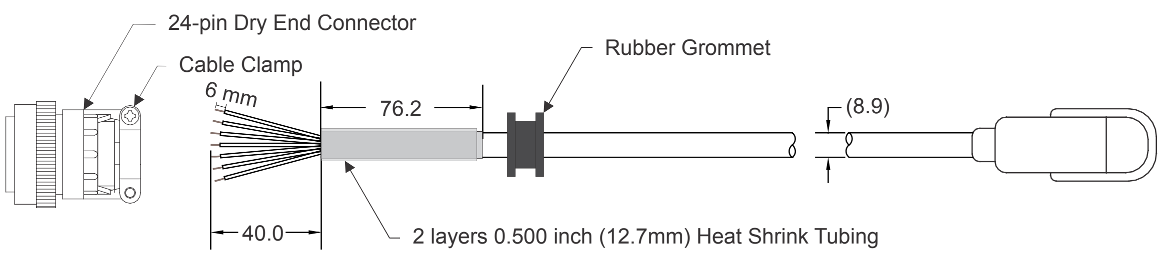


Figure 73. Mariner I/O Cable Construction

Checking the Wiring

After the connector is installed, use a multi-meter to confirm that the connector has been wired properly by performing an end-to-end continuity and adjacent pin isolation check (see Figure 19. Mariner I/O Cable Wiring, page 28).

1. Confirm that all pins in the dry end connector are not shorted. Check for >2 Mohms of resistance between each of the dry end pins.
2. Using a 2-inch jumper wire (such as a paper clip) connect pins 1 and 2 of the wet end connector. Confirm that the associated dry end pins are shorted together. The resistance should nominally be 0.033 Ohms per meter of cable conductor at 20°C. For example, a 30 meter cable has a nominal conductor resistance of 1 Ohm at 20°C. The total resistance should be 0.033 x 30 x 2 conductors = 1.98 Ohms.
3. Move the jumper to pins 1 and 3 of the wet end connector and confirm that pins 1 and 3 are wired properly.
4. Repeat step 3 for each of the remaining pins in the wet end connector. Each time, use pin 1 as the reference and then the other pin will be the pin that has not been tested.

NOTES

Chapter 5

TESTING THE WORKHORSE

In this chapter, you will learn:

- Testing the WorkHorse with *WinSC*
- Testing the WorkHorse with *BBTalk*
- Test Results
- Dock Side Tests
- Sea Acceptance Tests

This chapter explains how to test the WorkHorse using the *WinSC* and *BBTalk* programs. These tests thoroughly check the WorkHorse in a laboratory environment, but are no substitute for a practice deployment. You should test the WorkHorse:

- When you first receive the WorkHorse.
- Before each deployment or every six months.
- When you suspect instrument problems.
- After each deployment.

These test procedures assume all equipment is working. The tests can help you isolate problems to a major functional area of the WorkHorse. For troubleshooting information, see Troubleshooting.

For stationary deployments, the *WinSC* or *BBTalk* tests are the only tests required to verify the ADCP is operating correctly. When the ADCP is mounted to a moving vessel, use the Dock Side tests and the Sea Acceptance tests.

Testing the WorkHorse with *WinSC*

To test the ADCP:

1. Connect and power up the ADCP as shown in Setting up the WorkHorse System.
2. Start *WinSC* (for help on using *WinSC*, see the *WinSC* User's Guide).
3. At the **Welcome** screen, click **Test an ADCP**. Click **OK**. This will run the pre-deployment tests Deploy?, System?, TS?, PS0, PA, PC2, RS, and PC1-commands. The results of the tests will be displayed on screen and saved to the log file (*.scl).

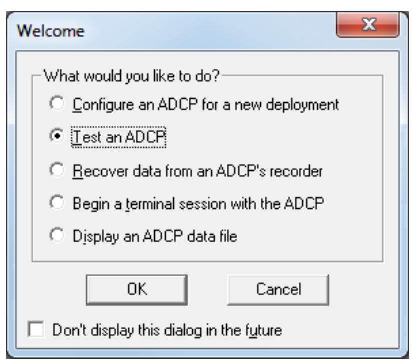


Figure 74. Using WinSC to Test an ADCP

Testing the WorkHorse with *BBTalk*

For stationary deployments, the *WinSC* or *BBTalk* tests are the only tests required to verify the ADCP is operating correctly. When the ADCP is mounted to a moving vessel, use the Dock Side test and the Sea Acceptance tests.

To test the ADCP:

1. Interconnect and apply power to the system as described in Setting up the WorkHorse System.
2. Start the *BBTalk* program (for help on using *BBTalk*, see the RDI Tools User's Guide).
3. Press **<F2>** and run the script file *TestWH.rds*. The *TestWH.rds* script file runs PS0, PS3, PA, PC2, and the PC1 tests. The results of the tests will be displayed and saved to the log file *WH_RSLTS.txt*.

Windows 7® will save the log file to: *C:\Users\username\AppData\Local\VirtualStore\Program Files (x86)\RD Instruments\RDI Tools*.

Using Windows XP®, the *BBTalk* program saves the test results file to different locations based on how the program was started. When you start *BBTalk* from the desktop icon and run the test script file, the result log file is created on the desktop. If you run *BBTalk* from the start menu, the results file is put in *C:\Documents and Settings\All Users\Start Menu\Programs\RD Instruments\RDI Tools*. It is only when you double-click the *.rds file in the RDI Tools folder that the results are saved to the RDI Tools folder.

To make sure the result file is always saved to the same location, see the RDI Tools User's Guide for instructions.

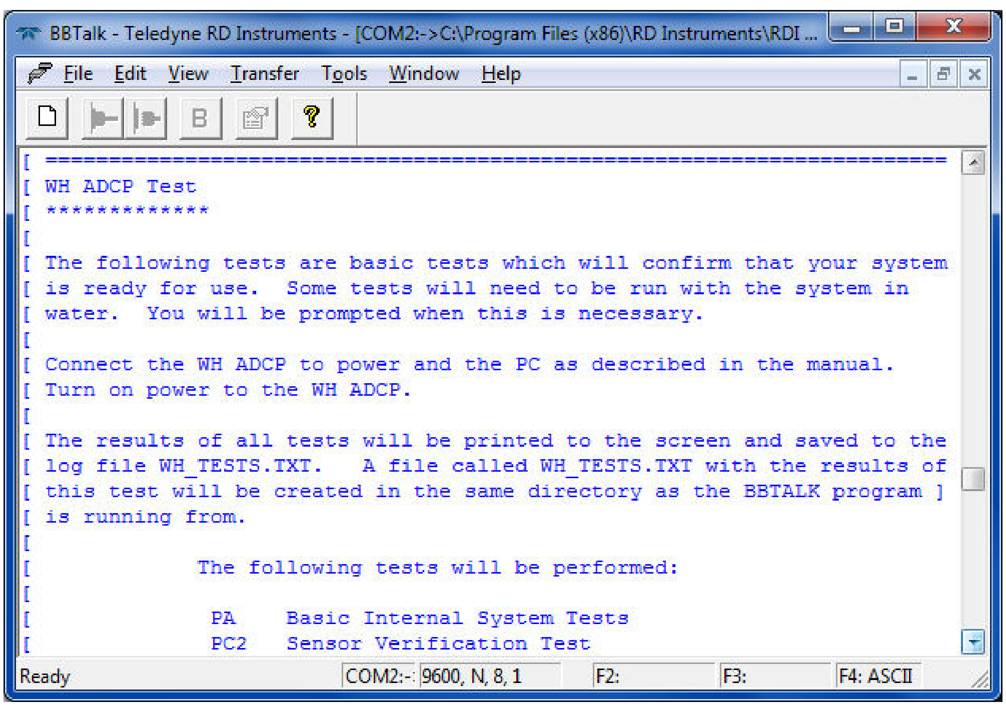


Figure 75. Using BBTalk to Test an ADCP

Test Results

This section shows an example of the test result printout after running the *WinSC* tests or the *BBTalk* script file TestWH.rds.

The built-in tests require you to immerse the transducer faces in water. If you do not, some of the tests may fail. Running the tests in air will not harm the ADCP.

Deploy Commands List

WinSC sends the ADCP the Deploy? command. This will show a list of the deployment commands and their current setting. For example;

```
deploy?
Deployment Commands:
RE ----------------------- Recorder ErAsE
RN ----------------------- Set Deployment Name

WD = 111 100 000 --------- Data Out (Vel,Cor,Amp; PG,St,P0; P1,P2,P3)
WF = 0088 ---------------- Blank After Transmit (cm)
WN = 030 ----------------- Number of depth cells (1-128)
WP = 00045 --------------- Pings per Ensemble (0-16384)
WS = 0200 ---------------- Depth Cell Size (cm)
WV = 175 ----------------- Mode 1 Ambiguity Vel (cm/s radial)

BP = 000 ----------------- Bottom Track Pings per Ensemble

TE = 01:00:00.00 --------- Time per Ensemble (hrs:min:sec.sec/100)
TF = **/**/**,**:**:** --- Time of First Ping (yr/mon/day,hour:min:sec)
TP = 01:20.00 ------------ Time per Ping (min:sec.sec/100)
TS = 94/01/30,00:11:17 --- Time Set (yr/mon/day,hour:min:sec)

EA = +00000 -------------- Heading Alignment (1/100 deg)
EB = +00000 -------------- Heading Bias (1/100 deg)
ED = 00000 --------------- Transducer Depth (0 - 65535 dm)
ES = 35 ------------------ Salinity (0-40 pp thousand)
EX = 11111 --------------- Coord Transform (Xform: Type,Tilts,3 Bm,Map)
EZ = 1111101 ------------- Sensor Source (C,D,H,P,R,S,T)

CF = 11111 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
CK ----------------------- Keep Parameters as USER Defaults
CR # --------------------- Retrieve Parameters (0 = USER, 1 = FACTORY)
CS ----------------------- Start Deployment
```

System Commands List

WinSC sends the ADCP the System? command. This will show a list of the system commands and their current setting. For example;

```
>system?
System Control, Data Recovery and Testing Commands:
AC ----------------------- Output Active Fluxgate & Tilt Calibration data
AF ----------------------- Field calibrate to remove hard/soft iron error
AR ----------------------- Restore factory fluxgate calibration data
AX ----------------------- Examine compass performance
AZ ----------------------- Zero pressure reading

CB = 411 ----------------- Serial Port Control (Baud; Par; Stop)
CP # --------------------- Polled Mode (0 = NORMAL, 1 = POLLED)
CZ  ---------------------- Power Down Instrument

FC ----------------------- Clear Fault Log
FD ----------------------- Display Fault Log
```

```
OL ----------------------- Display Features List

PA ----------------------- Pre-Deployment Tests
PC1 ---------------------- Beam Continuity
PC2 ---------------------- Sensor Data
PS0 ---------------------- System Configuration
PS3 ---------------------- Transformation Matrices

RR ----------------------- Recorder Directory
RF ----------------------- Recorder Space used/free (bytes)
RY ----------------------- Upload Recorder Files to Host
```

Time Set

WinSC sends the ADCP the TS? command. This will show the current setting of the real time clock. For example;

```
>TS?
TS = 98/06/17,07:31:27 --- Time Set (yr/mon/day,hour:min:sec)
>
```

Recorder Free Space

WinSC sends the ADCP the RS command. This will show the amount of used and free recorder space in megabytes. For example;

```
>RS
RS = 000,010 --------- REC SPACE USED (MB), FREE (MB)
>
```

Display System Parameters

This tells the ADCP to display specific information about your ADCP. Both *WinSC* and *BBTalk* run this test. For example:

```
>ps0
  Instrument S/N:  0
       Frequency:  307200 HZ
   Configuration:  4 BEAM, JANUS
     Match Layer:  10
      Beam Angle:  20 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  DOWN
       Sensor(s):  HEADING  TILT 1  TILT 2  DEPTH  TEMPERATURE  PRESSURE
Pressure Sens Coefficients:
              c3 = +0.000000E+00
              c2 = +0.000000E+00
              c1 = -2.500000E-03
          Offset = +0.000000E+00

Temp Sens Offset:  -0.20 degrees C

    CPU Firmware:  16.xx
   Boot Code Ver:  Required:  1.13   Actual:  1.13
    DEMOD #1 Ver:  ad48, Type:  1f
    DEMOD #2 Ver:  ad48, Type:  1f
    PWRTIMG  Ver:  85d3, Type:   6
Board Serial Number Data:
   08  00 00 02 C9 20 A7  09 CPU727-2000-00H
   4D  00 00 00 D4 97 37  09 PIO727-3000-03C
>
```

Verify the information is consistent with what you know about the configuration of your system. If PS0 does *not* list all your sensors, there is a problem with either the communications to the transducer or a problem with the receiver board.

Instrument Transformation Matrix

PS3 sends information about the transducer beams. Only the *BBTalk* script file TestWH.rds runs this test. The WorkHorse uses this information in its coordinate-transformation calculations; for example, the output may look like this:

```
ps3
Beam Width:   3.7 degrees

Beam     Elevation     Azimuth
  1         -70.14      269.72
  2         -70.10       89.72
  3         -69.99        0.28
  4         -70.01      180.28

Beam Directional Matrix (Down):
  0.3399    0.0017    0.9405    0.2414
 -0.3405   -0.0017    0.9403    0.2410
 -0.0017   -0.3424    0.9396   -0.2411
  0.0017    0.3420    0.9398   -0.2415

Instrument Transformation Matrix (Down):    Q14:
  1.4691   -1.4705    0.0078   -0.0067       24069  -24092     127    -109
 -0.0068    0.0078   -1.4618    1.4606        -111     127  -23950   23930
  0.2663    0.2657    0.2657    0.2661        4363    4354    4353    4359
  1.0367    1.0350   -1.0359   -1.0374       16985   16957  -16972  -16996
Beam Angle Corrections Are Loaded.
>
```

If the WorkHorse has beam angle errors, they are reflected in the instrument transformation matrix and the Beam Directional matrix. This matrix, when multiplied by the raw beam data gives currents in the *x*, *y*, *z*, and *e* directions.

Pre-deployment Test

This diagnostic test checks the major WorkHorse modules and signal paths. Both *WinSC* and *BBTalk* run this test. For example, the output may look like this:

```
>PA
PRE-DEPLOYMENT TESTS
CPU TESTS:
  RTC......................................PASS
  RAM......................................PASS
  ROM......................................PASS
RECORDER TESTS:
  PC Card #0..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (short)...................PASS
  PC Card #1..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (short)...................PASS
DSP TESTS:
  Timing RAM..............................PASS
  Demod  RAM..............................PASS
  Demod  REG..............................PASS
  FIFOs...................................PASS
SYSTEM TESTS:
  XILINX Interrupts... IRQ3  IRQ3  IRQ3 ...PASS
  Wide Bandwidth..........................PASS
```

```
  Narrow Bandwidth.........................PASS
  RSSI Filter..............................PASS
  Transmit.................................PASS
SENSOR TESTS:
  H/W Operation............................PASS
```

Display Heading, Pitch, Roll, and Orientation

The PC2 test displays heading, pitch angle, roll angle, up/down orientation and attitude temperature in a repeating loop at approximately 0.5-sec update rate. Any key pressed exits this command and returns the user to the command prompt. Both *WinSC* and *BBTalk* run this test.

```
Press any key to quit sensor display ...
Heading   Pitch    Roll   Up/Down    Attitude Temp   Ambient Temp  Pressure
301.01°  -7.42°  -0.73°    Up          24.35°C        22.97°C        0.0 kPa
300.87°  -7.60°  -0.95°    Up          24.36°C        22.97°C        0.0 kPa
300.95°  -7.60°  -0.99°    Up          24.37°C        22.97°C        0.0 kPa
300.71°  -7.61°  -0.96°    Up          24.37°C        22.98°C        0.0 kPa
```

Beam Continuity

The PC1 tests the beam continuity by measuring the quiescent Receiver Signal Strength Indicator (RSSI) levels. There must be a change of more than 30 counts when the transducer face is rubbed. Both *WinSC* and *BBTalk* run this test.

The PC1 test is designed to measure the relative noise in the environment and then have you apply more noise by rubbing the ceramics with your hand. Sometimes your hand does not generate enough noise for the system to detect. This could be due to the environment you are in or for other reasons. A simple, safe, and easy to find material that works very well as a replacement to your hand is packaging material (a.k.a. bubble wrap). Using this instead of your hand will very likely provide enough relative frictional difference for the system to pass.

```
BEAM CONTINUITY TEST
When prompted to do so, vigorously rub the selected
beam's face.
If a beam does not PASS the test, send any character to
the ADCP to automatically select the next beam.

Collecting Statistical Data...
  52  48  50  43

Rub Beam 1 = PASS
Rub Beam 2 = PASS
Rub Beam 3 = PASS
Rub Beam 4 = PASS
```

This test must be performed with the ADCP out of water and preferably dry.

If the PC1 test fails, your system may still be okay. In this case deploy the ADCP into a bucket or container of water (preferably at least 0.5 meters deep). Record some data using *BBTalk* and the log file (**F3** key), or record data straight to the recorder card if your ADCP has one. Then look at the data using the *WinADCP* program and make sure that the echo amplitude counts in the 1st depth cell for all beams is between 128 and 192. If they are not, contact Field Service for further troubleshooting tips.

Dock Side Tests

The following checks should occur at Dock Side prior to performing the Sea Acceptance Tests. These tests will verify the WorkHorse ADCP is ready for the Sea Acceptance Tests and confirm the peripherals attached to the ADCP.

These tests only apply to moving vessel deployments.

Dock Side Diagnostic Test

The following test will confirm the connection of the WorkHorse Deck box (Mariner) to the Transducer or WorkHorse to the computer.

Table 16: Dock Side Test Set Up

Set up	Description
Platform/Vessel	The vessel should be tied to the dock or at anchor. The transducer should be in water. All other sonar devices and equipment should be turned off.
WorkHorse	Connect the ADCP as described in Setting up the WorkHorse System. The Gyro/Navigation connection may or may not be connected at this point.
Computer	The TRDI *BBTalk* program should be running, communications port setting (F5) to match the connection to the PC and WorkHorse ADCP baud rate requirements (default 9600,N,8,1).

Use the following steps to interconnect the WorkHorse system and to place the ADCP in a known state.

1. Interconnect and apply power to the system as described in Setting up the WorkHorse System.
2. Start the *BBTalk* program.
3. Press **End** to wake up the ADCP. Send the PA command to the ADCP. See Pre-deployment Test for an example of the test result printout.

Dock Side Peripheral Tests

The WorkHorse requires (at minimum) input for heading (true north) and for position fixes (GPS). Additionally, the WorkHorse can make use of pitch and roll data to correct for the tilt.

Heading can be input directly to the WorkHorse deck box through an external synchro gyro or stepper gyro (Mariner only). Heading can also (or instead of) be input and combined with WorkHorse data in the computer software *VmDas*. This heading input is done through the communications port of the computer with the NMEA 0183 string $HDT or $HDG as specified in the **Transforms** tab in *VmDas*.

If the gyro connection is used for the heading input, then the Gyro Interface Board must be first configured to match the platform's gyro output. Follow the instructions in Gyrocompass Interface Considerations on how to setup the Gyro Interface Board.

Pitch and Roll data can be input directly to the Mariner deck box through an external synchro gyro. Pitch and Roll can also (or instead of) be input and combined with WorkHorse data in the computer software *VmDas*. This heading input is done through the communications port of the computer with the TRDI proprietary NMEA string $PRDID.

Navigation data can only be combined with WorkHorse data in the computer software *VmDas*. This navigation input is done through the communications port of the computer with the NMEA proprietary strings $GGA and $VTG.

See the VmDas User's Guide and/or the WinRiver II User's Guide for help on integrating NMEA Devices.

Table 17: Dock Side Peripheral Tests Set up

Set up	Description
Platform/Vessel	The Gyro, Navigation, and Pitch/Roll sensors should be attached to the appropriate place on either the WorkHorse deck box or the computer communication port. The devices should be on and should stable (in the case of gyros this may require a spin up time of up to 12 hours).
WorkHorse	The WorkHorse should be connected as described in Setting up the WorkHorse System, AC Power connected to the deck box/ADCP, and the power switch turned on.
Computer	The TRDI *BBTalk* program should be running, communications port setting (F5) to match the connection to the PC and WorkHorse ADCP baud rate requirements (default 9600,N,8,1).

Testing the Gyro Connections to the Deck box (Mariner Only)

The following sequence of commands should be sent after powering up the WorkHorse deck box. These commands will wake up the ADCP (<BREAK>), initialize the WorkHorse (CR1), and save the initialization (CK).

```
<BREAK> press the end key
CR1
CK
```

The following command should be sent to test the gyro input to the WorkHorse deck box.

```
PC2
```

The response from the ADCP should be as follows:

```
>PC2
Heading          Pitch      Roll        Temperature
 (ext)           (ext)      (ext)       cts     degs
 000.0           +00.0      +00.0       243E    23.9
```

Testing the Navigation Connections to the Compute (VmDas)r

Start *VmDas* in the Data Collect mode. On the **View** menu, select **NMEA Communications**. Confirm that the Navigation Device NMEA string is viewable and the $GGA string is present.

The **Navigation Data** window in *VmDas* (see Figure 76) shows a text box of the position and velocity data from a NMEA navigation device. You can use this to verify the navigation connections.

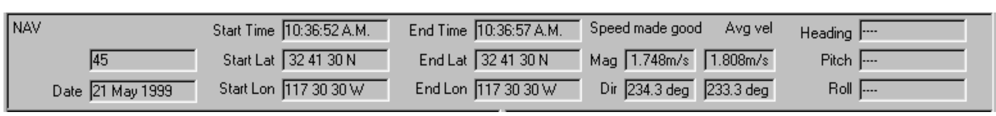


Figure 76. Testing the Navigation Connections

Testing $HDG Heading Connections to the Computer (VmDas)

Start *VmDas* in the Data Collect mode. On the **View** menu, select **Nmea Communications**. Confirm that the Navigation Device NMEA string is viewable and the $HDG string is present. Note that the data for this information may appear on the same communications port as the navigation data or on a separate input port.

Testing $PRDID Heading Connections to the Computer (VmDas)

Start *VmDas* in the Data Collect mode. On the **View** menu, select **Nmea Communications**. Confirm that the Navigation Device NMEA string is viewable and the $PRDID string is present. Note that the data for this information may appear on the same communications port as the navigation data or on a separate input port.

Testing the Navigation Connections to the Compute (WinRiver II)r

Start *WinRiver II* in the Acquire mode. On the **View** menu, select **Device Logs**. Confirm that the Navigation Device NMEA string is viewable and the $GGA string is present.

Table 18: Dock Side Peripheral Test Results

Test	Test Criterion
External Gyro Connection Test	Verify that the Gyro inputs for Heading, Pitch and Roll (if included) are reasonable for the platform's attitude. The Temperature reading should match the expected water temperature at the transducer.
External Heading NMEA Connection Test	Verify that the Navigation Device NMEA string is viewable and the $GGA string is present.
External Heading NMEA Connection Test	Verify that the Navigation Device NMEA string is viewable and the $HDT or $HDG string is present.
External Heading NMEA Connection Test	Confirm that the Navigation Device NMEA string is viewable and the $PRDID string is present.

Sea Acceptance Tests

This procedure is intended to test the WorkHorse at sea. This procedure assumes that the Dock Side Testing (see Dock Side Tests) procedure has been run and that all of the items have passed or been confirmed to be operational. The following tests will not obtain favorable results unless all of this work has been performed.

These tests only apply to blue water moving vessel deployments using *VmDas*. See the *VmDas* User's Guide for instructions on how to use this program.

The reason for Sea Acceptance Testing is that although the Dock Side Tests confirm the WorkHorse is operational, they do not confirm that the system is able to perform to its specifications. The performance of any ADCP relies greatly upon the installation into any platform. Therefore, the system must be tested at sea to understand the effects of the platform on the ADCP performance.

At Sea Testing includes tests for Acoustic Interference, Profiling Range, and Profiling Reasonableness testing. For each of these tests, the following equipment and ADCP set up requirements are recommended.

Equipment Required

- WorkHorse 300 kHz, 600 kHz, or 1200 kHz ADCP with firmware 16.xx or greater
- Computer
- *VmDas* Program
- *WinADCP* Program
- Navigation Interface Connected
- Heading Interface Connected

VmDas Set up

1. Start *VmDas*. On the **File** menu, click **Collect Data**. On the **Options** menu, click **Load**. Select the Default.ini file and click **Open**.
2. On the **Options** menu, click **Edit Data Options**. Click the **ADCP Setup** tab. Set the **Ensemble Time** to the **Ping as fast as possible**.
3. Select the **Use Command File** box. Use Table 19 to choose a command file for your ADCP, and load it into *VmDas* using the **Browse** button.

Table 19: Command Files

File Name	Description
WH300DEF.txt	Default set up for a WH 300 kHz ADCP to provide the most range with the optimal precision.
WH600DEF.txt	Default set up for a WH 600 kHz ADCP to provide the most range with the optimal precision.
WH1200DEF.txt	Default set up for a WH 1200 kHz ADCP to provide the most range with the optimal precision.

4. On the **Options** menu, click **Edit Data Options**. Click the **Averaging** tab. Set the **Short Term Average** to 300 seconds (5 minutes). Set the **Long Term Average** to 600 seconds (10 minutes).

Interference Test

The WorkHorse transmits and receives acoustic signals from the water. If other sonar devices are operating on the platform at the same time as the ADCP it is possible for those signals to bias the ADCP data. Therefore, all ADCPs must be tested to ensure that they are not receiving interference from other sonar equipment on board the vessel.

The following Interference Test will determine if there is interference from other devices on board the vessel.

Interference Test Platform Test Set up

This test requires that the platform be in water deeper than the ADCP's maximum expected profiling range. Use the following table to determine the minimum water depth required.

Table 20: Interference Test Minimum Water Depth Requirement

300 kHz ADCP	600 kHz ADCP	1200 kHz ADCP
400 meters	150 meters	60 meters

The platform speed for this test is drifting. The motors may be running if required for platform safety. The test sequence starts with ALL sonar and non-essential electronic equipment turned off. Only the ADCP should be on for the first test. This test establishes a base line for the interference and is critical to the rest of the tests. After a 10-minute period the first sonar device is turned on, transmission started, and the data is reviewed for interference terms. At the end of this 10-minute period the first sonar device is turned off and then the next sonar device is turned on and started pinging for 10 minutes. This process repeats for each of the sonar devices.

Interference Test Computer Screen Display Set up

View the RAW data (*.ENR files) being collected by the *VmDas* program in the *WinADCP* program contour plots for echo intensity data. This data will show the single ping return levels.

How to Identify Interference

If there is an interference term, the echo intensity data will show spurious echo intensity jobs. An example of what an interference term may look like what is shown in Figure 77.

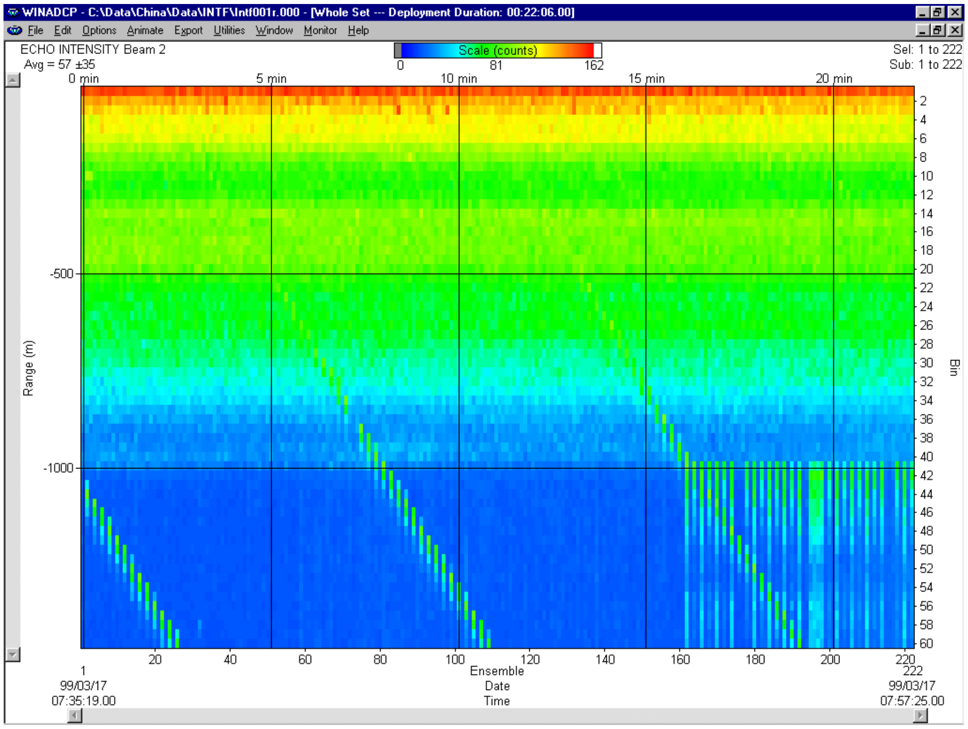


Figure 77. Interference Test

The interference term appears as the periodic green blocks in the data set. The interference is some what lost in the upper part of the profile however it can be seen clearly seen once the system reaches the noise floor (the point where signals are no longer being returned from the water).

Interference terms such as above seen anywhere in the echo intensity profile data will result in a bias to the ADCP data.

Water Profile Range Test

The range of any ADCP is directly dependent on the level of backscattering material in the water, the transmit power into the water, the received sensitivity, and the level of the background noise. Each of these effects the range of the system in different ways, but in the end can result in reduced or extended range as follows.

- The ADCPs transmit power and receive sensitivity are fixed based on the transducer frequency. However, these may be affected by installation of an acoustic window in front of the transducer. A window will absorb both sound transmitted by the ADCP and the sound returned from backscatter in the water.
- The volume of the backscatter in the water will affect the range. All specifications for range assume that there is a certain amount of backscatter in the water. The backscatter volume is not controllable in any way.
- The background noise changes as the platform's speed increases or decreases. There are two types of noise created by the moving platform; first, there is the noise due to propeller and engines; and second, there is the noise created by the rushing water across the platform and ADCP transducer.

This test is used to determine the effects of the background noise on the range of the ADCP. This information can be used to determine the optimum speed of the platform to obtain the desired range required.

Water Profile Range Platform Test Set up

This test requires that the platform be in water deeper than the ADCP's maximum expected profiling range. Use the following table to determine the minimum water depth required.

Table 21: Water Profile Range Test Minimum Water Depth

300 kHz	600 kHz	1200 kHz
250 meters	100 meters	40 meters

The platform course for this test is a continuous straight line. The speed of the platform will be varied during this test. At each speed, the system will be set to collect data for a minimum of 10 minutes. The following table lists the recommended speeds.

Table 22: Water Profile Range Test Platform Speed

Test #	Speed
Speed 1	Drifting
Speed 2	3 knots
Speed 3	6 knots
Speed 4	9 knots
Speed 5	12 knots
Speed 6	Maximum Speed

Water Profile Range Computer Screen Display Set up

View the Tabular Display of the Long Term Average data (10 minute averages) in the *VmDas* program.

How to Determine the Maximum Range of the ADCP

The data collected in the long-term average (10 minutes) tabular display will be used to determine the maximum range of the ADCP. The maximum profiling range of the system is determined by locating the last valid bin and then using that ping to determine the range. To determine the last valid bin the following criterion is used:

- The last bin must be above the bottom side lobe area
- The bin must be > 25% of the sum of 3-beams Solutions (percent good 1) and 4-beams Solutions (percent good 4), [(PG1 + PG4) > 25%].
- The correlation value for at least 3 beams must be above the threshold of 64 counts

Locate the last valid bin for each of the speeds and fill in the table below.

Platform Speed	Last Valid Bin Number	Range to Last Bin	Average RSSI Value at Last Bin

Notes:

- Platform Speed must be input as a measurement from the Bottom Track (if in range) or the GPS speed.
- Range to Last Bin is calculated as follows: ((bin size) * (last bin number)) + (NF command)
- Average RSSI Value at Last Bin is the average of the 4 beams RSSI values in the last bin number

The results from the above test should be compared to the specified nominal range of the system. Assuming that there are sufficient scatterers in the water, the acoustic window is not attenuating the signal, and that that the platform background noise is variable there should be a speed at which the nominal range of the system is obtained.

Ringing Test

The ADCP transmits an acoustic pulse into the water. The main lobe of this pulse bounces off particles in the water and the signals returned from these particles are used to calculate the velocity of the water. The main lobe of the transmitted pulse is what we are using to process and calculate a velocity. The transmitted pulse, however, is made up of many side lobes off the main lobe. These side lobes will come in contact with metal of the transducer beam itself and other items in the water.

The energy from the side lobes will excite the metal of the transducer and anything bolted to the transducer. This causes the transducer and anything attached to it to resonate at the system's transmit frequency. We refer to this as "ringing." If the ADCP is in its receive mode while the transducer is ringing then it will receive both the return signals from the water and the "ringing." Both of these signals are then processed by the ADCP. The ringing causes bias to the velocity data.

All ADCPs "ring" for some amount of time. Therefore, each ADCP requires a blanking period (time of no data processing) to keep from processing the ringing energy. Each ADCP frequency has a different typical ringing duration. A blanking period (time of not processing data) is required at the beginning of each profile. The blanking distances required for the typical ringing period for each WorkHorse frequency is shown in the following table.

Table 23: Required Blanking Distance

Frequency	Typical Blank Period for Ringing
300kHz	2 meters
600kHz	1 meters
1200kHz	0.5 meters

Ringing will bias the velocity estimation to a lower value than it should be. However, when the platform motion is removed from the water profile data it will appear as a large velocity, which is the opposite of what it is really doing. This effect is caused because the vessel motion portion of the water profile data has been biased low.

Ringing Test Platform Test Set up

The key to success on this test is that the water velocity and direction not change over the entire test period of 120 minutes. This may be difficult to adhere to in regions with large tidal effects. The test requires that the platform be within the ADCP bottom tracking range so that valid bottom track can be used. Use the following table to determine the optimum water depth range required.

Table 24: Ringing Test Water Depth Requirement

300kHz ADCP	600kHz ADCP	1200kHz ADCP
100-200 meters	50-100 meters	10-20 meters

Platform speed should be held to as fast a speed as possible without loosing any bottom tracking data for a period of 30 minutes. Typically, this will be a speed of 6-9 knots. Some experimentation may be required to find the maximum bottom track speed for the given depths above.

Ringing Test Computer Screen Display Set up

The Magnitude and Direction Profile Display of the Long Term Average data (10 minute averages) will be viewed in the *VmDas* program.

How to Determine the Ringing Test Results

Viewing the Long Term average of the magnitude and direction profile data, look for unreasonable shears from bin 1 to bin 2 to bin 3 and so on. If an unreasonable shear is seen, this is most likely ringing and your blanking needs to be increased by the following formula:

(bin size) * (last bin number with ringing) * 0.80

*The total blanking period is typical blanking period plus the increased blanking period required. The above value should be used to change both the NF and WF commands in all configuration files for this ADCP.

Transducer Alignment Test

This test only applies to WorkHorse Mariner systems using an external heading.

The mounting alignment of the transducer to the relative position of the heading input from the vessel is critical in the velocity estimates made by the ADCP. If either of these are not known and corrected for, it will result in both directional and velocity estimate errors in the velocity data.

It is possible to confirm if the transducer alignment is correct by collecting data over the same water in several different directions. If the transducer is aligned, then the both the magnitude and direction of the currents will appear the same in all directions that the platform travels.

Platform Testing Setup

The key to success on this test is that minimal water velocity and direction change over the entire test period. The following test will take a minimum of five hours to collect. This length of time is required in order to obtain enough data samples to reduce the noise sufficiently. This test requires that the platform be within the ADCP bottom tracking range, so that valid bottom track can be used, and that reliable GPS data be available (DGPS is recommended). Use the following table to determine the optimum water depth range required.

Table 25: Transducer Alignment Test Water Depth Requirement

Mariner 300 kHz	Mariner 600 kHz
80-160 meters	25-75 meters

The platform speed is to be held at a constant speed. Any speed between 5 to 10 knots is acceptable, however once a speed is selected then the vessel should maintain that speed during the entire course. The course for this test contains a minimum of five legs. Each leg must be a minimum of 30 minutes long (1 to 2 hours per leg is the optimal time). The course of ship travel is shown in **Figure** 78. All data must be collected in beam coordinates.

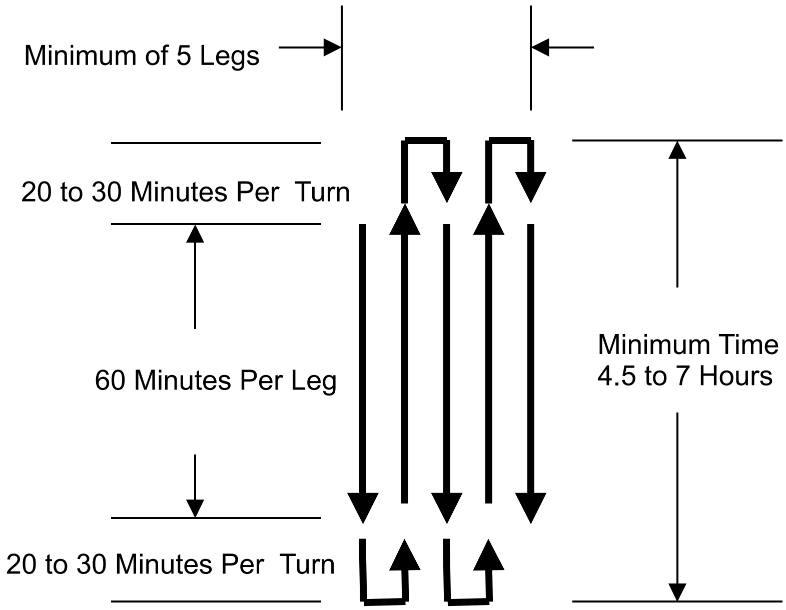


Figure 78. Transducer Alignment Test

Computer Screen Display Setup

View the *VmDas* ship track display of bin 3 with the bottom track reference. The Long Term Average (5 minute averages) data should be viewed.

Each of the vertical lines represents the point when the vessel changed directions.

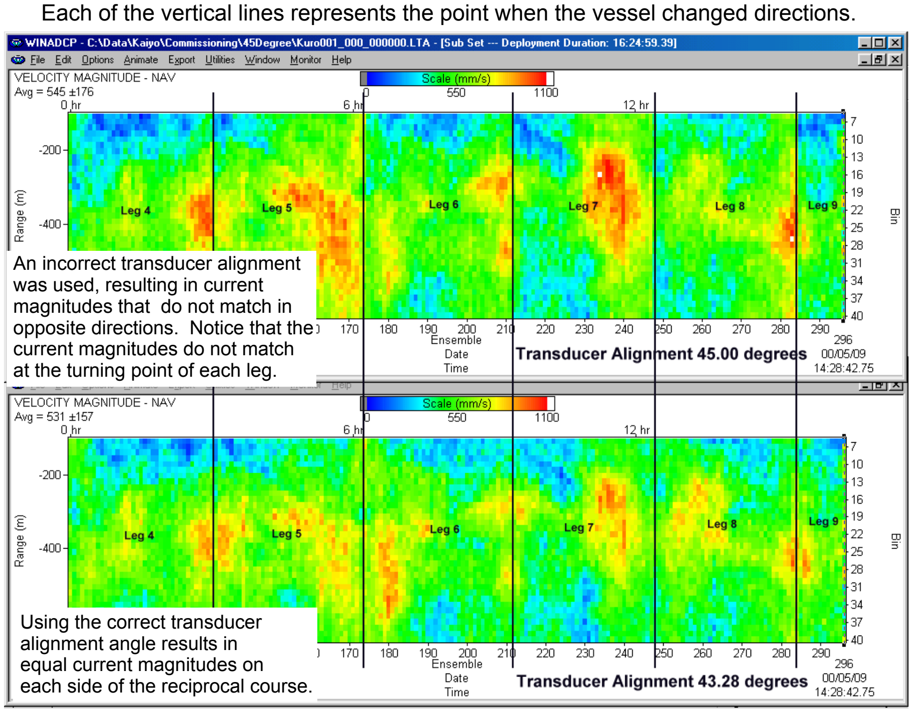


Figure 79. Transducer Alignment Display

Transducer Alignment Results Sheet

A pass condition is if the velocities in each of the ship track plotted directions has the reasonably the same magnitude and direction. It is common to see some wild velocity magnitude and directions. This happens as a result of the effects of the turn on the gyro heading device or the latency of the heading updates for a GPS heading input.

If the direction of the currents is not the same in each of the directions then it will be necessary to enter in a transducer misalignment angle. The 5-minute averages of both GPS and Bottom Track Direction are compared in at least 2 of the legs traveled. An average direction along each leg is calculated for both the GPS and Bottom Track data. The difference in the average directions is the misalignment angle.

Record the results of this portion of the Transducer Alignment with Bottom Track Reference with the formula:

Misalignment Angle = (GPS Average Direction) – (Bottom Track Average Direction)

Misalignment Angle Required	Degrees

Changing the transducer alignment angle, reprocessing the data, and finally playing back the same data file again allows you to confirm if the misalignment angle correction is correct. A pass condition is if the velocities in each of the ship track plotted directions has the reasonably the same magnitude and direction. It is common to see some wild velocity magnitude and directions.

Record the results of the verification of the Transducer Alignment with Bottom Track Reference:

Alignment Verification	Pass/Fail

Change the data display reference from bottom track to the navigation data in the VMDAS program. A pass condition exists if little to no change in the velocity magnitude and direction occurred when switching to the navigation data reference

Record the results of this portion of the Transducer Alignment with Navigation Reference:

Navigation Verification	Pass/Fail

Water Profile Reasonableness Test

The mounting alignment of the WorkHorse transducer to the relative position of the heading input from the vessel is critical in the velocity estimates made by the ADCP. If either of these are not known and corrected for, it will result in both directional and velocity estimate errors in the water velocity data.

It is possible to confirm if the transducer alignment is correct by collecting data over the same water in several different directions. If the transducer is properly aligned, then both the magnitude and direction of the currents will appear the same in all directions that the platform travels.

Water Profile Reasonableness Platform Test Set up

The key to success on this test is that the water velocity and direction not change over the entire test period of 120 minutes. This may be difficult to adhere to in regions with large tidal effects. The test requires that the platform be within the ADCP bottom tracking range so that valid bottom track can be used. Use the following table to determine the optimum water depth range required.

Table 26: Water Profile Reasonableness Water Depth Requirement

300 kHz	600 kHz	1200 kHz
100-200 meters	50-90 meters	10-40 meters

Platform speed is held at a constant 5 knots during the entire course. The course for this test contains 4 legs. Each leg must be approximately 4500 meters (except for leg 2 which will be one half the length of each of the other legs). The course will appear as shown in Figure 80. The actual starting direction is not critical as long as the course completes the pattern shown in Figure 80.

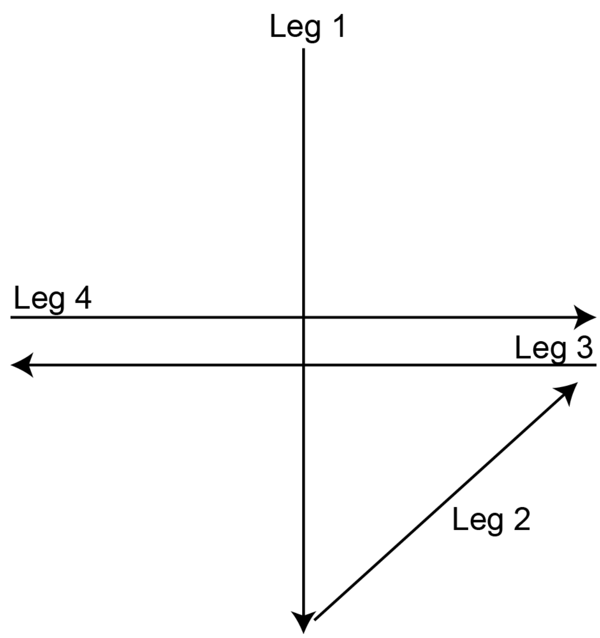


Figure 80. Water Profile Reasonableness Course

Water Profile Reasonableness Display Set up

View the *VmDas* Ship Track display of bin 3 with the bottom track reference. The Short Term Average (5 minute averages) data should be viewed.

How to Determine Water Profile Reasonableness

A pass condition is if the velocities in each of the ship track plotted directions has reasonably the same magnitude and direction. It is common to see some wild velocity magnitude and directions during turns. This happens as a result of the effects of the turn on the gyro heading device or the latency of the heading updates for a GPS heading input.

If the direction of the currents is not the same in each of the four directions, then it will be necessary to enter in a transducer misalignment angle. Changing the transducer alignment angle and playing back the same data file again allows you to determine the misalignment angle. The best way to perform this check out is to use incremental change of 5-10 degrees at a time.

Assuming that the misalignment angle was not required or could be determined, it is now possible to use the same data just collected to determine how reasonable the navigation data input is. Change the data display reference from bottom track to the navigation data in the *VmDas* program. There should be little to no change in the velocity magnitude and direction if the navigation data is a valid input for a reference.

Bottom Tracking Test

The bottom tracking capability of the ADCP varies depending on the type of bottom (hard, soft, rock, sand, etc.), the slope of the bottom, and the speed of the vessel (background noise).

Before testing the Bottom Track capabilities, the Water Profiling Range Test must be performed. Through the results of this test, determine the platform speed in which the range to the last valid bin obtained the specified nominal range of the ADCP frequency being used.

If it was not possible to reach the specified nominal range during the Water Profiling Range test, then determine the speed at which it allowed the best range possible. Calculate the percentage of the nominal range that was obtained by the system.

Bottom Tracking Platform Test Set up

The key to this test is to operate the system in an area where both the minimum and maximum bottom tracking range can be obtained. The platform will travel over water that is very shallow (<10 meters) to very deep (greater than the maximum bottom track range). It does not matter if the water starts deep and goes shallow or vice-versa.

The course of the platform should be a relatively straight line. The platform speed should be no greater than the velocity recorded in the Water Profiling Range Test.

Bottom Tracking Computer Screen Display Set up

View the raw data display of the *VmDas* bottom track display window.

How to Determine Bottom Tracking Reasonableness

Viewing the bottom track velocity data, record the maximum and minimum average of the bottom track depths in the table below.

Beam Number	Minimum Depth (meters)	Maximum Depth (meters)
Beam 1		
Beam 2		
Beam 3		
Beam 4		

A pass condition is if the maximum depth of the system is equal to the specification for the nominal bottom track range.

If the system was not able to water profile to the nominal range, then the bottom track range should be reduced to no more than the same percentage as the water profile loss.

If the Bottom Track did obtain the complete range and the Water Profile did not, then it is likely that there is insufficient backscatter in the water to obtain the specified range.

NOTES

Chapter 6

TROUBLESHOOTING

In this chapter, you will learn:

- Basic Steps in Troubleshooting
- Troubleshooting a Communication Failure
- Troubleshooting a Built-In Test Failure
- Troubleshooting a Beam Failure
- Troubleshooting a Sensor Failure
- System Overview

Considering the complexity of the WorkHorse, TRDI has provided as much information as practical for field repair; *fault location to the component level is beyond the scope of these instructions*. The provided information assumes that faults are isolated with a large degree of certainty to a Least Replaceable Assembly (LRA) level only. The time to repair the system will be minimized if an entire replacement unit is available in the field. If time to repair is of essence, Teledyne RD Instruments strongly advises the availability of the listed LRAs.

Table 27: List of Least Replaceable Assemblies

LRA	Description
ADCP	The entire ADCP; includes the electronics, housing, transducer ceramic assemblies, and end-cap.
Deck Box (Mariner only)	The Deck Box contains all electronics necessary to supply power, provide user communication and gyro interface.
I/O Cable	Connects the ADCP with the Deck Box (Mariner) or Computer.
Serial Cable	Connects the Mariner Deck Box to the computer.
End-Cap	Includes the end-cap, connector, and internal I/O cable.
ADCP electronics	The spare boards kit Includes the PIO, CPU, and DSP boards.
PC Card	Replaceable PC recorder card.

Since these Least Replaceable Assemblies are manufactured in different configurations, please contact Teledyne RD Instruments (see Technical Support for contact information) to obtain the correct part number for your specific system configuration. When contacting Teledyne RD Instruments about a replacement assembly, please provide the serial numbers of the ADCP and Deck Box. If you want to replace the I/O Cable only, then please provide the cable length.

Equipment Required

Special test equipment is not needed for trouble shooting and fault isolation. The required equipment is listed in Table 28. Any equipment satisfying the critical specification listed may be used.

Table 28: Required Test Equipment

Required Test Equipment	Critical Specification
DMM	Resolution: 3 ½ digit DC-Voltage Range: 200 mV, 2V, 20 V, 200V DC-Voltage Accuracy: ± 1% AC-Voltage Range: 200 V, 450 V AC-Voltage Accuracy: ± 2% Resistance Range: 200, 2 k, 20 k, 200 k, 20 MOhm Res.-Accuracy: ± 2% @ 200 Ohm to 200 kOhm Res.-Accuracy: ± 5% @ 20 Mohm Capacitance Range: 20 nF, 2 uF, 20 uF Capacitance Accuracy: ± 5%
Serial Data EIA Break-Out Box such as from International Data Sciences, Inc. 475 Jefferson Boulevard Warwick, RI 02886-1317 USA.	Model 60 or similar is recommended as it eases the troubleshooting of RS-232 communication problems significantly. Other manufacturers or models may be substituted.

The EIA Break-out Panel is not necessary, but eases RS-232 communication problems troubleshooting significantly.

Basic Steps in Troubleshooting

The first step in troubleshooting is determining what type of failure is occurring. There are four types of failures:

- Communication failure
- Built-In test failure
- Beam failure
- Sensor failure

Communication failures can be the hardest problem to solve as the problem can be in any part of the system (i.e. the computer, WorkHorse, cable, or power). The symptoms include having the system not respond, or not responding in a recognizable manner (for example "garbled" text).

Built-In test failures will appear when the system diagnostics are run. Use *WinSC* or *BBTalk* to identify the failing test.

Beam failures can be identified when collecting data or during the user-interactive performance tests.

Sensor failures can also be identified when collecting data or during the user-interactive performance tests. The sensor may send incorrect data, or not be identified by the system.

Troubleshooting the WorkHorse

Although the WorkHorse is designed for maximum reliability, it is possible for a fault to occur. This section explains how to troubleshoot and fault isolate problems to the Least Replaceable Assembly level (see Table 27). Before troubleshooting, review the procedures, figures, and tables in this guide. Also, read the System Overview to understand how the WorkHorse processes data.

Under all circumstances, follow the safety rules listed in the Troubleshooting Safety.

Troubleshooting Safety

Follow all safety rules while troubleshooting:

Servicing instructions are for use by service-trained personnel. To avoid dangerous electric shock, do not perform any service unless qualified to do so.

Complete the ground path. The power cord and the outlet used must have functional grounds. Before power is supplied to the WorkHorse, the protective earth terminal of the instrument must be connected to the protective conductor of the power cord. The power plug must only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.

Any interruption of the earthing (grounding) conductor, inside or outside the instrument, or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury.

Only fuses with the required rated current, voltage, and specified type must be used. Do not repair fuses or short circuit fuse-holders. To do so could cause a shock or fire hazard.

Do not install substitute parts or perform any unauthorized modifications to the instrument.

Measurements described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

Do not attempt to open or service the power supply.

Any maintenance and repair of the opened instrument under voltage should be avoided as much as possible, and when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

Troubleshooting a Communication Failure

WorkHorse ADCPs communicate by means of two serial communication channels. The user can choose between RS-232 and RS-422 classes of serial interfaces with a switch on the PIO board in the ADCP.

To successfully communicate, both the host computer and the ADCP must communicate using the same class of serial interface. Standard serial interfaces in IBM compatible computers are also RS-232.

If you have just received your WorkHorse from TRDI, the standard configuration is RS-232 for Sentinels and RS-422 for Monitors and Mariners.

If you are using a high baud rate and/or a long I/O cable (greater than 50 meters) connected to a Sentinel ADCP, RS-232 may not work. Switch to RS-422 and try to wake up the WorkHorse again.

Most communication problems are associated with incorrect cabling (i.e. the serial cable is connected to the wrong port) or data protocols (i.e. the wrong baud rate is set between the ADCP and computer).

Incorrect Wakeup Message

When you send a break and the wakeup message is not readable (garbled), this may indicate a communications mismatch or lost boot code.

- Sending a break causes "garbage" to appear on the screen. The "garbage" text may keep scrolling. This happens when the computer is using RS-232 and the ADCP is set for RS-422 or vice-versa. Check the RS-232/RS-422 switch on the PIO board (see Communications Setting).
- Sending a break causes "garbage" to appear on the screen. You can hear the ADCP "beep" when the break is sent. The "garbage" text does not keep scrolling. Check that the ADCP and computer

are both using the same baud rate. See the CB-command in the WorkHorse Command and Output Data Format guide.

- If the ADCP gives a steady "beep" when power is applied, the ">" prompt appears on the screen, and an "X" appears when additional breaks are sent, this may indicate that the boot code has been lost. This can happen if you abort while downloading new firmware. Try downloading the firmware again.

No Wakeup Message

When you send a Break and do not see the wakeup message, you need to isolate the problem to a computer fault, power, cable failure, or an ADCP problem.

Check the following items:

1. Connect the ADCP to a computer as shown in Setting up the WorkHorse System. Check that all cable connections are tight.
2. Is the ADCP AC power adapter working? Is the input voltage to the AC power adapter between 100 to 240 VAC? Is the output level 48 VDC?
3. If the ADCP is running from a battery, check that the battery voltage is above 30 VDC. ADCPs will work at 20 VDC with at least 400 milli amps; however, both lithium and alkaline battery packs with voltages below 30 VDC are at or near their end of life, and are approaching uselessness.
4. Is the computer hooked up properly? Does it have power?
5. Make sure that your computer and the *BBTalk* programs are set up to use the communication port the serial cable is connected to on the computer.
6. In the case where the ADCP is only able to accept a SOFT BREAK due to telemetry components that will not "pass" a HARD BREAK to the ADCP and where you can cycle power, TRDI recommends that you consider removing power for one week. Re-apply power after a week and the ADCP should wake up.

The ADCP automatically stores the last set of commands used in RAM. Removing power for one week allows the RAM to lose its backup power. When power is re-applied, the ADCP will then do a 'cold start' (see ADCP Checks).

This is something that can be done without recovering the instrument. It assumes power can be cycled without recovering the ADCP and the ADCP is still functioning. The cost benefits of waiting a week needs to be weighed against the cost of divers recovering the ADCP.

Check the Power

The following test can be done with a voltmeter to check the power. Check the power going into the ADCP by measuring the voltage on the end of the cable that connects to the WorkHorse at Pins 3 and 7 (GND) (see WorkHorse Cables). The voltage should be +48 VDC (using the standard AC adapter) or +48 VDC if you are using the Deck Box. If not, check the voltage at the other end of the cable, the AC adapter, and Deck Box (Mariner only).

Check the I/O Cable

This test will check the communication between the computer and Monitor or Sentinel WorkHorse.

To check the cable:

1. Disconnect both ends of the cable and measure the continuity using a DMM (see WorkHorse Cables for the wiring diagram). Correct any problems found.
2. Reconnect the I/O cable to host computer.
3. Load *BBTalk* on your computer. Select the proper communications port (see the RDI Tools User's Guide for help on using *BBTalk*).
4. For RS-232 communications, short pins 1 and 2 together on the female 7-pin connector that was plugged into the WorkHorse (see WorkHorse Cables). If you are using RS-422, connect a jumper between pin 2 to pin 6 and another jumper between pins 1 to pin 5 of the underwater connector at the WorkHorse end of the cable.
5. Type any characters on the keyboard. The keys you type should be echoed on the screen. If you see characters, but not correctly (garbage), the cable may be too long for the baud rate. Try a lower baud rate. If this works disconnect the jumper on pins 1 and 2 and then push any keys on the keyboard. You should NOT see anything you type.
6. If the keys are echoed correctly on the screen, the computer and the communication cable are good. Re-connect the I/O cable to the WorkHorse. The above loop-back test does not show if transmit and receive pairs are interchanged. Thus, it is important that you check the wiring diagrams provided in WorkHorse Cables.

A loop-back test does not show if transmit and receive wires or pairs are interchanged, even though characters may be displayed correctly.

Check the Mariner Cables

This test will check the serial communication cable between the computer and Deck Box (Mariner only).

To check the cable:

1. Disconnect both ends of the cable and measure the continuity using a DMM (see WorkHorse Cables for the wiring diagram). Correct any problems found.
2. Reconnect the serial cable to host computer. Start the Teledyne RD Instruments software utility program *BBTalk* on your computer. Make sure to select the proper communications port.
3. For testing a RS-232 cable, jumper pins 2 and 3 at the far end of the cable. To check a RS-422 cable, connect one jumper between pin 2 to 4, and one jumper between pins 7 to 8.
4. Type any characters on the keyboard. The keys you type should be echoed on the screen. If you see some characters, but not correctly, the cable may be too long for the baud rate. Try a lower baud rate. If this works disconnect the jumper and then push any keys on the keyboard. You should NOT see anything you type.
5. If you use cables that are **not** supplied by Teledyne RD Instruments you must make sure that transmit and receive pairs are not interchanged. The above loop-back test does not show if transmit and receive pairs are interchanged. Thus, it is important that you check the wiring diagrams provided in WorkHorse Cables.

A loop-back test does not show if transmit and receive wires or pairs are interchanged, even though characters may be displayed correctly.

6. If the keys are echoed correctly on the screen, the computer and the communication cable are most likely good. Re-connect the serial cable to the Deck Box. If the WorkHorse still does not wakeup, there could still be a problem with the Deck Box or ADCP.

ADCP Checks

Once you have eliminated possible problems with the power, I/O cable, communications settings, and the computer, that leaves the ADCP as the source of the problem. The following checks may help in some situations.

To Cold Start the ADCP:

1. Remove the housing to gain access to the PC boards.
2. Remove *all* power to the ADCP.

> Disconnect the power cables P1 and P2 on the PIO board to ensure that NO POWER is applied to the ADCP during the next step.

3. Short TP10 to TP11 on the PIO board for 10 seconds.
4. Remove the jumper.
5. Connect the computer and connect power to the ADCP. Send a break to the ADCP. This should start the ADCP in the "cold start" mode.

To check the fuse:

Check the fuse on the PIO board is not blown (see Fuse Replacement for fuse replacement procedures).

> Only fuses with the required rated current, voltage, and specified type must be used. Do not repair fuses or short circuit fuse-holders. To do so could cause a shock or fire hazard.

Check for Boot Code Error:

If the ADCP gives a steady "beep" when power is applied, the ">" prompt appears on the screen, and a "X" appears when additional breaks are sent, this may indicate that the boot code has been lost. This can happen if you abort while downloading new firmware. Try downloading the firmware again.

Mariner Deck Box Checks

Once you have eliminated possible problems with the WorkHorse power, the serial data communication cable, and the host computer, that may leave the Deck Box as the source of the problem.

> The Deck Box contains Electro Static Sensitive Devices. You must take accepted ESD prevention measures before opening the Deck Box.

To check the deck box:

1. One of the interconnecting cables inside the Deck Box may not be fully seated. Turn off power. Remove the top cover of the Deck Box and check that all of the cables are properly seated.
2. Check the Deck Box fuses are not blown (see Fuse Replacement for fuse replacement procedures).
3. Verify that the **Power Status** LED indicator located at the front panel next to the circuit breaker switch is lit. Make sure power to the Deck Box is connected and that the circuit breaker is in the ON position.
4. Verify that if you send push the Reset button, the **Channel 1 In** LED on the front panel lights up temporarily. If it does, that means that the serial data receive channel seems to be functioning. If it does not light up then the receive channel is not functioning.

5. If the **Channel 1 In** LED indicator on the front panel does light up while pushing **Reset**, verify that the **Channel 1 Out** LED next to it responses by lighting up temporarily as well. If the **Channel 1 Out** LED does light up, but there is no Wake-Up message displayed on the computer screen, then this indicates there is still a problem with the serial data transmit path. A serial data Break-Out box between the Deck Box and the serial communications cable would be helpful for narrowing down the problem.
6. If the Break-Out box does not indicate any data transmission from the Deck Box to the computer but the **Channel 1 Out** LED front panel indicator does, the problem most likely is with the Deck Box. Switch power to the Deck Box off, and after a few seconds on again. Repeat the Deck Box Checks from the beginning. If the system does not respond normally, it may be malfunctioning and you should contact Teledyne RD Instruments.
7. If the Break-Out box does indicate data transmission but there are no characters displayed on the computer screen, then the problem still lies with the communications cable or the computer.

Troubleshooting a Built-In Test Failure

The built-in diagnostic tests check the major ADCP modules and signal paths. The spare boards kit may be used to repair some failures. This kit includes:

- Spare Boards including PIO board, CPU board, and DSP board. These boards are held together with the standard M4 screw assembly and kept inside a protective anti-static bag.
- A disk containing your original beam cosine matrix table
- Tools for installation

The Spare Boards kit is not included with the system. You can order the kit by contacting Teledyne RD Instruments Customer Service department (see How to Contact Teledyne RD Instruments and Table 15, page 89).

When to use the Spare Boards Kit

Use this Kit whenever you have any of the following problems:

- Cannot communicate to the WorkHorse and you have ensured that the serial port on the computer, WorkHorse Cable, Deck Box (Mariner only), and WorkHorse RS-232 to RS-422 converter (if applicable) are all working properly.
- Your WorkHorse fails any of the following PA tests at any time:

  CPU Tests:
  - RTC
  - RAM
  - ROM

  DSP Tests:
  - Timing RAM
  - Demod RAM
  - Demod REG
  - FIFOs

  System Tests:
  - XILINK Interrupts
  - Receive Loop Back Test

- Your WorkHorse fails any of the following PA tests provided the items indicated by {} have been checked:

  Recorder Tests:

  Any recorder tests fails {provided that the PCMCIA card(s) have been checked for proper installation, operation and they are DOS formatted; we STRONGLY recommend checking PCMCIA cards in a computer before replacing the boards}

  System Tests:

  Transmit {if the WorkHorse fails when it is in water and air bubbles have been rubbed from the faces}

  Sensor Tests:

  H/W Operation {if the WorkHorse fails when it is NOT sitting/resting on its side, or located near a large magnetic field like a motor in a boat}

The spare boards kit will not correct any of the following failures:

- A damaged beam or its urethane surface
- Damage to the transducer beam connections below the copper shield
- If it passes all PA tests and yet the data is all marked as bad
- Fails the following PA test:

System Tests:
Wide Bandwidth {bandwidth tests may fail due to external interference}

Narrow Bandwidth {bandwidth tests may fail due to external interference}

RSSI Filter

Transmit

Table 29: Pre-deployment Test (PA) Possible Cause of Failures

PA Test Name	Possible Cause of Failure

`Pre-Deployment Tests CPU Tests:`
`RTC`
`RAM`
`ROM`
	CPU board failed

`Recorder Tests:`
`PC Card #0`
`Card Detect`
`Communication`
`DOS Structure`
`Sector Test (short)`
`PC Card #1`
`Card Detect`
`Communication`
`DOS Structure`
`Sector Test (short)`
	PC card not plugged in
	PC card failed
	DSP board failed

`DSP Tests:`
`Timing RAM`
`Demod RAM`
`Demod REG`
`FIFOs`
	DSP board failed

`System Tests:` `XILINX Interrupts`	DSP or CPU board failed
`Receive Loop-Back`	DSP or CPU board failed

`Wide Bandwidth`
`Narrow Bandwidth`
`RSSI Filter`
	Not in water
	External interference
	DSP or Receiver board failed

`Transmit`	Not in water or PIO board failed
`Sensor Tests:` `H/W Operation`	PIO board failed Receiver board failed Pressure sensor failed ADCP laying on its' side

Troubleshooting a Beam Failure

The PC1 test is designed to measure the relative noise in the environment and then have you apply more noise by rubbing the ceramics with your hand. Sometimes your hand does not generate enough noise for the system to detect. This could be due to the environment you are in or for other reasons. A simple, safe, and easy to find material that works very well as a replacement to your hand is packaging material (a.k.a. bubble wrap). Using this instead of your hand will very likely provide enough relative frictional difference for the system to pass.

If the PC1 test fails, your system may still be okay. In this case deploy the ADCP into a bucket or container of water (preferably at least 0.5 meters deep). Record some data using *BBTalk* and the log file (**F3** key), or record data straight to the recorder card if your ADCP has one. Then look at the data using the *WinADCP* program and make sure that the echo amplitude counts in the 1st depth cell for all beams is between 128 and 192. If they are not, contact Field Service for further troubleshooting tips.

If the beam continuity test still fails and/or the echo amplitude indicates a problem, a bad DSP board, Receiver board, PIO board, or a bad beam may cause the failure. If replacing the DSP and PIO board (included with the spare boards kit) does not fix the problem, the ADCP must be returned to TRDI for repair.

```
>PC1

BEAM CONTINUITY TEST

When prompted to do so, vigorously rub the selected
beam's face.

If a beam does not PASS the test, send any character to
the ADCP to automatically select the next beam.

Collecting Statistical Data...
  41  46  45  43  41  46  45  43  41  46  45  42  41  46  44  42

Rub Beam 1 = PASS |   NOTE - Possible cause of failure
Rub Beam 2 = PASS |          DSP Board
Rub Beam 3 = PASS |          Receiver Board
Rub Beam 4 = PASS |          PIO Board
>                 |          Beam
```

This test must be performed with the ADCP out of water and preferably dry.

Troubleshooting a Sensor Failure

If the PA test fails the sensor test, run PC2 to isolate the problem. The ambient temperature sensor is mounted on the receiver board. This sensor is imbedded in the transducer head, and is used for water temperature reading. The attitude temperature sensor is located on the PIO board under the compass. The ADCP will use the attitude temperature if the ambient temperature sensor fails.

If one of the temperature sensors fails, the PC2 test will show both sensors at the same value.

```
>PC2
Press any key to quit sensor display ...

Heading   Pitch    Roll   Up/Down    Attitude Temp   Ambient Temp   Pressure
301.01°  -7.42°  -0.73°    Up          24.35°C        22.97°C         0.0 kPa
300.87°  -7.60°  -0.95°    Up          24.36°C        22.97°C         0.0 kPa
300.95°  -7.60°  -0.99°    Up          24.37°C        22.97°C         0.0 kPa
300.71°  -7.61°  -0.96°    Up          24.37°C        22.98°C         0.0 kPa
300.69°  -7.61°  -0.96°    Up          24.35°C        22.98°C         0.0 kPa
300.76°  -7.60°  -0.98°    Up          24.38°C        22.97°C         0.0 kPa
>
```

If the temperature sensor is bad, the data can still be collected with no effects to accuracy or quality. Contact TRDI about scheduling a repair of the temperature sensor at your convenience.

For external sensor verification, see Dock Side Tests.

Fault Log

To determine why a sensor failed, view the fault log. To view the fault log, start *BBTalk*. Press the **End** key to wake up the ADCP. Type the following commands: **CR1**, **PA**, **FD**, **FC**. The fault log will be displayed by the FD command and is cleared by the FC command.

```
[BREAK Wakeup A]

WorkHorse Broadband ADCP Version x.xx
Teledyne RD Instruments (c) 1996-1997
All rights reserved.
[BREAK Wakeup A]
>CR1
>PA
|          (PA test results (not shown))
|
>FD
Total Unique Faults   =     2
Overflow Count        =     0
Time of first fault:   97/11/05,11:01:57.70
Time of last fault:    97/11/05,11:01:57.70

Fault Log:
Entry #  0 Code=0a08h  Count=    1  Delta=    0 Time=97/11/05,11:01:57.70
 Parameter = 00000000h
  Tilt axis X over range.
Entry #  1 Code=0a16h  Count=    1  Delta=    0 Time=97/11/05,11:01:57.70
 Parameter = 00000000h
  Tilt Y axis ADC under range.
End of fault log.
>FC
```

System Overview

This section presents a functional description of WorkHorse operation using block diagrams.

Operating Modes

The WorkHorse has two modes of operation: *command mode*, and *ping mode* (also referred to as "Deployment Saver" Mode). Depending on what mode the ADCP is in; it will go either to sleep, or to resume pinging.

Command Mode

Whenever you wake up your WorkHorse, power dissipation increases from less than 1 mW to around 2.2 W. If you leave the WorkHorse in command mode without sending a command for more than 5 minutes, the WorkHorse automatically goes to sleep. This protects you from inadvertently depleting batteries.

- If the ADCP receives a BREAK, it will go to the command prompt and wait for a command. The ADCP will wait at the command prompt for five minutes. If no commands have been sent, it will go to sleep (also called "Battery Saver" mode).
- If you press the reset switch (located on the CPU board), the ADCP will go to sleep.
- If the ADCP receives a CS-command, it will go into the ping mode and begin pinging. If a TF-command (Time of First Ping) was sent prior to the CS-command, then the ADCP will go to sleep until the TF time occurs.
- If the ADCP does a COLD wakeup (i.e. an unknown state), it will go to the command prompt.
- If the ADCP is asleep for approximately nine hours, it wakes up to charge the capacitor used to maintain RAM. Once the capacitor is charged (this only takes a few seconds), the ADCP goes back to sleep.

Ping Mode

After you send commands to the WorkHorse that tells it to start collecting data, the WorkHorse goes into deployment saver mode. If power is somehow removed and later restored, the WorkHorse simply picks up where it left off and continues to collect data using the same set up.

- If the ADCP receives a BREAK, it will go to the command prompt, but stays in the ping mode. If a valid command is received, the ADCP will switch to the command mode. If no valid command is received, a warning will be displayed after four minutes, indicating that the system will self-deploy. After a total of five minutes with no input, the ADCP will resume pinging.
- If you press the reset switch, and an alarm is currently set for the next ping, the ADCP will go to sleep. If no alarm is set, the system will start a new deployment and starts pinging immediately unless a TF-command had been set after the last BREAK. In this case, the ADCP will go to sleep until the TF time occurs.
- If the ADCP does a COLD wakeup, the system will start a new deployment and starts pinging immediately unless a TF-command had been set after the last BREAK. In this case, the ADCP will go to sleep until the TF time occurs if the TF time is valid (i.e., not in the past).
- If the ADCP is asleep for approximately nine hours, it wakes up to charge the capacitor used to maintain RAM. Once the capacitor is charged, if a valid alarm is set for the next ping time, the ADCP goes back to sleep and waits for the alarm. If no alarm is set, the ADCP will resume pinging immediately, or wait for the TF time (if valid), and then start pinging.

Overview of Normal WorkHorse Operation

Refer to Figure 81 through Figure 83. The following events occur during a typical data collection cycle.

1. The user or a controlling software program sends data collection parameters to the WorkHorse. The user/program then sends a CS-command to start the data collection cycle. The firmware program stored in the CPU microprocessor takes control of WorkHorse operation based on the commands received through the serial I/O cable.

   Figure 81 shows a flow chart of the wake-up logic used by the WorkHorse. The WorkHorse determines what to do based on where the wake-up came from (a Break, CS-command, battery saver timer, or watchdog timer was detected).
2. On the PIO Board, the POWER REGULATOR circuit sends a transmit command to the POWER AMPLIFIER circuit. This tells the WorkHorse to start acoustic transmissions (pinging) on all TRANSDUCERS.
3. The TRANSDUCERS receive echoes from the backscatter. The RECEIVER board amplifies and translates the echoes into a base-band frequency.
4. The CPU board processes the received echoes.
5. After echo reception, the WorkHorse injects a self-test signal into the RECEIVER board and processes the signal as normal data for test purposes.
6. The THERMISTOR measures water temperature at the transducer head and sends it to the CPU via the DSP Board.
7. The PIO Board sends pitch and roll from the TILT SENSOR and WorkHorse heading from the COMPASS to the DSP Board. The DSP Board digitizes this information and sends it to the CPU for processing.
8. The CPU repeats steps “b” through “g” for a user-defined number of pings. The CPU averages the data from each ping to produce an ensemble data set.
9. At the end of the ensemble (sampling) interval, the CPU sends the collected data to the serial I/O connector or PCMCIA recorder.

Functional Description of Operation

The following paragraphs describe how the WorkHorse operates and interacts with its modules. Refer to Figure 81 through Figure 83 throughout this description.

Input Power

The WorkHorse Monitor/Sentinel requires a DC supply between 20 volts and 50 volts. Either an external DC power supply or internal battery packs can provide this power. Figure 82 shows the DC voltage power distribution path.

Monitor External DC Power Supply – With an external supply, power is applied to pins 3 (positive) and 7 (negative) on the external connector (see Figure 83). The power then goes through an electromagnetic interference (EMI) filter on the PIO Board. This filter reduces the chance that external noise sources associated with the external power source can disrupt WorkHorse operation.

Sentinel Internal Battery Packs – Each internal battery pack uses 28 alkaline “D” cells. Each pack supplies a nominal output voltage of 42 volts open circuit when fresh. The diode-isolated battery packs can only power the WorkHorse; they cannot “charge” each other.

Mariner Deck Box – The deck box automatically scales the input voltage to the proper level. No special jumpers or switch settings are required to select the input voltage. If more than one power source is connected to the deck box, the highest voltage source will be used. Although this is not recommended, it will not damage the deck box.

AC Power. The deck box accepts input voltages of 98 to 264 VAC, 50 to 60Hz (J27). This input voltage will be converted to 48 VDC. This is the voltage supplied to the ADCP.

12 VDC Car Battery. Use a 12 VDC car battery (J26) when AC power is not available. The deck box converts the voltage to 48 VDC. This is the voltage supplied to the ADCP. Use the largest rated amp-hour battery as possible. A car battery should last one to two days powering a 1200-kHz River ADCP.

DC Power Supply. If you are using an external DC power supply connected to the deck box on J25 (20 to 50 VDC, 3.0 A), the voltage from the external power supply is sent *directly* to the ADCP. This is useful if you want to increase (higher voltage level) or decrease (lower voltage level) the range of the ADCP. The current requirement for the power supply is listed as a reference. Using a lesser-rated power supply can cause the voltage level to drop. The ADCP will draw only the current it needs.

Board Descriptions

PIO Board.

- Receives the filtered/internal power.
- Uses a diode "OR" gate to determine which power source to use (external or internal). With both sources connected, the OR gate selects the "higher" voltage for WorkHorse use.
- Limits the in-rush of current to the WorkHorse and provides over- and negative-voltage protection. Either condition will blow a protective fuse. However, damage could occur to other circuits before the fuse blows. Please ensure you apply only voltages within the specified range (+20 to +50 VDC).
- Converts the operating power supply (filtered/isolated 20 to 50 VDC) in a DC-to-DC converter to the +5 VDC (Vcc) used to power all other WorkHorse circuits.
- Uses the Power Amplifier circuit on the PIO board to generate the high-amplitude pulse AC signal that drives the sonar transducers. The Power Amplifier sends the drive signal to the Receiver Board.
- RS-232/RS-422 switch.

CPU Board.

- Real time clock.
- Generates most of the timing and logic signals used by the WorkHorse.

DSP Board.

- Contains the PCMCIA recorder slots.
- Analog to Digital converter.
- Digitizes information from sensors and sends sensor information to the CPU.

Receiver Board.

- Tuning functions
- Receiver functions
- Temperature sensor
- Interface for pressure sensor

Sensors

This section describes the standard WorkHorse sensors. The PIO and DSP boards control the environmental sensors and contain unit-specific data. Sensors include:

Temperature Sensor (Thermistor) - Used to measure the water temperature. The system uses this data to calculate the speed of sound. This sensor is embedded in the transducer head and is not field replaceable.

Up/Down Sensor - Determines whether the transducer head is facing up or down. This sensor is located on the PIO board.

Compass - Determines the Beam 3 heading angle of the WorkHorse using a flux-gate compass. This sensor is located on the PIO board. The flux-gate measured earth magnetic field vector together with the tilt sensor pitch and roll information is used to determine the heading. Since the tilt sensor data is only valid when the ADCP is ±20° from vertical, the heading information is also limited to this range.

Attitude Sensor - Determines the tilt angles of the WorkHorse. This sensor is located on the PIO board. The attitude sensor uses a pitch and roll liquid-filled sensor. This sensor is functional to an angle of ±20° from vertical.

Pressure Sensor (optional) - Measures pressure at the WorkHorse transducer. This sensor is embedded in the transducer head and is not field replaceable.

The CPU microprocessor controls a multiplexed analog-to-digital converter to accept analog data from the sensors. Digital data are taken in directly. The pressure sensor incorporates a Wheatstone Bridge strain gage to measure the water pressure at the transducer faces. Depth is calculated from pressure, with water density adjusted by the salinity (ES) setting.

Calibration data for the sensors, a beam-angle correction matrix, and unit identification parameters (frequency, serial number, firmware version, etc.) are stored in ROM.

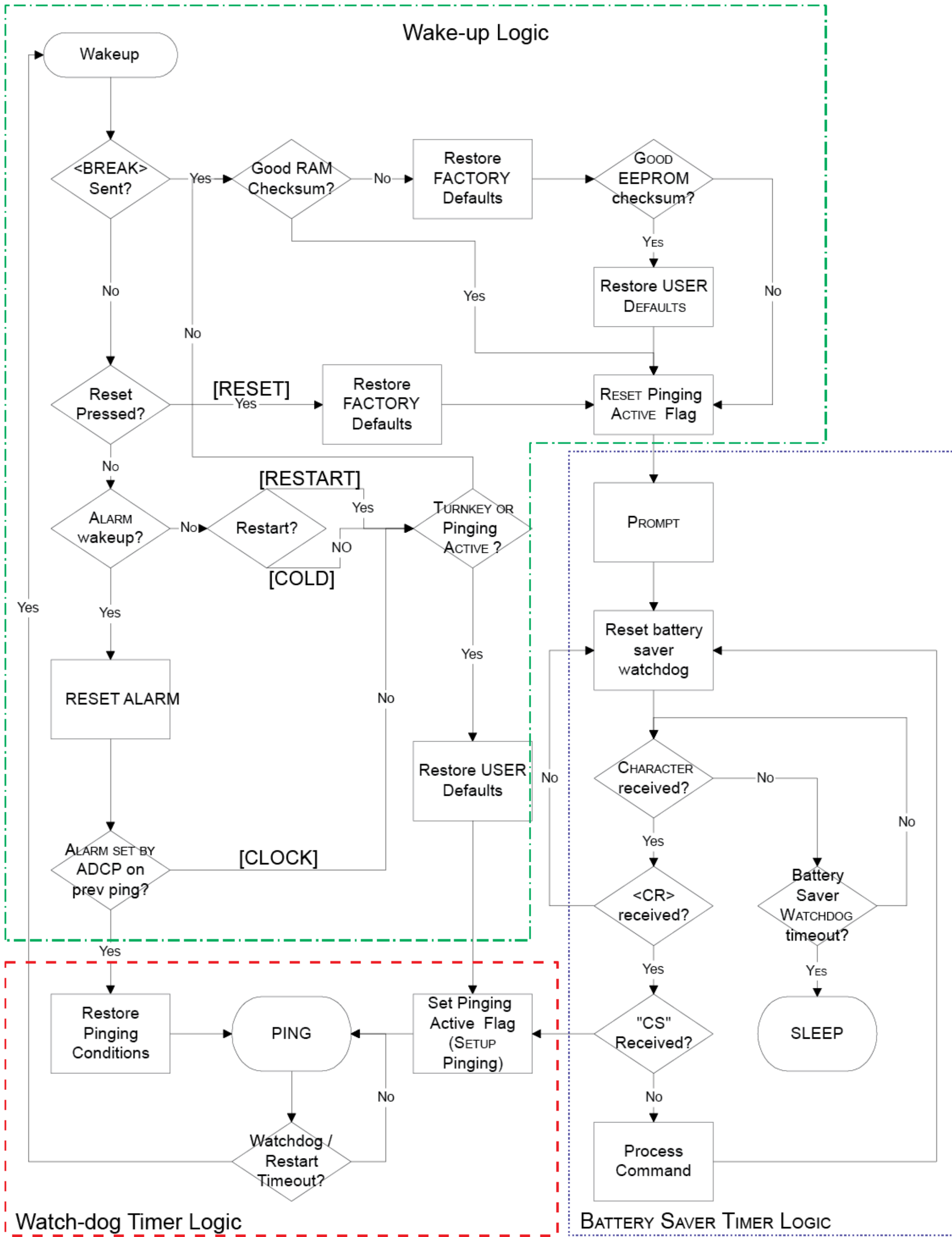


Figure 81. WorkHorse Wake-up and Timer Logic

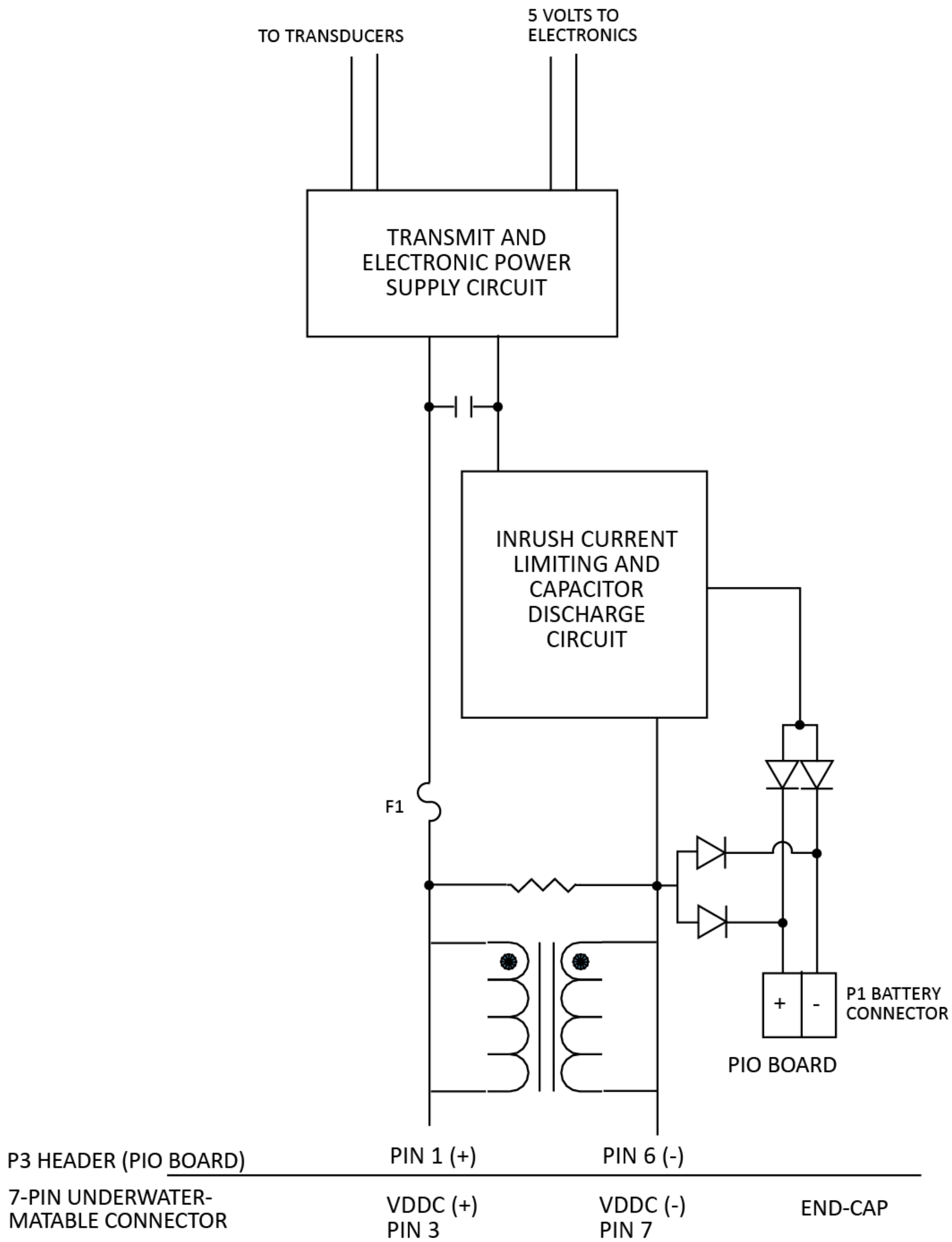


Figure 82. Mariner/Monitor/Sentinel DC Power Path

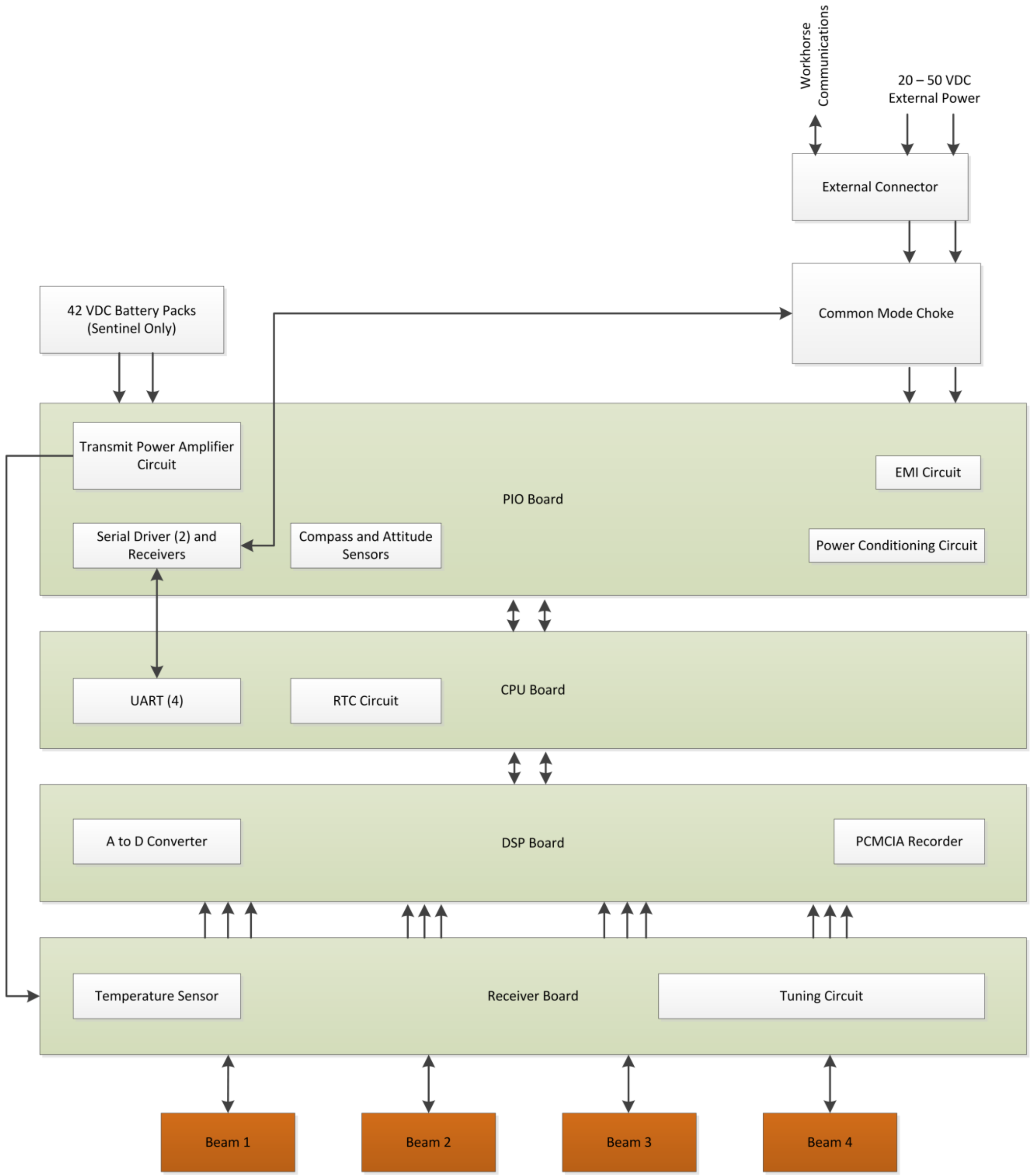


Figure 83. WorkHorse Block Diagram

NOTES

Chapter 7

RETURNING SYSTEMS TO TRDI FOR SERVICE

In this chapter, you will learn:

- How to pack and ship the ADCP
- How to get a RMA number
- Where to send your ADCP for repair

Shipping the ADCP

This section explains how to ship the WorkHorse ADCP.

Remove all customer-applied coatings or provide certification that the coating is nontoxic if you are shipping a WorkHorse ADCP to TRDI for repair or upgrade. This certification must include the name of a contact person who is knowledgeable about the coating, the name, manufacturer of the coating and the appropriate telephone numbers. If you return the equipment without meeting these conditions, TRDI has 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 ADCP through a Customs facility, be sure to place the unit so identifying labels are not covered and can be seen easily by the Customs Inspector. Failure to do so could delay transit time.

TRDI strongly recommends using the original shipping crate whenever transporting the WorkHorse ADCP.

If you need to ship the WorkHorse ADCP, use the original shipping crate whenever possible. If the original packaging material is unavailable or unserviceable, additional material is available through TRDI.

For repackaging with commercially available materials:

1. Use a strong shipping container made out of wood or plastic.
2. 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.
3. Seal the shipping container securely.
4. Mark the container FRAGILE to ensure careful handing.
5. In any correspondence, refer to the WorkHorse ADCP by model and serial number.

Returning Systems to the TRDI Factory

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

Step 1 - Request a Return Material Authorization

To obtain a Return Material Authorization (RMA) number and shipping instructions for the return of your instrument, do one of the following:

- Open the RMA using the web link: http://adcp.com/support/sendADCP.aspx
- Contact Customer Service Administration at rdicsadmin@teledyne.com
- Call +1 (858) 842-2600

When requesting a RMA number, please give us the following information:

- What is being shipped (include the serial number)
- When you plan to send the shipment
- What issue(s) need to be corrected
- Name of the Field Service Engineer that knows about the issue
- When you need the instrument returned

TRDI's Customer Service will then respond with the RMA number for the shipment. Please include this number on all packages and correspondence.

Step 2 – Provide a MSDS as necessary

Please provide a Material Safety Data Sheet (MSDS) if the system/transducer is painted with antifouling paint.

Step 3 - Ship via air freight, prepaid

Urgent Shipments should be shipped direct to TRDI via overnight or priority air services. Do not send urgent airfreight as part of a consolidated shipment. If you ship consolidated, it will cost less, 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: Teledyne RD Instruments, Inc. (RMA Number)
14020 Stowe Drive
Poway, California 92064

Airport of Destination = San Diego
Notify Paxton, Shreve and Hayes

Phone: +1 (619) 232-8941
Fax: +1 (619) 232-8976

Step 4 - Urgent shipments

Send the following information by fax or telephone to TRDI.

Attention: Customer Service Administration

Fax: +1 (858) 842-2822

Phone: +1 (858) 842-2600

- 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

Returning Systems to TRDI Europe Factory

When shipping the system to TRDI Europe, the following instructions will help ensure the WorkHorse ADCP arrives with the minimum possible delay. Any deviation from these instructions increases the potential for delay.

Step 1 - Request a Return Material Authorization

To obtain a Return Material Authorization (RMA) number and shipping instructions for the return of your instrument, do one of the following:

- Open the RMA using the web link: http://adcp.com/support/sendADCP.aspx
- Contact Customer Service Administration at rdiefs@teledyne.com
- Call +33(0) 492-110-930

When requesting a RMA number, please give us the following information:

- What is being shipped (include the serial number)
- When you plan to send the shipment
- What issue(s) need to be corrected
- Name of the Field Service Engineer that knows about the issue
- When you need the instrument returned

TRDI's Customer Service will then respond with the RMA number for the shipment. Please include this number on all packages and correspondence.

Step 2 – Provide a MSDS as necessary

Please provide a Material Safety Data Sheet (MSDS) if the system/transducer is painted with antifouling paint.

Step 3 - Ship Via Air Freight, Prepaid

Urgent Shipments should be shipped direct to TRDI via overnight or priority air services. Do not send urgent airfreight as part of a consolidated shipment. If you ship consolidated, it will cost less, 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.

Mark the package(s) as follows:

To: Teledyne RD Instruments, Inc. (RMA Number)
2A Les Nertieres
5 Avenue Hector Pintus
06610 La Gaude, France

Step 4 - Include Proper Customs Documentation

The Customs statement must be completed. It should be accurate 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 5 - Send the Following Information by Fax or Telephone to TRDI

Attention: Sales Administration

Phone: +33(0) 492-110-930

Fax: +33(0) 492-110-931

- 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

NOTES

Chapter 8

SPECIFICATIONS

In this chapter, you will learn:

- Specifications
- Outline Installation Drawings

A brief review of ADCP operation may help you understand the specifications listed in this section.

The specifications and dimensions listed in this section are subject to change without notice.

The ADCP emits an acoustic pulse called a PING. Scatterers that float ambiently with the water currents reflect some of the energy from the ping back to the ADCP. The ADCP uses the return signal to calculate a velocity. The energy in this signal is the *echo intensity*. Echo intensity is sometimes used to determine information about the scatterers.

The velocity calculated from each ping has a *statistical uncertainty*; however, each ping is an independent sample. The ADCP reduces this statistical uncertainty by averaging a collection of pings. A collection of pings averaged together is an *ensemble*. The ADCP's maximum *ping rate* limits the time required to reduce the statistical uncertainty to acceptable levels.

The ADCP does not measure velocity at a single point; it measures velocities throughout the water column. The ADCP measures velocities from its transducer head to a specified range and divides this range into uniform segments called *depth cells* (or *bins*). The collection of depth cells yields a *profile*. The ADCP produces two profiles, one for velocity, and one for echo intensity.

The ADCP calculates velocity data relative to the ADCP. The velocity data has both speed and direction information. If the ADCP is moving, and is within range of the bottom, it can obtain a velocity from returns off the bottom. This is called *bottom tracking*. The bottom track information can be used to calculate the absolute velocity of the water. The ADCP can get absolute direction information from a heading sensor.

The following tables list the specifications for the WorkHorse ADCP. About the specifications:

1. All these specifications assume minimal ADCP motion - pitch, roll, heave, rotation, and translation.
2. Except where noted, this specification table applies to typical set ups and conditions. Typical set ups use the default input values for each parameter (exceptions include Pings Per Ensemble and Number of Depth Cells). Typical conditions assume uniform seawater velocities at a given depth, moderate shear, moderate ADCP motion, and typical echo intensity levels.
3. The total measurement error of the ADCP is the sum of:
    - Long-term instrument error (as limited by instrument accuracy).
    - The remaining statistical uncertainty after averaging.
    - Errors introduced by measurement of ADCP heading and motion.
4. Because individual pings are independent, the statistical uncertainty of the measurement can be reduced according to the equation:

$$\frac{Statistical\ Uncertainity\ for\ One\ Ping}{\sqrt{Number\ of\ Pings}}$$

Table 30: Broad Bandwidth Water Profiling

Depth Cell Size[1]	Nominal range 15m[2] 1200 kHz			Nominal range 55m[2] 600 kHz			Nominal range 135m[2] 300k Hz		
Vertical Resolution	Range[3] (m)	Single Ping Std. dev. (cm/s)	Std. dev.[4] (cm/s)	Range[3] (m)	Single Ping Std. dev. (cm/s)	Std. dev.[4] (cm/s)	Range[3] (m)	Single Ping Std. dev. (cm/s)	Std. dev.[4] (cm/s)
0.25m	11.27	14.43	1.93						
0.50m	12.36	7.21	0.98	38.18	14.42	1.93			
1.0m	13.67	3.60	0.50	42.01	7.21	0.99	83.25	14.43	1.92
2.0m	15.12	1.80	0.24	46.49	3.60	0.51	92.62	7.21	0.98
4.0m				51.50	1.80	0.25	103.66	3.60	0.50
8.0m							116.10	1.81	0.24

NOTES
1. User's choice of depth cell size is not limited to the typical values specified.
2. Broad bandwidth mode is set with the WB command (WB0 by default).
3. Range, which depends on cell size, is specified here for Broad bandwidth mode at 5° C, typical ocean backscatter, and nominal 32 VDC battery power. Using 48 VDC will increase the range by 5 to 10% depending on conditions.
4. Broad bandwidth mode 50 water pings per ensemble standard deviation.
5. Table applies to WorkHorse Monitor/Sentinel/Mariner ADCPs.

Table 31: Narrow Bandwidth Water Profiling

Depth Cell Size[1]	Nominal range 15m[2] 1200 kHz			Nominal range 55m[2] 600 kHz			Nominal range 135m[2] 300 kHz		
Vertical Resolution	Range[3] (m)	Single Ping Std. dev. (cm/s)	Std. dev.[4] (cm/s)	Range[3] (m)	Single Ping Std. dev. (cm/s)	Std. dev.[4] (cm/s)	Range[3] (m)	Single Ping Std. dev. (cm/s)	Std. dev.[4] (cm/s)
0.25m	14.74	27.69	3.77						
0.50m	15.97	13.82	1.93	52.02	29.75	4.04			
1.0m	17.41	6.89	0.98	56.33	14.86	2.07	117.42	29.76	4.02
2.0m	18.96	3.45	0.48	61.27	7.40	1.06	128.11	14.86	2.05
4.0m				66.72	3.70	0.51	140.63	7.41	1.05
8.0m							154.39	3.72	0.52

NOTES
1. User's choice of depth cell size is not limited to the typical values specified.
2. Narrow bandwidth mode is set with the WB command (WB1).
3. Range, which depends on cell size, is specified here for Narrow bandwidth mode at 5° C, typical ocean backscatter, and nominal 32 VDC battery power. Using 48 VDC will increase the range by 5 to 10% depending on conditions.
4. Narrow bandwidth mode 50 water pings per ensemble standard deviation.
5. Table applies to WorkHorse Monitor/Sentinel/Mariner ADCPs.

Table 32: WorkHorse Range

Frequency	Range (m) @ 32VDC	Range (m) @ 48VDC	Depth Cell Size (m)
1200kHz	18.96	20.4	2
600kHz	66.72	70.9	4
300kHz	140.63	167.7	8

Range, which depends on cell size, is specified here for narrow bandwidth mode at 5° C, typical ocean backscatter, and nominal 32 VDC battery power (Sentinel) and 48VDC input power (Mariner/Monitor).

Table 33: Bottom Track Profile Parameters

System Frequency	1200 kHz	600 kHz	300 kHz
Maximum Altitude (m)*	28	100	260
Minimum Altitude (m)	0.8 (Mariner)	1.4 (Mariner)	2

* @ 48VDC input power.

Table 34: Bottom Track Velocity (for |V| < 10 m/s)

Precision (cm/s)*	1200 kHz	600 kHz	300 kHz
V=1.0 m/s	0.5	0.4	0.5
V=3.0 m/s	0.8	0.7	1.0
V=5.0 m/s	1.0	1.0	1.4
Reduced Accuracy BT (cm/s)	±1.15% ± 0.4	±1.15% ± 0.4	±1.15% ± 0.4
High Accuracy BT (cm/s)	±0.4% ± 0.4	±0.4% ± 0.4	±0.4% ± 0.4
Maximum Ping Rate**	1 to 10 Hz	0.5 to 7 Hz	0.5 to 7 Hz

* Water and Bottom velocity precision are standard deviations of horizontal velocities for single pings. The standard deviation for an ensemble of pings will decrease proportional to the square root of the number of pings averaged together.

* Single Ping Precision calculated for an altitude of one-half maximum altitude for a given frequency.

** Ping rates vary due to altitude, baud rate, and amount of water profiled.

Table 35: Profile Parameters

Item	Specification
Velocity accuracy	
1200 and 600 kHz	± 0.25% of the water velocity relative to the ADCP ± 2.5mm/s
300 kHz	± 0.5% of the water velocity relative to the ADCP ± 5 mm/s
Velocity resolution	1 mm/s
Velocity range	± 5m/s (default), ± 20m/s (maximum)
Number of depth cells	1 to 255
Ping rate	2 Hz (typical)

Table 36: Echo Intensity Profile

Item	Specification
Vertical resolution	Depth cell size
Dynamic range	80 dB
Precision	± 1.5dB (relative measure)

Table 37: Standard Sensors

Temperature (Transducer Mounted)	
Range	-5° to 45° C
Uncertainty	±0.4° C
Resolution	0.01°
Tilt	
Range	±15°
Uncertainty	±0.5° (up to 15°)
Precision	± 0.5°
Resolution	0.01°
Compass [1]	
Type	flux gate
Long-term accuracy	±2° @ 60° magnetic dip angle, 0.5G total field
Precision	± 0.50 @ 60° magnetic dip angle, 0.5G total field
Resolution	0.01°
Max tilt	± 15°
Optional Pressure Sensor [2]	
Available Pressure Ratings	1, 2, 5, 10, 20, 50, 100, 200, 400, 500, or 1000 BAR
Short-term uncertainty	±0.1%
Max. drift	±0.25%

1. Includes built-in field calibration procedure. Compass uncertainty is for tilts less than 15°.
2. Other pressure ratings may be special-ordered.

Table 38: Transducer and Hardware

Item	Specification
Beam angle	20°
Configuration	4 beam, convex
Internal memory	Memory card not included with Monitor and Mariner models. Sentinel and Long Ranger ADCPs come standard with one memory card. Two PCMCIA memory card slots are available. The maximum memory for each slot is 2GB, with the total memory capacity not to exceed 4GB.
Communications	Serial port selectable by switch for RS-232 or RS-422. ASCII or binary output at 1200 to 115,200 baud.

Table 39: Environmental Specifications

Item	Specification
Operating temperature with or without batteries	-5° to 45°C
Short Term Storage/Shipping (<45days) temperature (Batteries Installed)	-5° to 45°C
Long Term Storage (>45days) temperature (Batteries Installed)	O° C to 21° C
Long Term Storage (>45days) temperature (Batteries Removed)	-30° to 60°C
Long Term (>45days) Battery Storage	Batteries should be stored in cool dry air with a temperature range of O° C to 21° C
Battery Shelf Life	Use within one year

Do not deploy the system with batteries that are older than the Warning date. It should be noted, that while a battery pack will not be dead after the Warning date, the actual performance of the battery is in doubt and may not have sufficient capacity for the deployment.

TRDI batteries have four dates on them:

Manufacture Date is the date the battery was built and final tested.

TRDI Ship by Date provides the maximum duration that the battery will remain on our shelves before we will ship and is 6 months after our manufacture date.

Warning Do not Deploy After Date* provides the last date when the battery should be used to start a deployment and is 12 months from the manufacture date.

Expiration Date provides the date when the battery should no longer be considered useful and is 2 years from the manufacture date.

*A battery pack used to start a deployment prior to the Warning Date means that it will perform as expected and provide the required power for any deployment that was created using the TRDI planning module. For example, if your deployment is going to be 12 months long and the battery label shows it is nine months old, it is safe to use the battery.

Table 40: Power

System	Specification
Sentinel	
DC input	20 to 50 VDC external power supply
Battery Voltage	42 VDC (new), 28 VDC (depleted)
Battery Capacity	450 watt hours @ 0° C
External Battery Pack	42 VDC (new), 28 VDC (depleted). Holds up to two 450 watt hour batteries
Transmit	16W @ 35V (1200kHz), 37W @ 35V (600kHz), 115W @ 35V (300kHz)
Monitor	
DC input	20 to 50 VDC external power supply or 42 VDC External Battery Pack
Transmit	22W @ 48V (1200kHz), 60W @ 48V (600kHz), 190W @ 48V (300kHz)
Mariner	
Deck Box Input	12 VDC, 20 to 50V DC external power supply, 110 to 220 VAC
Transmit	22W @ 48V (1200kHz), 60W @ 48V (600kHz), 190W @ 48V (300kHz)

Outline Installation Drawings

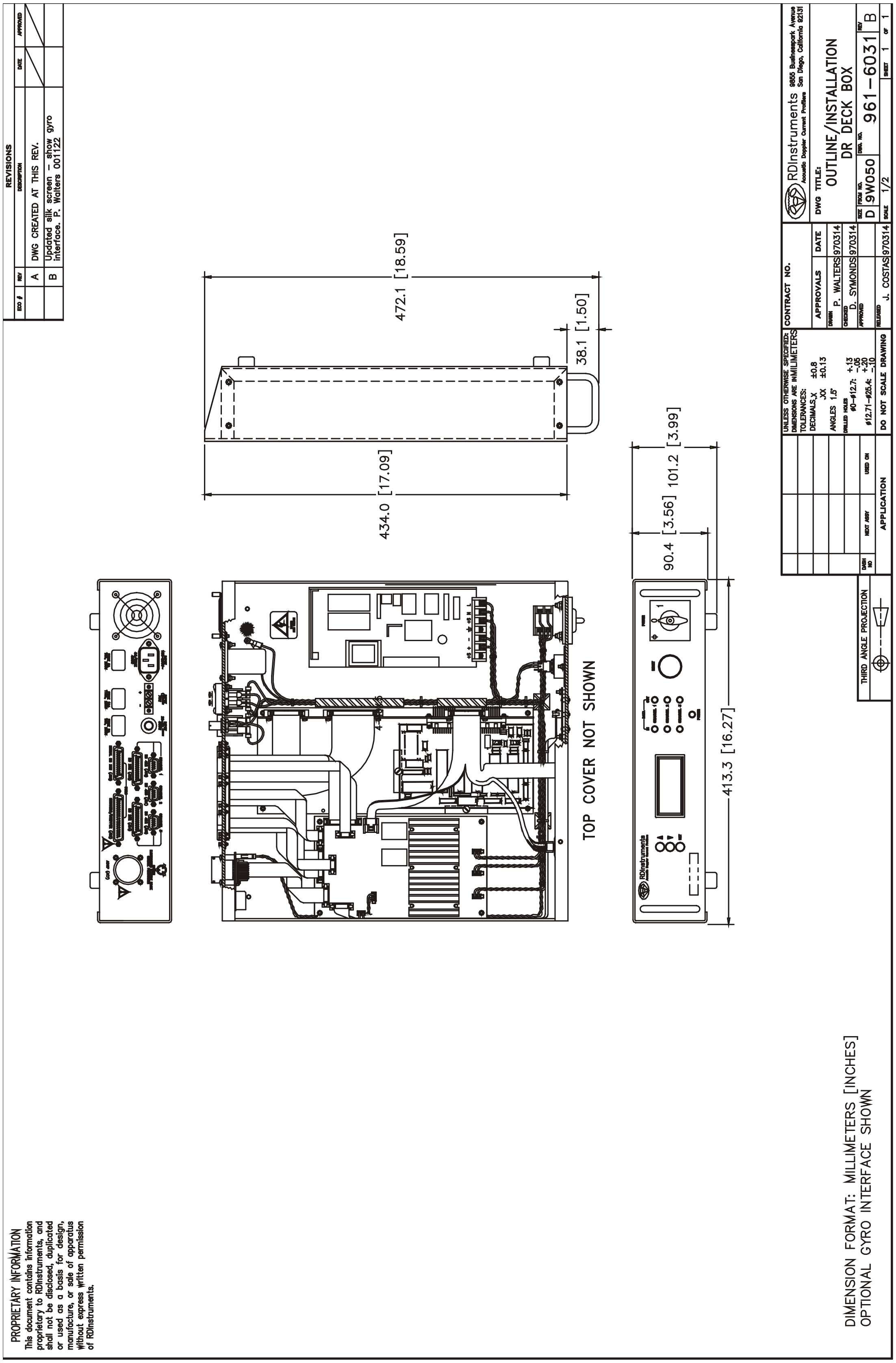
The following drawings show the standard WorkHorse Monitor, Sentinel, Mariner, and Mariner Deck Box dimensions and weights.

Table 41: Outline Installation Drawings

Description	Drawing #
Mariner Deck Box	961-6031
External Battery Case	967-6007
6000 meter External Battery Case	967-4001
1200 kHz Mariner	967-6032
300/600 kHz Mariner	967-6033
1200 kHz Monitor/Sentinel	967-6034
300/600 kHz Monitor/Sentinel	967-6035
300/600 kHz 500 meter Monitor/Sentinel	967-6044
1200 kHz 500 meter Monitor/Sentinel	967-6045
6000 meter 300kHz Sentinel	967-6113
6000 meter 600kHz Sentinel	967-6114
6000 meter 300kHz Monitor	967-6115

Outline Installation Drawings are subject to change without notice. Verify you have the latest version of the drawing by contacting TRDI before building mounts or other hardware.

961-6031


REVISIONS
A DWG CREATED AT THIS REV.
B Updated silk screen - show gyro interface. P. Walters 001122
472.1 [18.59]
38.1 [1.50]
434.0 [17.09]
90.4 [3.56]
101.2 [3.99]
413.3 [16.27]
TOP COVER NOT SHOWN
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE in MILLIMETERS
DO NOT SCALE DRAWING
APPLICATION
THIRD ANGLE PROJECTION
CONTRACT NO.
APPROVALS DATE
P. WALTERS 970314
D. SYMONDS 970314
J. COSTAS 970314
RDInstruments 9855 Businesspark Avenue San Diego, California 92131
DWG TITLE:
OUTLINE/INSTALLATION DR DECK BOX
D 9W050 961-6031 B
1/2
PROPRIETARY INFORMATION
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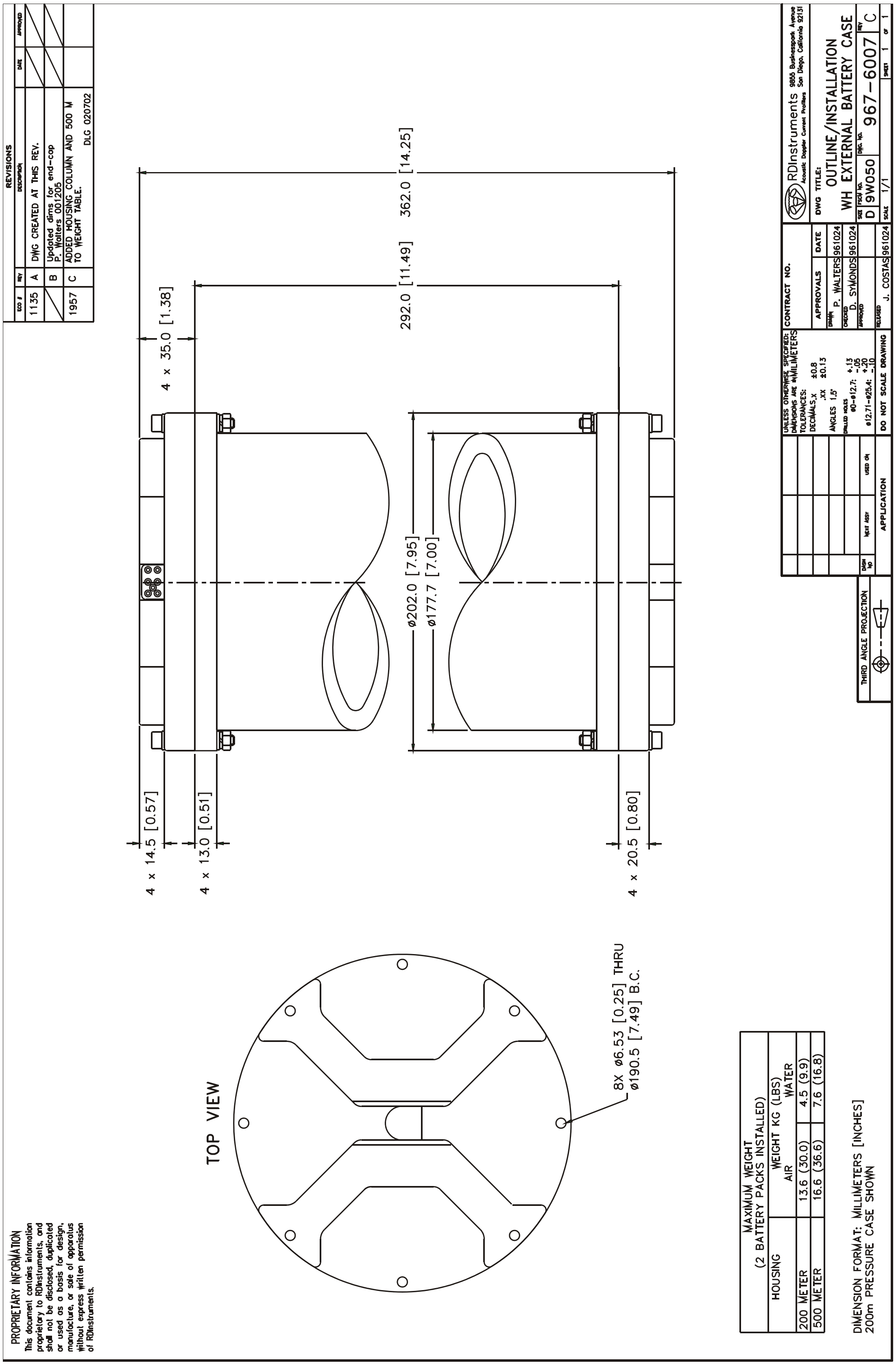
DIMENSION FORMAT: MILLIMETERS [INCHES]
OPTIONAL GYRO INTERFACE SHOWN

967-6007



REVISIONS
1135 A DWG CREATED AT THIS REV.
B Updated dims for end-cap P. Walters 001205
1957 C ADDED HOUSING COLUMN AND 500 M TO WEIGHT TABLE. DLG 020702
362.0 [14.25]
292.0 [11.49]
4 x 35.0 [1.38]
Ø202.0 [7.95]
Ø177.7 [7.00]
4 x 14.5 [0.57]
4 x 13.0 [0.51]
4 x 20.5 [0.80]
TOP VIEW
8X Ø6.53 [0.25] THRU
Ø190.5 [7.49] B.C.
MAXIMUM WEIGHT
(2 BATTERY PACKS INSTALLED)
HOUSING
WEIGHT KG (LBS)
AIR
WATER
200 METER 13.6 (30.0) 4.5 (9.9)
500 METER 16.6 (36.6) 7.6 (16.8)
DIMENSION FORMAT: MILLIMETERS [INCHES]
200m PRESSURE CASE SHOWN
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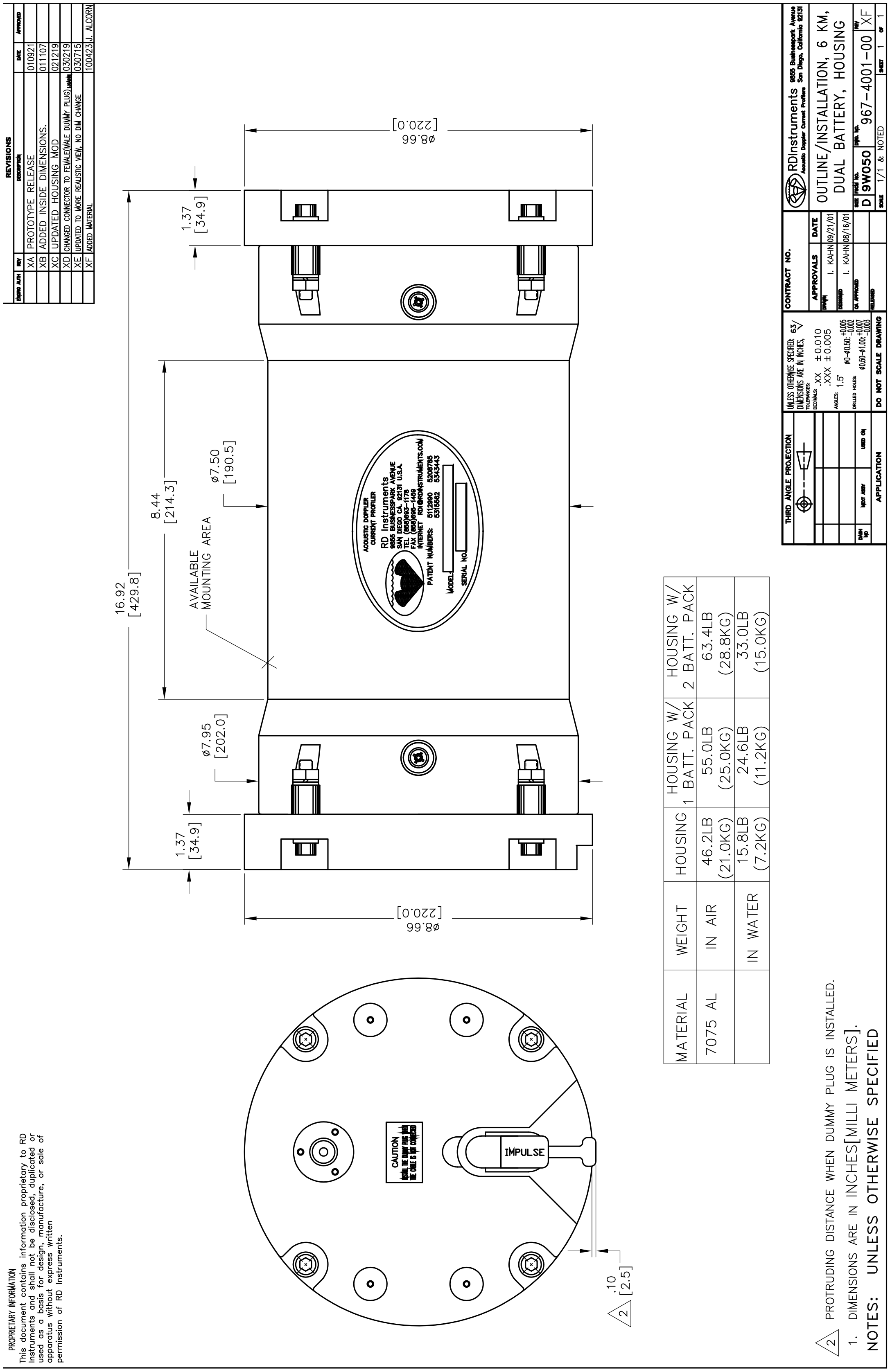
THIRD ANGLE PROJECTION
APPLICATION
DO NOT SCALE DRAWING
APPROVALS
P. WALTERS 961024
D. SYMONDS 961024
J. COSTAS 961024
RDInstruments
9855 Businesspark Avenue San Diego, California 92131
DWG TITLE:
OUTLINE/INSTALLATION
WH EXTERNAL BATTERY CASE
D 9W050 967-6007 C
SCALE 1/1

967-4001


REVISIONS
XA PROTOTYPE RELEASE 010921
XB ADDED INSIDE DIMENSIONS. 011107
XC UPDATED HOUSING MOD 021219
XD CHANGED CONNECTOR TO FEMALE(MALE DUMMY PLUG) 030219
XE UPDATED TO MORE REALISTIC VIEW, NO DIM CHANGE 030715
XF ADDED MATERIAL 100423 J. ALCORN
PROPRIETARY INFORMATION
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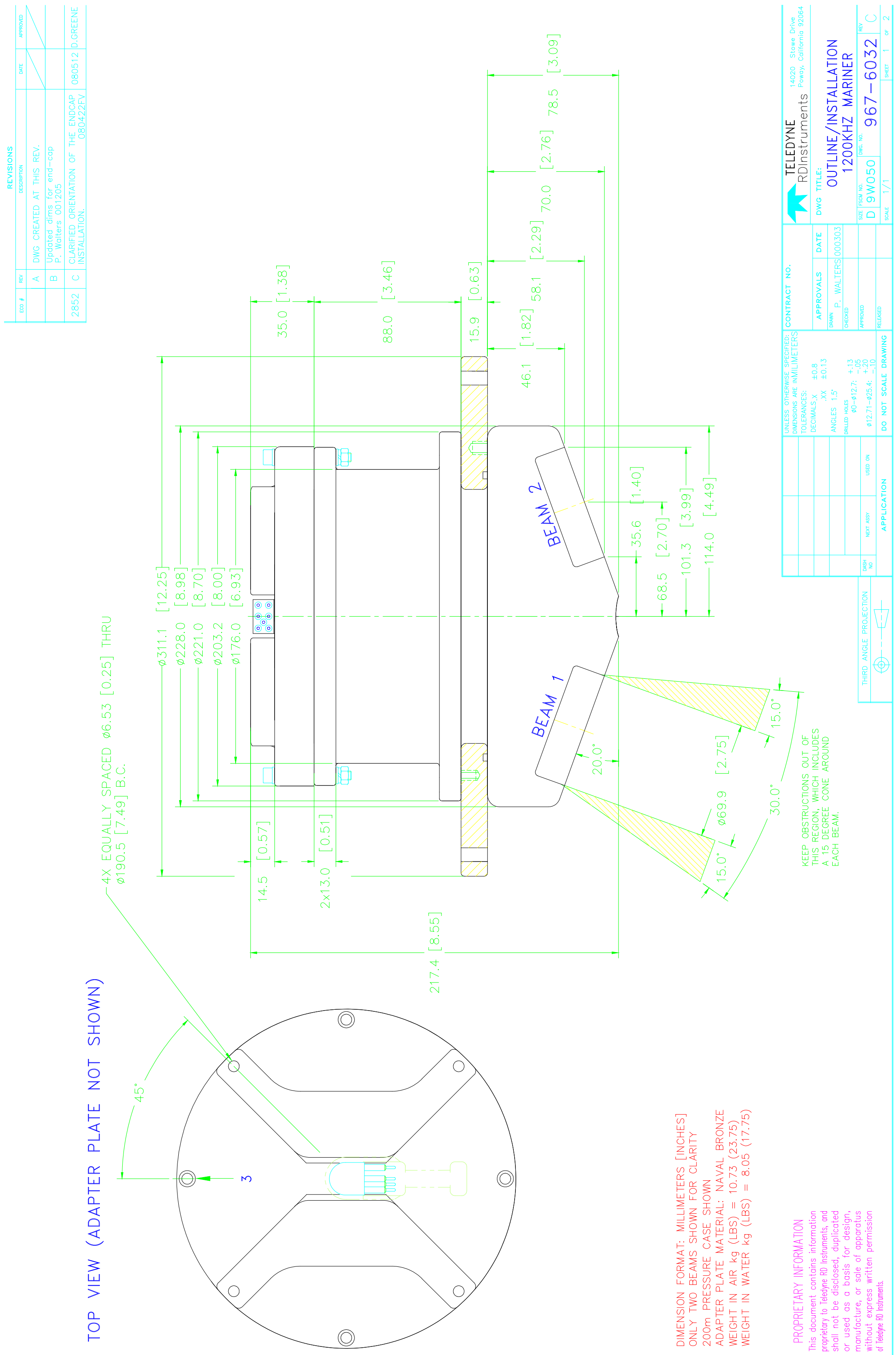
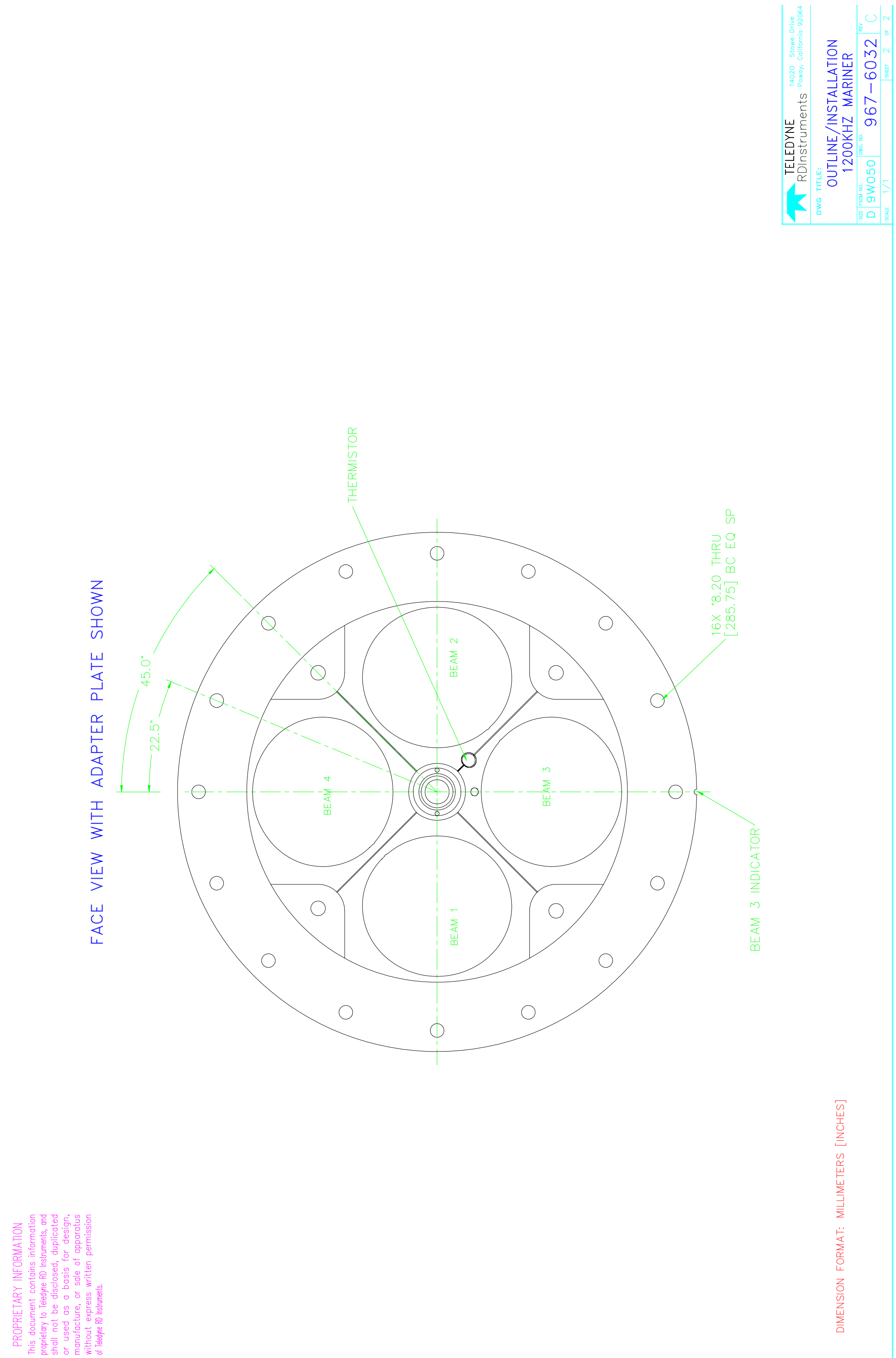
ø8.66 [220.0]
1.37 [34.9]
16.92 [429.8]
8.44 [214.3]
ø7.50 [190.5]
ø7.95 [202.0]
AVAILABLE MOUNTING AREA
.10 [2.5]
IMPULSE
CAUTION
MATERIAL | WEIGHT | | HOUSING | HOUSING W/ 1 BATT. PACK | HOUSING W/ 2 BATT. PACK
7075 AL | IN AIR | | 46.2LB (21.0KG) | 55.0LB (25.0KG) | 63.4LB (28.8KG)
| IN WATER | | 15.8LB (7.2KG) | 24.6LB (11.2KG) | 33.0LB (15.0KG)
RDInstruments 9855 Businesspark Avenue San Diego, California 92131
OUTLINE/INSTALLATION, 6 KM, DUAL BATTERY, HOUSING
D 9W050 967-4001-00 XF
SCALE 1/1 & NOTED SHEET 1 OF 1
DRAWN I. KAHN 09/21/01
DESIGNED I. KAHN 08/16/01
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING
NOTES: UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS ARE IN INCHES[MILLI METERS].
2 PROTRUDING DISTANCE WHEN DUMMY PLUG IS INSTALLED.

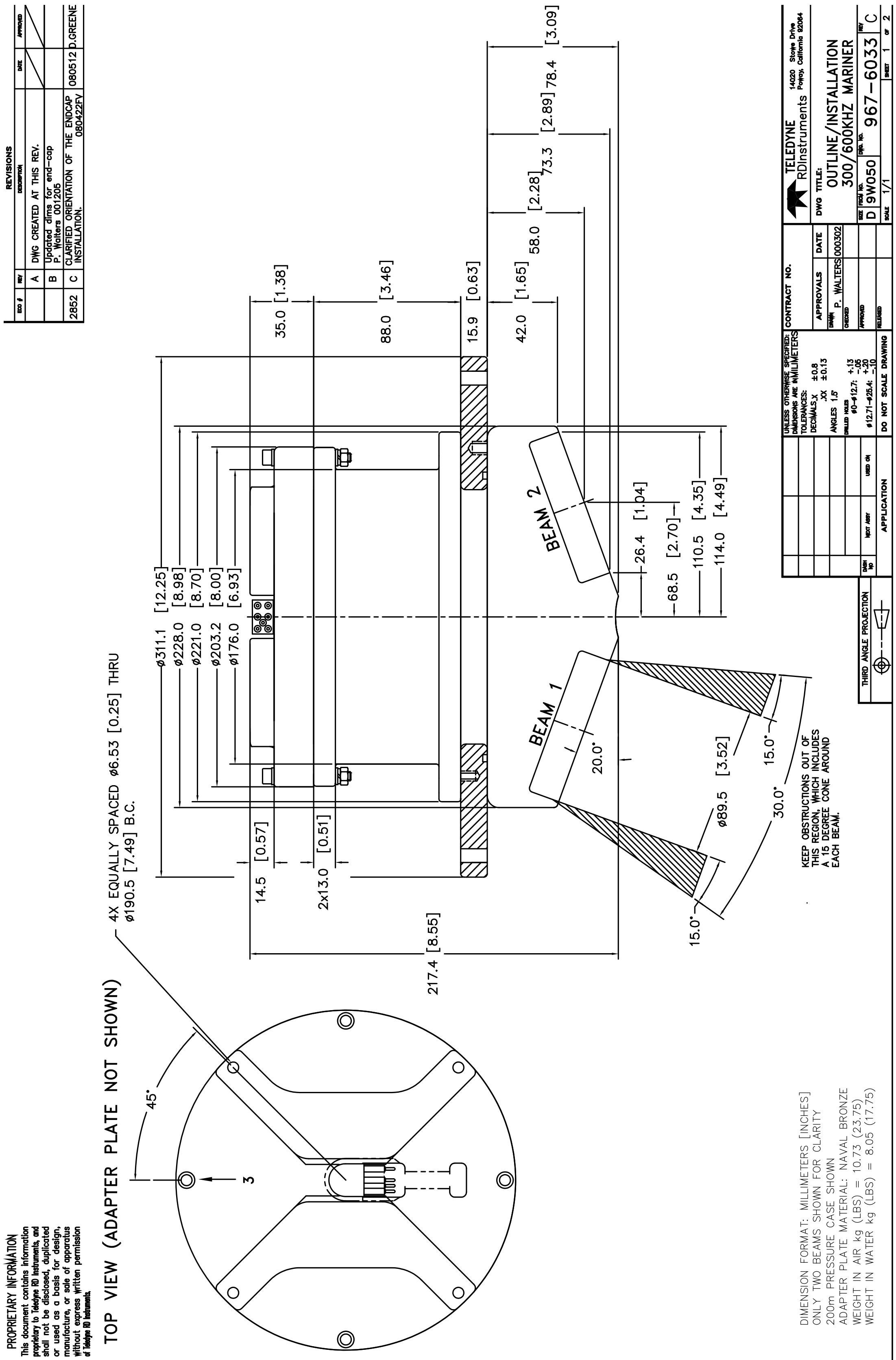
967-6032 Sheet 1



967-6032 Sheet 2



967-6033 Sheet 1



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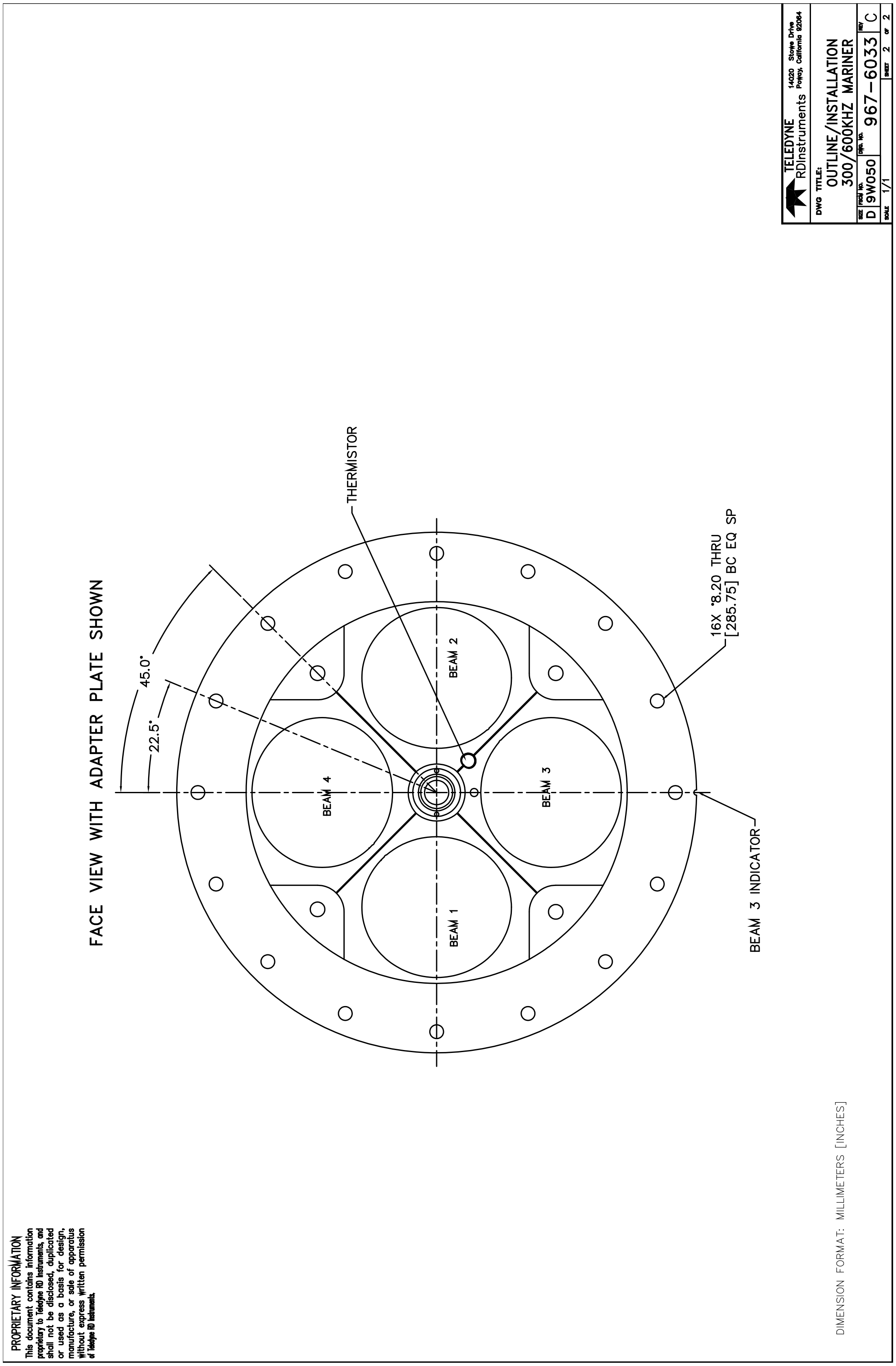

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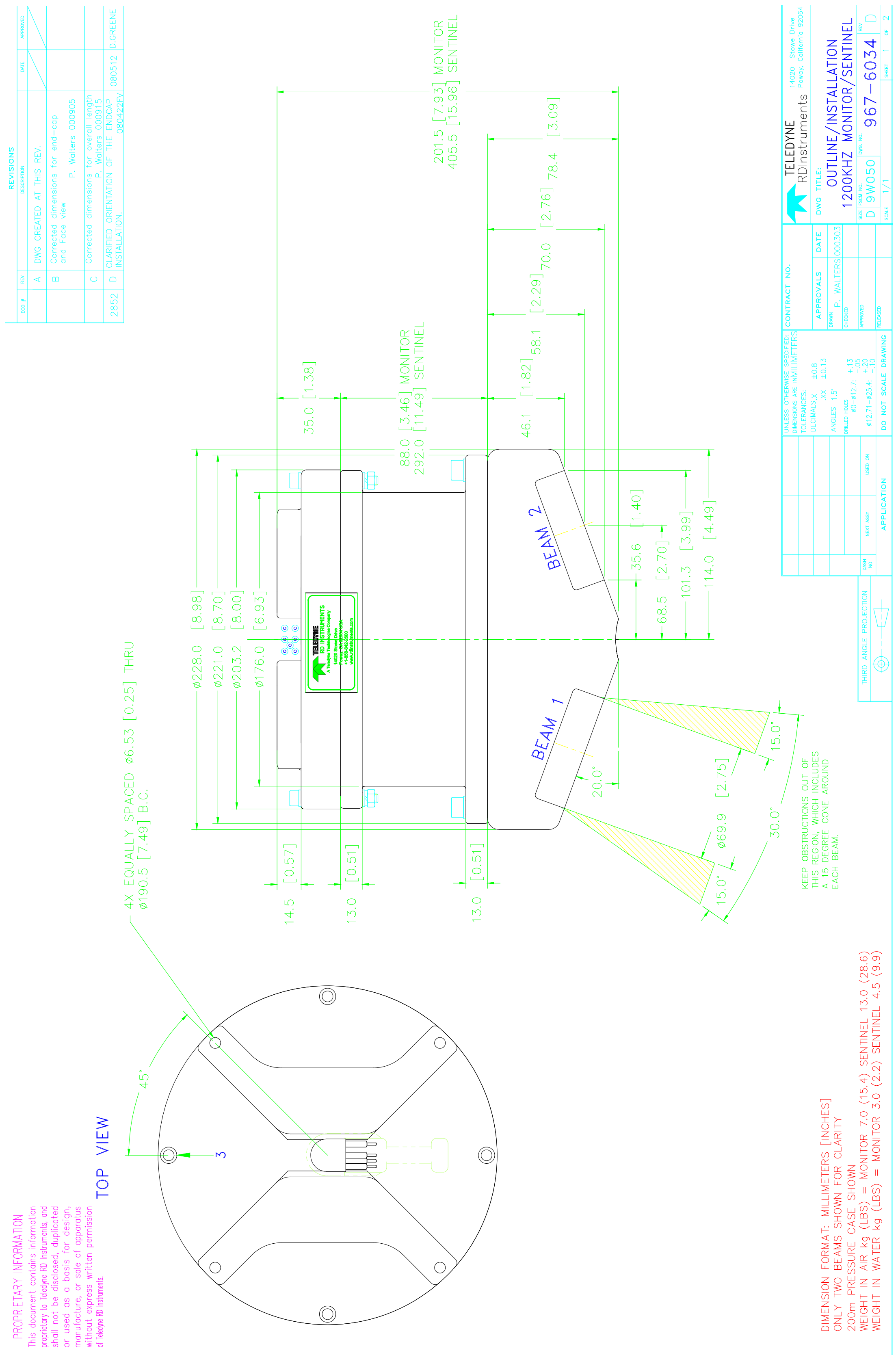

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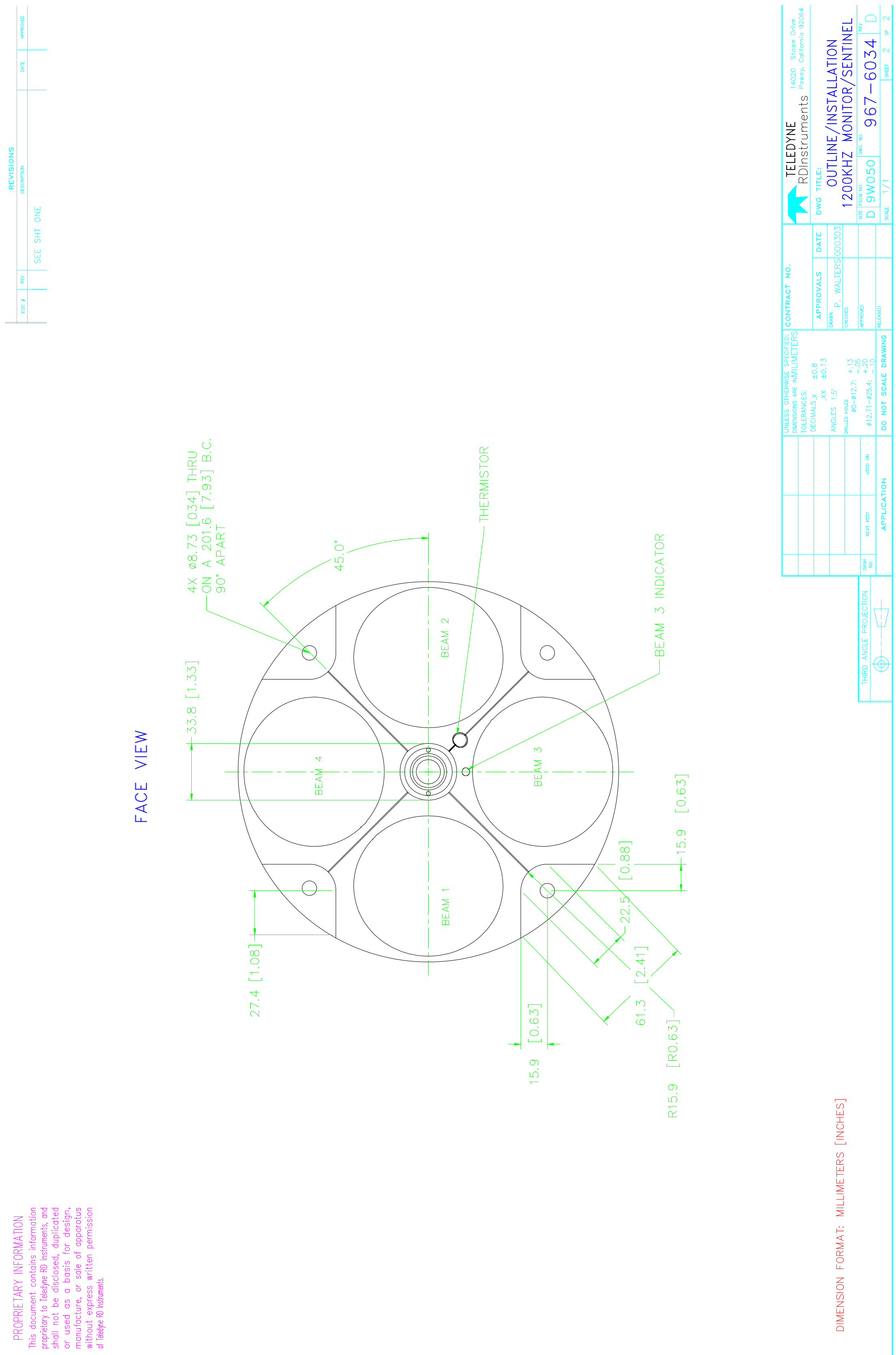
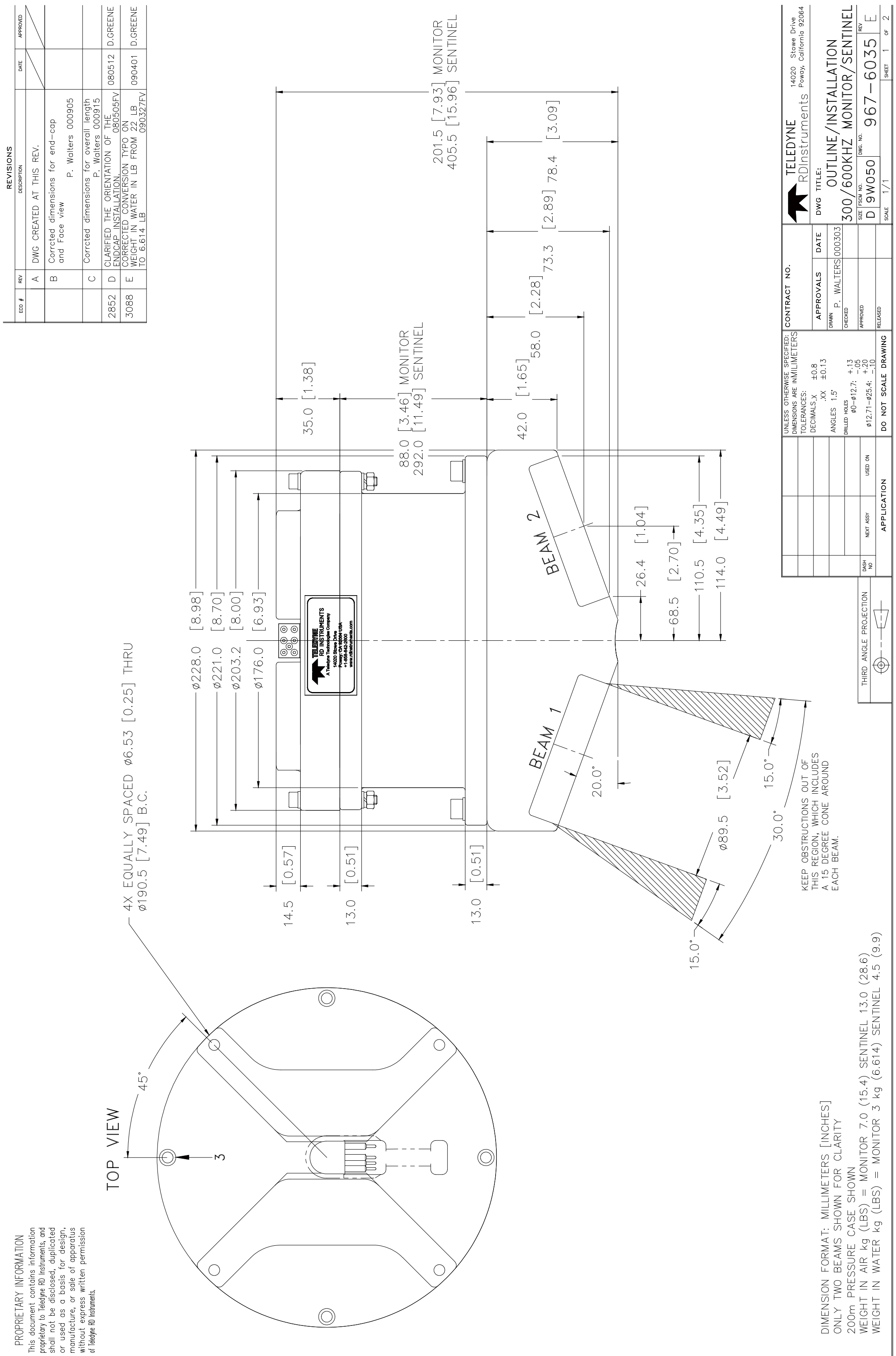
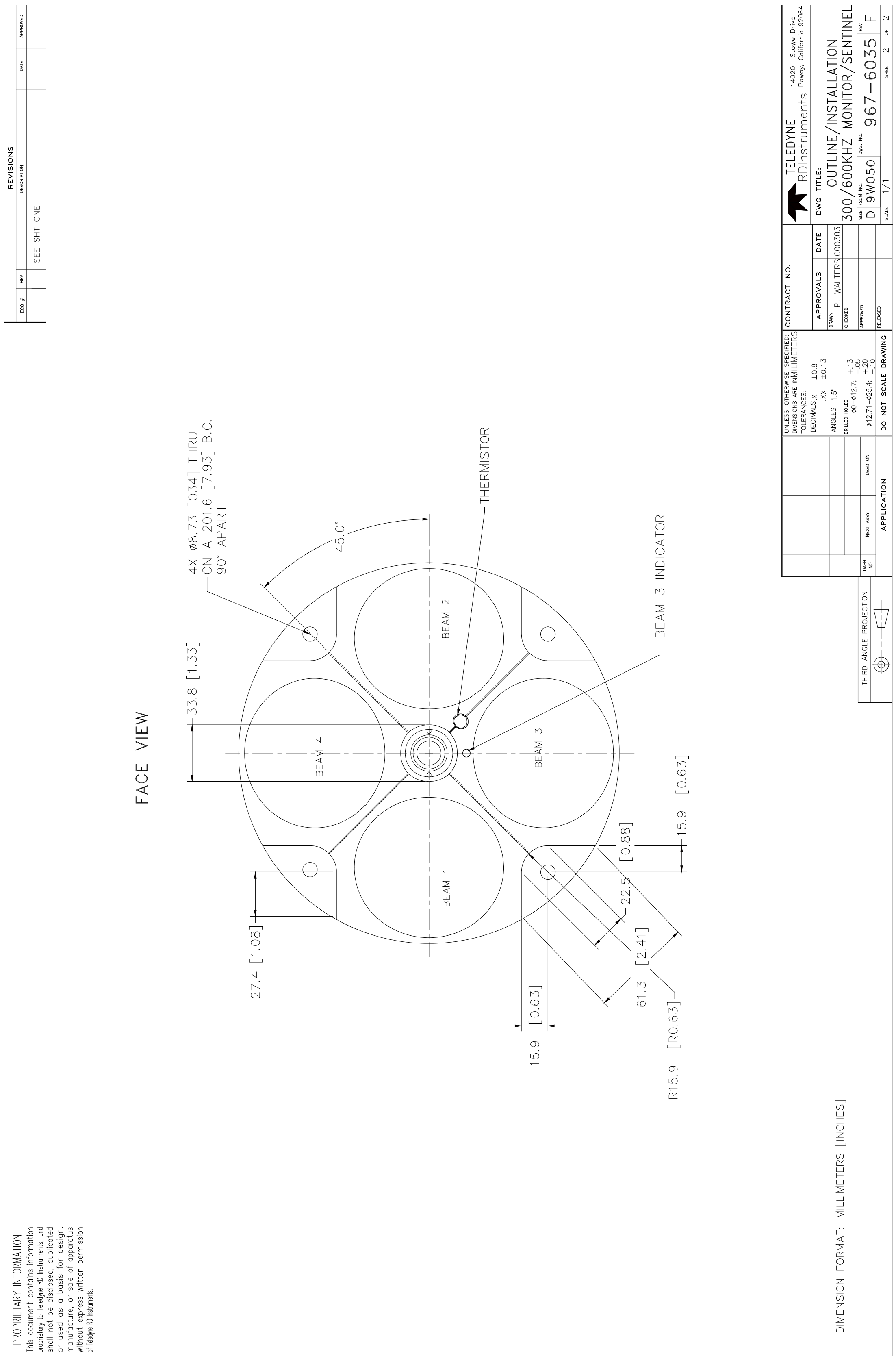


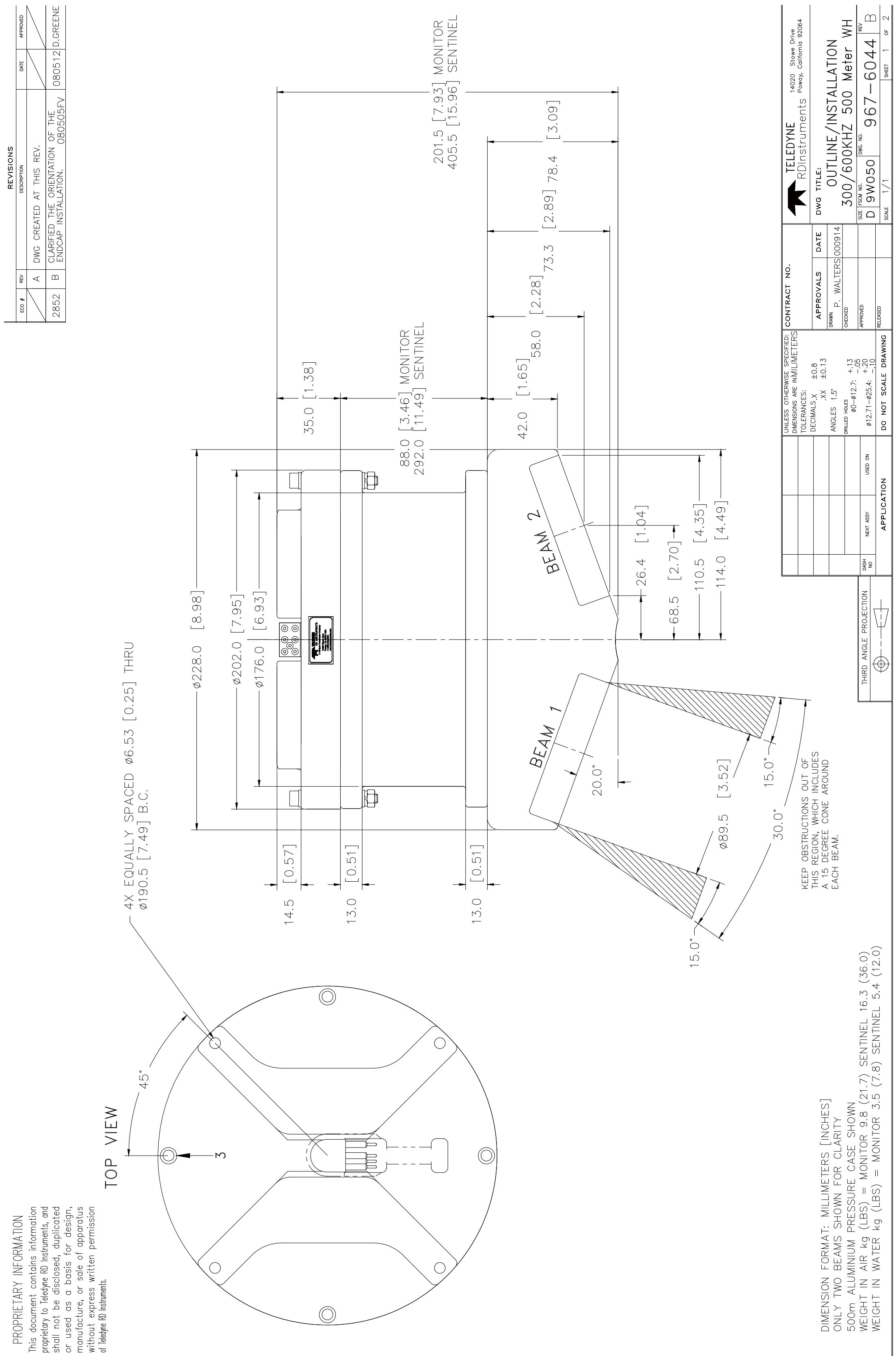
967-6035 Sheet 1



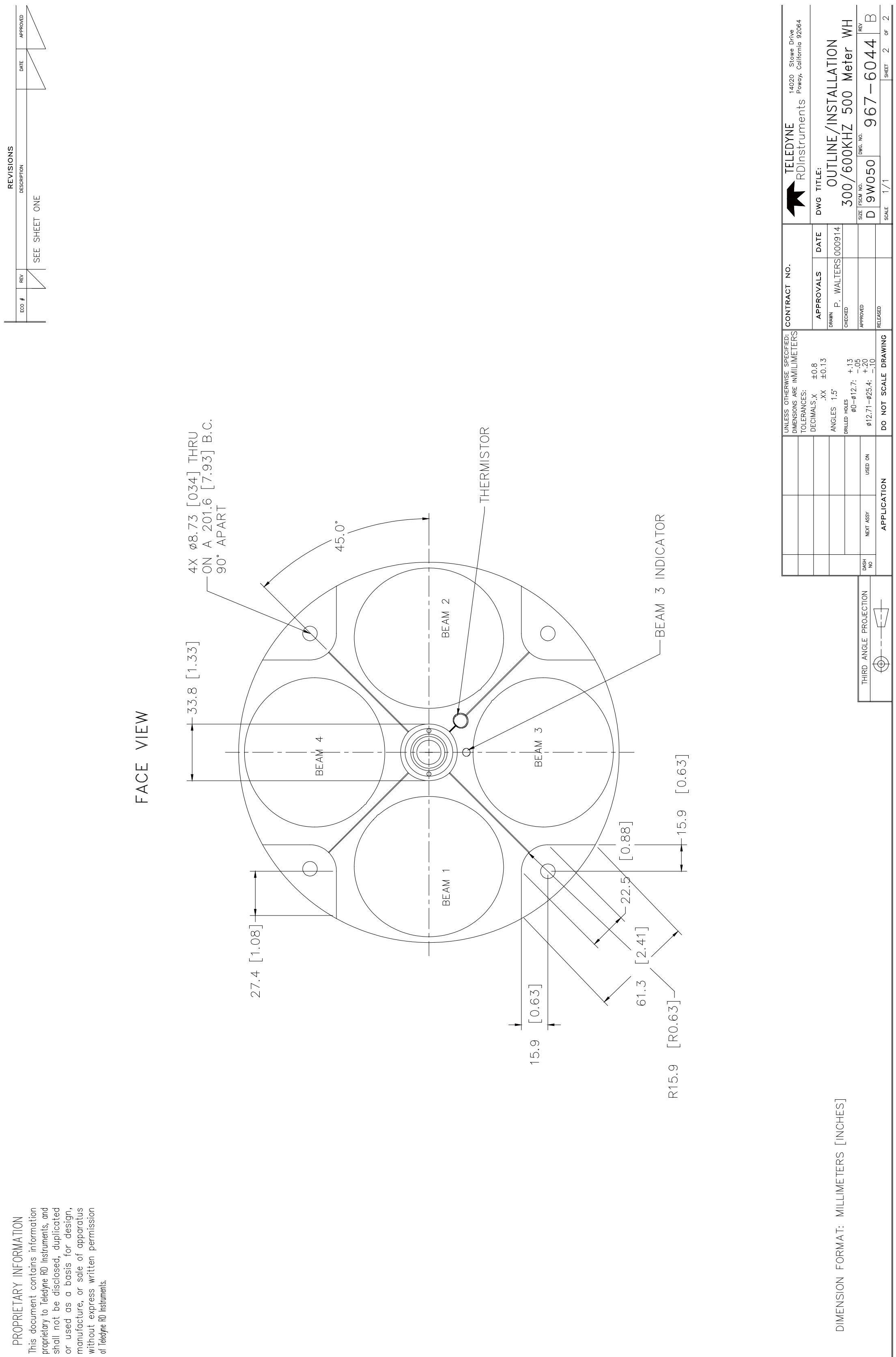
967-6035 Sheet 2



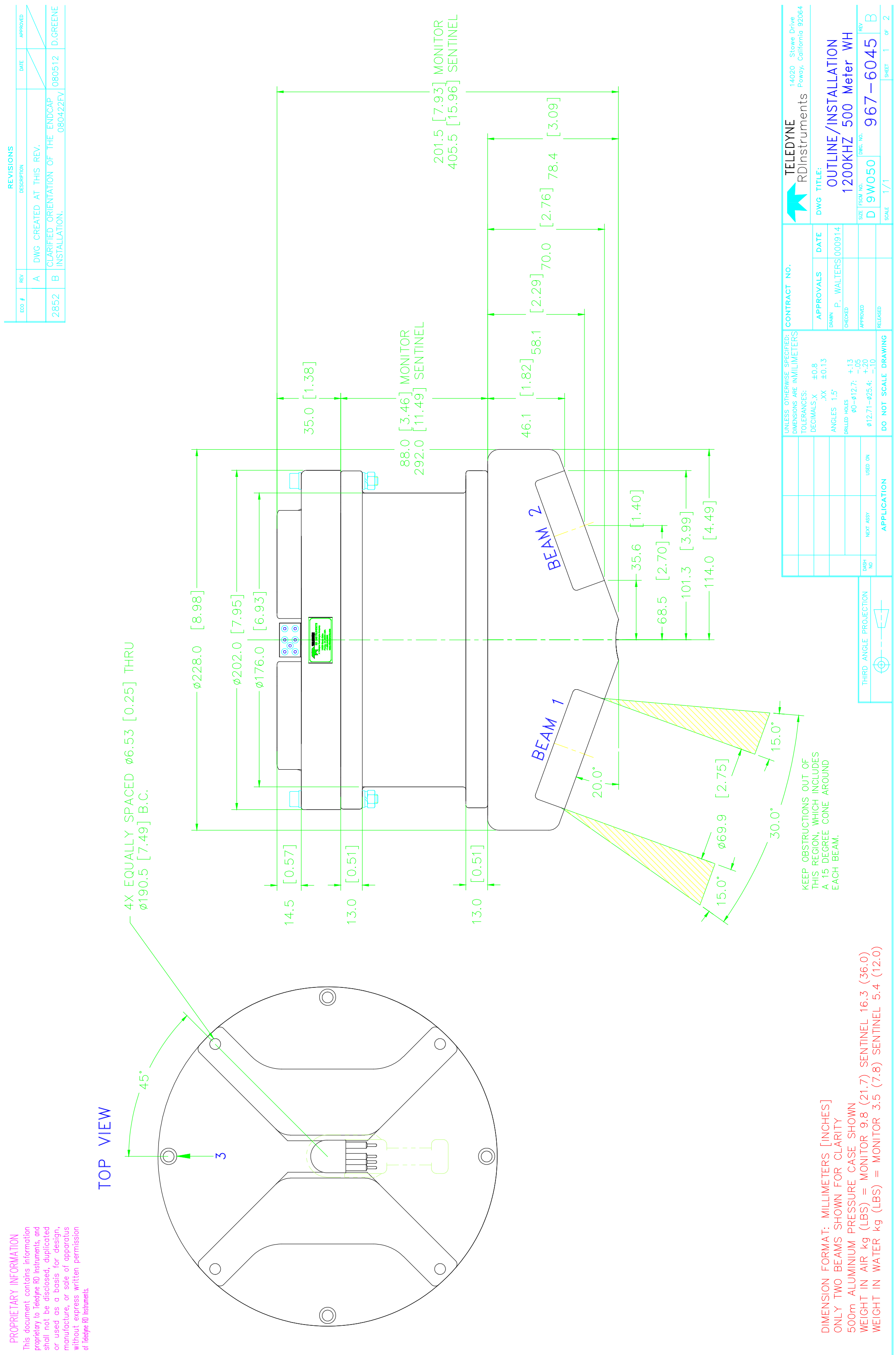
967-6044 Sheet 1



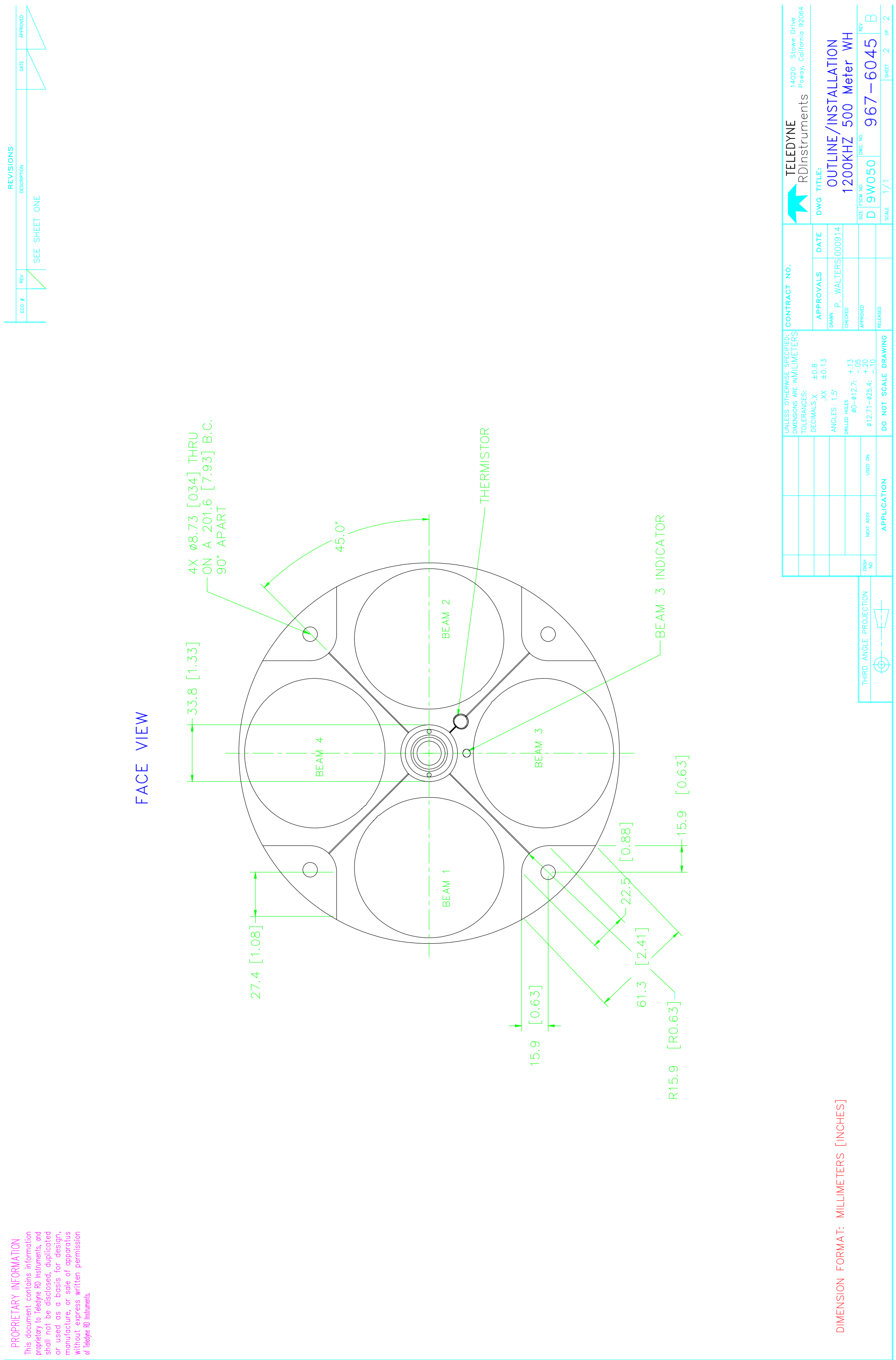
967-6044 Sheet 2



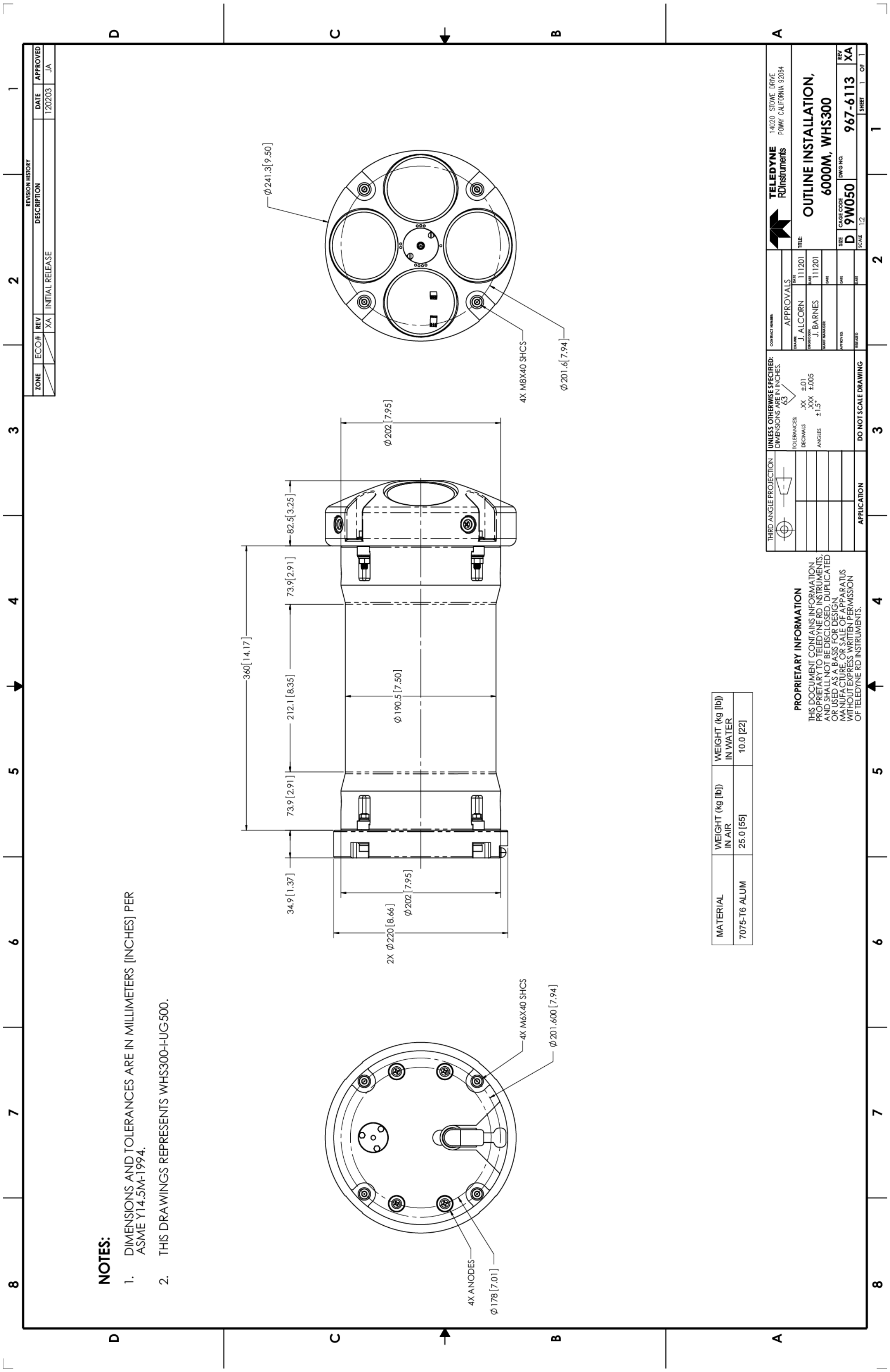
967-6045 Sheet 1



967-6045 Sheet 2



967-6113


NOTES:
1. DIMENSIONS AND TOLERANCES ARE IN MILLIMETERS [INCHES] PER ASME Y14.5M-1994.
2. THIS DRAWINGS REPRESENTS WHS300-I-UG500.
REVISION HISTORY
ZONE
ECO#
REV
DESCRIPTION
DATE
APPROVED
XA
INITIAL RELEASE
120203
JA
Ø241.3 [9.50]
4X M8X40 SHCS
Ø201.6 [7.94]
Ø202 [7.95]
82.5 [3.25]
73.9 [2.91]
360 [14.17]
212.1 [8.35]
Ø190.5 [7.50]
73.9 [2.91]
34.9 [1.37]
Ø202 [7.95]
2X Ø220 [8.66]
4X M6X40 SHCS
Ø201.600 [7.94]
4X ANODES
Ø178 [7.01]
MATERIAL
7075-T6 ALUM
WEIGHT (kg [lb]) IN AIR
25.0 [55]
WEIGHT (kg [lb]) IN WATER
10.0 [22]
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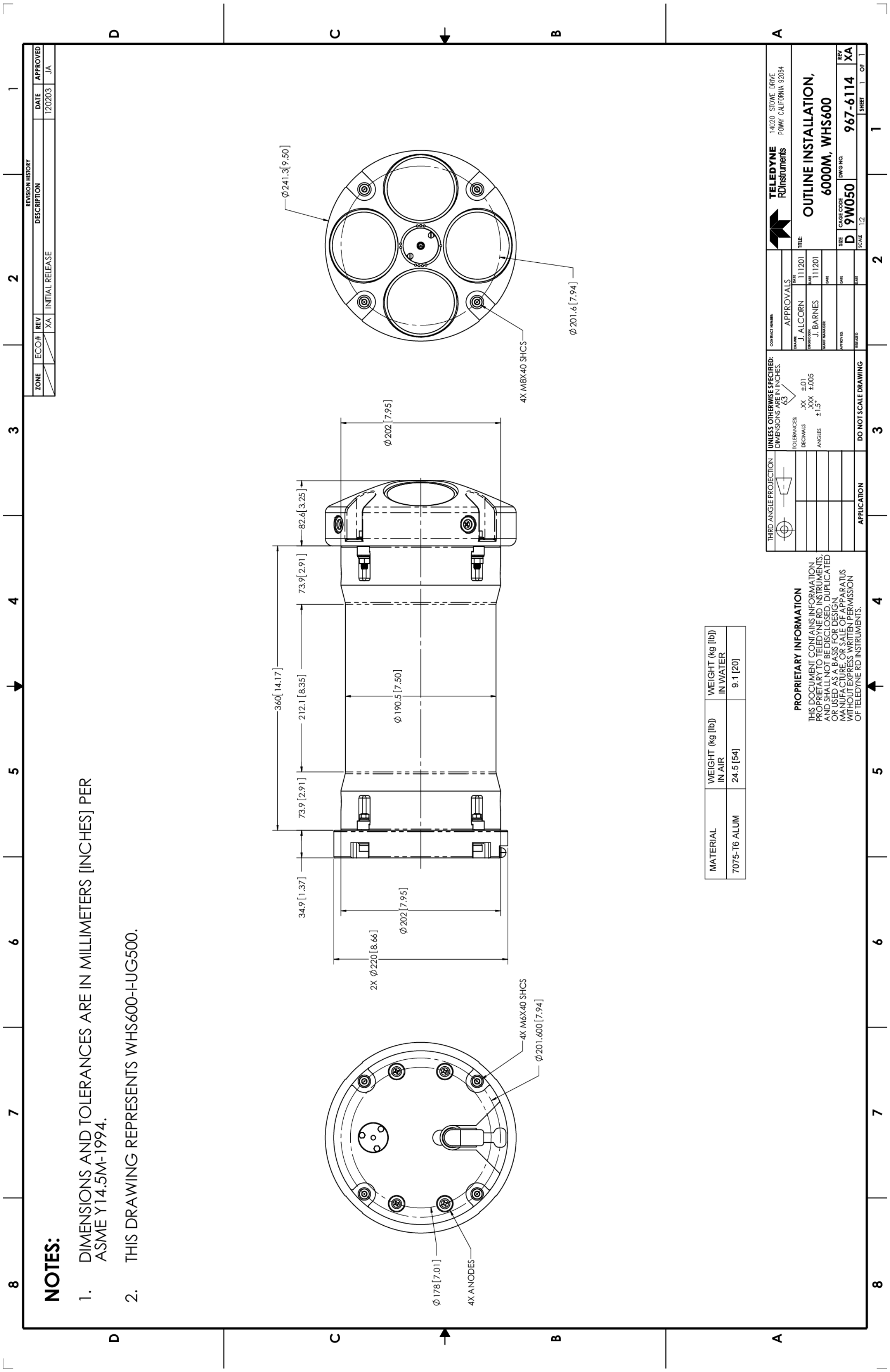
THIRD ANGLE PROJECTION
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES.
TOLERANCES:
DECIMALS .XX ±.01 .XXX ±.005
ANGLES ±1.5°
APPLICATION
DO NOT SCALE DRAWING
APPROVALS
J. ALCORN 111201
J. BARNES 111201
TELEDYNE RDInstruments
14020 STOWE DRIVE POWAY CALIFORNIA 92064
OUTLINE INSTALLATION, 6000M, WHS300
SIZE D
CAGE CODE 9W050
DWG NO. 967-6113
REV XA
SCALE 1:2
SHEET 1 OF 1
A B C D
1 2 3 4 5 6 7 8

967-6114


NOTES:
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2. THIS DRAWING REPRESENTS WHS600-I-UG500.
MATERIAL
7075-T6 ALUM
WEIGHT (kg [lb]) IN AIR
24.5 [54]
WEIGHT (kg [lb]) IN WATER
9.1 [20]
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TELEDYNE RDInstruments
14020 STOWE DRIVE POWAY CALIFORNIA 92064
OUTLINE INSTALLATION, 6000M, WHS600
D 9W050 967-6114 XA
DO NOT SCALE DRAWING
APPLICATION
THIRD ANGLE PROJECTION
J. ALCORN 111201
J. BARNES 111201
XA INITIAL RELEASE 120203 JA
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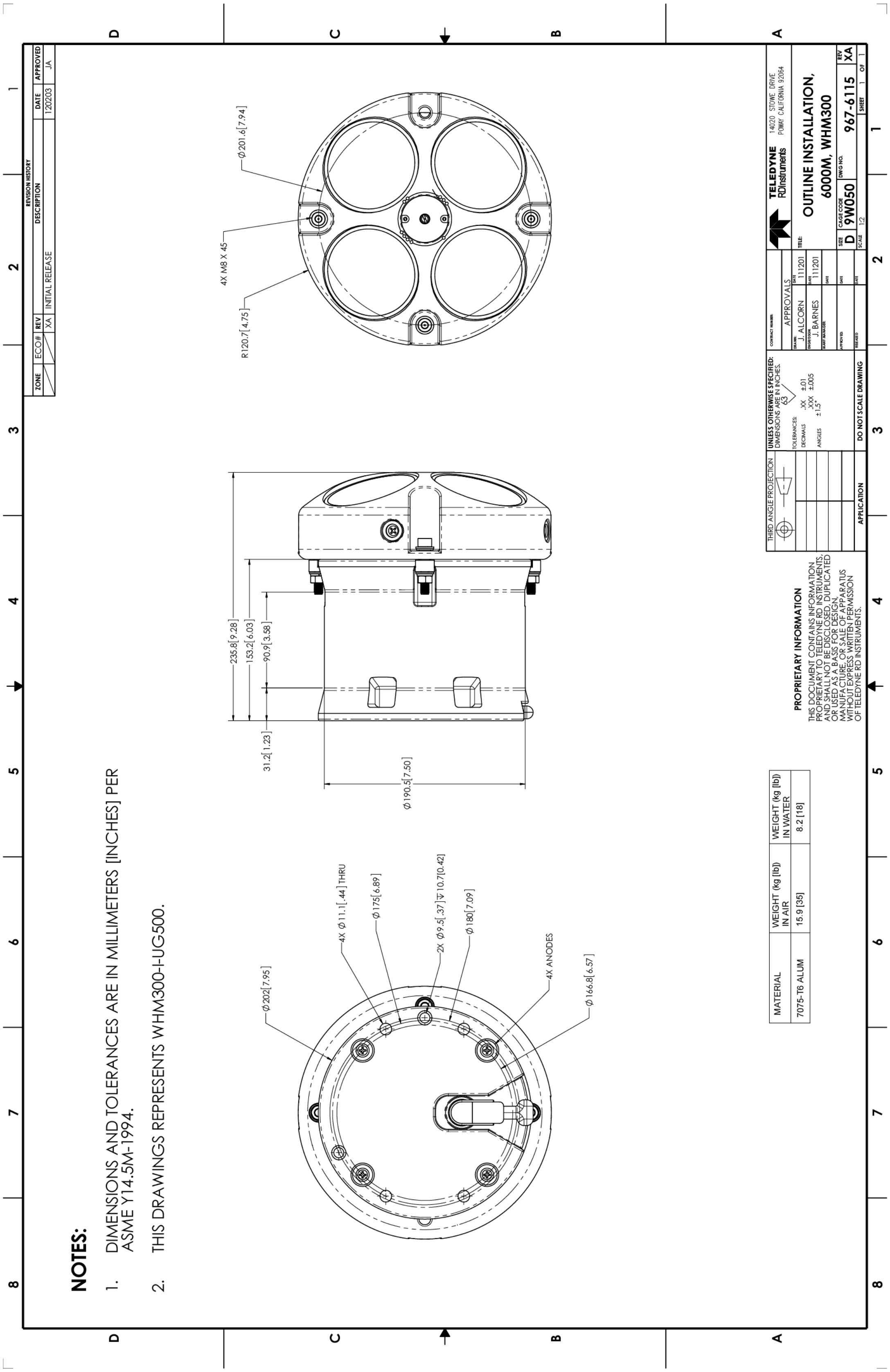
Ø201.6 [7.94]
4X M8X40 SHCS
Ø202 [7.95]
82.6 [3.25]
73.9 [2.91]
360 [14.17]
212.1 [8.35]
Ø190.5 [7.50]
34.9 [1.37]
2X Ø220 [8.66]
4X M6X40 SHCS
Ø201.600 [7.94]
Ø178 [7.01]
4X ANODES

967-6115


NOTES:
1. DIMENSIONS AND TOLERANCES ARE IN MILLIMETERS [INCHES] PER ASME Y14.5M-1994.
2. THIS DRAWINGS REPRESENTS WHM300-I-UG500.
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R120.7[4.75]
235.8[9.28]
153.2[6.03]
90.9[3.58]
31.2[1.23]
Ø190.5[7.50]
Ø202[7.95]
4X Ø11.1[.44] THRU
Ø175[6.89]
2X Ø9.5[.37] 10.7[0.42]
Ø180[7.09]
4X ANODES
Ø166.8[6.57]
MATERIAL
7075-T6 ALUM
WEIGHT (kg [lb]) IN AIR
15.9 [35]
WEIGHT (kg [lb]) IN WATER
8.2 [18]
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REVISION HISTORY
ZONE
ECO#
REV
DESCRIPTION
DATE
APPROVED
XA
INITIAL RELEASE
120203
JA
THIRD ANGLE PROJECTION
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES.
TOLERANCES:
DECIMALS .XX ±.01 .XXX ±.005
ANGLES ±1.5°
APPROVALS
J. ALCORN
111201
J. BARNES
111201
APPLICATION
DO NOT SCALE DRAWING
TELEDYNE RDInstruments
14020 STOWE DRIVE POWAY CALIFORNIA 92064
TITLE:
OUTLINE INSTALLATION, 6000M, WHM300
SIZE D
CAGE CODE 9W050
DWG NO. 967-6115
REV XA
SCALE 1:2
SHEET 1 OF 1

NOTES

Appendix A

NOTICE OF COMPLIANCE

In this chapter, you will learn:

- China RoHS requirements
- Material disclosure table

Date of Manufacture

China RoHS requires that all Electrical and Electronic Products are marked with a Date of Manufacture. This is the starting point for the Environmental Friendly Use Period, described below.

Environmental Friendly Use Period (EFUP)

Per SJ/T 11364-2006 – Product Marking, the EFUP is defined as the time in years in which hazardous/toxic substances within Electrical and Electronic Products (EIP) will not, under normal operating conditions, leak out of the Product, or the Product will not change in such a way as to cause severe environmental pollution, injury to health, or great damage to property. TRDI has determined the Environmental Friendly Use Period shall be Ten (10) years.

The purpose of the marking is to assist in determining the restricted substance content, recyclability, and environmental protection use period of our covered products, as required in Chinese law, and does not reflect in any way the safety, quality, or warranty associated with these TRDI products.

Some homogenous substance within the EIP contains toxic or hazardous substances or elements above the requirements listed in SJ/T 11363-2006. These substances are identified in Table 42.

WEEE

The mark shown to the left is in compliance with the Waste Electrical and Electronic Equipment Directive 2002/96/EC (WEEE).

This symbol indicates the requirement NOT to dispose the equipment as unsorted municipal waste, but use the return and collection systems according to local law or return the unit to one of the TRDI facilities below.

Teledyne RD Instruments USA	**Teledyne RD Instruments Europe**	**Teledyne RD Technologies**
14020 Stowe Drive Poway, California 92064	2A Les Nertieres 5 Avenue Hector Pintus 06610 La Gaude, France	1206 Holiday Inn Business Building 899 Dongfang Road, Pu Dong Shanghai 20122 China

CE

This product complies with the Electromagnetic Compatibility Directive 89/336/EEC, 92/31/EEC. The following Standards were used to verify compliance with the directives: EN 61326(1997), A1(1998), A2(2001) – Class "A" Radiated Emissions.

Material Disclosure Table

In accordance with SJ/T 11364-2006, the following table disclosing toxic or hazardous substances contained in the product is provided.

Table 42. Toxic or Hazardous Substances and Elements Contained in Product

零件□目(名称) Component Name	有毒有害物□或元素 Toxic or Hazardous Substances and Elements					
	□ Lead (Pb)	汞 Mercury (Hg)	□ Cadmium (Cd)	六价□ Hexavalent Chromium (Cr^{6+})	多溴□苯 Polybrominated Biphenyls (PBB)	多溴二苯□ Polybrominated Diphenyl Ethers (PBDE)
□能器配件 Transducer Assy.	X	X	O	X	O	O
接收机□路板/数据□理器□路板 Receiver PCB/ DSP PCB	O	O	O	O	O	O
微□理器□路板/□入□出口□路板 CPU PCB/PIO PCB	O	O	O	O	O	O
机体装配 Housing Assy.	O	O	O	O	O	O
底座装配 End-Cap Assy.	O	O	O	O	O	O
□池□ Battery Pack	O	O	O	O	O	O
交流□□□器 AC Voltage Adapter	O	O	O	O	O	O
水下专用电缆 Underwater Cable	O	O	O	O	O	O
□用装运箱和泡沫塑料□ Shipping Case w/Foam	O	O	O	O	O	O

O: 表示□有毒或有害物□在□部件所有均□材料中的含量均在 SJ/T 11363-2006 □准□定的限量要求以下。
O: Indicates that the toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit required in SJ/T 11363-2006.
X: 表示□有毒或有害物□至少在□部件的某一均□材料中的含量超出 SJ/T 11363-2006 □准□定的限量要求。
X: Indicates that the toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in SJ/T 11363-2006.

NOTES