EXO User Manual

ADVANCED WATER QUALITY MONITORING PLATFORM

YSI

a xylem brand

Item# 603789REF
Revision F

THIS IS AN INTERACTIVE DOCUMENT

When viewing this document as an Adobe PDF, hovering your cursor over certain phrases will bring up the finger-point icon. Clicking elements of the Table of Contents, website URL's, or references asking you to see a certain section will take automatically to those locations. **No scrolling required!**

Product components

Carefully unpack the instrument and accessories and inspect for damage. If any parts or materials are damaged, contact YSI Customer Service at 800-897-4151 (+1 937 767-7241) or the authorized YSI distributor from whom the instrument was purchased.

Technical Support

Telephone: 800 897 4151 (USA), +1 937 767 7241 (Globally)

Monday through Friday, 8:00 AM to 5:00 ET

Fax: +1 937 767 9353 (orders)

Email: info@ysi.com

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Safety information

Please read this entire manual before unpacking, setting up or operating this equipment. Pay attention to all precautionary statements. Failure to do so could result in serious injury to the operator or damage to the equipment. Make sure that the protection provided by this equipment is not impaired. Do not use or install this equipment in any manner other than that specified in this manual.

Precautionary symbols

NOTE: *Information that requires special emphasis*

NOTICE: Indicates a situation which, if not avoided, may cause damage to the instrument

⚠ **CAUTION:** Indicates a potentially hazardous situation that may result in minor or moderate injury

⚠ **WARNING:** Indicates a potentially hazardous situation which could result in death or serious injury

Table of Contents

Section 1
EXO Platform Overview

1.1 EXO1 Sonde Overview

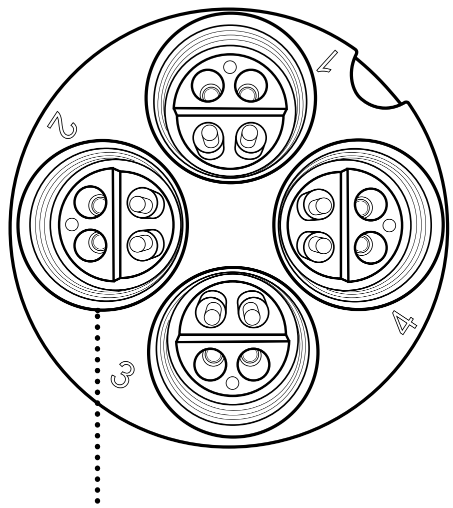
The EXO1 sonde is a multiparameter instrument that collects water quality data. The sonde collects the data with up to four user-replaceable sensors and an integral pressure transducer. Each sensor measures its parameter via a variety of electrochemical, optical, or physical detection methods. Each port accepts any EXO sensor and automatically recognizes its type. Depending on user-defined settings, the EXO1 will collect data and store it onboard the sonde, transfer the data to a data collection platform (DCP), or relay it directly to a user's PC or EXO Handheld. *See section 6 for information specific to vented level sondes.*

Users communicate with the sonde via a field cable to an EXO Handheld, Bluetooth® wireless connection to a PC or EXO Classic Handheld, or a USB connection (via communications adapter) to a PC.

Specifications

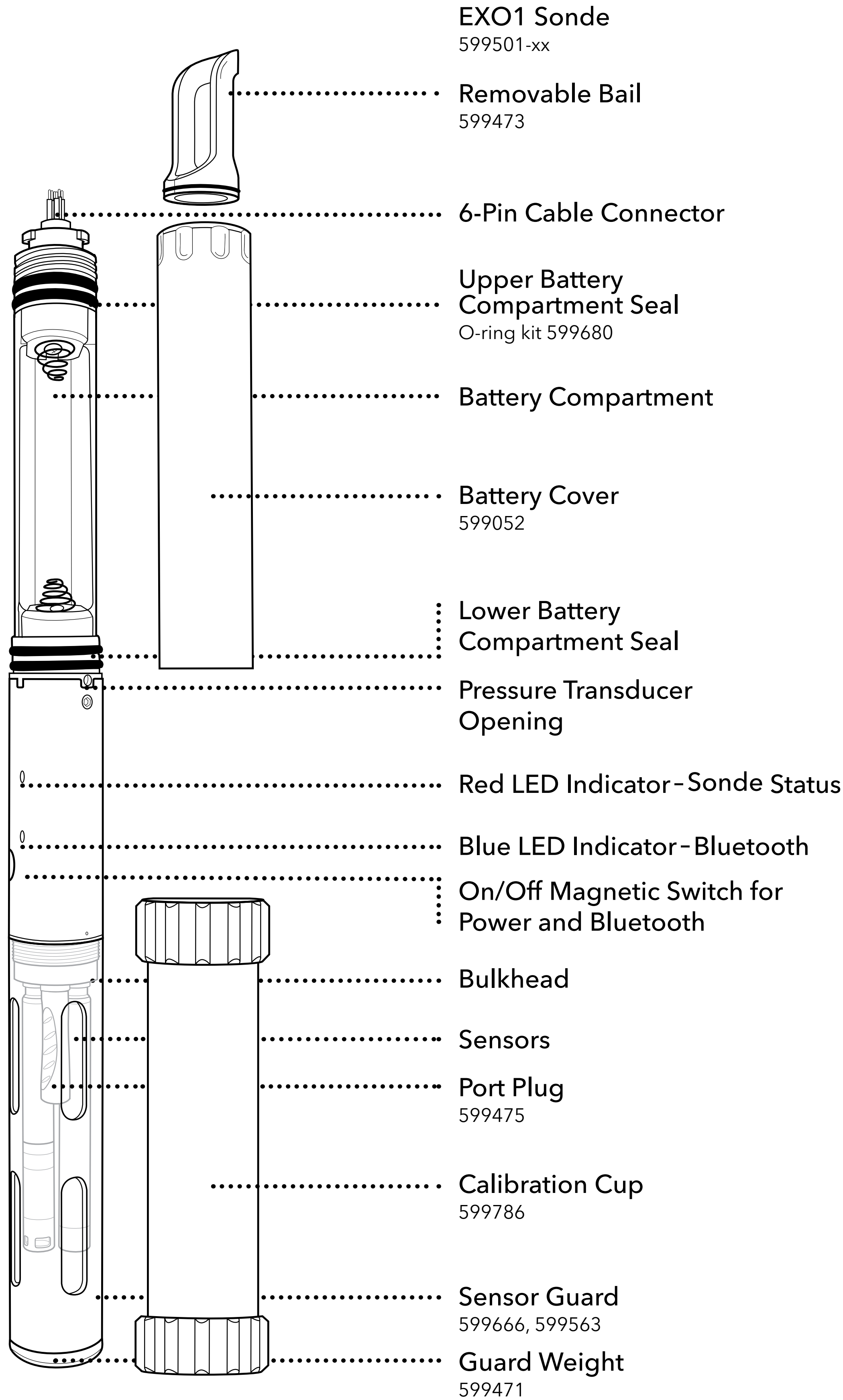
Operating Environment *Depth Rating*	250 meters, 820 feet
Material	Xenoy®, Lexan®, bronze, titanium, 316 stainless steel
Internal Logging Memory Capacity	512 MB
Software	Kor Interface Software
Communications *Sonde* *Adapters*	Bluetooth, Field Cable, USB, RS-485; USB, SDI-12/RS-232, Modbus
Power *External* *Internal*	9-16 VDC 2 D-size batteries
Temperature *Operating* *Storage*	-5 to 50°C -20 to +80°C
Battery Life	90 days typically
Dimensions *Diameter* *Length* *Weight*	4.70 cm,1.85 in 64.77 cm, 25.50 in 1.42 kg, 3.15 lb w batt.

EXO1 Bulkhead



Universal Sensor Ports

NOTE: *Starting 2014, EXO sonde bulkhead material changed from bronze to titanium.*


EXO1 Sonde
599501-xx
Removable Bail
599473
6-Pin Cable Connector
Upper Battery Compartment Seal
O-ring kit 599680
Battery Compartment
Battery Cover
599052
Lower Battery Compartment Seal
Pressure Transducer Opening
Red LED Indicator – Sonde Status
Blue LED Indicator – Bluetooth
On/Off Magnetic Switch for Power and Bluetooth
Bulkhead
Sensors
Port Plug
599475
Calibration Cup
599786
Sensor Guard
599666, 599563
Guard Weight
599471

1.2 EXO2 Sonde Overview

The EXO2 sonde is a multiparameter instrument that collects water quality data. The sonde collects the data with up to six user-replaceable sensors and an integral pressure transducer. Each sensor measures its parameter via a variety of electrochemical, optical, or physical detection methods. Each port accepts any EXO sensor and automatically recognizes the type of sensor. Depending on user-defined settings, the EXO2 will collect data and store it onboard the sonde, transfer the data to a data collection platform (DCP), or relay it to a user's PC or EXO Handheld via cable, USB connection, or Bluetooth connection.

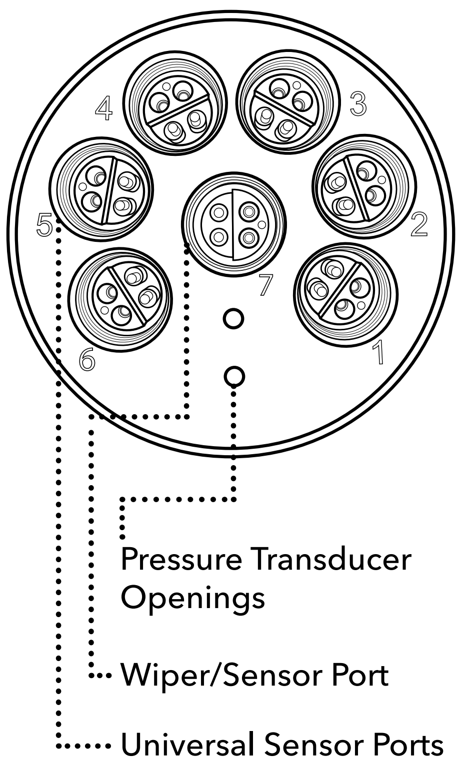
In addition to six standard sensor ports, the EXO2 also has a bulkhead port for a central wiper (or an additional sensor) and an auxiliary port on top of the sonde. This auxiliary port will allow the user to connect the EXO2 to other EXO sondes. *See section 6 for information specific to vented level sondes.*

Users communicate with the sonde via a field cable to an EXO Handheld, Bluetooth® wireless connection to a PC or EXO Handheld, or a USB connection (via communications adapter) to a PC. *See section 2.6 for a communication overview.*

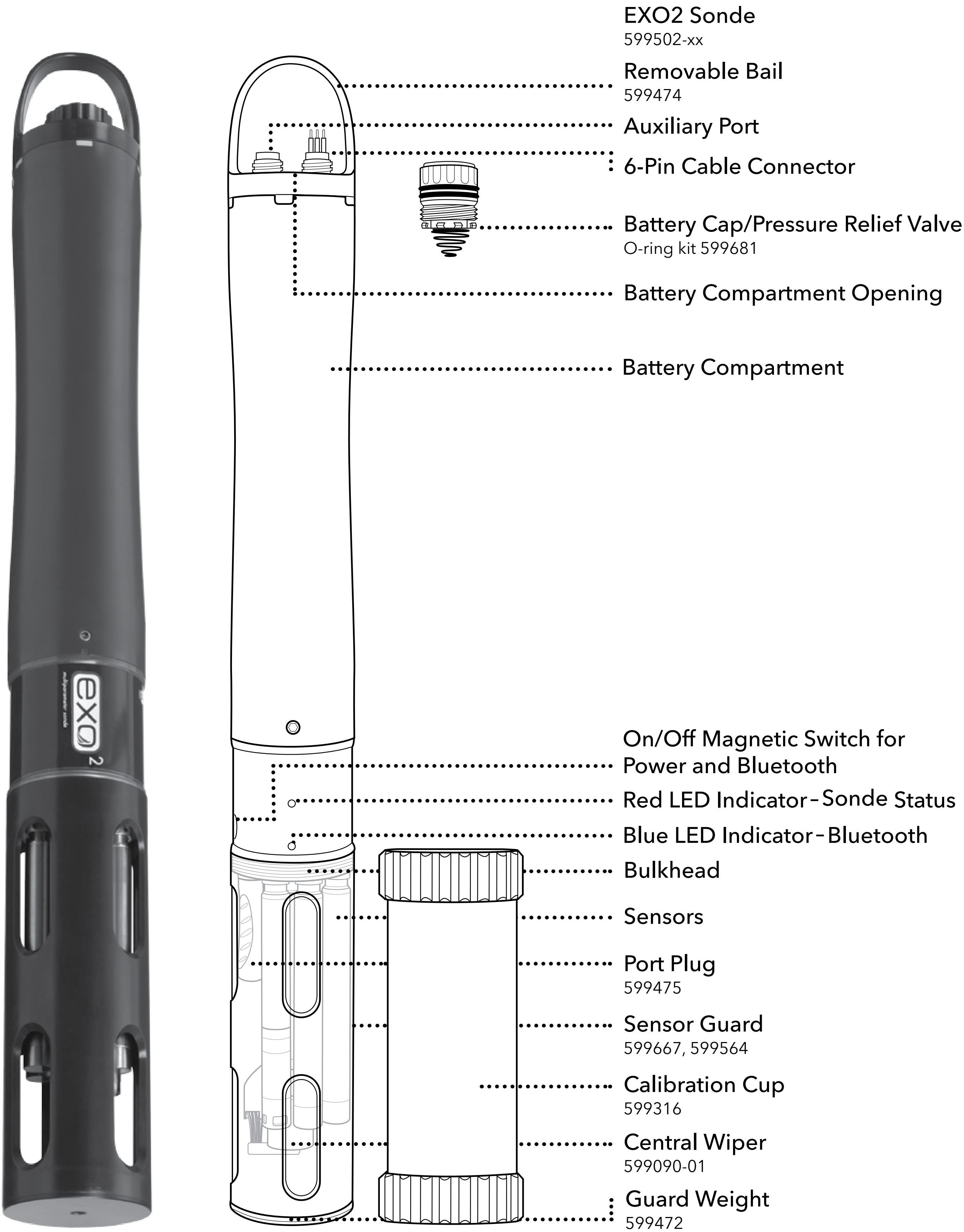
Specifications

Operating Environment *Depth Rating*	250 meters, 820 feet
Material	Xenoy, Lexan, bronze, titanium, 316 stainless steel
Internal Logging Memory Capacity	512 MB
Software	Kor Interface Software
Communications *Sonde* *Adapters*	Bluetooth, Field Cable, USB, RS-485; USB, SDI-12/RS-232 Modbus
Power *External* *Internal*	9-16 VDC 4 D-size batteries
Temperature *Operating* *Storage*	-5 to +50°C -20 to +80°C
Battery Life	90 days typically
Dimensions *Diameter* *Length* *Weight*	7.62 cm, 3.00 in 71.1 cm, 28.00 in 3.60 kg, 7.90 lb w batt.

EXO2 Bulkhead

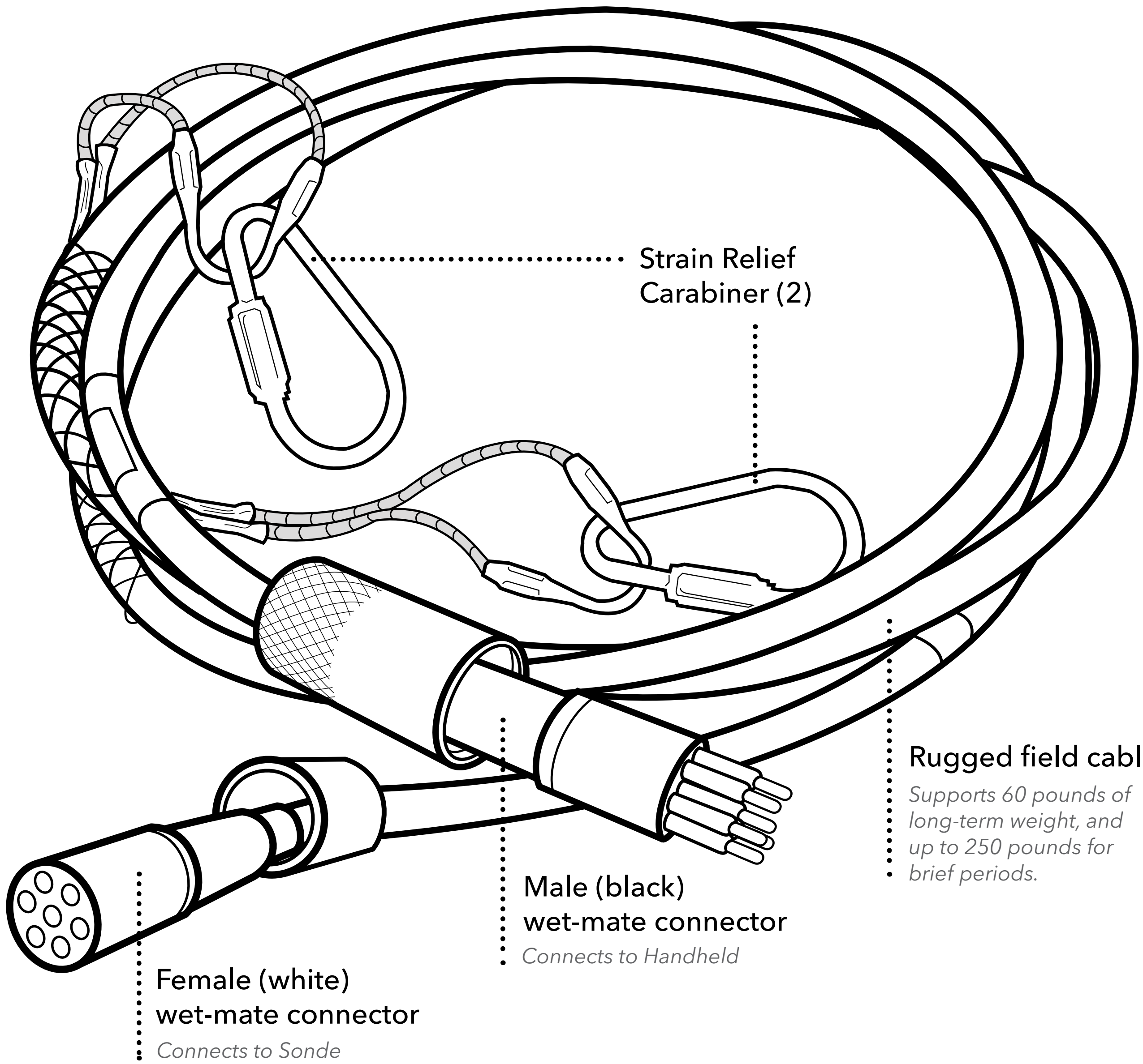


NOTE: *Starting 2014, EXO sonde bulkhead material changed from bronze to titanium.*


EXO2 Sonde
599502-xx
Removable Bail
599474
Auxiliary Port
6-Pin Cable Connector
Battery Cap/Pressure Relief Valve
O-ring kit 599681
Battery Compartment Opening
Battery Compartment
On/Off Magnetic Switch for Power and Bluetooth
Red LED Indicator – Sonde Status
Blue LED Indicator – Bluetooth
Bulkhead
Sensors
Port Plug
599475
Sensor Guard
599667, 599564
Calibration Cup
599316
Central Wiper
599090-01
Guard Weight
599472

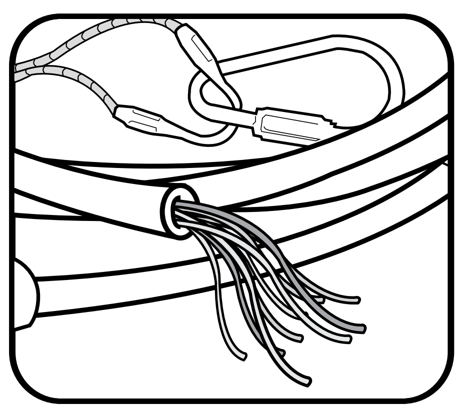
1.3 EXO Cables
Overview

The EXO rugged field cable comes in many different lengths and options to meet the needs of your specific application. Selecting the correct cable length and coupler will ensure the best quality data for your project. For a full list of cable options and precautions for extended cables, *please see the following page*.



Flying Lead Cable Vented and Non-Vented

A flying lead cable option is available which is intended for wiring to a data collection platform (DCP) or a data logger. A vented flying lead option is for use with a vented sonde only.
See section 6 for more information.



Cable Options

599431-01	EXO Cable Coupler, Titanium
599431-02	EXO Cable Coupler, Brass
599040-2	EXO 2 meter Field Cable
599040-4	EXO 4 meter Field Cable
599040-10	EXO 10 meter Field Cable
599040-15	EXO 15 meter Field Cable
599040-33	EXO 33 meter Field Cable
599040-66	EXO 66 meter Field Cable
599040-100	EXO 100 meter Field Cable
599040-150	EXO 150 meter Field Cable
599040-200	EXO 200 meter Field Cable
599040-250	EXO 250 meter Field Cable
599040-300	EXO 300 meter Field Cable
599008-10	EXO 10 meter Flying Lead Cable
599008-15	EXO 15 meter Flying Lead Cable
599008-33	EXO 33 meter Flying Lead Cable
599008-66	EXO 66 meter Flying Lead Cable
599008-100	EXO 100 meter Flying Lead Cable
599210-4	EXO 4 meter VENTED Flying Lead Cable
599210-10	EXO 10 meter VENTED Flying Lead Cable
599210-15	EXO 15 meter VENTED Flying lead Cable
599210-33	EXO 33 meter VENTED Flying Lead Cable

Extended Field Cables Precaution

Be aware, longer cables are made to order and there is an **eight week lead time** to build the product. There are some limitations for applications using EXO cable lengths greater than 100 meters- whether by extended cables, or by means of cable-coupling.

NOTICE: To prevent system problems related to power and signal integrity, make sure you understand the system limitations if you plan to use cable couplers or extended cables.

Voltage drop through long cables can adversely affect the available power at the sonde.
Here are some techniques to prevent such problems:

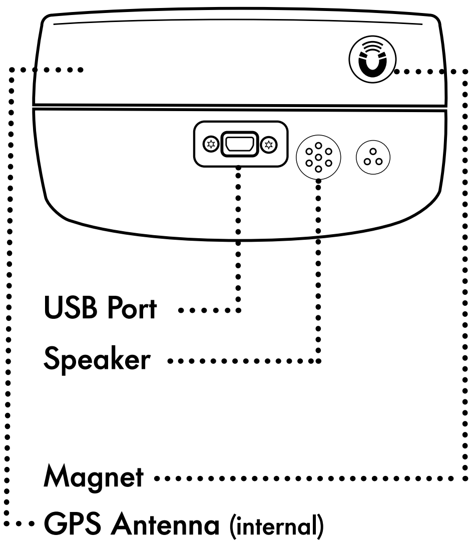
- Use Alkaline or high-capacity NiMH batteries in the sonde. This serves a dual purpose of adding weight in the sonde for profiling applications, as well as preventing system reboots during period of high current demand.
- Do not use EXO's USB SOA or Handheld as the sole power source for systems with large payloads (many optical or high power sensors). These devices do not provide a voltage high enough for use with extended cables.
- Limit use of EXO's auxiliary port to lower power devices.
- Power the sondes with a regulated power supply (12V-14V) capable of supplying 1A. This will ensure sufficient power is reaching the sonde.

1.4 EXO Handhelds Overview

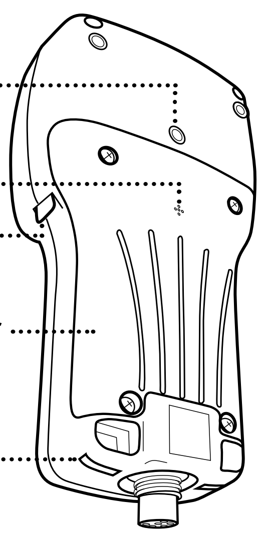
The EXO Classic Handheld (HH) is a rugged, microcomputer-based instrument that allows the user to display sonde readings, configure sondes, store and retrieve data, and transfer data from sondes to a computer. Equipped with GPS, barometer, and custom operating system, the Handheld communicates via Bluetooth wireless technology, field cable, or USB connector. (**NOTE:** *The USB connection is only used when connecting the Handheld to a PC.*) The unit utilizes an adjustable backlit screen for easy day or night viewing. Pre-installed KOR software facilitates all user interaction and provides powerful control over data collection.

EXO Classic Handheld

Top View



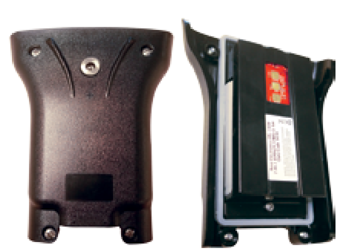
Back View



Please see section 5.6 for EXO Classic Handheld battery replacement instructions.

Specifications

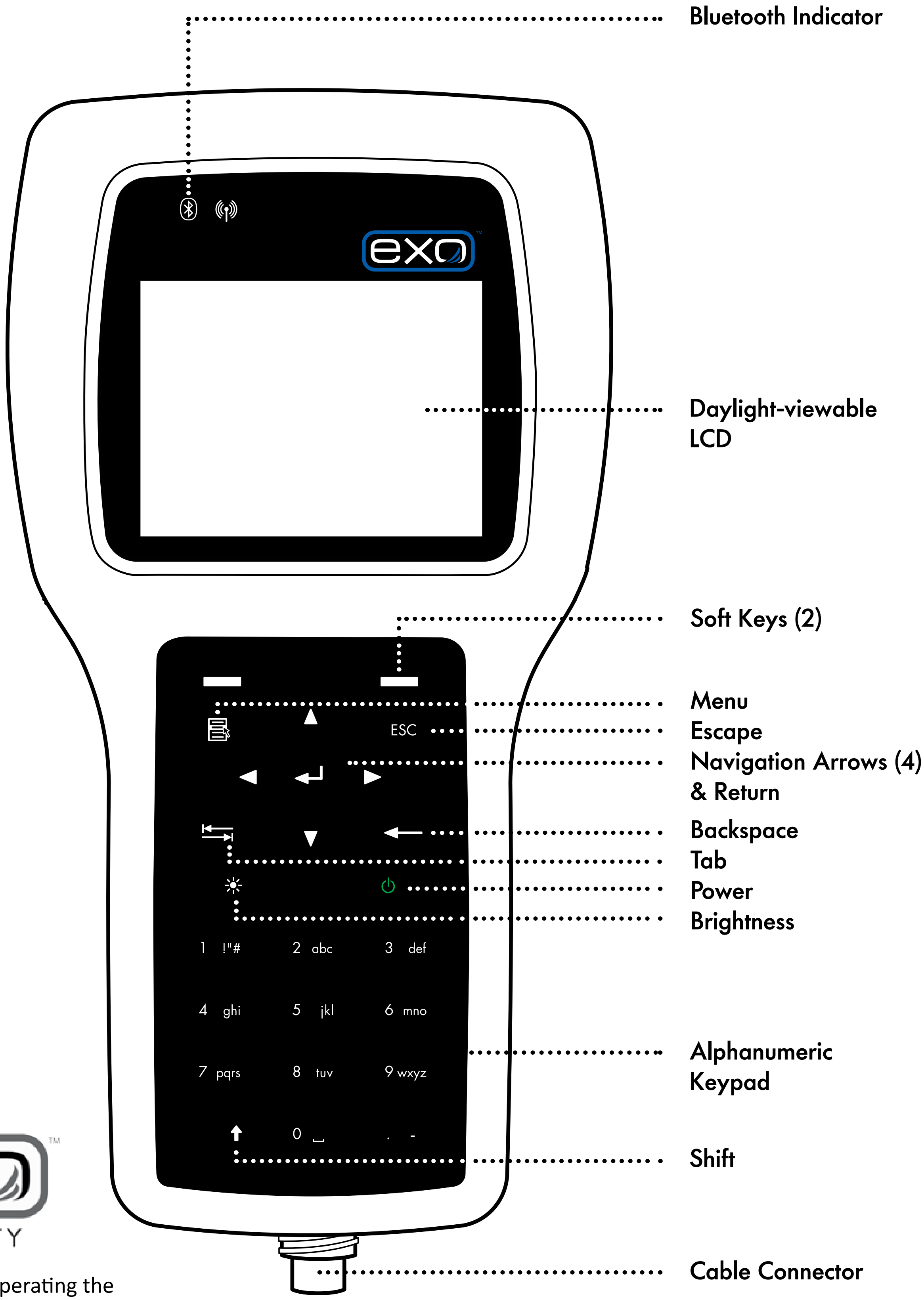
Barometer	Yes
GPS	Yes
Audio Speaker	Yes
Operating System	Windows CE 5.0
Material	Polycarbonate/ABS housing,rated to IP-67 in factory tests; polycarbonate lens
Memory	2 GB
Software	Kor Interface Software
Communications	Bluetooth, Field Cable, USB
Power *Internal*	4 C-size alkaline batteries or optional Li-Ion Pack
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Dimensions *Width* *Length* *Weight w. batt.*	 11.9 cm, 4.7 in 22.9 cm, 9.0 in 0.91 kg, 2.1 lb



A rechargeable Li-Ion battery pack is an available option (599622).

EXO Classic Handheld

EXO Classic Handheld 599150



For a walkthrough on operating the classic EXO Handheld, join us at EXO-University.com

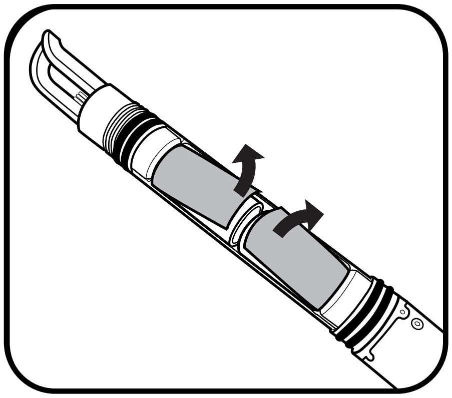
EXO Handheld Update

A new and improved EXO Handheld is currently in development, and is scheduled for release in 2016. In addition to being more compact and lighter, the new handheld will feature improved KOR 2.0 software functionality, integrated Lithium-Ion battery pack (no need to swap out batteries), and a whole lot more to be revealed at a later date. Keep your eyes on EXOwater.com for handheld update news!

Section 2
Operation

2.1 Sonde
Install or Replace EXO 1 Batteries

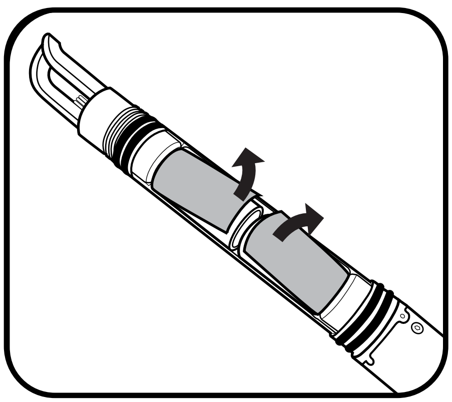
EXO1 water quality sondes use two (2) D-cell batteries as a power source. Using alkaline batteries, users can expect approximately 90 days of deployment from a fully loaded sonde that samples once every 15 minutes. However, deployment times may vary greatly depending on water temperature, sampling rate, sensor payload, and brand of battery. *See battery life specification, next page.* **NOTICE:** Do not use Ni-Cad or 3.6V Lithium batteries in the EXO1 sonde.



1 Remove battery cover

Start with a clean and dry sonde. Hold the sonde horizontally with the bail up and twist the battery cover counterclockwise until free. If necessary, slide the sonde tool's larger opening over the end of the battery compartment and use it as a lever to break the compartment free. Then slide off the battery cover.

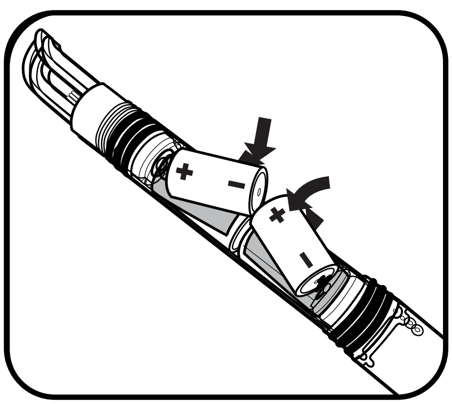
NOTICE:
Do not remove the screws on the sonde.
Do not clamp the sonde in a vise.



2 Remove old batteries

Expose the batteries by flipping the isolation flap up away from the batteries, and pull the batteries free of their compartment. Always dispose of used alkaline batteries according to local requirements and regulations.

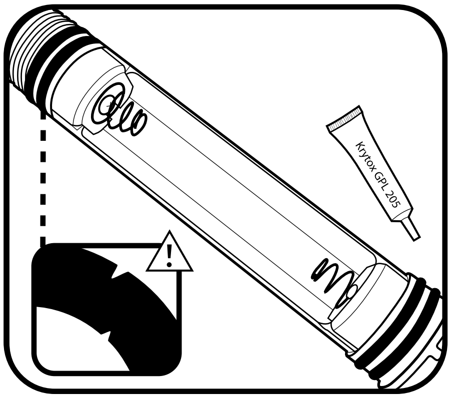
Clean the inside of the battery compartment with a lint-free cloth.



3 Install new batteries

Install the new batteries so that the positive terminals point towards the bail (away from the sensor bulkhead). Replace the isolation flap over the batteries.

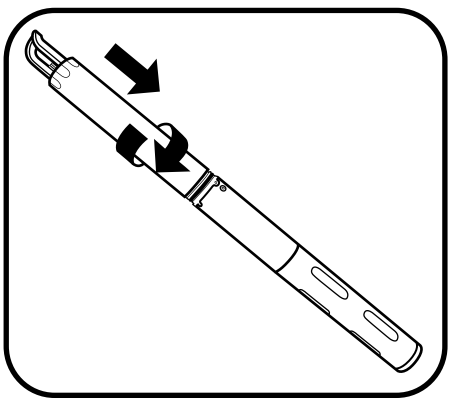
NOTICE:
Do not use Ni-Cad or 3.6V Lithium batteries in the sondes.
Damage to the circuit board is not covered under warranty.



4 Check and service o-rings

NOTE: *Before replacing the battery cover, check and service the four o-rings.*

Ensure that the o-rings are not nicked or torn and that they have no contaminants or particles on them or the sealing surfaces inside the battery cover. Clean the o-rings with a lint-free cloth. Then apply a thin coat of Krytox® lubricant to each o-ring.



5 Replace battery cover

Twist the battery cover clockwise until it stops at the rubber gasket. The gasket does not provide a seal and does not need to be compressed.

NOTICE: Do not overtighten; overtightening will not create a strong seal and may damage the sonde.

The EXO1 sonde has a resealing pressure relief valve;
no maintenance is required.

If a battery failure occurs that results in battery acid leakage into the battery compartment, the sonde must be returned to a service center for evaluation. Some battery acid will damage the plastic in the battery compartment.

Battery life specification

When using alkaline batteries: Approximately 90 days at 20˚C at a 15-minute logging interval, and temperature/conductivity, pH/ORP, Optical DO, and turbidity installed. Battery life is heavily dependent on sensor configuration and is given for a typical sensor ensemble.

Battery life is reduced in cold-water applications.

When using rechargeable nickel metal hydride (NiMH) batteries: Estimated battery life is not available because NiMH batteries vary greatly in manufacturer capacity and discharge curves. We recommend a NiMH D-cell battery with a minimum rating of 10,000 milliamp hours that are fully charged each time they are used.

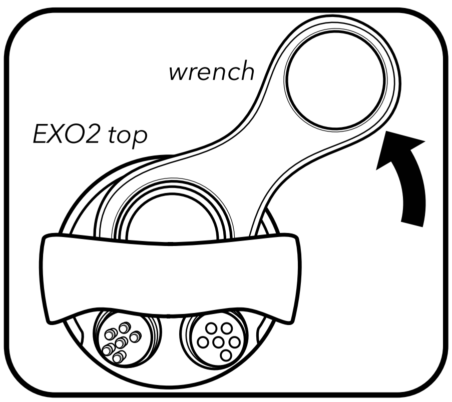
2.2 Sonde
Install or Replace EXO 2 Batteries

EXO2 water quality sondes use four (4) D-cell batteries as a power source. Using alkaline batteries, users can expect approximately 90 days of deployment from a fully loaded sonde that samples once every 15 minutes. However, deployment times may vary greatly depending on water temperature, sampling rate, sensor payload, wiper frequency, and brand of battery. *See battery life specification, next page.* **NOTICE:** Do not use Ni-Cad or 3.6V Lithium batteries in the EXO2 sonde.

Pressure in Battery Compartment

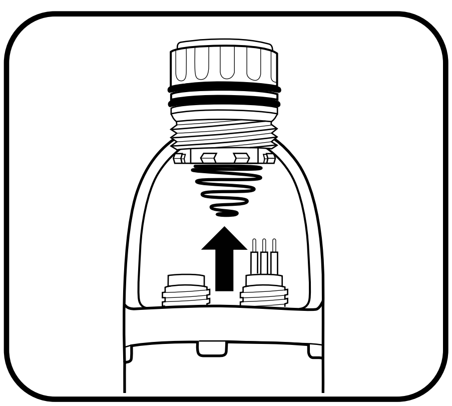
The EXO2 sonde is equipped with a pressure relief valve to protect against catastrophic battery failure. If the valve is open (indicating an over-pressure situation), the battery cap must be replaced. Significant water leakage into battery compartment requires that your instrument be evaluated by the manufacturer or Authorized Service Center before the next deployment.

⚠ **WARNING:** Do not paint over or cover the pressure release valve in any way.
Blocking the pressure release valve can lead to dangerously high internal pressure.



1 Loosen battery cap

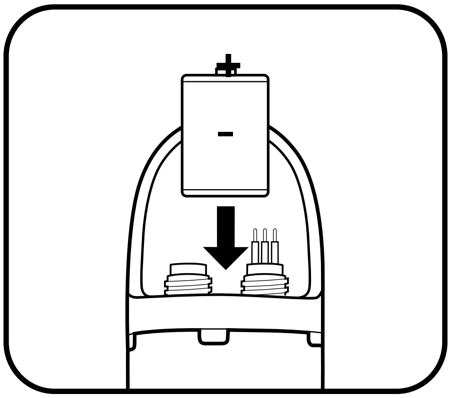
Start with a clean and dry sonde. Slide the sonde tool's smaller opening over the battery cap on top of the EXO2. Using the tool as a lever, firmly turn the tool counterclockwise until the battery cap is loose.



2 Remove battery cap and old batteries

Once the cap is sufficiently loose, remove the cap and old batteries from the well. Always dispose of used alkaline batteries according to local requirements and regulations.

Clean the o-ring sealing surfaces with a lint-free cloth. Inspect down into the battery tube to make sure it is clean and dry.

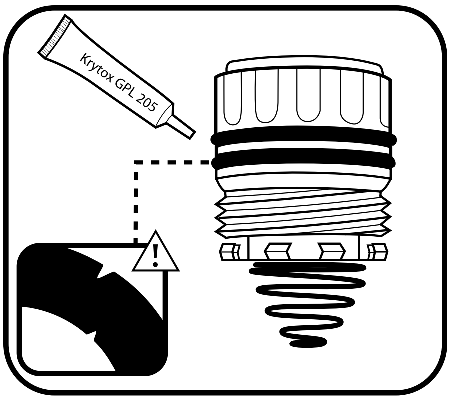


3 Insert new batteries

NOTICE:

Do not use Ni-Cad or 3.6V Lithium batteries in the sondes.
Damage to the circuit board is not covered under warranty.

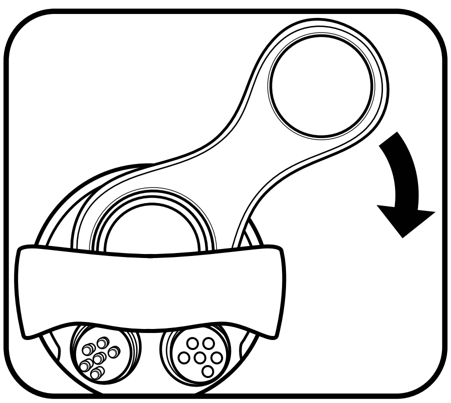
With the positive terminal facing up, insert four (4) new D-cell batteries into the battery well.



4 Check and service o-rings

NOTE: *Before replacing the battery cover, inspect and service the four o-rings.*

Ensure that the o-rings are not nicked or torn and that they have no contaminants or particles on them or the sealing surfaces inside the battery cover. Then apply a thin coat of Krytox® lubricant to each o-ring and sealing surface.



5 Replace battery cap

After servicing the cap's o-rings, insert the cap in its recess. Then, using your thumb, press down on the pressure relief valve while turning the cap clockwise. Once the cap threads are engaged, use the tool to tighten until snug.

NOTICE: Do not overtighten; overtightening will not create a strong seal and may damage the sonde. When completed, the top o-ring of the cap must be below the battery compartment opening.

If a battery failure occurs that results in battery acid leakage into the battery compartment, the sonde must be returned to a service center for evaluation. Some battery acid will damage the plastic in the battery compartment.

Battery Life Specification

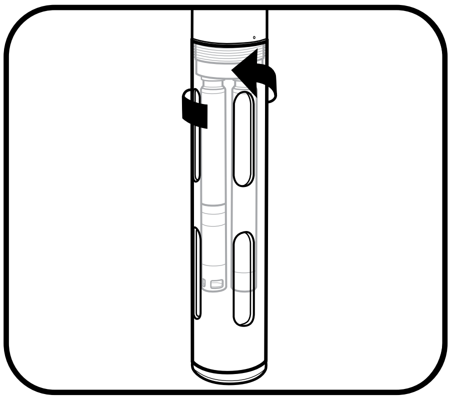
When using alkaline batteries: Approximately 90 days at 20˚C at a 15-minute logging interval, and temperature/conductivity, pH/ORP, Optical DO, turbidity, and Total Algae-PC installed along with a central wiper which rotates once every logging interval. Battery life is heavily dependent on sensor configuration and is given for a typical sensor ensemble.

Battery life is reduced in cold-water applications.

When using rechargeable nickel metal hydride (NiMH) batteries: Estimated battery life is not available because NiMH batteries vary greatly in manufacturer capacity and discharge curves. We recommend a NiMH D-cell battery with a minimum rating of 10,000 milliamp hours that are fully charged each time they are used.

2.3 Install/Remove Guard or Cal. Cup

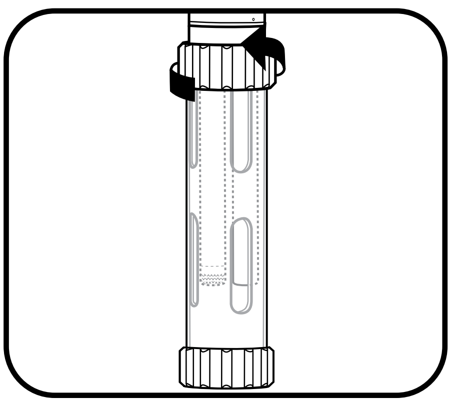
Sonde guards protect EXO sensors from impact throughout deployment. Users must install the guard prior to data collection. The calibration cup (cal cup) is used for storage and calibration. **NOTE:** *We recommend using two guards: one for field deployments and a second used exclusively for calibrations. Using a second guard will minimize calibration solution contamination (especially for turbidity).* EXO calibration cups install over an installed sonde guard. This configuration reduces the amount of standards required for calibration and protects the sensors during calibration.



1 Install/remove sonde guard

Install guard by threading it onto the sonde bulkhead threads. Rotate the guard clockwise on the bulkhead to install, taking care not to pinch your fingers. Rotate it counterclockwise to remove. Always use one guard for deployment/storage and the other for calibration only.

NOTICE: Take care not to let the guard damage unguarded pH or pH/ORP sensors when installing and removing.

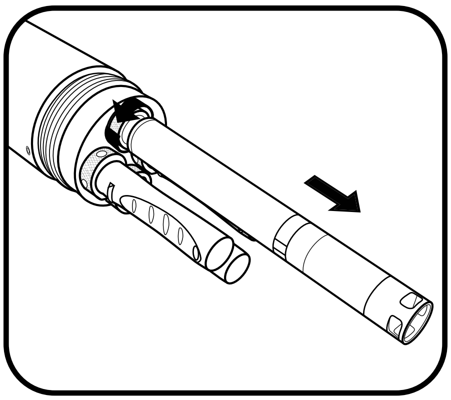


2 Install/remove calibration cup

Before installation, loosen (but do not remove) the cup's clamping ring. Then, with the sonde guard already installed, slide the cal cup over the guard until the bottom of the guard rests against the bottom of the cal cup. Tighten the ring until snug. To remove the cal cup, loosen the ring by 1/4 turn and pull the guard free from the cup.

2.4 Install/Remove Sensors

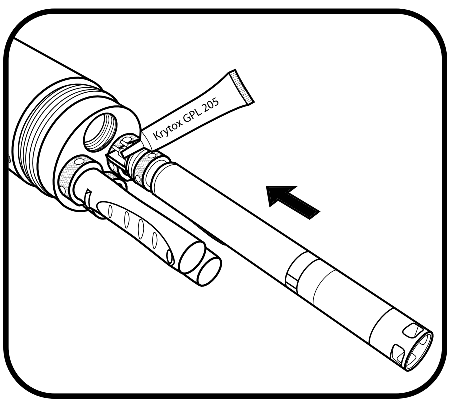
EXO sensors have identical connectors and identify themselves via onboard firmware; therefore, users can install any probe into any universal sonde port. The exception is the wiper for the EXO2 sonde, which must be installed in the central Port 7. Individual ports are physically identified by an engraved number on the sonde bulkhead. Although the probes are wet-mateable, users should clean, lubricate, and dry the sonde and sensors connectors prior to installation or service. **NOTE:** The data displayed on the Handheld / Desktop KOR, and the order of the exported data will be in the same order that the sensors are installed. (e.g. A turbidity sensor in port 1 will display turbidity values first. The sensor in port 2, second, and so on).



1 Remove probe or port plug

Remove the calibration cup and sensor guard from the sonde. Place the sonde on a clean, flat surface and prevent it from rolling.

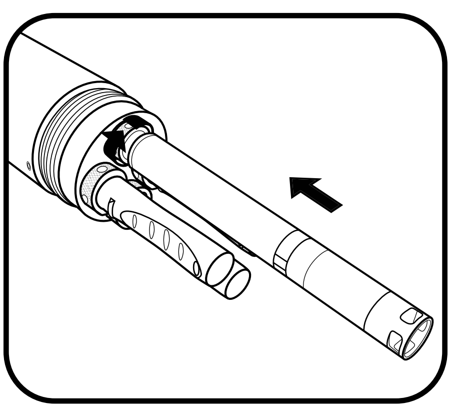
If removing a sensor or port plug, use the probe tool in the locking nut and rotate counterclockwise to loosen. Pull the probe straight out of the port and place on a clean surface. Wipe dry with a clean, lint-free cloth.



2 Clean port and install sensor

Visually inspect the port for contamination. If the port is dirty or wet, clean it with a clean, lint-free cloth or compressed air. Apply a light coat of Krytox grease to the rubber mating surfaces of the connector (not the o-ring) and a small dab of Krytox grease on the threads of the locking nut.

If the sensor is new or being taken out of storage remove any hydration caps or buffer bottles on the probe. Insert the sensor into the port by properly aligning the connectors' pins and sleeves (male and female contacts); then press them firmly together.



3 Tighten locking nut

Taking care not to cross-thread the grooves, finger-tighten the locking nut clockwise. When the nut and o-ring are seated against the bulkhead, tighten the nut with probe tool 1/4 turn until snug. Once sensors or plugs are installed, reinstall the sensor guard to protect sensors from impact damage.

NOTICE: Take care not to twist the probe body when tightening and loosening the locking nut. Excessive twisting of the probe can damage the connector and is not covered under warranty.

2.5 Sonde States and LED Descriptions

States

An EXO sonde is always in one of three operational states: *Off, Awake,* and *Asleep*. These states determine the sonde's current power usage and logging potential. When *Off* , the sonde is not powered and cannot collect data (no batteries installed, no topside power). Users can apply power to the sonde internally, using batteries, or externally with an EXO field cable attached from the topside port to an EXO Handheld, DCP or other approved power source. Once power is applied to a sonde, it is either *Awake* or *Asleep*.

States

Off: Not powered,
no data collection.

Asleep: Low power.
Waiting for command.

Awake: Full power.
Ready to collect.

LED Indicators

● Blue LED – Bluetooth

None: Off, not active.

On Solid: On, not linked.

2 Hz Blink: On, successfully linked.

● Red LED – Sonde State

None: Sonde is Off or Asleep with logging disabled.

0.1 Hz Blink: Sonde is Asleep with logging enabled.

1 Hz Blink: Sonde is Awake.

On: Sonde is Awake with faults.

When in an *Asleep* state, the sonde remains in a very low power setting and waits for a user command or its next scheduled logging interval. An *Awake* sonde is fully powered and ready to collect data. Once awakened, a sonde remains *Awake* for five minutes after its last communication via Bluetooth or 30 seconds after its last communication via the topside port. The sonde also automatically awakens 15 seconds before its next scheduled logging interval.

LED Indicators

Each sonde has two LED indicators that show the sonde's status. The blue LED indicates the Bluetooth's wireless connection status. The red LED indicates the sonde's current state.

The Bluetooth light (blue) is activated by a magnet swipe at the magnetic activation area. When the blue LED is off, the Bluetooth is disabled. When the light is on continuously, the Bluetooth is enabled, but no link has been established. When the blue LED blinks at 2 Hz, the sonde's Bluetooth is on, and has established a link.

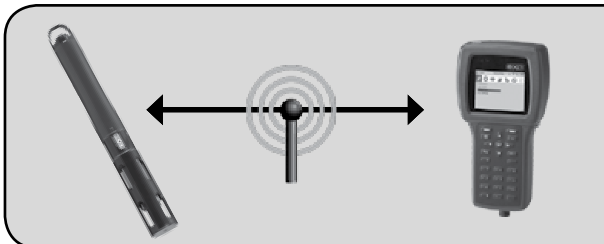
When the red sonde state LED is off, the sonde is either *Off* or *Asleep* and not logging. When it blinks at 0.1 Hz (once every 10 seconds), the sonde is *Asleep* and logging is enabled. When the red light blinks at 1 Hz, the sonde is *Awake* and has no faults. If the red light is lit continuously, the sonde is *Awake* and has detected faults, such as problems with the system that need to be fixed prior to use.

Modes

Within the *Awake* state, the sonde has three modes, which are activated via Kor software. When "Inactive (Off)," the sonde does not log any data. In "Real-Time" mode, the sonde continuously collects data at a user-specified interval (default is 2 Hz). "Sample/Hold" mode allows users to easily synchronize data between the sonde's data logger and an external data collection platform.

2.6 Connection Methods Overview

Below is a high level overview of various methods you can use to connect and communicate with your EXO sonde:

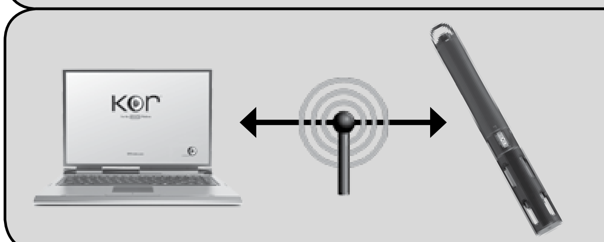


Wireless Bluetooth, Sonde-to-Classic HH

- Lab Calibration
- Hardware Setup
- Transfer Data from Sonde

Field Cable, Sonde-to-Handhelds

- Lab Calibration
- Hardware Setup
- Transfer Data from Sonde
- Field Sampling

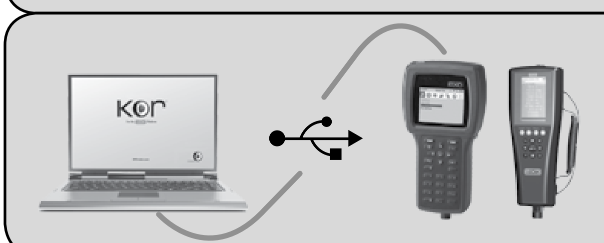


Wireless Bluetooth, Computer-to-Sonde

- Lab Calibration
- Hardware Setup
- Transfer & Export Data

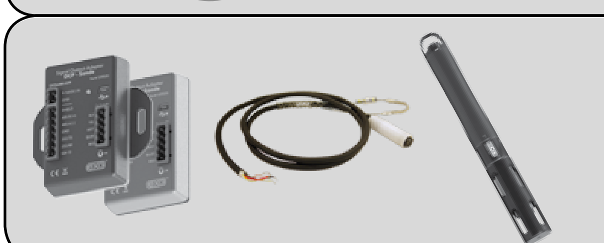
SOA-USB Adapter, Sonde-to-Computer

- Lab Calibration
- Hardware Setup
- Transfer & Export Data
- Field Sampling
- Update Firmware



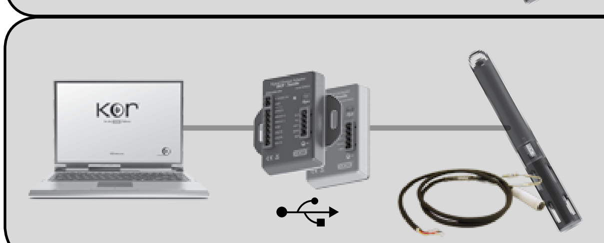
Direct USB, Computer-to-Handhelds

- Transfer & Export Data
- Update Firmware



Flying Lead Cable, Sonde-to-Com. Adapter

- Long-Term Monitoring with a Data Collection Platform or SCADA Modbus

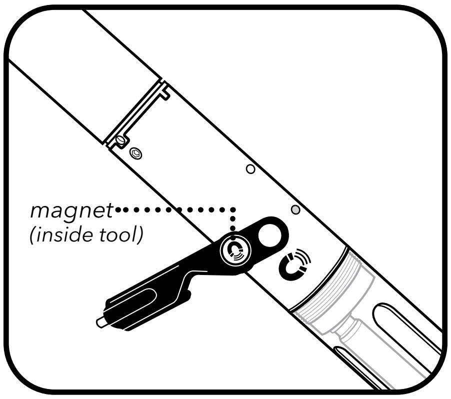


USB Passthrough Mode

- Direct USB communication to sonde, through DCP 2.0 / Modbus using KorEXO softwawre.

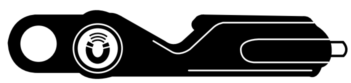
2.7 Awaken Sonde, Activate Bluetooth

Once power is applied to the sonde, internally or externally, users can awaken their sondes from *Sleep* state using any of several methods. Primarily, users activate EXO sondes and the Bluetooth connections via a magnetic switch installed in sonde's electronics compartment. The sonde will automatically disable the connection and go to sleep once it has not received a Bluetooth signal for 5 minutes or a signal from the topside connector for 30 seconds. In order to activate their sondes, users should keep a magnet with them when setting up and deploying sondes. *For more information on sonde states and LEDs, see section 2.5.*

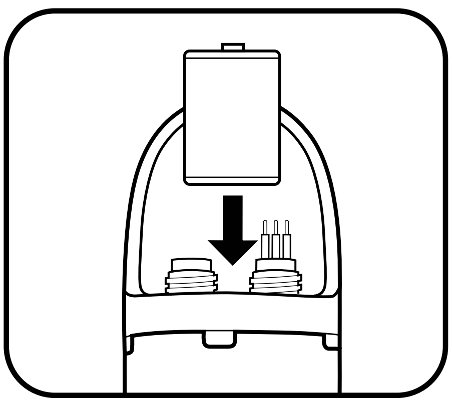


1 Awaken sonde with magnet

Users can make their sonde go to the Awake state by holding a magnet at the magnetic activation area on the sonde's bulkhead (identified by the illustrated magnet symbol on the label). Simply hold the magnet within one (1) cm of the symbol until the LEDs activate. EXO Handhelds and sensor tools contain embedded magnets identified by the same symbol.



NOTE: *The magnetic tool was updated in 2014. Item #599469 "EXO Sensor Tool Kit".*

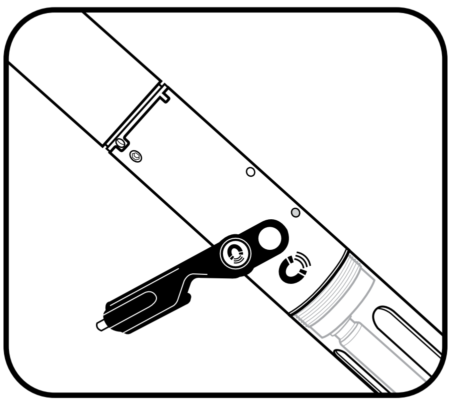


2 Awaken sonde without magnet

Users can also make their sonde go to the Awake state using any of the following methods.

- Cycling power to the sonde (uninstalling/installing batteries).
- Communicating via the topside port.
- Inserting a sensor.

In addition to these manual methods, the sonde also automatically awakens for scheduled unattended logging (programmed in KOR).



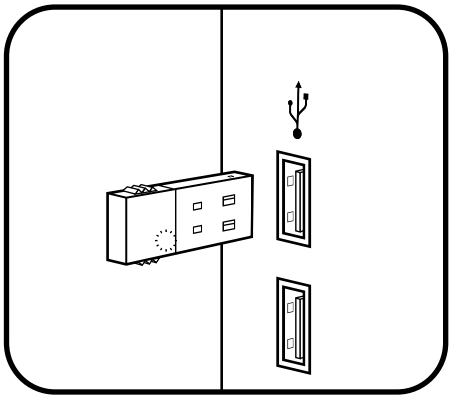
3 Activate sonde's Bluetooth

Users activate Bluetooth by holding a magnet at the magnetic activation area in the same way as described in Step 1. In addition to magnetic activation, users can also activate Bluetooth by:

- Cycling power to the sonde (uninstalling/installing batteries).
- Enabling Bluetooth via a connection at the topside port in KOR.

2.8 Connect Sonde Bluetooth

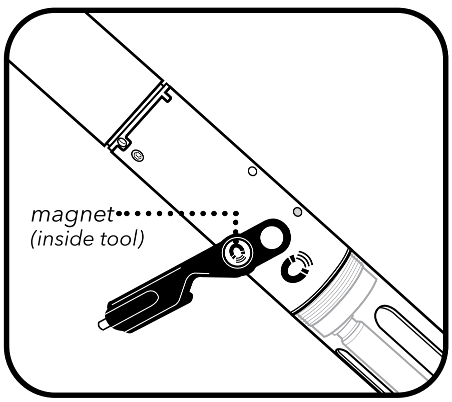
Before users can communicate wirelessly with their EXO sondes, they must establish a Bluetooth link. All EXO sondes are equipped with Bluetooth wireless. This technology provides a secure, two-way, reliable communication channel with which users can communicate with their sondes above water without cables. Many new computers are equipped with Bluetooth wireless installed internally; those without Bluetooth can use a Bluetooth dongle (not included). Follow the manufacturer's instructions for installing the dongle's software and hardware. Administrative permissions and IT support may be required depending on the adapter and your PC settings.



1 Install Bluetooth dongle (optional)

If your computer is not equipped with internal Bluetooth radio, insert a Bluetooth dongle (not provided) into any of the computer's USB ports. Wait for the computer to automatically install the device and its drivers. Once the installation is complete, the computer should indicate that the device is installed and ready to use.

The preferred Bluetooth configuration is Windows 7 with native Windows Bluetooth drivers and software.



2 Activate sonde's Bluetooth

Users activate Bluetooth wireless by holding a magnet at the magnetic activation area. In addition to magnetic activation, users can also activate Bluetooth by:

- Applying power to the sonde (remove and reinstall batteries)

3a Establish Bluetooth link–Search Bluetooth (Win 7 or Win XP)

1. Launch KOR software and click the Connections menu.
2. Click Rescan button.
3. Click Search Bluetooth button. This may take up to 40 seconds, and may require several attempts using the Refresh button.
4. Select the device from the list and click Connect.

When the connection is complete, KOR automatically displays the Dashboard screen with live data.

3b Establish Bluetooth link(Win XP)

1. Click the Bluetooth icon in the system tray (lower right), select "Add a Bluetooth Device" and complete the device wizard.
2. Activate your sonde's Bluetooth.
3. Check "My device is setup and ready to be found," then click "Next."
4. Locate the sonde name (starts with YSI) from the list and click Next. (If not found, click "Search Again.")
5. Select "Enter the device's pairing code" and click Next. Then enter the pairing code 9876. Click "Next."
6. Windows assigns an outgoing comm port. Select Finish.
7. See step 3a to complete the connection in KOR.

3c Establish Bluetooth link (Win 7)

1. Open the Windows Start menu and click Devices and Printers.
2. Select "Add a Device" from the top of the screen.
3. Locate the sonde name (starts with YSI) from the list and click Next.
4. Select "Enter the device's pairing code" and click Next. Then enter the pairing code 9876. Click "Next."
5. Windows will configure the device, install drivers, and assign a comm port.
6. See step 3a to complete the connection in KOR.

4 Confirm successful link

Once the device has been added, confirm that the device appears in:

- Win XP - Devices tab of the BT Devices window
- Win 7 - Devices and Printers screen

If the device is not listed, attempt the establishment process again.

This process establishes a secure wireless link between the sonde and a PC. Once established, users will not need to perform this process again in order to link with the sonde.

Ports

KOR automatically scans ports for both USB adapters and Bluetooth. To view the comm port associated with Bluetooth:

- Win XP : Go to the Bluetooth menu on your computer, click Show Bluetooth Devices, click on the device you added, then click Properties > Services.
- Win 7 : Go to the Devices and Printers screen, right-click your sonde, then click Properties > Hardware.

2.9 Communication Adapters Overview

The EXO platform now offers expanded communication adapter (com. adapter) options. Below is a high level overview of the com. adapter options available to you. Choosing the right adapter for your application, based on the desired communication protocol, will be a key factor in the success of your project. **NOTE:** *Each com. adpater requires its own USB driver update, go to* EXOwater.com *to download the latest drivers.*

EXO USB Signal Output Adapter (599810)

This adapter supports a connection between an EXO sonde and a PC through a wired USB interface with the top-side connector. Transfer files and make changes to the sonde from your laptop or other USB ready smart device.

See section 2.10 for EXO SOA connection instructions.

EXO DCP Signal Output Adapter 2.0 (599820)

An updated version of our classic DCP-SOA. This com. adapter is intended for use in long term monitoring applications. Requires an EXO sonde, data logger, and flying lead cable to function. This adapter converts an EXO sonde signal into either SDI-12 or RS-232.

See section 2.11 for more information on the EXO DCP SOA 2.0

EXO Modbus Signal Output Adapter (599825)

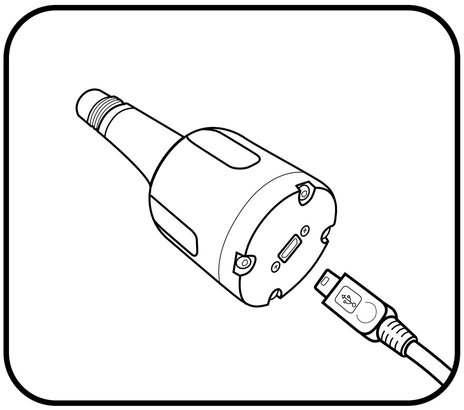
This com. adapter is inteded for use in a SCADA system. Requires an EXO sonde and flying lead cable to function. This adapter converts an EXO signal into a Modbus protol over RS-232 or RS-485.

See section 2.14 for more information on the EXO Modbus SOA.

2.10 Communication Adapters
USB

The USB signal output adapter (USB-SOA 599810) allows users to connect to an EXO sonde over a standard USB connection. Although the USB-SOA is rugged and water resistant, users should protect its connectors with the included cap when not in use. **NOTICE:** The SOA should never be submerged.

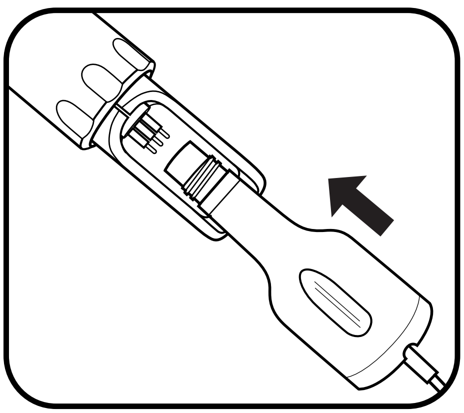
Prior to use, users must install KOR software and its drivers on the associated PC. The USB-SOA will not work without the drivers that accompany KOR. Visit EXOwater.com for the latest drivers.



1 Connect USB cable to SOA and PC

Remove the protective cap from the USB end of the SOA, and ensure that the connector is clean and dry. Then insert the small end of the provided USB cable into the SOA connector and the large, standard side into one of the PC's USB ports. *The sonde should not be connected at this time.*

Attaching the adapter to the PC causes a new device to be recognized. Windows automatically installs the drivers and creates a new port. Each new adapter that is attached creates a new port.



2 Connect SOA to sonde

Remove the plug from the male 6-pin connector on the sonde. Apply a light layer of Krytox grease to the male pins on the sonde and the female connector on the USB-SOA. Then align the connector's six pins and jackets, and press them firmly together so that no gap remains.

Ports

KOR automatically scans ports for both USB adapters and Bluetooth. To view the USB adapter and its associated comm port, go to the Control Panel on your computer, click Device Manager, then click Ports.

Next, open KOR, go to connections, rescan and select the adapter from the list and click connect.

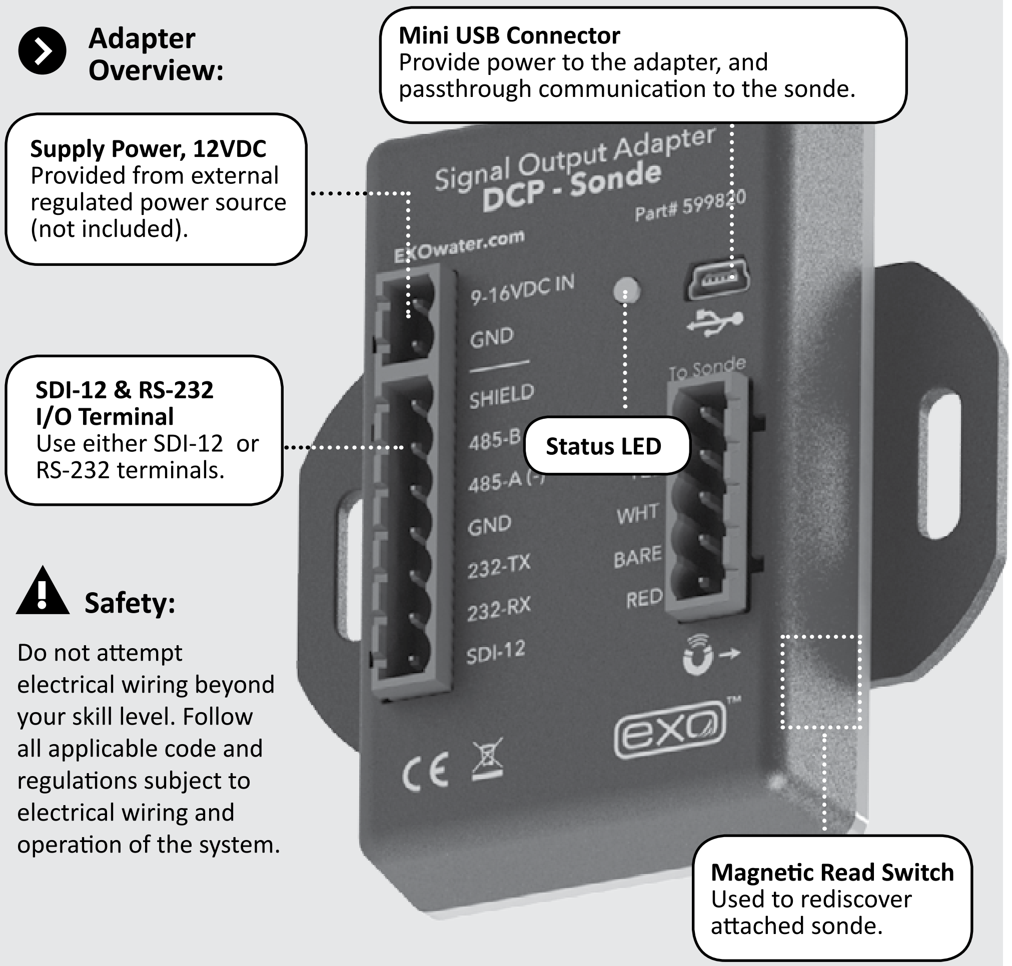
2.11 Communication Adapters
Data Collection Platform 2.0 (DCP)

Delivering quality data where and when you need it most.

Introduction:

The 599820 is a communication adapter for the EXO multiparameter sonde platform. It converts the proprietary signal from the water quality sonde into either SDI-12 or RS-232 signals. The adapter simplifies integration into 3rd party DCP systems, and also features a USB port that supports passthrough communication directly to the connected sonde. This feature allows configuration, calibration, and data transfer without having to disconnect the field cabling.

Adapter Overview:



Safety:

Do not attempt electrical wiring beyond your skill level. Follow all applicable code and regulations subject to electrical wiring and operation of the system.

Specifications
Supply Voltage: 9 - 16 VDC or USB 5 VDC
Current Draw Adapter: ~20mA typical (@12VDC)
Current Draw Sonde: ~sleep 0.25mA reading and 100mA during operation
Max Net Current Draw for Systems: ~120mAmps (@12VDC)
Dimensions: L=3.5", W=3.5", H=1.5" (89cm x 89cm x 38cm)
Operating Temp: -40°C to +60°C
Storage Temp: -50°C to +80°C
Humidity: 0 to 99% non-condensing

What's Included:

The 599820 EXO Communication Adapter comes with:

- (1) DCP 2.0 Adapter
- (3) green wiring terminal blocks (Sonde 5-pin, Power 2-pin, DCP 7-pin)
- (1) Panel mounting bracket
- (1) Hook and loop fastener

If any item is missing, please contact info@ysi.com for replacements.

You'll also need:

- Flat blade screwdriver for terminal blocks
- Phillip's screwdriver for panel mount bracket
- EXO magnetic sensor tool (optional)
- EXO Flying Lead Field cable (599008-x)
- EXO sonde system, sensors, and associated hardware
- Latest KOR software (available from EXOwater.com)

Getting Started

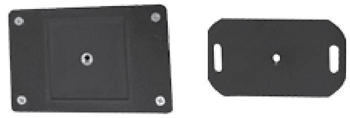
Mounting:

The adapter should be protected from the elements, and it is recommended it be mounted inside of a sealed enclosure with desiccant to prevent condensation.

The adapter includes a panel mount in addition to self-adhesive hook and loop fastener. Either of these two methods can be used to securely mount the adapter. Use the provided Phillips screw to secure the panel mount:

Panel Mount

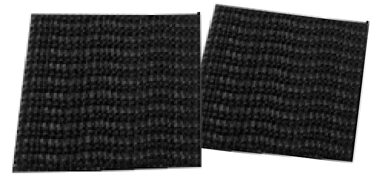
1:



2:

Back Front

Self-Adhesive Hook and Loop Fastener



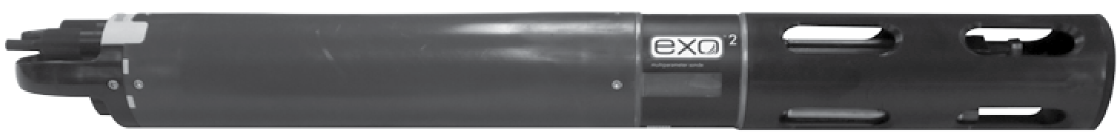
Note: If using self adhesive hook and loop, clean and dry both surfaces before applying.

Status LED Indications	
Off	No power
On	No Sonde connected
Flashing at 1 Hz	Sonde connected, everything normal
Flashing at 1/10 Hz	Low power sleep (Will flash on for 1 second when magnetic switch is activated.)

Wiring

Have the following ready:

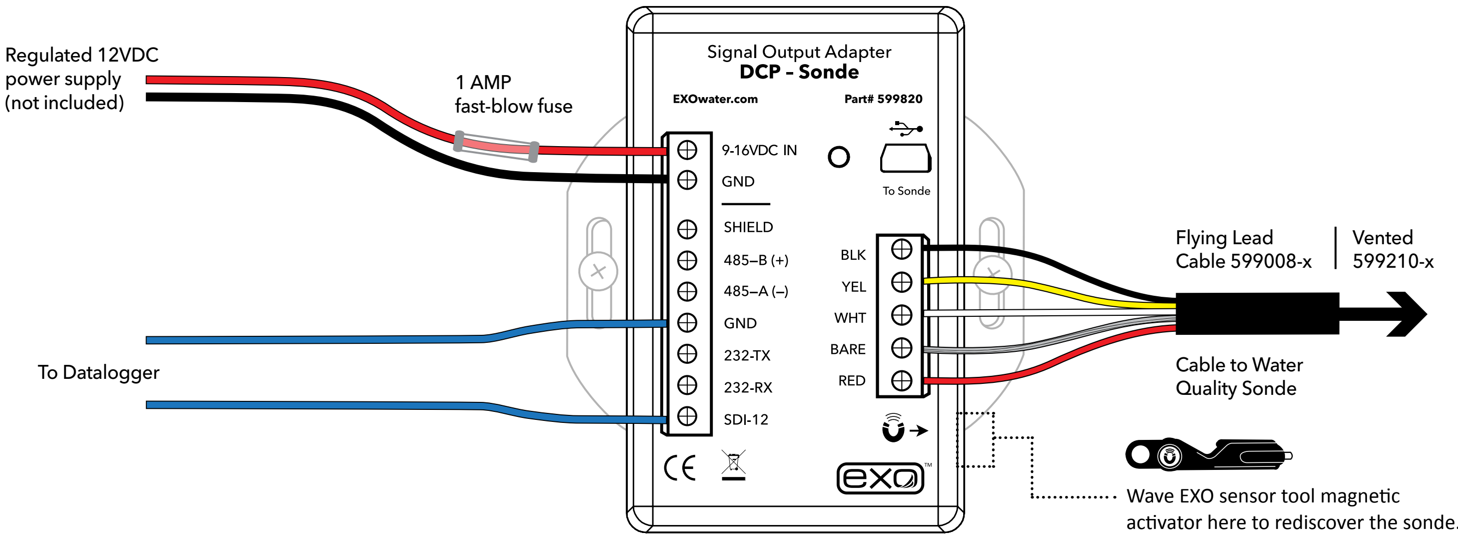
- EXO Sonde
- DCP 2.0 Adapter
- Flying Lead Cable
- Desiccant if using Vented Cable
- Flat blade screwdriver
- Power & Data Logger Wires



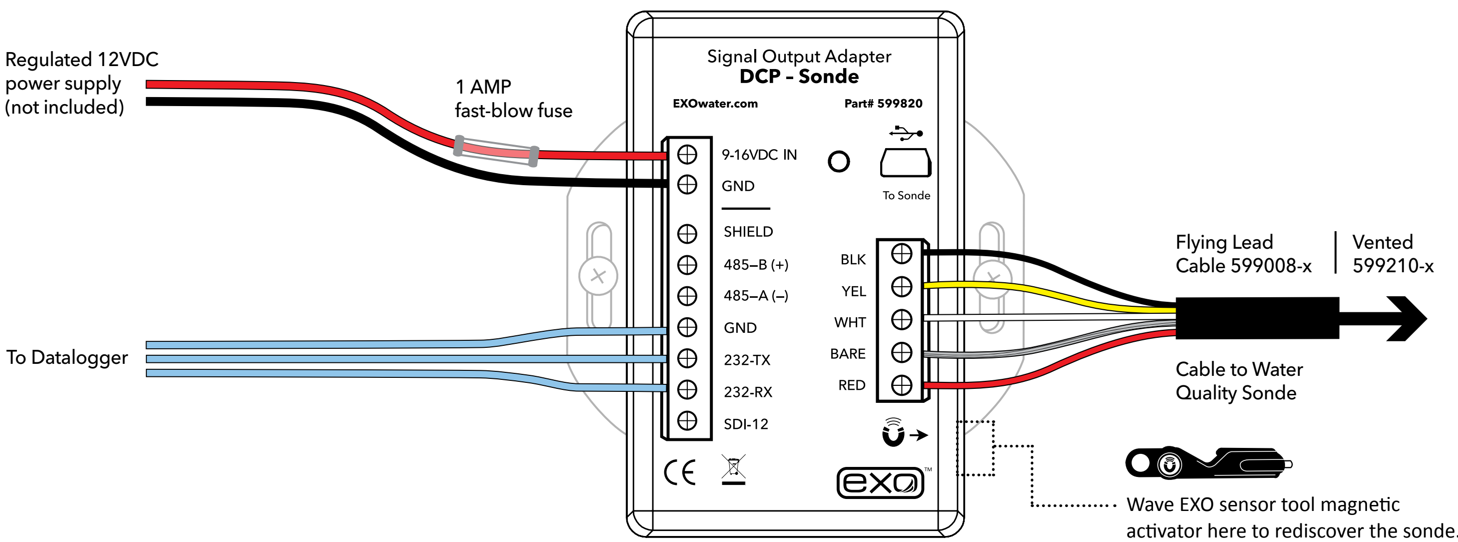
Webinar | A Simple Guide to Collecting Water Quality Data
Learn the basics of wiring your Sonde up to a DCP:
https://goo.gl/B4PPK7

Wiring Continued

Next wire the flying lead cable, power, and DCP ports as labeled in one of the following configurations:



OR



When connecting new sondes to the DCP adapter, it may be necessary to redetect the sonde. This can be done by power cycling the adapter or by using the magnetic read switch at the lower right hand side of the enclosure. Waving the magnet in the EXO sensor tool, over the area referenced by the square above, will force a network redetect where all new sensors and configurations will be discovered.

Note: The orange wire on the flying lead cable to the sonde will not be used. It can be taped back during installation.

USB Passthrough Mode

The 599820 DCP Signal Output Adapter can function in a similar fashion as the 599810 USB communication adapter. After the Signal Output Adapter is wired as shown in the previous configuration, connecting to the USB port on the adapter will allow direct communications with the sonde using KorEXO software. **USB passthrough drivers** will automatically be installed along with KOR 2.0 software, they are also available separately from the EXOwater.com website. Install these drivers on your PC to communicate with a signal output adapter (SOA) through any version of Desktop KOR:

Note: USB utilizes Communication Device Class (CDC) and installs as com port on PC: “YSI SOA/DCP Gen2”.
The USB connection may also be used to update firmware on the adapter using KOR software.

Output Configuration

In order to appropriately setup a sonde to communicate measurements to a datalogger, it is critical to align the settings from the sonde and the logger.

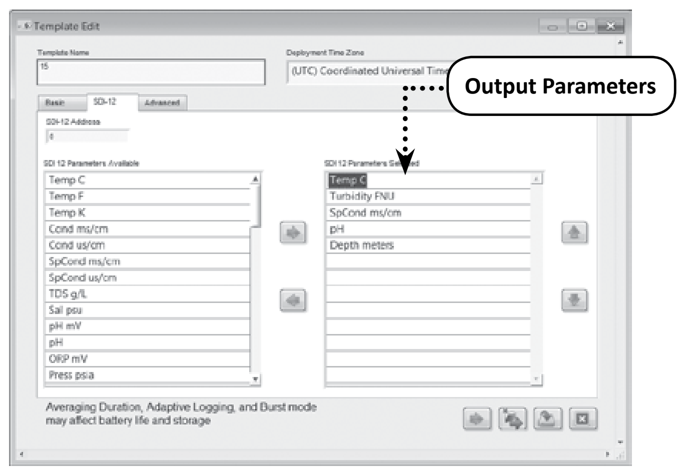
In the KorEXO software |**Deployment Settings**| choose the parameters and sort order, then push the template to the sonde. (Kor Version 1.0 shown on the top-right, and KorEXO version 2.0 shown above on the bottom-right.)

In both versions the complete list of parameters is shown in the left column and the selected parameters to output via the DCP 2.0 adapter are shown on the right. This template can be saved locally on the PC, but it must also be pushed down to the sonde for the settings to take effect. So be sure to apply the template to the sonde.

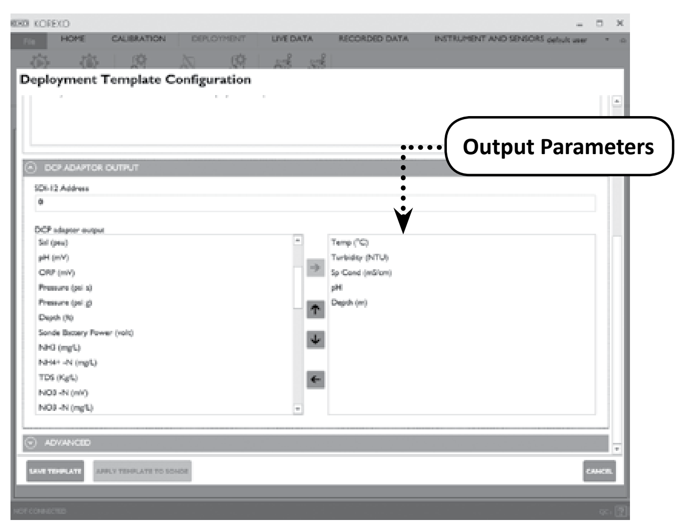
Note: there are two options when applying the template to the sonde, apply without logging or with logging. Either option may be used. When deploying with logging the sonde will create a redundant log file inside the sonde. Without logging the only data will be available to the RS-232 or SDI-12 outputs.

⚠ For access to the beta software, or assistance changing the default settings, please contact Technical Support at info@ysi.com.

(**Note:** KorEXO 2.0 software still in development, screen will change in final release.)



Kor Version 1.0



KorEXO Version 2.0.x

EXO DCP Signal Output Adapter Programming Basics

1. SDI-12 Interface

- **General**
  - Compatible with v1.3 of SDI-12 specification
  - Supports following standard commands:
    - '!' Address Query
    - 'A' Change Address
    - 'C' Concurrent Measurement
    - 'D' Data
    - 'I' Identification
    - 'M' Start Measurement
    - 'V' Start Verification

- **Extended Commands**
  - SDI-12 'Z' command
  - Supports the following RS232 commands:
    - 'sn' Serial Number
    - 'para' Parameter List
    - 'twipeb' Start wipe
    - 'ver' S/W version
    - 'ssn' Sensor Serial Numbers

2. RS-232 Interface

- **General**
  - Command Line
  - '#' is user prompt
  - Commands are not case senstive
  - Only spaces are recognized as delimiters
  - A command is terminated by a <CR>
  - Minimum time from power up to valid readings is 19 seconds

- **Command List**

See RS-232 commands in Section 2.12
See SDI-12 Port Settings in Section 2.13.

An example of a NEMA enclosure where the DCP Signal Output Adapter is wired.

2.12 Communication Adapters RS-232

The EXO DCP Signal Output Adapter (SOA) supports limited RS-232 commands. The SOA supports both SDI-12 and RS-232 communications. The order of the RS-232 parameter output is controlled by the SDI-12 tab on the deployment menu.

[ ] indicates argument is optional **<i>** indicates argument is an integer

data
Returns one line of data readings. Data parameters specified in para command. Data delimiter is specified in the setdelim command.

dowait [<i>]
Turns "wait for DO" on if <i>=1 and off if <i>=0. The response is "OK". If you do not supply <i>, then the response is the current value of dowait. When enabled the SOA/DCP will not return data until sonde has been on for "dowarmup" seconds.

dowarmup [<i>]
Sets DO sensor warmup time where <i>=warmup time in seconds. The response is "OK". If you do not supply <i>, then the response is the current value for dowarmup. When "dowait" is enabled the SOA/DCP will not return data until sonde has been on for "dowarmup" seconds.

fltreset
Resets all sonde sensor filters. The response is "OK".

hwipesleft
Returns a value other than 0 if a wiper event is in progress. The value returned is normally the amount of "half" wipes that are left to go. When wiping is completely finished, the value will go to 0.

para
Returns the parameter numbers of all parameters selected for output. Each number returned matches one for one with the values returned in the data command. The numbers are space delimited.

para [<i1> <i2> <i3> <i4> …]
Sets the data parameter codes used with the data and run commands. The parameters are space delimited. If you do not supply any parameters then the response is the current list of parameters. Maximum number of parameters is 32.

pwruptorun [<i>]
Turns "power up to run" on if <i>=1 and off if <i>=0. The response is "OK". If you do not supply <i>, then the response is the current value of pwruptorun.

run
Causes the sonde to SOA/DCP to take sonde readings at a 1Hz rate. The output is similar to the Data command except that readings are taken continuously. No headers are output. To abort send '0', <esc>, or turn power off to the SOA/DCP and then reapply.

setcomm [<i1>] [<i2>]
Changes the SOA/DCP's comm port baud rate and data length. The baud rate will be immediately changed after this command, so you will need to reconfigure your terminal to match.

<i1> can be:

2 - 1200 baud	6 - 19200 baud
3 - 2400 baud	7 - 38400 baud
4 - 4800 baud	8 - 57600 baud
5 - 9600 baud (default)	9 - 115200 baud

<i2> can be:

0 - 7 bits

1 - 8 bits

Send these commands to the DCP via an RS-232 hyperterminal window configured with the following:

Bits per second	9600
Data bits	8
Parity	None
Stop bits	1
Flow control	None

setdelim [<i>]
Changes the SOA/DCP's delimiter used in the data command response. If you do not supply <i>, then the response is the current value for delimiter.

<i> can be: 0 = space, 1 = TAB, 2 = comma, 3 = none

setecho [<i>]
Enables (<i>=1) or disables (<i>=0) command echoes. When echoes are disabled, commands sent to the SOA/DCP will not be 'echoed' back and there will be no '# ' prompt. If you do not supply <i>, then the response is the current value for echo.

setmode [<i>]
Sets the RS232 mode. If <i>=0, mode is normal. If <i>=1 mode is NMEA. If you do not supply <i>, then the response is the current value for mode.

setradix [<i>]
Sets the radix point used for data output. If <i>=0 radix will be '.'. If <i>=1 radix will be ','. Note that in SDI12 mode, the response to a 'D' command will always be with '.' regardless of this setting. The response is "OK". If you do not supply <i>, then the response is the current value for radix.

setsonde [<i>]
Selects a sonde for RS-232 communications when more than 1 sonde are daisy-chained. <i> represents the order of the sonde in the chain where 1st sonde = 0, 2nd = 1, 3rd = 2. The response is "OK". If you do not supply <i>, then the response is the current value for sonde.

sn
Returns the unique serial number programmed into every YSI sonde.

ssn
Returns the unique serial number for the sonde and all attached sensors

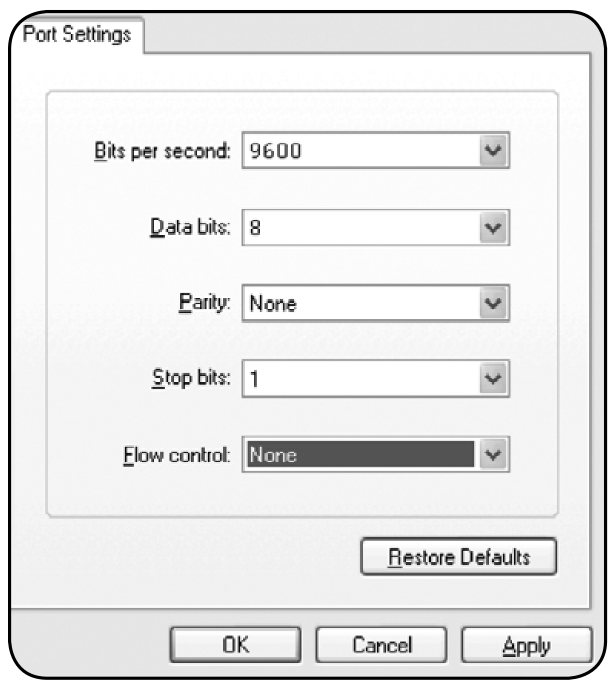
setperiod [<i>]
Sets the period for the data output in RUN mode. The period is set to <i> milliseconds. Minimum value is 250 (1/4 second), maximum value is 30000 (30 seconds). If you do not supply <i>, then the response is the current value for period. For periods less than 1000 and baud rates below 9600, the data output may be unreliable.

time [<hh:mm:ss>]
Allows user to set time in the sonde in the HH:MM:SS format. The response is "OK". If you do not supply <hh:mm:ss>, then the response is the current value of time.

twipeb
Starts a wiper event. The response is the approximate time in seconds it will take to perform the wipe.

ver
Returns the software version number of the sonde.

verdate
Returns the time and date at which the current version of software in the sonde was compiled.



RS-232 settings should resemble this image.

2.13 Communication Adapters
SDI-12

The sonde can be connected to an SDI-12 bus using a DCP Signal Output Adapter (SOA). The SOA provides the necessary SDI-12 electrical interface and communicates to the sonde via the topside RS-485 interface. The SOA will automatically recognize when a sonde is connected and retrieve the SDI-12 address and ID from the sonde. The SDI-12 data parameter list is set by the user in the Deploy menu. Go to Deploy | Open Template | Edit Template menu and click on the SDI-12 tab.

- All codes below 223 are 6-series compatible (except TSS).
- Maximum of 23 codes in sonde parameter list.

Parameter	Code
Temperature, °C	1
Temperature, °F	2
Temperature, °K	3
Conductivity, mS/cm	4
Conductivity, uS/cm	5
Specific Conductance, mS/cm	6
Specific Conductance, uS/cm	7
TDS, g/L	10
Salinity, PPT	12
pH, mV	17
pH	18
ORP, mV	19
Pressure, psia	20
Pressure, psig	21
Depth, m	22
Depth, ft	23
Battery, V	28
Turbidity, NTU	37
NH3 (Ammonia), mg/L	47
NH4 (Ammonium), mg/L	48

Parameter	Code
Date, DDMMYY	51
Date, MMDDYY	52
Date, YYMMDD,	53
Time, HHMMSS	54
TDS, kg/L	95
NO3 (Nitrate), mV	101
NO3 (Nitrate), mg/L	106
NH4 (Ammonium), mV	108
TDS, mg/L	110
Chloride, mg/L	112
Chloride, mV	145
TSS, mg/L	190
TSS, g/L	191
Chlorophyll, ug/L	193
Chlorophyll, RFU	194
ODO, %Sat	211
ODO, mg/L	212
ODO, %Sat Local	214
BGA-PC, RFU	216
BGA-PE, RFU	218

Parameter	Code
Turbidity, FNU	223
Turbidity, Raw	224
BGA-PC, ug/L	225
BGA-PE, ug/L	226
fDOM, RFU	227
fDOM, QSU	228
Wiper Position, V	229
External Power, V	230
BGA-PC, Raw	231
BGA-PE, Raw	232
fDOM, Raw	233
Chlorophyll, Raw	234
Potassium, mV †	235
Potassium, mg/L †	236
NLF Conductivity, mS/cm	237
NLF Conductivity, uS/cm	238
Wiper Peak Current, mA	239
Vertical Position, m	240
Vertical Position, ft	241

† **Note:** Potassium is considered future functionality, there is currently no EXO probe for Potassium (as of 2015).

2.14 Communication Adapters
Modbus

Delivering quality data where and when you need it most.

Introduction:

The 599825 is a communication adapter for the EXO multiparameter sonde platform. It converts the proprietary signal from the water quality sonde into a Modbus protocol over either RS-232 or RS-485 signals. The adapter simplifies integration into 3rd party SCADA systems, and also features a USB port that supports passthrough communication directly to the connected sonde. This feature allows configuration, calibration, and data transfer without having to disconnect the field cabling.

Adapter Overview:

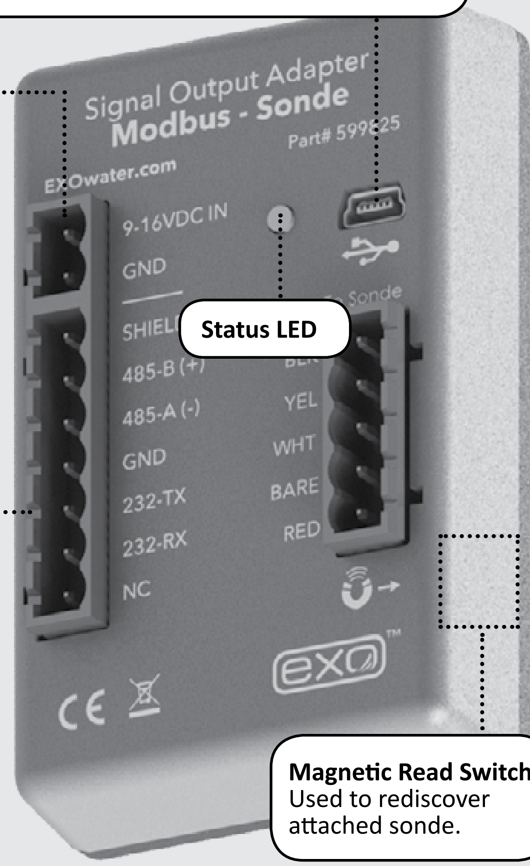
Mini USB Connector
Used to configure adapter settings, provide power to the adapter, and passthrough communication to the attached sonde.

Supply Power, 12VDC
Provided from external regulated power source (not included).

Modbus I/O Terminal
Use either 485 (default) or RS-232 terminals.

Status LED

Magnetic Read Switch
Used to rediscover attached sonde.



Safety:

Do not attempt electrical wiring beyond your skill level. Follow all applicable code and regulations subject to electrical wiring and operation of the system.

Specifications

Supply Voltage: 9 - 16 VDC or USB 5 VDC

Current Draw Adapter: ~20mA typical (@12VDC)

Current Draw Sonde: ~sleep 0.25mA reading and 100mA during operation

Max Net Current Draw for Systems: ~200mAmps (@12VDC)

Dimensions: L=3.5", W=3.5", H=1.5" (89cm x 89cm x 38cm)

Operating Temp: -40°C to +60°C

Storage Temp: -50°C to +80°C

Humidity: 0 to 99% non-condensing

What's Included:

The 599825 EXO Communication Adapter comes with:

- (1) Modbus Adapter
- (3) green wiring terminal blocks (Sonde 5-pin, Power 2-pin, Modbus 7-pin)
- (1) Panel mounting bracket
- (1) DIN rail mounting bracket
- (1) Hook and loop fastener

If any item is missing, please contact info@ysi.com for replacements.

You'll also need:

- Flat blade screwdriver for terminal blocks
- Phillip's screwdriver for panel mount bracket or din rail bracket
- EXO magnetic sensor tool (optional)
- EXO Flying Lead Field cable (599008-x) or Vented Flying Lead cable (599210-x)
- EXO sonde system, sensors, and associated hardware
- Latest KOR software (available from EXOwater.com)

Getting Started

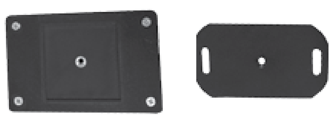
Mounting:

The adapter should be protected from the elements, and it is recommended it be mounted inside of a sealed enclosure with desiccant to prevent condensation.

The adapter includes a panel mount or a DIN rail mount in addition to self-adhesive hook and loop fastener. Any of the three methods can be used to securely mount the adapter. Use the provided Phillips screw to secure the panel or din rail mount:

Panel Mount

1:

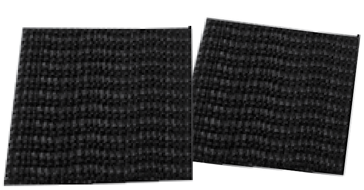


2:

Back Front

DIN Rail Mount

Self-Adhesive Hook and Loop Fastener



Note: If using self adhesive hook and loop, clean and dry both surfaces before applying.

Status LED Indications	
Off	No power
On	No Sonde connected
Flashing at 1 Hz	Sonde connected, everything normal
Flashing at 1/10 Hz	Low power sleep (Will flash on for 1 second when magnetic switch is activated.)

Configuration:

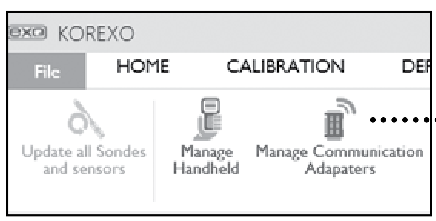
Note: You will need to use KorEXO 2.0 if you want to edit the default communication settings on the 599825 Modbus adapter.

⚠ For access to the beta software, or assistance changing the default settings, please contact Technical Support at info@ysi.com.

Default Settings	
Bus: RS-485	**Parity:** None
Mode: RTU	**Data Bits:** 8
Baud rate: 9600	**Stop Bit:** 1
Modbus Address: 1 (AKA slave address)	

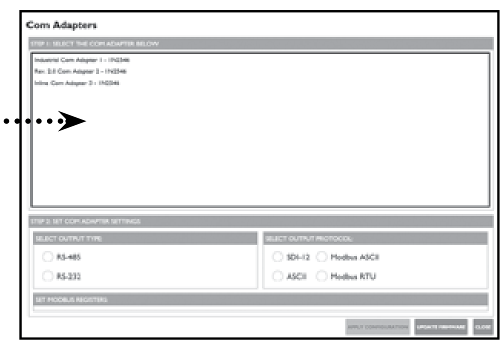
If your application requires RS-232, ASCII, or alternative addresses and baud rates please use the software to change the adapter settings:

Navigate to the **Instruments and Sensors** tab and select the "**Manage Communication Adapters**" button:

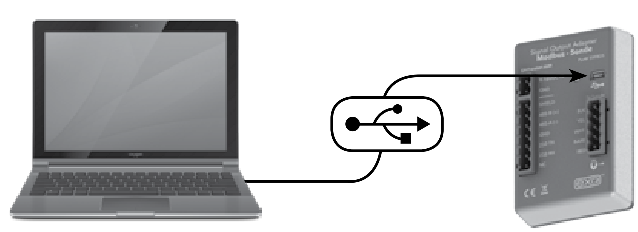


KorEXO Version 2.0.x

(**Note:** Software still in development, screen will change in final release.)



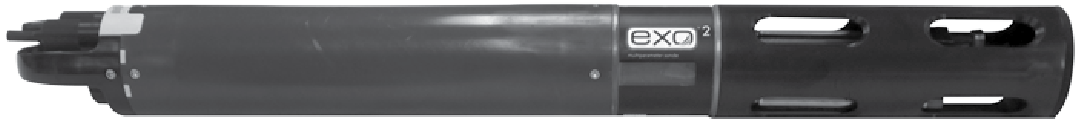
USB passthrough drivers will automatically be installed along with KOR 2.0 software, they are also available separately from the EXOwater.com website. Install these drivers on your PC to communicate with a signal output adapter (SOA) through any version of Desktop KOR:



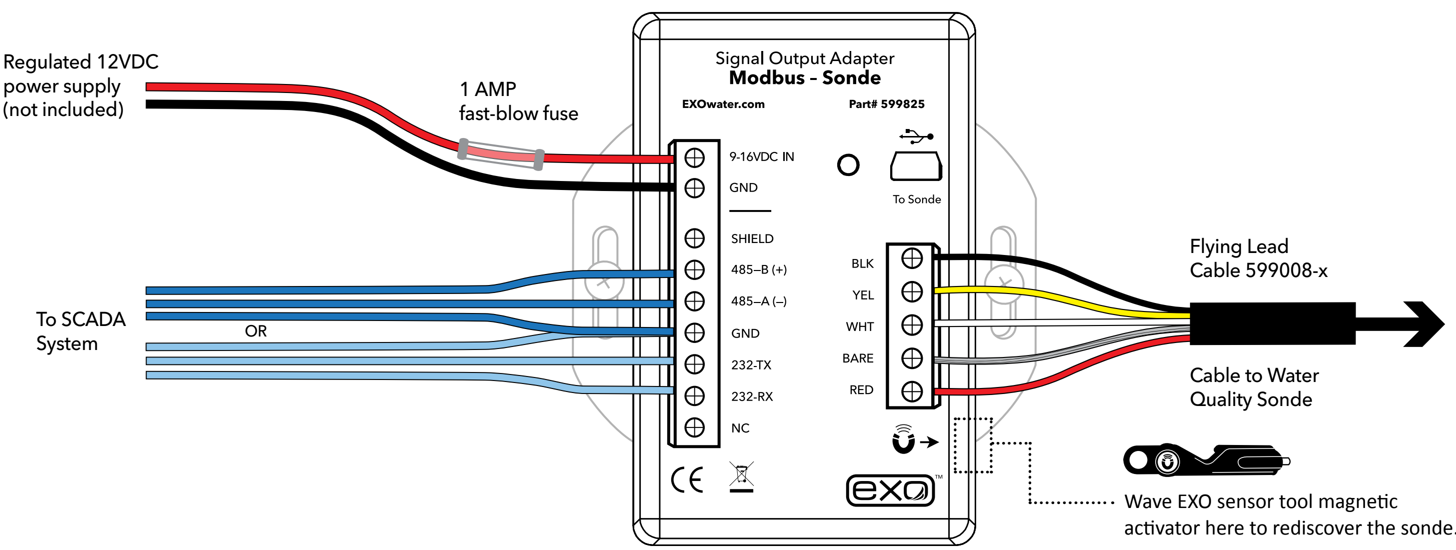
Wiring

Have the following ready:

- EXO Sonde
- Com Adapter
- Flying Lead Cable
- Flat blade screwdriver
- Power & SCADA Wires



Next wire the flying lead cable, power, and Modbus ports as labeled:



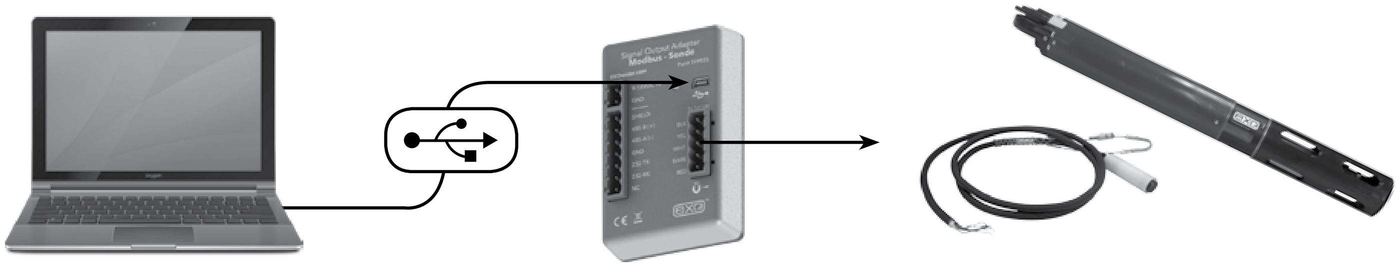
Note: The orange wire on the flying lead cable to the sonde will not be used. It can be taped back during installation.

Note: 3rd party RS-485 to TCP adapters may be used in conjunction with the EXO Modbus Adapter, however we are unable to provide specific support or configuration settings for these modules. The gridconnect "Net485" adapter has been successfully used in applications requiring TCP Modbus interface.

When connecting new sondes to the Modbus adapter, it may be necessary to redetect the sonde. This can be done by power cycling the adapter or by using the magnetic read switch at the lower right hand side of the enclosure. Waving the magnet in the EXO sensor tool, over the area referenced by the square above, will force a network redetect where all new sensors and configurations will be discovered.

USB Passthrough Mode

The 599825 Modbus Adapter can function in a similar fashion as the 599810 USB communication adapter. It will power the device and provide limited power to the sonde. After the Modbus adapter is wired as shown in the previous configuration, connecting to the USB port will allow direct communications with the sonde using KorEXO software.



Note: USB utilizes Communication Device Class (CDC) and installs as com port on PC: "YSI SOA/DCP Gen2".
The USB connection may also be used to update firmware on the adapter using KOR software.

General Modbus Information

- Register references are to the typical Holding Registers. Depending on your SCADA system these may be the 400,000 registers, the 40,000 registers, or simply the register values defined in this document. In this document the register value will generally be used. In all cases the register value will be +1 from the address value.
- The Output adapter makes use of the Modbus Holding register system to transfer data. It will respond to the Modbus commands "Read Holding Registers", "Write Single Register" and "Preset Multiple Registers". For all other commands the 599825 Modbus Adapter will return an illegal function exception. In general if you attempt to read or write from to a reserved or unused area, the 599825 Modbus adapter will return an illegal data access exception.
- The 599825 Modbus adapter is a slave device.
- The Modbus adapter maintains a current set of data in the holding registers. Use the "Read Holding Registers" command to obtain the most recent set of data from sonde connected to the 599825 Modbus adapter. Each parameter from the EXO water quality sonde is stored in a different register (or register pair). Also in different registers is status information from the 599825 Modbus adapter and the same command is used to read status. Values in still other registers control which parameters are enabled in the sonde. Programmers can enable and disable sonde parameters by writing to these registers using the "Preset Multiple Register" command.
- There are 3 main register areas to deal with the parameters:
  - Parameter type
  - Parameter status
  - IEEE floating point parameter data
    (Scaled integer parameter data, available but not recommended for use.)

Each of these areas is 32 registers long, except for the floating point data area which is 32 register pairs long. The first register (or register pair for the floating point data) in each area corresponds to the first parameter, the second corresponds to the second parameter, etc.

An example of a NEMA enclosure where PLC + Modbus adapter are wired.

General Modbus Information

40,000 Read Holding Address	40,000 Read Holding Register	Read/Write	Description
0	1	Read/Write Single Reg	**Sample Period:** The period in seconds at which the SOA will sample the sonde data and update holding registers (value between 0-3600)
1	2	Write Only Single Reg	**Force Sample:** Write any value here to force the SOA to update holding registers with sonde data allow 15 seconds for values to show up in data registers
2	3	Write Only Single Reg	**Force Wipe:** Write any value here to force the connected sonde to run its wiper
3-127	4-128	--	Unused – reserved for future special functions
128-159	129-160	Read/Write	**Parameter type:** The PLC must write to this area to tell the SOA what parameters it wants. Up to 32 parameters can be written here. After the last parameter the PLC must write a "0. The table on the "**Available Parameters Codes**" page lists the valid parameter type codes.
160-225	161-256	--	Reserved for future parameter type
256-287	257-288	Read Only	**Parameter status:** The PLC can read back the values in these registers to check the status of the parameters. The value in register 257 corresponds to the parameter type in register 129 and so on. The meaning of the returned value is: 0 – The parameter is available. 1 – The parameter type has not been set (i.e. type = 0) 2 – The parameter requested is not currently available.
288-383	289-384	--	Reserved for future parameter status
384-447	385-448	Read Only	**IEEE 754 Floating point parameter data:** This is the actual parameter data in floating point form. Two registers are used for each value to make up the 32 bits required for a 4 byte IEEE floating point number. The value in register pair 385:386 corresponds to the parameter type in register 129 and so on. It is highly recommended that this be used rather than the scaled integer format.
448-639	449-640	--	Reserved for future IEEE floating point parameter data
640-671	641-672	Read Only	**Scaled integer parameter data:** The PLC should only read data from the SOA using this method if it cannot handle floating point data. Most PLCs can manipulate floating point values, so you should try to avoid reading scaled integer values. The value in register 641 corresponds to the parameter type in register 129 and so on. The values are scaled according to a fixed table in the SOA. The scaled data is in an unsigned integer format. Each parameter type has a specific range and resolution. Refer to the scaled integer range table (page 8) for values for each parameter. For example, temperature °C has the range of –50 to 605.35, with a resolution of 0.01. Here are some integer values that could be returned along with their engineering equivalents: **0:** -50°C or less. **1:** -49.99°C **2:** -49.98°C **5000:** 0°C **7234:** 22.34°C **7500:** 25°C **65534:** 605.34°C **65535:** 605.35°C or higher
672-767	673-768	--	Reserved for future scaled integer parameter data
768+	769+	--	Unused

Common Acronyms: PCL Programmable Logic Controller
SCADA Supervisory Control and Data Acquisition

Registry Configuration

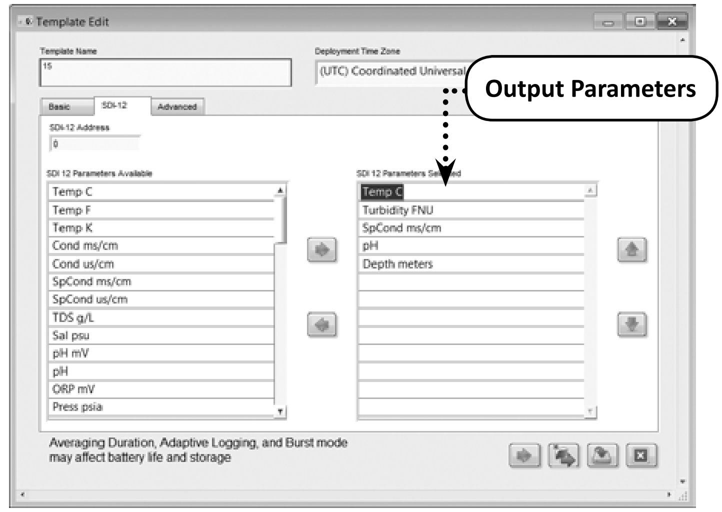
This section deals with mapping the water quality parameter types to the respective holding register 129-160. These are the measurement values generated by the water quality sonde. There are two methods to set the parameter map. The preferred method is to use the deployment templates available in any version of KorEXO. This standard functionality allows the parameters to be selected and saved. Alternatively the registers may be directly written by the SCADA system.

In the KorEXO software |**Deployment Settings**| choose the parameters and sort order, then push the template to the sonde. (Kor Version 1.0 shown on the top-right, and KorEXO version 2.0 shown above on the bottom-right.)

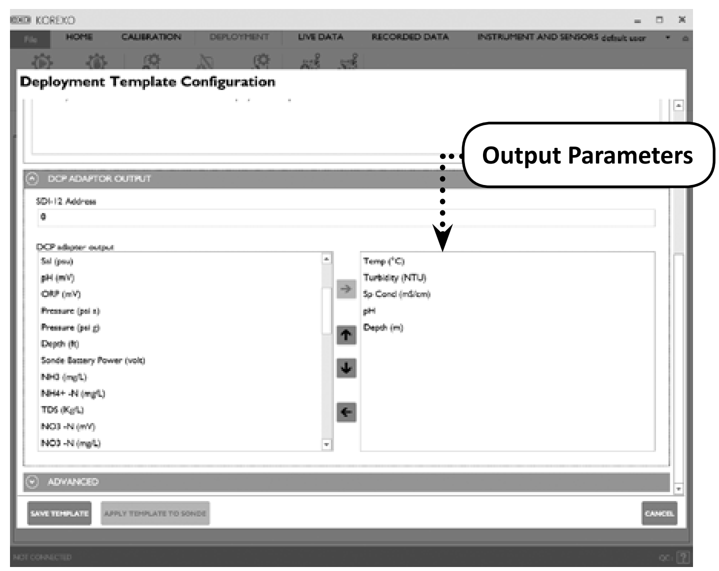
In both versions the complete list of parameters is shown in the left column and the selected parameters to output via the Modbus adapter are shown on the right. This template can be saved locally on the PC, but it must also be pushed down to the sonde for the settings to take effect. So be sure to apply the template to the sonde.

Note: There are two options when applying the template to the sonde, apply without logging or with logging. Either option may be used. When deploying with logging the sonde will create a redundant log file inside the sonde. Without logging, the data will only be available to the SCADA system.

In the example below: Temp °C, Turbidity, SpCond, pH, and Depth M were chosen. This will automatically create a register map as follows:



Kor Version 1.0



KorEXO Version 2.0.x

Read Holding Address	Read Holding Register	Read/Write	Value	Description
128	129	Read/Write	1	The parameter code for Temp °C is displayed here
129	130	Read/Write	223	The parameter code for Turbidity (FNU or NTU) is displayed here
130	131	Read/Write	6	The parameter code for Sp Cond ms/cm is displayed here
131	132	Read/Write	18	The parameter code for pH is displayed here
132	133	Read/Write	22	The parameter code for Depth M is displayed here
133	134	Read/Write	0	Zero indicates the end of the register/parameter map

These register maps are stored in the sonde, and automatically program the 599825 Modbus adapter when power cycled or the magnetic read switch is activated. The alternative method is to write these parameter codes using the SCADA system in the format indicated above.

Available Parameter Codes

The alternative setup method is to write these parameter codes using the SCADA system in the format indicated. The table below is the reference list of all available parameter codes for Read Holding Registers 129-160.

Parameter	Code
Temperature, °C	1
Temperature, °F	2
Temperature, °K	3
Conductivity, mS/cm	4
Conductivity, uS/cm	5
Specific Conductance, mS/cm	6
Specific Conductance, uS/cm	7
TDS, g/L	10
Salinity, PPT	12
pH, mV	17
pH	18
ORP, mV	19
Pressure, psia	20
Pressure, psig	21
Depth, m	22
Depth, ft	23
Battery, V	28
Turbidity, NTU	37
NH3 (Ammonia), mg/L	47
NH4 (Ammonium), mg/L	48

Parameter	Code
Date, DDMMYY	51
Date, MMDDYY	52
Date, YYMMDD,	53
Time, HHMMSS	54
TDS, kg/L	95
NO3 (Nitrate), mV	101
NO3 (Nitrate), mg/L	106
NH4 (Ammonium), mV	108
TDS, mg/L	110
Chloride, mg/L	112
Chloride, mV	145
TSS, mg/L	190
TSS, g/L	191
Chlorophyll, ug/L	193
Chlorophyll, RFU	194
ODO, %Sat	211
ODO, mg/L	212
ODO, %Sat Local	214
BGA-PC, RFU	216
BGA-PE, RFU	218

Parameter	Code
Turbidity, FNU	223
Turbidity, Raw	224
BGA-PC, ug/L	225
BGA-PE, ug/L	226
fDOM, RFU	227
fDOM, QSU	228
Wiper Position, V	229
External Power, V	230
BGA-PC, Raw	231
BGA-PE, Raw	232
fDOM, Raw	233
Chlorophyll, Raw	234
Potassium, mV †	235
Potassium, mg/L †	236
NLF Conductivity, mS/cm	237
NLF Conductivity, uS/cm	238
Wiper Peak Current, mA	239
Vertical Position, m	240
Vertical Position, ft	241

† **Note:** Potassium is considered future functionality, there is currently no EXO probe for Potassium (as of 2015).

The subsequent values for the parameter map are displayed in IEEE floating point parameter format (IEEE 754). The Parameter data is stored in read only address 385-448. Two address are used for each value to make up the 32 bits required for a 4 byte IEEE floating point number. The value in address pair 385:386 corresponds to the parameter type in register 129, etc.

In our example let's assume the following values: Temp 25.11°C, Turbidity 2.34 FNU, SpCond 3.02 ms/cm, pH 7.23, and Depth 1.45 M

Read Holding Address	Read Holding Register	Read/Write	Value (IEEE 754)	Description
384	385	Read	0xE147	The least significant 16 bits of the 32-bit floating point value for 25.11
385	386	Read	0x41C8	The most significant 16 bits of the 32-bit floating point value for 25.11
386	387	Read	0x47AE	The least significant 16 bits of the 32-bit floating point value for 3.02
387	388	Read	0x4041	The most significant 16 bits of the 32-bit floating point value for 3.02
388	389	Read	0x5C29	the least significant 16 bits of the 32-bit floating point value for 7.23
389	390	Read	0x40E7	The most significant 16 bits of the 32-bit floating point value for 7.23

Advanced Configuration

The 599825 Modbus adapter will automatically sleep after 60 seconds of not being queried. To prevent the adapter from sleeping, query the adapter more frequently than 60 seconds. Alternatively program a sample interval into register 1. This is the interval the 599825 Modbus adapter will refresh its readings from the underwater sonde. It can be advantageous to sample at a 10 or 15 minute interval to extend the life of the sensors.

As an example a 10 minute (600 second) sample value in register 1 will query the sonde every 10 minutes to refresh the values in 385-448 IEE floating point registers. It is recommended you program a sample interval into the 599825 Modbus adapter half that of your scan interval. As an example if your SCADA will query the adapter every 20 minutes (1200 seconds) then it is recommended you write a 10 minute (600 seconds) sample value in address 1. This methodology will ensure the queried data is never more than 10 minutes old.

Activating the wiper: The EXO2 system is likely equipped with an central wiper to clean the sensors. There are two different mechanisms to activate the wiper.

The first is to write any number into register #3, this will trigger the EXO sonde to wipe the sensors in both directions. 60 seconds should be allocated for the wiping to complete, and the data presented to the Modbus holding registers during the wiping sequence will not be representative of the water quality because of the effects of the wiper passing over the sensors. It may be helpful to program a routine wipe interval into the SCADA system as well as an operator button to manually trigger the wipe sequence.

The second method is to program the sonde to autonomously sample at an interval that is greater than every two minutes. By default the sonde will wipe all the sensors before taking a reading. So programming a 1 hour deployment in the KorEXO software the sonde with automatically wipe the sensors. Note the real time data presented over Modbus during the wiping sequence will not be representative of the water quality because of the effects of the wiper passing over the sensors. This methodology will generate a redundant set of data internal to the sonde to compliment the data presented to the SCADA system.

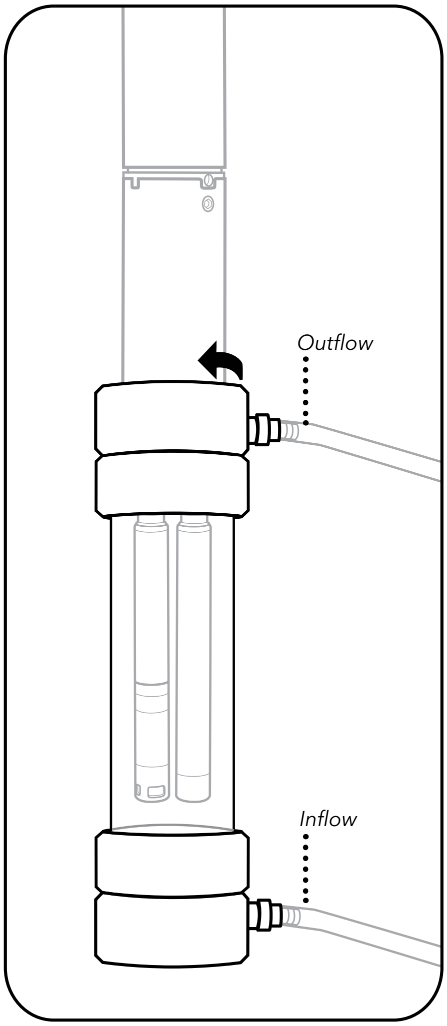
Scaled Integer Range Table

Parameter	Code	Scale Low	Scale High
Temperature, °C	1	-50	605.35
Temperature, °F	2	-50	605.35
Temperature, °K	3	0	655.35
Conductivity, mS/cm	4	0	655.35
Conductivity, uS/cm	5	0	65535
Specific Conductance, mS/cm	6	0	655.35
Specific Conductance, uS/cm	7	0	65535
TDS, g/L	10	0	65.535
Salinity, PPT	12	0	65.535
pH, mV	17	-1638.4	1638.35
pH	18	-27.768	39.767
ORP, mV	19	-1638.4	1638.35
Pressure, psia	20	-50	605.35
Pressure, psig	21	-50	605.35
Depth, m	22	-50	605.35
Depth, ft	23	-50	605.35
Battery, V	28	0	65.535
Turbidity, NTU	37	0	6553.5
NH3 (Ammonia), mg/L	47	0	655.35
NH4 (Ammonium), mg/L	48	0	655.35
Date, DDMMYY	51	N/A	N/A
Date, MMDDYY	52	N/A	N/A
Date, YYMMDD,	53	N/A	N/A
Time, HHMMSS	54	N/A	N/A
TDS, kg/L	95	0	65.535
NO3 (Nitrate), mV	101	-1638.4	1638.35
NO3 (Nitrate), mg/L	106	0	655.35
NH4 (Ammonium), mV	108	-1638.4	1638.35
TDS, mg/L	110	0	65535
Chloride, mg/L	112	0	655.35

Parameter	Code	Scale Low	Scale High
Chloride, mV	145	-1638.4	1638.35
TSS, mg/L	190	0	6553.5
TSS, g/L	191	0	6.5535
Chlorophyll, ug/L	193	0	655.35
Chlorophyll, RFU	194	0	655.35
ODO, %Sat	211	0	655.35
ODO, mg/L	212	0	65.535
ODO, %Sat Local	214	0	655.35
BGA-PC, RFU	216	0	655.35
BGA-PE, RFU	218	0	655.35
Turbidity, FNU	223	0	6553.5
Turbidity, Raw	224	0	655.35
BGA-PC, ug/L	225	0	655.35
BGA-PE, ug/L	226	0	655.35
fDOM, RFU	227	0	655.35
fDOM, QSU	228	0	655.35
Wiper Position, V	229	0	65.535
External Power, V	230	0	65.535
BGA-PC, Raw	231	0	655.35
BGA-PE, Raw	232	0	655.35
fDOM, Raw	233	0	655.35
Chlorophyll, Raw	234	0	655.35
Potassium, mV	235	-1638.4	1638.35
Potassium, mg/L	236	0	655.35
NLF Conductivity, mS/cm	237	0	655.35
NLF Conductivity, uS/cm	238	0	65535
Wiper Peak Current, mA	239	0	65.535
Vertical Position, m	240	-50	605.35
Vertical Position, ft	241	-50	605.35

2.15 Connect Sonde Flow Cell

There are two versions of the EXO flow cell: EXO1 flow cell (599080) and EXO2 flow cell (599201). Flow rate of the flow cell is typically between 100 mL and 1 L per minute. Maximum flow rate depends on tubing type, size, and length. Maximum pressure for each flow cell is 25 psi. Flow cell volumes (without sensors installed) are approximately 410 mL for EXO1, and 925 mL for EXO2.



1 Inspect sonde and flow cell

Remove the sonde guard or calibration cup from the sonde so that the sensors are exposed.

Make sure that the threads of the sonde and flow cell as well as all o-rings are clean and free of any particles such as sand, grit, or dirt.

2 Insert sonde into flow cell

Insert the sonde into the top of the flow cell. Be careful not to bump or scrape the sensors on the sides of the flow cell.

Screw the sonde into the flow cell by turning the sonde clockwise until it is hand-tightened into place; do not use a tool.

3 Connect tubing to flow cell

Install the Quick Connect tube fittings onto the flow cell by inserting them into the Quick Connect coupling body. They should snap into place.

Connect the tubing from your pump (not included) to the Quick Connect tube fittings, making sure that the tubing is pushed securely onto the fittings. The inflow should be at the bottom of the flow cell and the outflow should be at the top.

Keep flow cell vertical to purge it and ensure air release from Conductivity/Temperature sensor.

NOTICE: Do not turn on water to the system *until* the flow cell is securely connected.

2.16 Daisy Chaining Sonde Expansion

It is possible to daisy chain up to three EXO2 sondes using the built-in topside auxiliary port. Below is a quick start guide for setting up sondes for long-term deployment in this application.

NOTE: *These instructions are for the DCP-SOA 1.0. With the new 2.0 model, you no longer have to be this meticulous about the order in which you connect the instruments. Simply hook all the components together and then use the magnetic activation on the side of the DCP-SOA 2.0 to allow it to reset and rebuild the map.*

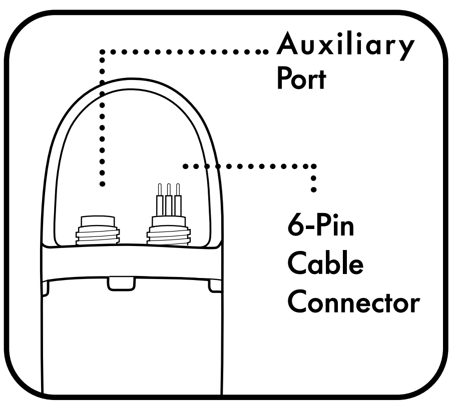
1 Set Deployment Times

Connect to each sonde individually via KOR. One by one, use the Deploy menu to Read Current Sonde Settings and make changes to the deployment templates. If using SDI-12 communications (recommended), set each sonde with a unique SDI-12 address.

2 Connect the Sondes

Remove power from the DCP adapter and remove all batteries from the instruments, then connect the 2-3 sondes in series using standard EXO field cables (connecting one sonde’s communications connector with another sonde’s topside auxiliary port).

NOTE: *Total cable length cannot exceed 300m, and the sondes themselves cannot exceed 250m depth.*



3 Connect Sondes to SOA-DCP

Using a flying lead cable, connect the topmost sonde to an EXO DCP Signal Output Adapter. Install batteries in the sonde furthest from the DCP adapter first. Then install batteries in the next sonde furthest from the adapter and then the sonde closest to the adapter if there are three sondes attached. Make sure the installed batteries are new and have around 6.0 volts supplied.

The final step is to apply power to the DCP adapter.

4 Test the System

Once the batteries have been installed and power has been supplied to the DCP adapter - use the SDI-12/RS232 commands in section 2.12 and 2.13, communicate with each daisy chained sonde to ensure data is collected.

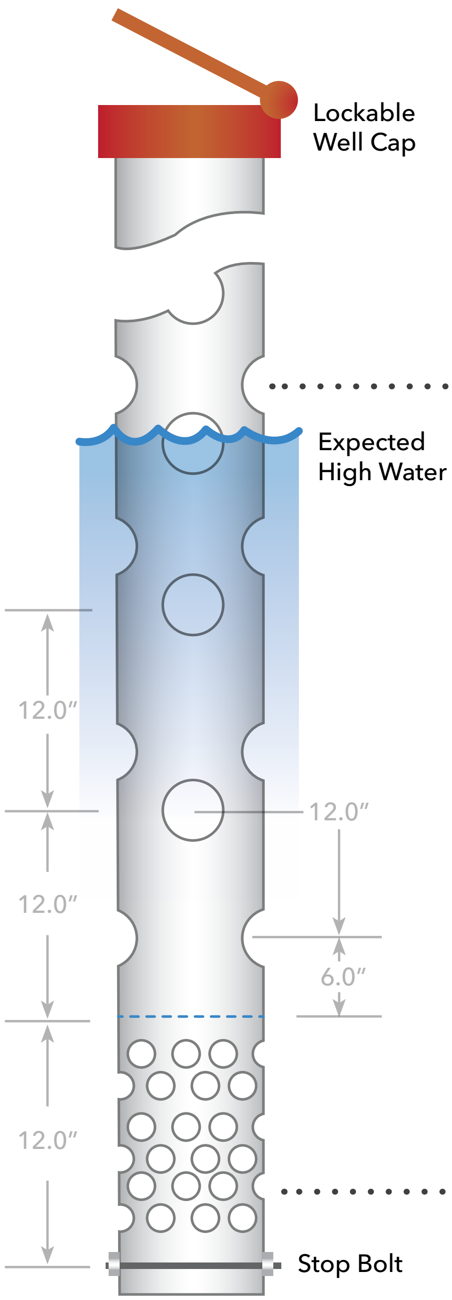
NOTE: *Deploy the daisy chained system with a support cable connected to the bail of each sonde. If any changes are made to the configuration of the setup, the DCP adapter will need to be power cycled so the changes will take effect.*

2.17 Sonde Clamping / Mooring
Long-Term Monitoring

In long-term monitoring applications, where the sonde will be left unattended for long periods of time, it is critical that you properly mount and protect your EXO sonde. This will ensure you receive quality data and that your instrument is not lost in a flood or other natural event. While there are many options available to you to secure your sonde for long-term monitoring, including mooring cages and protective housing, below you will find a general guide for the most common method - the deployment tube.

Vertical Deployment Tube

The most common configuration for a deployment tube, typically off a pier or other fixed location. Highly recommended for the highest quality data as it ensures a proper flow of water to the sensors, and avoids stagnation.



MATERIALS

- SCH 40 or SCH 80 - 4″ PVC Pipe
- 1/2″ SS Bolt, 6″ Long
- 1/2″ Flat Washers, Lock and Nut
- 4″ Lockable Well Cap, Plastic or Aluminum
- 5200 Marine Sealant (for bonding pipe to cap)

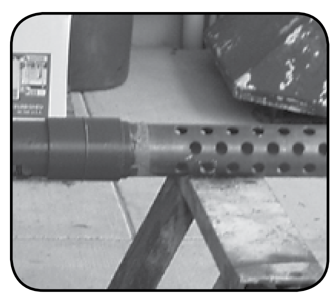
INSTRUCTIONS

Vent or tube flushing hole pattern:
2.5″ internal diameter.

Start one set 6″ from end or top of sensor holes.
Drill two holes at 0° and 180°.
Start second set of two holes at 12″ from sensor holes, drill at 90° and 270°.

Sensor area hole pattern:
1.0″ internal diameter, 1.5″ on center from 1.0″ above stop pin.


Mounted to Pier

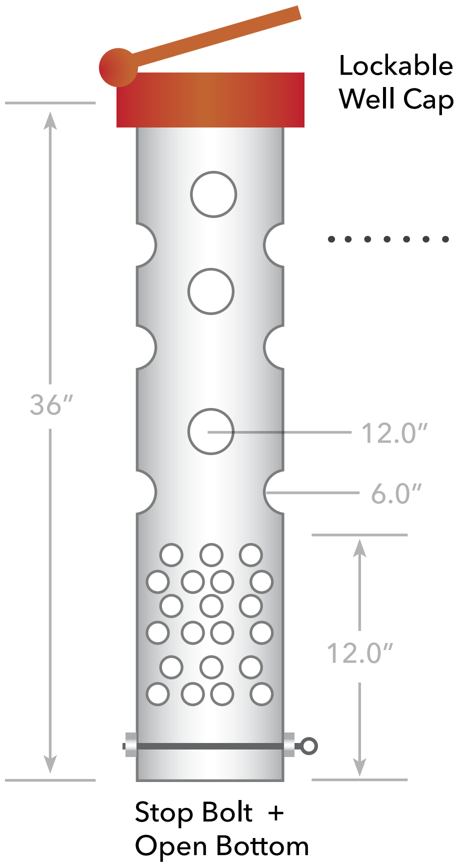

Copper Design

NOTES

- Clean and degrease pipe prior to modifications
- In marine and other fouling sites paint inside and out with anti-fouling paint
- Clean pipe at least twice a year

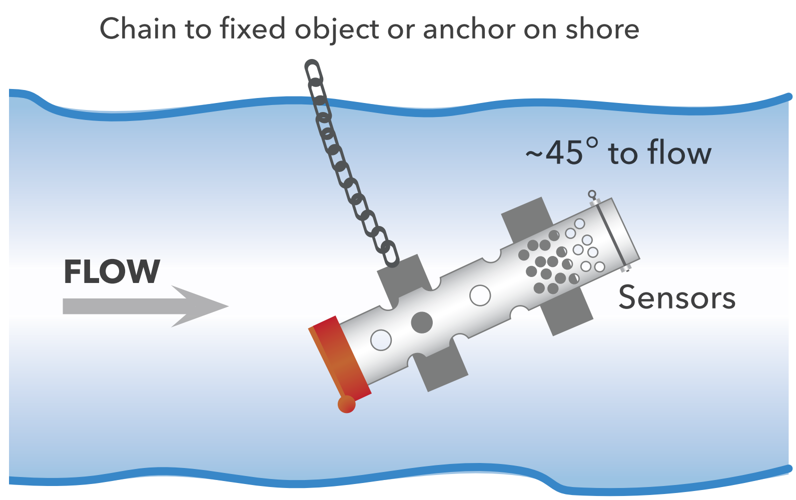
Horizontal Deployment Tube

In shallow water applications it is possible to deploy your EXO sonde horizontally. However, care must be taken that the sensors stay submerged and hydrated. This configuration has inherent risks such as sediment build up and is somewhat susceptible to flooding events even when properly fixed in place.



MATERIALS

- SCH 40 or SCH 80 - 4″ PVC Pipe, 36″ Long
- 1/2″ SS Bolt or Eye Bolt, 6″ Long
- 1/2″ Flat Washers, Lock and Nut
- 4″ Lockable Well Cap, Plastic or Aluminum
- 5200 Marine Sealant (for bonding pipe to cap)
- Two heavy weighted slabs to support pipe

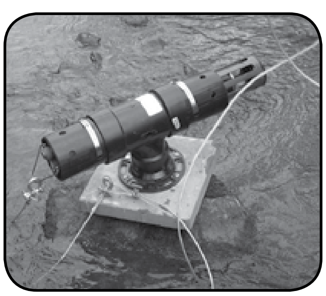


INSTRUCTIONS

<u>Vent or tube flushing hole pattern</u>:
2.5″ internal diameter.

Drill one set of two, starting 6″ from sensor holes at 0° and 180°. Drill second set of two 12″ holes upwards at 90° and 270°.

<u>Sensor area hole pattern</u>:
1.0″ internal diameter, 1.5″ on centers 12″ area from 1″ above stop bolt.



Shows exposed sensors.
No debris deployments only.

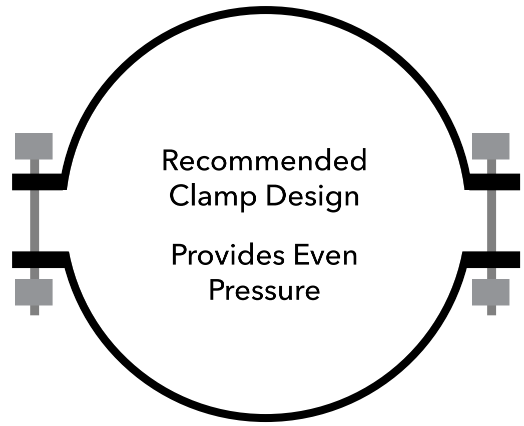
NOTES

- PVC pipe must be firmly secured to its base or mount to prevent loss in high flows
- Mount and pipe should be treated with anti-fouling paint if in fouling environment
- Secure submerged parts to shore with chain or SS wire rope to a fixed object
- Never clamp sonde directly to mount

Sonde Clamping Guide

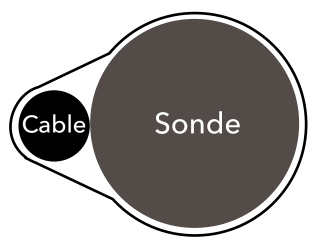
Great care should be taken when securing an EXO sonde to other objects. The preference is to deploy the sonde inside of a PVC pipe without clamps as described previously. However, if clamping is desired, the sonde should never be mounted directly to a mooring line, steel cable or piling as the presssure from a band clamp will defor the sonde and potentially cause leaks. **NOTICE:** Damage and leaks from improper clamping is not covered under warranty.

Preferred Clamping Areas

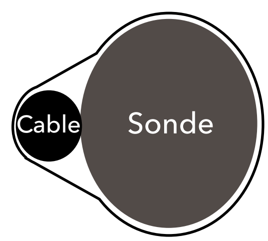


Incorrect Clamping

NOTICE: Under pressure from the band clamp, the sonde can become oblong, causing failure of the o-rings.



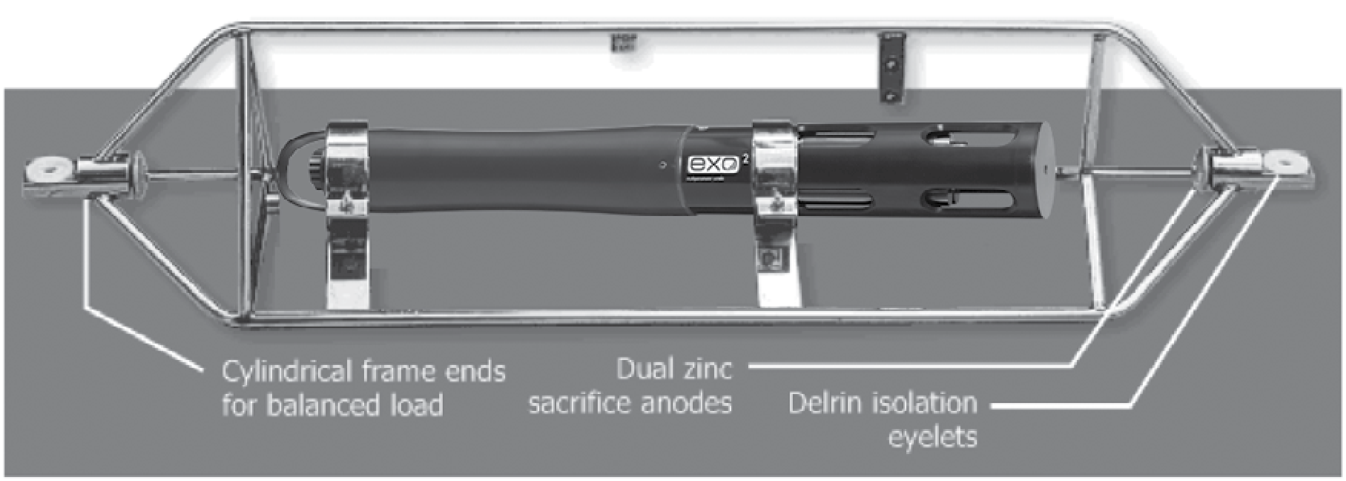
Band Clamp



Band Clamp
Under Pressure

Mooring Cages

Some users prefer to house their Sonde in a protective mooring cage for their application.



Section 3
KorEXO Software

3.1 KorEXO Software
Introduction

Users interface with the EXO sondes and handheld via KOR software. Once the software is installed and a device is connected to a computer or an EXO handheld, launch the KOR software. For KOR Installation instructions, see section 3.2.

There are currently two versions Kor Software for the EXO Platform:

KorEXO 1.0.x

KorEXO 1.0.x is the official release of KorEXO software. This is the version that comes with all Sondes currently.

To update to the most recent version of KorEXO software, please visit **EXOwater.com**

NOTE: *Firmware updates require all instrumentation (Handheld, sonde, sensors, and desktop software) be updated to function properly.*

KorEXO 2.0

KorEXO 2.0 is currently in beta testing and is scheduled for release in 2016. It will feature a variety of additions and increased functionality.

If you're using KorEXO 2.0 the software will prompt you to update automatically.

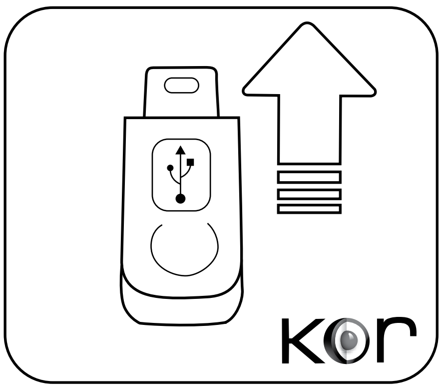
For access to the beta software please contact Technical Support at **info@ysi.com**.

After KorEXO 2.0 is officially released, training videos will be made available on YouTube. Stay tuned at: **YSI.com/KorEXO**

3.2 Install KorEXO 1.0.x Software

The desktop KOR software is supplied with all EXO sondes on a USB flash drive. Installing the software will require Administrative privileges on the local PC. It is important to install KOR software prior to using the USB Signal Adapter, as the required drivers for the adapter are installed along with KOR software.

NOTE: *A "lite" version of KOR software on the EXO handheld does not require any installation.*



1 Install KOR software and drivers

Insert USB drive and install software using the startup.exe file. Select all these items to install: EXO-KOR software, National Instruments supporting software, and USB drivers for the EXO USB adapter. When complete, KOR will reside in the root Program menu (not in a subfolder) with the following icon:

Additionally, a folder called National Instruments will be created; however this information will not be accessed through the course of normal operation.

Reboot the computer after installation of the software.

Minimum requirements:

Minimum requirements on a computer for KOR software:

- Windows®XP (service pack 3) or newer Windows operating platform (Windows®7 recommended)
- Microsoft .NET (any version from 2.0 through 3.5 Service Pack 1)*
- 500 MB of hard disk space (1 GB recommended)
- 2 GB of RAM (4 GB recommended)
- Screen with resolution of 1280x800 or greater
- Available USB 2.0 port
- Internet access for software updates
- Optional: Integral Bluetooth or USB dongle Bluetooth adapter

2 Software updates

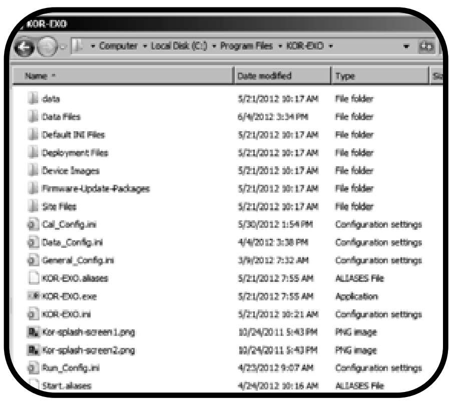
When they become available, updated versions of KOR software will be posted to EXOwater.com. Users will need to register a free account to access the software download.

**Download and install a Microsoft executable file that helps your computer run applications developed using the .NET framework: www.microsoft.com/download. Search for "dotnetfx.exe".*

3.3 KorEXO 1.0.x Software
Data Files and File Locations

KOR software is installed onto your computer's default hard drive, which is typically C:\ on most Windows-based PCs. The KOR program is then placed into the program file directory. On XP and Windows 7 (and newer) 32-bit systems, this folder is simply called Program Files. On 64-bit systems KOR is placed in the Program File (x86) folder. The two most common file paths are:

C:\Program Files\KOR-EXO\ *(XP and 32-bit Windows 7)*
C:\Program Files (x86)\KOR-EXO\ *(64-bit Windows 7)*



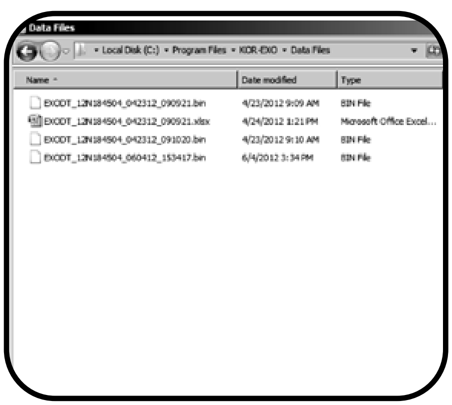
Data folders

Data Files: These are the binary data files from EXO, which are only accessible via KOR. We strongly recommend you maintain all binary data files in this folder and also create a back-up copy.

Deployment Files: Templates for deployments are stored here. They may be moved to another computer to provide consistent deployments across your organization.

Site Files: These contain the site details used by KOR; *future functionality, not active yet.*

NOTICE: Do not edit, move, or rename other files. This could damage KOR and affect system reliability.



Data files

Binary data files and data files are in the KOR-EXO | Data Files folder. You can navigate to the KOR-EXO folder to access template and data files, if you want to copy them to another computer.

Data file names

Data files are given unique names to ensure no duplication. The file name structure is:

AAAAAAAA_YYMBBBBBB_MMDDYY_HHMMSS.bin

Sample: EXODT_12N768062_033012_182618.bin

AAAAAAAA: User-defined file prefix up to 8 characters, set in the deployment template or Run | Settings menu.

YYMBBBBBB: EXO sonde serial number. YY represents the year the sonde was manufactured, M corresponds to the month of manufacture, and BBBBBB is a unique sequential number. For live data capture files, the serial number is a number assigned to the instance of Desktop KOR or the serial number of the Handheld.

MMDDYY: MM is the month the data file was created, DD is the day of the month, and YY is the year.

HHMMSS: UTC time stamp where HH is the hour the file was created in 24-hour format, MM the minute, and SS the second.

.bin: binary file extension.

3.4 Update Firmware and Software
Sonde and Sensors

Users can check and update sensor or sonde firmware through the KOR interface software. This process may take up to 30 minutes depending on the number of sensors that will be updated.

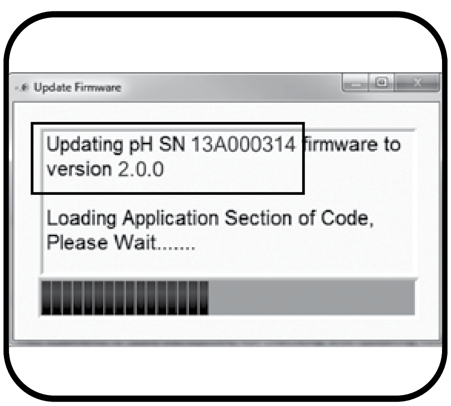
NOTE: *For best power management, update firmware while a device is connected via USB, as this will provide power to the device. However, if you use Bluetooth, we recommend installing fully charged batteries in the sonde.*

1 Connect to sonde

Each device must be connected to a computer running the Desktop version of KOR, and the computer must have internet access.

2 Open firmware submenu in KOR

Navigate to the Options menu in KOR, then to the Firmware submenu. Immediately after clicking the Firmware submenu button, KOR begins to search for connected sondes and sensors and loads the table with names, serial numbers, and current firmware versions.



3 Update sonde and sensor network

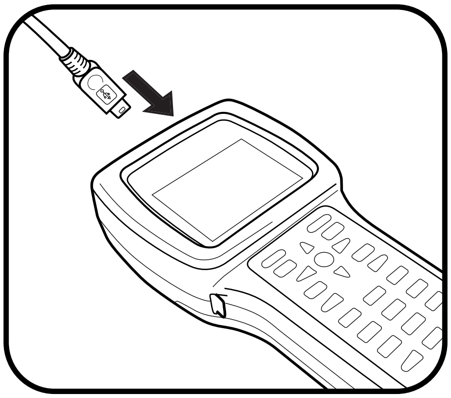
Click the update network button.

KOR then updates the device's firmware, which could take several minutes. If you experience problems with automatically downloading the latest firmware, please contact technical support at info@ysi.com.

NOTE: *Firmware updates require all instrumentation (Handheld, sonde, sensors, and desktop software) be updated to function properly.*

3.5 Update Firmware and Software
Classic Handheld

To update the instrument firmware and KOR software on the EXO Handheld, use the Desktop version of KOR on a computer with internet access. KOR Desktop will go online and pull updated files for the Handheld, which are then transferred to the Handheld.



1 Connect handheld to computer

Plug the small end of the USB cable into the port on the top side of the EXO Handheld. Plug the other end of the USB cable into a port on your computer. Wait for Windows to recognize the Handheld as a removable drive before the Handheld shows up in KOR software. This may take several minutes.

NOTE: *A text box will appear on the handheld once you have successfully connected to your PC. This is not an error warning, and will disappear once you disconnect the handheld from your PC.*

2 Update handheld

When the Handheld is connected to the PC, go to the Options | Firmware menu in KOR Desktop software. Select the Update Handheld button from the bottom-right corner of the menu.

Handheld information will be displayed in this box when successfully connected. Follow the prompts for completing the update process and rebooting the Handheld.

NOTE: *Firmware updates require all instrumentation (Handheld, sonde, sensors, and desktop software) be updated to function properly.*

Section 4
Sensors and Calibration

4.1 Sensors Overview

The EXO product line includes nine sensors that detect a variety of physical, chemical, and biological properties of natural water. EXO sensors are designed to collect highly accurate data under ever-changing environmental conditions.

Data Filtering

All EXO sensors share some common embedded software, including the filtering of real-time data. Sensors acquire environmental data at a constant rate, and use this stream of data as the input to the filtering algorithm that produces results seen by the user. EXO sondes collect data from the EXO sensors and are able to output data at rates up to 4 Hz. The EXO sensor data filtering process consists of four components (none of which is user selectable):

Basic Rolling Filter

The filter is fundamentally a rolling or window average of past acquired inputs to the filter, such that as a new data value is added to the summation, the oldest data value is removed, and the total summation is divided by the total number of data values. It is a simple average, just rolling or moving in time. Starting with the February 2014 software release, different rolling time windows for the filter are now supported.

Data Filtering Modes

Data filtering options are included in the handheld and desktop version of KOR. These settings can be modified within the Sonde Options menu (Options>Sonde) as well as within the deployment template settings. ***NOTE: Making any changes to data filtering options will stop a deployment.*** As a sonde takes measurements, it compares new readings to those taken in the previous 2-30 seconds (depending on the selected option). If the new reading is not significantly different than past measurements, then it merely factors into the rolling average with older data points to create a smooth curve. If the new reading is significantly different than past measurements, then it restarts the rolling average of data points.

Averaging options

Default – This mode provides optimum data filtering for all sensors. Provides the highest accuracy, automatic averaging during unattended monitoring or fixed mooring. This mode has up to 40 seconds of filtering on the sensors.
NOTE: This is the mode all sensors ship in and how sensors filtered data prior to this update.

Accelerated* – This mode should be used for spot sampling and slow (or paused) depth profiles. The sensors are averaging 5-10 seconds of data in a rolling window, unless there are any outliers.

Rapid* – This mode should be used where the sonde is moving quickly through the water, such as with rapid profiling and unique applications like auvs, gliders, or towed applications. The data will be noisy and will never settle on a single steady number. This mode has 2-3 second filtering on the sensors.

*TIP: Enable the Vertical Position parameter in the Depth unit options to view the real-time position of the sonde in the water column. This is helpful in profiling applications to ensure the sonde is lowered to the desired depth without waiting for the Depth data to stabilize.

Confirm averaging settings

To quickly check a sonde's data filtering options, examine the summary information at the top of either the desktop or handheld versions of KOR. On the desktop software, the word Default, Accelerated, or Rapid will be adjacent to the sonde's serial number. Similarly, on the handheld, the letter D, A, or R will be listed at the top right of the screen.

Adaptive Filtering

The drawback to a basic rolling filter is that response time to an impulse event is delayed, and the more entries in the average summation, the longer the delay for the result to converge on the true value. To correct this, the filter algorithm monitors the new data arriving and compares it to the current averaged result, looking for indication of an impulse event. When new data deviates from the average by more than a predetermined tolerance, the number of data entries within the rolling average is reduced to a minimum count and the remaining values are flushed with the new data. The result is a snap to the new value, entirely eliminating the inherent delay caused by the rolling average.

Outlier Rejection

Every time a newly acquired data value is added, the rolling average entries are scanned for outlier data. Although such data has already been determined to fall within the tolerances defined above, the remaining worst offenders are removed from the rolling average calculation. This outlier rejection allows for smoother continuous data results.

Calibration Stability

During calibration, the filtering is active as described, plus an additional feature works to provide stability feedback to the user. When the user attempts to calibrate a sensor, the sudden changes in environment are perceived as impulses or plunge events and the filtering reacts accordingly. The results immediately show the value of the solution, and after a few moments, the filter incrementally engages fully and supplies the smoothest data. However, as the sensor and the calibration solution work towards equilibrium, the measurement may slowly drift. The sensor will monitor the results from the filter and determine if the measurement is stable. It watches the results and calculates a slope from each and every result to the next. Once the slope settles and is consistently flat for approximately 30 seconds, the sensor is considered stable. KOR is then notified and calibration can continue.

Sensor Response Times

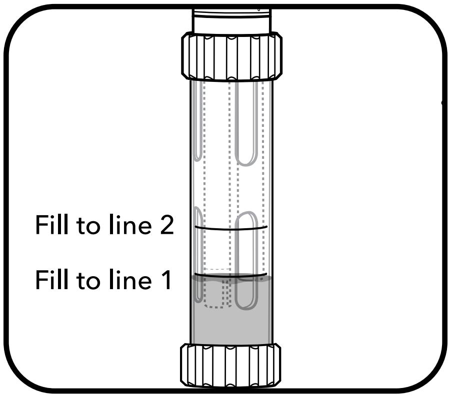
Response times for EXO sensors are based on laboratory testing. This testing, though stringent, cannot mimic the actual response times in the field due to the wide variety of use cases. To characterize an EXO sensor's response time, a step change in the sensor's primary output parameter is applied, and the time to reach 63% of the final stimulus value is recorded. Repeated characterization of multiple sensors provides the T63 specification.

Sensor Accuracy Specifications

To maintain accuracy specifications for EXO sensor, we recommend that users calibrate sensors in the lab in standards with temperatures as close to the ambient temperature of the field water as possible.

4.2 Calibration
Basic

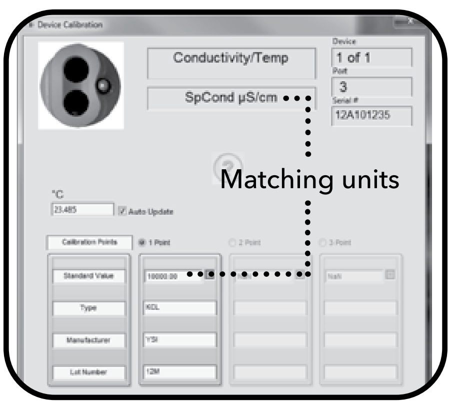
NOTE: *All EXO sensors should be user calibrated before initial use.*
EXO sensors (except temperature) require periodic calibration to assure high performance.
Calibration procedures follow the same basic steps with slight variations for particular parameters.
Conduct calibrations in a temperature-controlled lab.



Calibration set-up

For accurate results, thoroughly rinse the EXO calibration cup with water, and then rinse with a small amount of the calibration standard for the sensor you are going to calibrate. Two to three rinses are recommended. Discard the rinse standard, then refill the calibration cup with fresh calibration standard. Fill the cup to approximately the first line with a full sensor payload or the second line with small sensor payload. Volumes will vary, just make certain that the sensor is submerged. Be careful to avoid cross-contamination with other standards.

Begin with a clean, dry probe installed on the EXO sonde. Install the clean calibration guard over the probe(s), and then immerse the probe(s) in the standard and tighten the calibration cup onto the EXO sonde. We recommend using one sonde guard for calibration procedures only, and another sonde guard for field deployments. This ensures a greater degree of cleanliness and accuracy for the guard used in the calibration procedure.



Basic calibration in KOR software

Go to the Calibrate menu in KOR software. This menu's appearance will vary depending on the sensors installed in the sonde. Select the sensor you are going to calibrate from the list. Next select the parameter for the sensor you are going to calibrate. Some sensors have only one parameter option, while other sensors have multiple options.

In the next menu, select a 1-, 2-, or 3-point calibration, depending on your sensor. Enter the value of the standard you are using. Check that the value you enter is correct and its units match the units at the top of the menu (e.g., microSiemens versus milliSiemens). You may also enter optional information for type of standard, manufacturer of standard, and lot number.

Click the Start Calibration button. This action initiates the probe's calibration in the standard; initially the data reported will be unstable and then they will move to stable readings. Click the Graph Data button to compare the pre-cal and post-cal values in graph form. Users should confirm that the value is within their acceptable margin of error. Once readings are stable, click Apply to accept this calibration point. Repeat the process for each calibration point. **Click Complete when all points have been calibrated.**

A calibration summary appears with a QC score. View, export, and/or print the calibration worksheet. If a calibration error appears, repeat the calibration procedure.

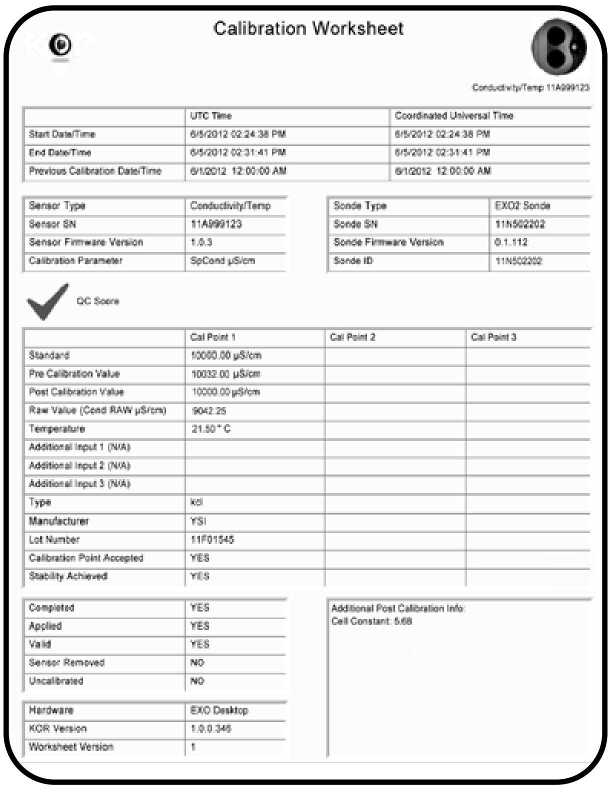
4.3 Calibration
Calibration Worksheet

The Calibration Worksheet is a record of the calibration for an EXO sensor. The worksheet contains quality assurance information including date and time of calibration, date of previous calibration, sensor firmware version, type of calibration performed, standard used, and QC score.

Calibration Worksheets are saved in the Calibration Files folder on the computer or the EXO Handheld that was used during calibration (not on the sonde or the sensors). All saved Worksheets can be accessed and viewed through the Data menu in KOR software.

Sample Worksheets:

1-point calibration of specific conductance on EXO conductivity/temperature probe



Calibration Worksheet

Conductivity/Temp 11A999123

	UTC Time	Coordinated Universal Time
Start Date/Time	6/5/2012 02:24:38 PM	6/5/2012 02:24:38 PM
End Date/Time	6/5/2012 02:31:41 PM	6/5/2012 02:31:41 PM
Previous Calibration Date/Time	6/1/2012 12:00:00 AM	6/1/2012 12:00:00 AM

Sensor Type	Conductivity/Temp	Sonde Type	EXO2 Sonde
Sensor SN	11A999123	Sonde SN	11N502202
Sensor Firmware Version	1.0.3	Sonde Firmware Version	0.1.112
Calibration Parameter	SpCond µS/cm	Sonde ID	11N502202

QC Score

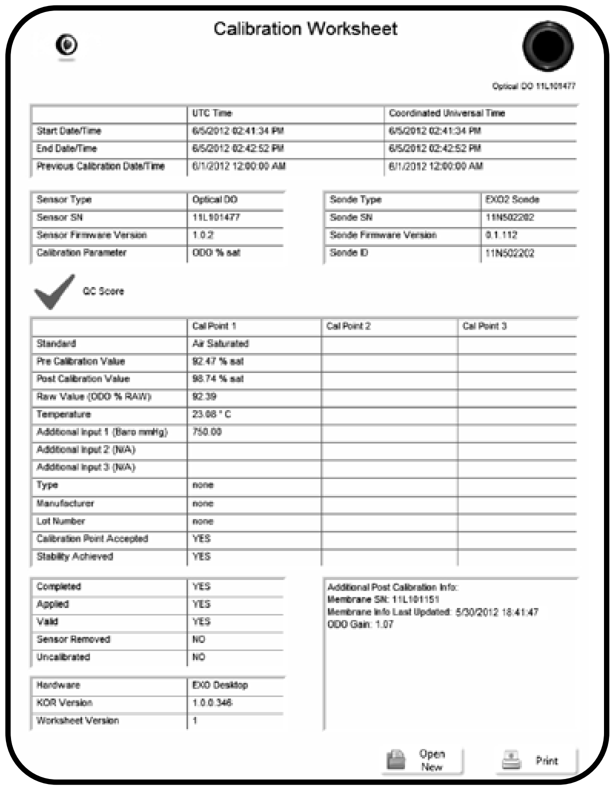
	Cal Point 1	Cal Point 2	Cal Point 3
Standard	10000.00 µS/cm		
Pre Calibration Value	10032.00 µS/cm		
Post Calibration Value	10000.00 µS/cm		
Raw Value (Cond RAW µS/cm)	9042.25		
Temperature	21.50 ° C		
Additional Input 1 (N/A)			
Additional Input 2 (N/A)			
Additional Input 3 (N/A)			
Type	kcl		
Manufacturer	YSI		
Lot Number	11F01545		
Calibration Point Accepted	YES		
Stability Achieved	YES		

Completed	YES
Applied	YES
Valid	YES
Sensor Removed	NO
Uncalibrated	NO

Hardware	EXO Desktop
KOR Version	1.0.0.346
Worksheet Version	1

Additional Post Calibration Info:
Cell Constant: 5.68

1-point calibration of percent saturation on EXO optical dissolved oxygen probe



Calibration Worksheet

Optical DO 11L101477

	UTC Time	Coordinated Universal Time
Start Date/Time	6/5/2012 02:41:34 PM	6/5/2012 02:41:34 PM
End Date/Time	6/5/2012 02:42:52 PM	6/5/2012 02:42:52 PM
Previous Calibration Date/Time	6/1/2012 12:00:00 AM	6/1/2012 12:00:00 AM

Sensor Type	Optical DO	Sonde Type	EXO2 Sonde
Sensor SN	11L101477	Sonde SN	11N502202
Sensor Firmware Version	1.0.2	Sonde Firmware Version	0.1.112
Calibration Parameter	ODO % sat	Sonde ID	11N502202

QC Score

	Cal Point 1	Cal Point 2	Cal Point 3
Standard	Air Saturated		
Pre Calibration Value	92.47 % sat		
Post Calibration Value	98.74 % sat		
Raw Value (ODO % RAW)	92.39		
Temperature	23.08 ° C		
Additional Input 1 (Baro mmHg)	750.00		
Additional Input 2 (N/A)			
Additional Input 3 (N/A)			
Type	none		
Manufacturer	none		
Lot Number	none		
Calibration Point Accepted	YES		
Stability Achieved	YES		

Completed	YES
Applied	YES
Valid	YES
Sensor Removed	NO
Uncalibrated	NO

Hardware	EXO Desktop
KOR Version	1.0.0.346
Worksheet Version	1

Additional Post Calibration Info:
Membrane SN: 11L101151
Membrane Info Last Updated: 5/30/2012 18:41:47
ODO Gain: 1.07

Open New

Print

Additional Post-Calibration Info

ODO Gain: The ODO gain is a diagnostic value recorded on the Calibration Worksheet and used for advanced diagnostic purposes. The nominal value is 1, and accurate calibrations of the DO sensor will only slightly deviate from this number.

Cell Constant: The cell constant is the current value of the conductivity and is a function of the factory original cell constant and the most recent user calibration. The cell constant will drift over time based on the sensor's electrodes, and the cell constant can be used to track drift.

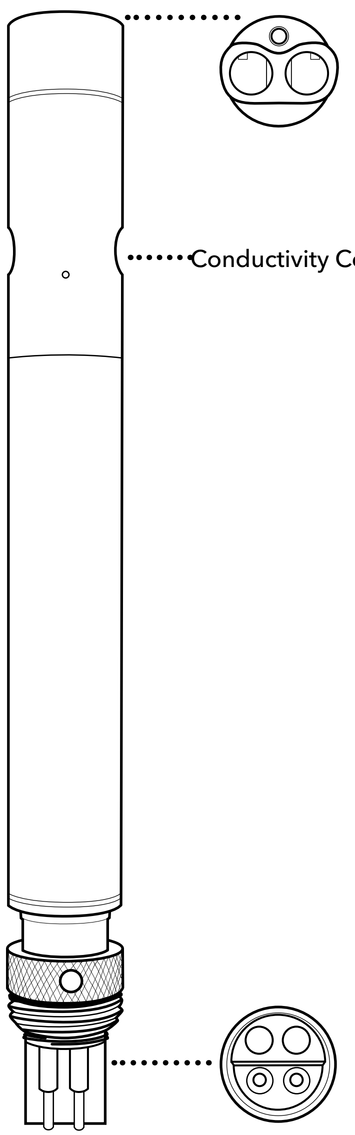
Slope: The slope for the pH sensor is the mV per decade (pH unit) where 59 is the typical value. Slope allows the user to track drift away from 59 to determine the life/aging of the sensor module.

Change mV: The change millivolts is the delta mV change between either 4 and 7 or 7 and 10 calibration values for the pH sensor. It is the mV deviation away from the middle calibration point number.

4.4 Conductivity/Temperature Sensor Overview

The EXO combination conductivity and temperature sensor should be installed in a sonde in nearly all sonde applications. Not only will this sensor provide the most accurate and fastest response temperature data, but it will also provide the best data for the use in temperature compensation for the other EXO probes. The conductivity data is used to calculate salinity, non-linear function (nLF) conductivity, specific conductance, and total dissolved solids, and compensate for changes in density of water (as a function of temperature and salinity) in depth calculations if a depth sensor is installed.

(continued)



599870-01

Specifications

Conductivity

Default Units	microSiemens/centimeter
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 200 mS/cm
Accuracy	0-100 mS/cm: ±0.5% of reading or 0.001 mS/cm, whichever is greater; 100-200 mS/cm: ±1% of reading
Response	T63<2 sec
Resolution	0.0001 to 0.01 mS/cm range-dependent
Sensor Type	4-electrode nickel cell

Temperature

Default Units	°Celsius
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Accuracy	-5 to 35°C: ±0.01°C 35 to 50°C: ±0.05°C
Response	T63<1 sec
Resolution	0.001°C
Sensor Type	Thermistor

Temperature Thermistor

The temperature sensor uses a highly stable and aged thermistor with extremely low-drift characteristics. The thermistor's resistance changes with temperature. The measured resistance is then converted to temperature using an algorithm. The temperature sensor receives a multi-point NIST traceable wet calibration and the accuracy specification of 0.01˚C is valid for expected life of the probe. No calibration or maintenance of the temperature sensor is required, but accuracy checks can be conducted.

Conductivity Electrodes

The conductivity sensor uses four internal, pure-nickel electrodes to measure solution conductance. Two of the electrodes are current driven, and two are used to measure the voltage drop. The measured voltage drop is then converted into a conductance value in milliSiemens (millimhos). To convert this value to a conductivity value in milliSiemens per cm (mS/cm), the conductance is multiplied by the cell constant that has units of reciprocal cm (cm-1). The cell constant for the conductivity cell is approximately 5.5/cm ±10%. For most applications, the cell constant is automatically determined (or confirmed) with each deployment of the system when the calibration procedure is followed.

Temperature Compensation

EXO sensors have internal thermistors for quality assurance purposes. Turbidity uses the internal thermistor for temperature compensation, while all other EXO sensors reference the C/T probe for temperature compensation. To display and log temperature, a C/T probe must be installed in an EXO sonde. Thermistor readings are logged in the sonde's raw data–viewable in KOR software–but are not included in data exported to Excel.

Conductivity = This is a measurement of water conductance from the drive and sense electrodes on the conductivity electrode. The output is in mS/cm or µS/cm. Note that the conductivity of solutions of ionic species is highly dependent on temperature, and the conductivity output is NOT compensated for temperature.

Specific Conductivity = When Specific Conductance is selected, the sonde uses the temperature and raw conductivity values associated with each determination to generate a specific conductance value compensated to 25°C by default. Both the Temperature Coefficient and reference temperature can be adjusted in the advanced sensor menu under calibration.

nLF Conductivity = The non-linear function (nLF) is defined by the ISO 7888 standard and is applicable for the temperature compensation of electrolytic conductivity of natural waters. This convention is typically used in German markets.

Salinity = Salinity is determined automatically from the sonde conductivity and temperature readings according to algorithms found in Standard Methods for the Examination of Water and Wastewater (ed. 1989). The use of the Practical Salinity Scale results in values that are unitless, since the measurements are carried out in reference to the conductivity of standard seawater at 15 °C.

4.5 Conductivity / Temperature Calibration

Clean the conductivity cell with the supplied soft brush before calibrating *(see section 5.9).*
Also, review the basic calibration description in section 4.2.

This procedure calibrates conductivity, non-linear function (nLF) conductivity, specific conductance, salinity, and total dissolved solids.

A variety of standards are available based on the salinity of your environment. Select the appropriate calibration standard for your deployment environment; we recommend using standards greater than 1 mS/cm (1000 µS/cm) for greatest stability.

Pour conductivity standard into a clean and dry or pre-rinsed EXO calibration cup. YSI recommends filling the calibration cup up to the second marked line to ensure the standard is above the vent holes on the conductivity sensor. Immerse the probe end of the sonde into the solution, gently rotate and/or move the sonde up and down to remove any bubbles from the conductivity cell.

Allow at least one minute for temperature equilibration before proceeding.

In the Calibrate menu, select Conductivity and then a second menu will offer the options of calibrating conductivity, nLF conductivity, specific conductance, or salinity. Calibrating any one option automatically calibrates the other parameters. After selecting the option of choice (specific conductance is normally recommended), enter the value of the standard used during calibration. Be certain that the units are correct and match the units displayed in the second window at the top of the menu.

Click Start Calibration. Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

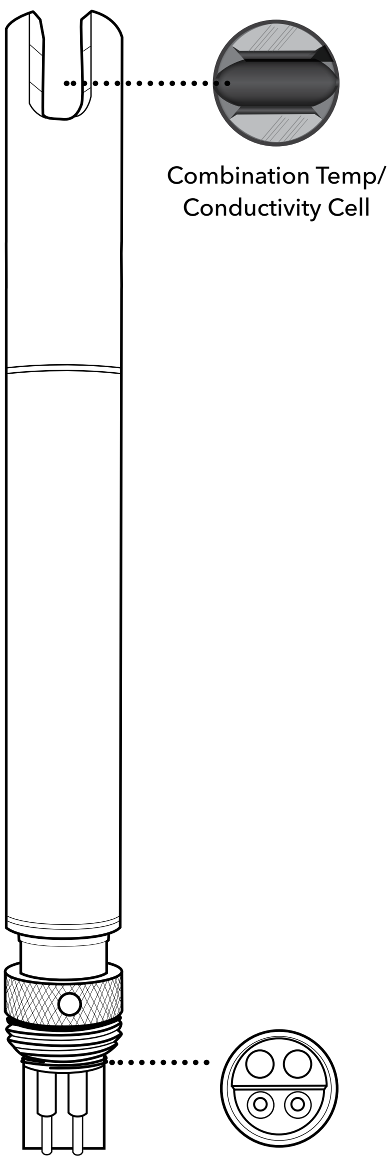
- If the data do not stabilize after 40 seconds, gently rotate the sonde or remove/reinstall the cal cup to make sure there are no air bubbles in the conductivity cell.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

Rinse the sonde and sensor(s) in tap or purified water and dry.

4.6 Wiped Conductivity / Temperature Sensor Overview

Biofilms, barnacles, and algal growth are common culprits of poor data quality, clogging up conductivity cells and coating sensor optics. While EXO2's Central Wiper can mechanically remove biofouling from other sensors to maintain data integrity over long deployment periods, in particularly high fouling environments the EXO Wiped C/T sensor provides improved representativeness of your conductivity data by avoiding stagnant readings and reducing the impact of micro-environments.



599827

EXO Wiped C/T Considerations

Sensor performance and specifications are well suited for continuous monitoring applications, where the EXO sonde is installed at a fixed location. For sampling and vertical profiling applications the legacy (599870) Conductivity Temperature probe which has a much faster temperature response should be used.

The Wiped C/T will have a different cell constant than the legacy Conductivity probes. A nominal cell constant of 0.469 +/-0.05 is typical on wiped conductivity.

ANNUAL MAINTENANCE SPECIAL

The EXO2 central wiper (599090) must have the wiper shaft seal serviced in the past 2 years prior to use with your new wiped C/T probe. The wiper will work harder grooming the new sensor, therefore if your wiper hasn't had the shaft seal properly maintained there is a chance it could stall mid deployment. As a matter of preventative maintenance, the EXO central wiper seals should be replaced and lubricated at an authorized service center once every 2 years regardless of your monitoring application.

Contact us to learn more: repairs@ysi.com or +1 (800) 765-4974 (US)

Download our Maintenance Brochure

Specifications

Conductivity

Range	0-100,000 µS/cm
Accuracy	±1% of reading or 2 µS/cm w.i.g.

Specific Conductance

Range	0-100,000 µS/cm
Accuracy	±1% of reading or 2 µS/cm w.i.g.

w.i.g. = whichever is greater

Temperature

Range	-5 – 50°C
Accuracy	±0.2°C
Response Time	T95<30sec

Watch Online
EXO2 Wiped (C/T) Video Quick Start Guide:
https://goo.gl/w67OQU

4.7 Wiped Conductivity / Temperature Calibration and Deployment

Calibration

A wet calibration of your new conductivity sensor should be completed before initial use. It is recommended you complete a single point calibration in a standard similar to the conductivity readings that you expect to measure. It is recommended not to use standards below 1,000 µs/cm for fresh water applications as they can become easily contaminated. The temperature sensor cannot be user calibrated. Best practice is to periodically test the performance of the temperature sensor against a NIST traceable thermometer at several reference points. **NOTE:** *All EXO sensors should be user calibrated before initial use.*

Deployment Setup

The Wiped C/T sensor is optimized for continuous monitoring where a variety of environmental fouling conditions can affect the performance of the sensor over time. Numerous solutions can be employed to mitigate the effects of bio-fouling. These can include the use of copper tape, anti-fouling guards, anti-fouling paints, as well as local techniques developed for site specific challenges. An effective monitoring program may employ a combination of techniques to limit bio-fouling to extend deployment times and subsequently reduce maintenance efforts. Using the central wiper to groom the conductivity cell before readings strives to reduce biofouling induced drift on the conductivity cell. If two conductivity sensors are installed in a single sonde, the temperature from the sensor with the lower port will be used for temperature compensation of other parameters.

The sensor includes a new central wiper brush (599673). A brush's wear and replacement intervals vary greatly based on specific application challenges, but 2-12 months use has been observed. Below are three examples of brush wear that will occur naturally over use. It is recommended the wiper brush be replaced before it reaches level 3 for optimal cleaning. We recommend using a new wiper brush with the initial deployment.

Level 1- New brush, minimal "splay"

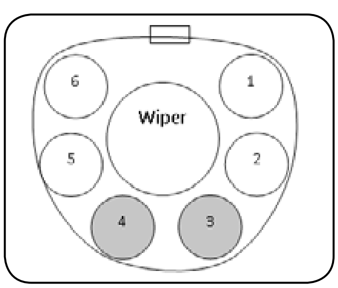
Level 2- Moderate splaying, have spare ready

Level 3- Excessive splay, replace to prevent stalling of wiper

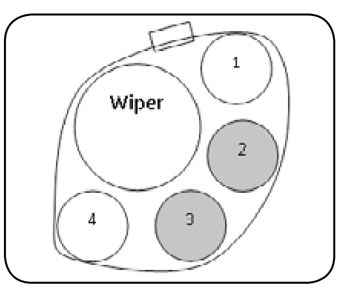
NOTICE: It is not recommended using wiped C/T in conjuction with EXO Ammonium, Nitrate, or Chloride electrodes as they are protected with a guard which accelerates the brush splay.

Sensor Installation

EXO sensors can be installed in any port, however for optimal cleaning avoid installing the Wiped Conductivity & Temperature sensor as the first or last sensor in a group. Having the sensor installed towards the middle of an array is optimal. Below are some examples:



Optimal Wiped C/T positions: 3 or 4



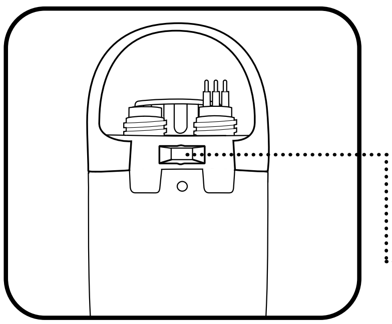
Optimal Wiped C/T positions: 2 or 3

A new sensor includes a kit (599831) containing probe alignment o-rings and disposable zip ties. These items are to be used to optimally align the wiped conductivity probe cell with the brush. Refer to the instruction sheet included in the kit for directions and recommendations for applying the spacers.

4.8 Depth and Level Sensor Overview

EXO measures depth of water with a non-vented strain gauge. (See section 6 if your sonde is equipped with vented level.) A differential strain gauge transducer measures pressure with one side of the transducer exposed to the water and the other side exposed to a vacuum. We calculate depth from the pressure exerted by the water column minus atmospheric pressure. Factors influencing depth measurement include barometric pressure, water density, and temperature. Calibration in the atmosphere "zeros" the sensor with respect to the local barometric pressure. A change in barometric pressure will result in a zero shift unless the transducer is recalibrated to the new pressure.

EXO sondes have intake openings to allow water to act on the strain gauge. The EXO1 intake is located in the yellow section between the battery compartment and label of the sonde.The EXO2 intake openings are two small holes on the face of the sonde bulkhead.

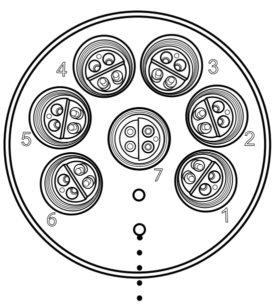


Location of Depth Sensor

Depth sensors on the EXO2 sondes are not on center. When deploying the sonde ***vertically,*** take care to ensure the sonde is redeployed in same position. Often a marker pin inside a PVC pipe is used. In ***horizontal*** deployments, take care to ensure the redeployments are always in the same orientation. This is especially important for the EXO2 sonde because the depth sensor is off-axis.

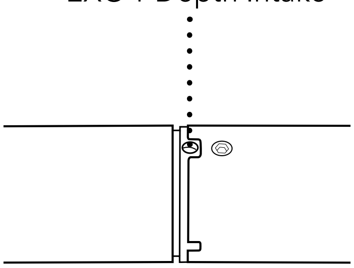
To assist with consistent horizontal orientation, the EXO2 sonde has **an indentation** at the top of the sonde for a marker or positioning pin.

The sonde should be installed with at least 1 cm of water above the intake ports.
If a conductivity sensor is installed, the depth will be compensated automatically for changes in the density of water as temperature and salinity change.



EXO 2 Depth Intake

EXO 1 Depth Intake



Depth Configuration

EXO sondes must be ordered with a specific depth option:

59950x-00 = no depth
59950x-01 = 0-10 m depth
59950x-02 = 0-100 m depth
59950x-03 = 0-250 m depth
59950x-04 = 0-10 m vented level

The depth configuration must be chosen at time of ordering. Once a sonde is shipped with a depth configuration it cannot be changed by the user.

Depth Sensor Location relative to other water quality sensors (see EXO sonde label)

Depth Sensor Location
27.2 cm (EXO1), 13.9 cm (EXO2)
to WQ Sensors

Specifications

Units	PSI, Depth (m, ft, bar)
Temperature	
Operating	-5 to +50°C
Storage	-20 to +80°C
Range	*Shallow:* 0 to 33 ft (10 m) *Medium:* 0 to 328 ft (100 m) *Deep:* 0 to 820 ft (250 m) *Vented:* 0 to 33 ft (10 m)
Accuracy	*Shallow:* ±0.04% FS (±0.013 ft or ±0.004 m) *Medium:* ±0.04% FS (±0.13 ft or ±0.04 m) *Deep:* ±0.04% FS (±0.33 ft or ±0.10 m) *Vented:* ±0.03% FS (±0.010 ft or ±0.003 m)
Response	T63<2 sec
Resolution	0.001 ft (0.001 m)
Sensor Type	Stainless steel strain gauge

4.9 Depth and Level Calibration

NOTE: *This calibration option is available only if your sonde is equipped with an integral depth sensor or a vented level sensor.*

For the calibration, make certain that the depth sensor or vented level sensor is in air and not immersed in any solution. *Also, review the basic calibration description in section 4.2.*

In the Calibrate menu, select Port D-Depth, then select Depth or Level from the second menu.

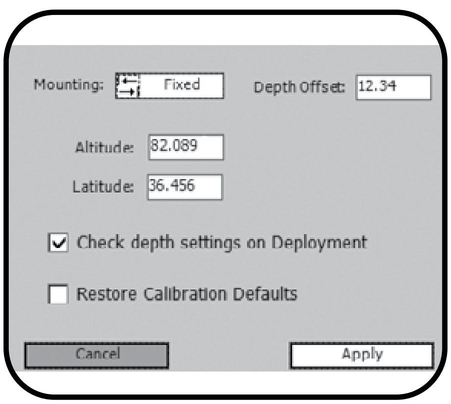
Click 1 Point for the Calibration Points. Enter 0 or go to the Advanced menu to enter a known sensor offset.

- If a depth offset is entered, the output value will shift by the value of the offset. Users may use an offset if referencing a water elevation against a known datum.

Click Start Calibration. Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point. This process zeros the sensor with regard to current barometric pressure.

Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

For best performance of depth measurements, users should ensure that the orientation of the sonde remains constant while taking readings. This is especially important for vented level measurements. Keep the sonde still and in one position while calibrating.



Advanced

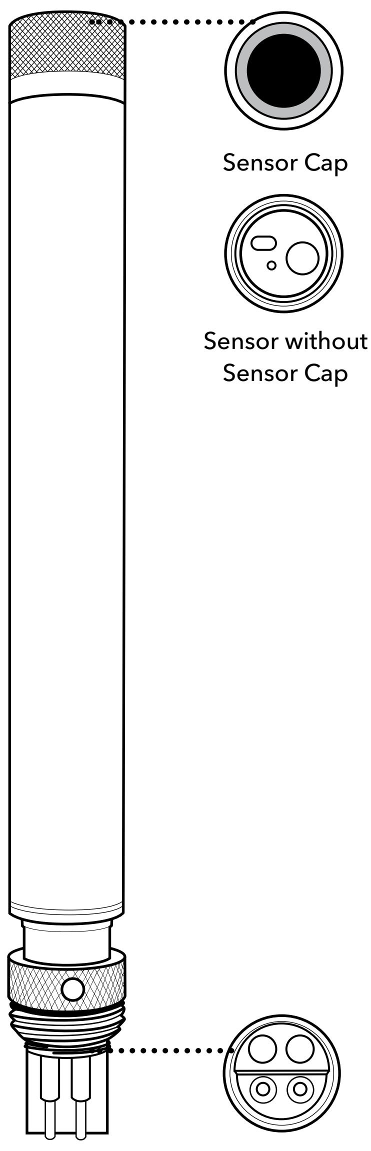
Mounting: Use the Advanced menu to select if a sonde will be mounted in a moving/profiling deployment instead of a fixed location.

Depth Offset: Enter a datum or barometric pressure offset at time of calibration. Barometric pressure offset allows the depth data to be post-processed for barometric pressure changes over the course of the deployment.

Altitude/Latitude: Enter the coordinates for the local altitude (in feet, relative to sea level) and latitude (in degrees) where the sonde is sampling. Latitude values are used in the calculation of depth or level to account for global variations in the gravitational field.

4.10 Dissolved Oxygen Sensor Overview

The principle of operation of the EXO optical dissolved oxygen sensor is based on the well-documented concept that dissolved oxygen quenches both the intensity and the lifetime of the luminescence associated with a carefully chosen chemical dye. The EXO DO sensor operates by shining a blue light of the proper wavelength on this luminescent dye which is immobilized in a matrix and formed into a disk. The blue light causes the immobilized dye to luminesce and the lifetime of this dye luminescence is measured via a photodiode in the probe. To increase the accuracy and stability of the technique, the dye is also irradiated with red light during part of the measurement cycle to act as a reference in the determination of the luminescence lifetime.



599100-01;
599110 sensor cap

When there is no oxygen present, the lifetime of the signal is maximal; as oxygen is introduced to the membrane surface of the sensor, the lifetime becomes shorter. Thus, the lifetime of the luminescence is inversely proportional to the amount of oxygen present and the relationship between the oxygen pressure outside the sensor and the lifetime can be quantified by the Stern-Volmer equation. For most lifetime-based optical DO sensors, this Stern-Volmer relationship

$$((\text{Tzero}/T) - 1) \text{ versus } O_2 \text{ pressure}$$

is not strictly linear (particularly at higher oxygen pressures) and the data must be processed using analysis by polynomial non-linear regression. Fortunately, the non-linearity does not change significantly with time so that, as long as each sensor is characterized with regard to its response to changing oxygen pressure, the curvature in the relationship does not affect the ability of the sensor to accurately measure oxygen for an extended period of time.

(continued)

Specifications

Units	% Saturation, mg/L
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 500% air sat. 0 to 50 mg/L
Accuracy	0-200%: ±1% reading or 1% air sat., whichever is greater; 200-500%: ±5% reading 0-20 mg/L: ±1% of reading or 0.1 mg/L; 20-50 mg/L: ±5% reading
Response	T63<5 sec
Resolution	0.1% air sat. 0.01 mg/L
Sensor Type	Optical, luminescence lifetime

Variables that Affect DO Measurements

Variables that could affect dissolved oxygen measurements include temperature, salinity, and barometric pressure. Temperature and salinity are compensated for during instrument calibration and field use with the use of additional sensors and/or instrument software settings. Barometric pressure relates to the pressure of oxygen in the calibration environment, and barometric pressure changes due to a change in altitude or local weather. Generally the effect of barometric pressure is overcome by proper sensor calibration to a standard pressure. However, if the user measures dissolved oxygen in something besides per cent saturation, then the EXO DO sensor can store a local barometric reading put into the KOR software (DO % local) or the EXO handheld can take a live barometric reading with its internal barometer (ODO % EU).

ODO % Sat = Raw DO reading corrected with temperature and local barometric pressure at the time of calibration. (Local pressure/760 mmHg x 100 = % Sat.)

ODO % Local = Raw DO reading corrected with temperature and % Sat output fixed to 100% regardless of barometric pressure entry. (The entered local barometric pressure is used by KOR software for mg/L calculations.)

ODO % EU = ODO % Sat reading corrected with live barometric reading (available only on EXO Handheld). Fixes the % Sat output to 100%, and conforms to British and EU standards.

4.11 Dissolved Oxygen Calibration

First review the basic calibration description in section 4.2.

ODO % sat and ODO % local – 1-point

Place the sonde with sensor into either saturated air or saturated water:
(a) Saturated air: Ensure there are no water droplets on the DO sensor or the thermistor. Place into a calibration cup containing about 1/8 inch of water that is vented by loosening the threads. (Do not seal the cup to the sonde.) Wait 10-15 minutes before proceeding to allow the temperature and oxygen pressure to equilibrate. Keep out of direct sunlight.
(b) Saturated water: Place into a container of water which has been continuously sparged with an aquarium pump and air stone for one hour. Wait approximately 5 minutes before proceeding to allow the temperature and oxygen pressure to equilibrate.

In the Calibrate menu, select ODO, then select ODO % sat or ODO % local. Calibrating in ODO % sat automatically calibrates ODO mg/L and ODO % local and vice versa.

Enter the current barometric pressure in mm of Hg (Inches of Hg x 25.4 = mm Hg).

> **NOTE:** *Laboratory barometer readings are usually "true" (uncorrected) values of air pressure and can be used "as is" for oxygen calibration. Weather service readings are usually not "true", i.e., they are corrected to sea level, and therefore cannot be used until they are "uncorrected".* An approximate formula for this "uncorrection" (where the BP readings MUST be in mm Hg) is:
> True BP = [Corrected BP] – [2.5 * (Local Altitude in ft above sea level/100)]

Click 1 Point for the Calibration Points. Enter the standard value (air saturated).

Click Start Calibration. Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

mg/L – 1-point

Place the sonde with sensor in a container which contains a known concentration of dissolved oxygen in mg/L and that is within ±10% of air saturation as determined by one of the following methods:

- Winkler titration
- Aerating the solution and assuming that it is saturated
- Measurement with another instrument

NOTE: *Carrying out DO mg/L calibrations at values outside the range of ±10 % of air saturation is likely to compromise the accuracy specification of the EXO sensor. For highest accuracy, calibrate in % saturation.*

In the Calibrate menu, select ODO, then select ODO mg/L. Calibrating in ODO mg/L automatically calibrates ODO % sat and vice versa.

Click 1 Point for Calibration Points. Enter the known mg/L concentration for the standard value. Click Start Calibration. Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point. Click Complete.

Rinse the sonde and sensor(s) in tap or purified water and dry.

ODO % sat, ODO % local or mg/L – 2-point (or zero point)

Normally it is not necessary to perform a 2-point calibration for the DO sensor, and the procedure is not recommended unless (a) you are certain that the sensor does not meet your accuracy requirements at low DO levels and (b) you are operating under conditions where you are certain to be able to generate a medium which is truly oxygen-free.

For ODO % sat or ODO % local, calibrate your sonde at zero oxygen and in water-saturated air or air-saturated water. For ODO mg/L, calibrate your sonde at zero oxygen and a known concentration of oxygen within ±10% of air-saturation. The key to performing a 2-point calibration is to make certain that your zero-oxygen medium is truly oxygen-free:

- If you use nitrogen gas for the zero-point calibration, make certain that the vessel you use has a small exit port to prevent back diffusion of air and that you have completely purged the vessel before confirming the calibration.
- If you use sodium sulfite solution for the zero-point calibration, prepare the solution at a concentration of approximately 2 g/L at least two hours prior to use and keep it sealed in a bottle which does not allow diffusion of oxygen through the sides of the container. Transfer the sodium sulfite solution rapidly from its container to the calibration cup, fill the cup as full as possible with solution to minimize head space, and seal the cup to the sonde to prevent diffusion of air into the vessel.

Place the sonde with DO and temperature sensors in a zero-oxygen medium.

In the Calibrate menu, select ODO, then select either ODO % sat, ODO % local or ODO mg/L.

Click 2 Point for the Calibration Points. Enter Zero Point as the value of the first standard.

Click Start Calibration. Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

- If you used sodium sulfite solution as your zero calibration medium, you must thoroughly remove all traces of the reagent from the probes and wiper prior to proceeding to the second point. We recommend that the second calibration point be in air-saturated water if you use sodium sulfite solution.

Next place the sensors in the medium containing a known oxygen pressure or concentration and wait at least 10 minutes for temperature equilibration. Click Proceed in the pop-up window. Then enter either the barometer reading in mm Hg (for ODO %) or the actual concentration of oxygen which was probably determined from a Winkler titration (for ODO mg/L). Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

NOTE: *Carrying out DO mg/L calibrations at values outside the range of ±10 % of air saturation is likely to compromise the accuracy specification of the EXO sensor. For highest accuracy, calibrate in % saturation.*

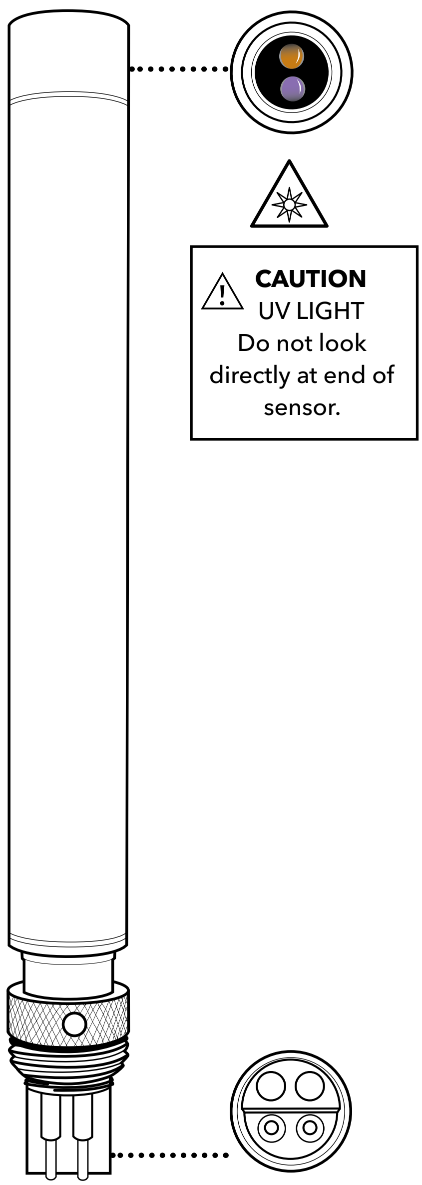
Rinse the sonde and sensor(s) in tap or purified water and dry.

4.12 fDOM Sensor Overview

The EXO fDOM (Fluorescent Dissolved Organic Matter) sensor is a fluorescence sensor which detects the fluorescent component of DOM (Dissolved Organic Matter) when exposed to near-ultraviolet (UV) light.

Colored Dissolved Organic Matter

Users might wish to quantify ***colored*** dissolved organic matter (CDOM) in order to determine the amount of light which is absorbed by stained water and thus is not available for the photosynthesis process carried out by subsurface aquatic plants and algae. In most cases, fDOM can be used as a surrogate for CDOM.



599104-01

Quinine Sulfate

A surrogate for fDOM is Quinine Sulfate, which, in acid solution, fluoresces similarly to dissolved organic matter. The units of fDOM are quinine sulfate units (QSUs) where 1 QSU = 1 ppb quinine sulfate and thus quinine sulfate is really a double surrogate for the desired CDOM parameter.

The EXO fDOM sensor shows virtually perfect linearity (R^2=1.0000) on serial dilution of a colorless solution of quinine sulfate. However, on serial dilution of stained water field samples, the sensor shows some underlinearity. The point of underlinearity in field samples varies and is affected by the UV absorbance of the DOM in the water. Testing shows that underlinearity can occur at fDOM concentrations as low as 50 QSU. This factor means that a field sample with an fDOM reading of 140 QSU will contain significantly more than double the fDOM of a sample that reads 70 QSU. This effect—good linearity in colorless quinine sulfate solution, but underlinearity in stained field samples—is also exhibited by other commercially available fDOM sensors and thus the performance of the EXO sensor is likely to be equivalent or better than the competition while providing the advantages of easy integration into a multiparameter package and automatic mechanical cleaning when used in monitoring studies with an EXO2 sonde.

Specifications

Units	Quinine Sulfate Units (QSU), ppb
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 300 ppb QSU
Response	T63<2 sec
Resolution	0.01 ppb QSU
Sensor Type	Optical, fluorescence
Linearity	R^2>0.999 for serial dilution of 300 ppb Quinine Sulfate solution
Detection Limit	0.07 ppb QSU
Optics: Excitation	365±5 nm
Emission	480±40 nm

4.13 fDOM
Calibration Standards

Quinine Sulfate Solution for fDOM Sensor

⚠ **WARNING:** Before using a quinine sulfate reagent (solid or solution) or sulfuric acid reagent, read the safety instructions provided by the supplier. Take extra precautions when making dilutions of concentrated sulfuric acid, as this reagent is particularly dangerous. Remember that only trained personnel should handle chemicals.

Preparation

Use the following procedure to prepare a 300 µg/L solution of quinine sulfate (300 QSU) that can be used to calibrate the EXO fDOM sensor for field use:

1. Purchase solid quinine sulfate dihydrate with a high purity (>99%).
   (Recommended supplier: Ward's Science, CAS# 6119-70-6.)
2. Purchase 0.1 N (0.05 M) sulfuric acid, to avoid the hazards of diluting concentrated sulfuric acid to make this reagent.
   (Recommended supplier: Fisher Scientific item# AA35651K7.)
3. Weigh 0.100 g of solid quinine sulfate dihydrate and quantitatively transfer the solid to a 100-mL volumetric flask. Dissolve the solid in about 50 mL of 0.05 M (0.1 N) sulfuric acid (H_2SO_4), dilute the solution to the mark of the volumetric flask with additional 0.05 M sulfuric acid, and mix well by repeated inversion. This solution is 1000 ppm in quinine sulfate (0.1%).
4. Transfer 0.3 mL of the 1000 ppm solution to a 1000 mL volumetric and then fill the flask to the top graduation with 0.05 M sulfuric acid. Mix well to obtain a solution of 300 µg/L (300 QSU or 100 RFU).
5. Store the concentrated standard solution in a darkened glass bottle in a refrigerator to retard decomposition. The dilute standard prepared in the previous step should be used within 5 days of preparation and should be discarded immediately after exposure to EXO's metal components.

Degradation of quinine fluorescence by copper and chloride

NOTICE: Exposure of the quinine sulfate solution to any copper-based component of the EXO sonde and sensors (primarily the wiper assembly) will begin to degrade the solution significantly within minutes. Quinine fluorescence is also degraded by the presence of chloride or halide ions, found in estuarine or seawater, conductivity standards, and Zobell solution. Thus, clean your sensors thoroughly and perform your calibration as quickly as possible on immersion of the sensors into the quinine sulfate solution. Discard the used standard. When quinine sulfate standards are required in the future, perform another dilution of the concentrated solution.

Effect of temperature on fluorescence

The intensity of the fluorescence of many dyes shows an inverse relationship with temperature. This effect must be accounted for when calibrating the EXO fDOM sensor with Quinine Sulfate Solution. Enter the QSU or RFU value from the table below that corresponds to the temperature of the standard.

Temp (˚C)	RFU	QSU	Temp (˚C)	RFU	QSU
30	96.4	289.2	18	101.8	305.4
28	97.3	291.9	16	102.7	308.1
26	98.2	294.6	14	103.6	310.8
24	99.1	297.3	12	104.6	313.8
22	100	300	10	105.5	316.5
20	100.9	302.7	8	106.4	319.2

4.14 fDOM Calibration

Review the basic calibration description in section 4.2.
Before calibrating, be certain that the sensing window is clean *(cleaning instructions, section 5.8)*.

This procedure calibrates fDOM RFU or fDOM QSU/ppb. If the user has both units selected, then this procedure must be performed twice, once for each unit, to completely calibrate the parameter.

For 2-point calibrations, the first standard must be clear water (0 µg/L). The second standard should be a 300 µg/L quinine sulfate solution. *(For detailed instructions for mixing this solution, see section 4.13.)*

NOTICE: Do not leave sensors in quinine sulfate solution for a long time. A chemical reaction occurs with the copper on the sonde (wiper assembly, sonde bulkhead, copper tape) that degrades the solution and causes it to drift. Also, start with very clean sensors, as the presence of chloride and halide ions (from estuarine or seawater, conductivity standards, and Zobell solution) can compromise QS fluorescence.

QSU – 1- or 2-point

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select fDOM, then select QSU/ppb. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 300 µg/L for second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points, and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Remove the central wiper from the EXO2 sonde before proceeding to the next step.

Next place the sensors in the correct amount of 300 µg/L quinine sulfate standard in the calibration cup. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, verify that no air bubbles reside on the sensing face of the sensor. If there are bubbles, gently shake or move the sensor to dislodge. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

RFU – 1- or 2-point

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select fDOM, then select RFU. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 100 RFU for second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points, and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Remove the central wiper from the EXO2 sonde before proceeding to the next step.

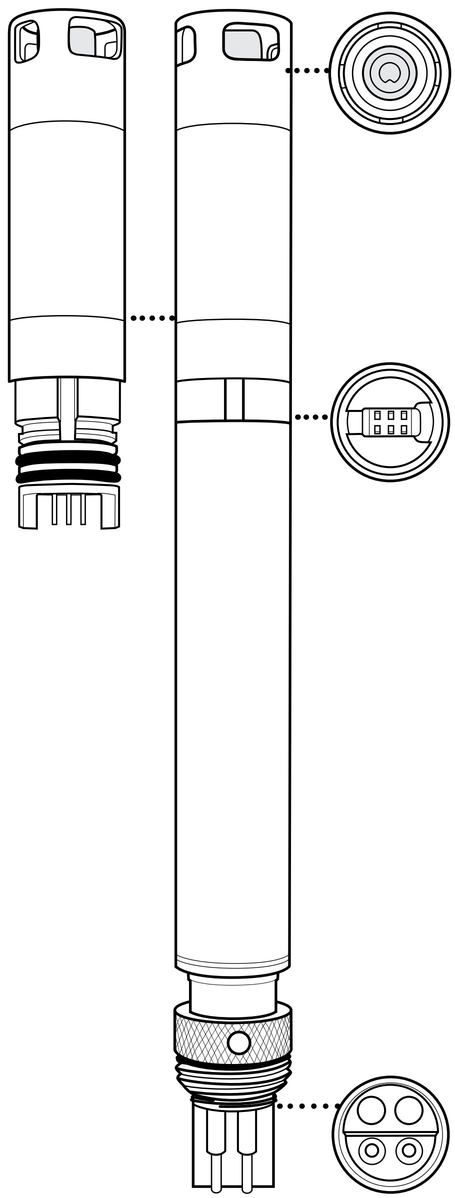
Next place the sensors in the correct amount of 300 µg/L quinine sulfate standard in the calibration cup. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, verify that no air bubbles reside on the sensing face of the sensor. If there are bubbles, gently shake or move the sensor to dislodge. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu. Rinse the sonde in tap or purified water and dry the sonde. Discard the used standard.

4.15 ISEs: Ammonium, Nitrate, & Chloride Sensors Overview

NOTE: ***Ammonium, nitrate, and chloride ion-selective electrodes (ISEs) should be used in <u>freshwater</u> applications only at depths of less than 55 feet (17 meters) and less than 25 psi.*** The ammonium and nitrate sensors use a silver/silver chloride wire electrode in a custom filling solution. The internal solution is separated from the sample medium by a polymer membrane, which selectively interacts with ammonium or nitrate ions. When the sensor is immersed in water, a potential is established across the membrane that depends on the relative amounts of ions in the sample and the internal solution. This potential is read relative to the Ag/AgCl reference electrode.

(continued)



599709, 599710, 599711;
599743-01, 599744-01, 599745-01 modules

Specifications

Ammonium - NH_4

Units	mg/L-N, millivolts
Temperature *Operating* *Storage*	 0 to 30˚C 0 to 30°C
Depth	0 to <55 ft (0 to <17 m)
Range	0 to 200 mg/L-N
Accuracy	±10% of reading or ±2 mg/L-N, whichever is greater
Response	T63<30 sec
Resolution	0.01 mg/L
Sensor Type	Ion-selective electrode
Conductivity	<1500 µS/cm

Nitrate - NO_3

Units	mg/L-N, millivolts
Temperature *Operating* *Storage*	 0 to 30˚C 0 to 30°C
Depth	0 to <55 ft (0 to <17 m)
Range	0 to 200 mg/L-N
Accuracy	±10% of reading or ±2 mg/L-N, whichever is greater
Response	T63<30 sec
Resolution	0.01 mg/L
Sensor Type	Ion-selective electrode
Conductivity	<1500 µS/cm

(Specs. continued)

Specifications *(continued)*

Chloride - Cl

Units	mg/L-Cl, millivolts
Temperature *Operating* *Storage*	 0 to 30°C 0 to 30°C
Depth	0 to <55 ft (0 to <17 m)
Range	0 to 18000 mg/L-Cl
Accuracy	±15% of reading or ±5 mg/L-Cl, whichever is greater
Response	T63<30 sec
Resolution	0.01 mg/L
Sensor Type	Ion-selective electrode
Salinity	30 psu

NOTE: Qualification testing for chloride was performed in a stirred calibration solution. Due to the solid state nature of the chloride ISE, the sensor exhibits moderate flow dependence. Mitigation can be achieved by stirring during calibration.

The chloride sensor uses a solid-state membrane attached to a conductive wire. This sensor operates in a similar fashion to the ammonium and nitrate sensors.

For all ISEs, the linear relationship between the logarithm of the ammonium, nitrate or chloride activity and the observed voltage, as predicted by the Nernst equation, is the basis for the determination.

Ammonium is calculated from the pH, salinity, and temperature readings. If a pH sensor is not in use, the instrument will assume the sample is neutral (pH 7) for the calculation. If a conductivity sensor (salinity) is not in use, the instrument will use the salinity correction value entered in the ammonium sensor calibration screen for the calculation.

Replaceable Sensor Module

The EXO ammonium, chloride, and nitrate sensors have a unique design that incorporates a user-replaceable sensor tip (module) and a reusable sensor base that houses the processing electronics, memory, and wet-mate connector. This allows users to reduce the costs associated with these sensors by only replacing the relatively inexpensive module periodically and not the more costly base.

The connection of the module to the sensor base is designed for one connection only and the procedure must be conducted in an indoor and dry environment. Once installed the module cannot be removed until you are prepared to replace it with a new module.
See section 5.16 for detailed instructions.

The typical life expectancy of an ISE sensor is three to six months, depending on use.

Precautions

- ISEs are intended for sampling purposes and **must** be calibrated frequently due to sensor drift.
- ISEs can be used in long-term deployments for qualitative trends. Use with an EXO wiper will deform the brush over time and may require more frequent brush replacement. The brush deformation may intensify with the fouling present in the monitored environment.
- ISE sensors only come in guarded configurations. Customers should not remove the plastic guard that protects the ISE membrane.
- For long-term deployments, sensor data should be compared to that of grab samples throughout the monitoring period to note drift.

For a full list of precautions see the end of section 4.16

4.16 ISEs: Ammonium, Nitrate, & Chloride Calibration

This procedure calibrates the EXO ammonium, chloride, or nitrate sensor. The sensors can be calibrated to one, two or three points. The 3-point calibration method assures maximum accuracy when the temperature of the media to be monitored cannot be anticipated; we strongly recommend a 3-point calibration for best performance of ISE sensors. Review the basic calibration description in section 4.2.

The temperature response of ion-selective electrodes is not as predictable as that of pH sensors. Therefore, be sure to carry out a 3-point calibration the first time you use the sensor. This will provide a default setting for the effect of temperature on your sensor. After this initial calibration, you can use the less time-consuming 2-point and 1-point routines to update the 3-point calibration. However, we strongly recommend a new 3-point calibration after each deployment of 30 days or longer.

Due to the nature of ion-selective electrodes, it is recommended that they be used for sampling purposes for the greatest accuracy. Using an ISE in long-term deployments is possible, but it's important to note that drift occurs over an extended period of time. Collecting grab samples from the site is encouraged to correct for drift. Additionally, sample readings should be taken after sensors have fully stabilized. Calibrating in a continuously stirred solution from 1 to 5 minutes has shown to improve sensor performance. For best performance sensors should be calibrated as close to the expected field conditions as possible.

For more ISE precautions, drift, and accuracy notes *please see "ISE Precautions" at the end of this section.*

1-point

Select the 1-point option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously, you can adjust the calibration by carrying out a 1-point calibration.

2-point

Select the 2-point option to calibrate the ammonium sensor using only two calibration standard solutions. In this procedure, the ammonium sensor is calibrated using a 1 mg/L NH_4^+ -N and 100 mg/L NH_4^+ -N calibration standard solutions. A 2-point calibration procedure (as opposed to a 3-point procedure) can save time if the temperature range of the media being monitored is known and stable.

3-point

Select the 3-point option to calibrate the ammonium sensor using three calibration standard solutions, two at ambient temperature and one at a temperature substantially different from ambient. The 3-point calibration method should be used to assure maximum accuracy when the temperature of the media to be monitored cannot be anticipated. 3-point calibration temperatures should span the range of interest, for example 20°C and 2°C for "cold" and 20°C and 30°C for "hot". The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to place the sensor in the additional calibration standard solution to complete the 3-point procedure. Be certain that the calibration standard solution and sensor are thermally equilibrated prior to proceeding with the calibration. The recommended order of calibration standards is (1) 1 mg/L NH_4^+ -N standard at ambient temperature, (2) 100 mg/L NH_4^+ -N standard at ambient temperature, and (3) 1 mg/L NH_4^+ -N standard at a different temperature (usually lower) than ambient, ±10°C minimum.

- To save time during calibration, chill/heat a sufficient amount of 1 mg/L NH_4^+ -N calibration standard solution prior to the start of calibration.

Ammonium Pre-calibration

Soaking

EXO Ammonium Sensors are shipped dry in a container that holds a sponge soaked in 100mg/L ammonium standard solution. Before initial use the sensor membrane needs to be soaked in 100mg/L ammonium standard solution (YSI Item # 003843). Most users find it useful to soak the sensors overnight; shorter soaking times may be used if the sensor output is monitored and is fully stabilized.

In addition to initially soaking the sensor, users may also see improved performance if the ammonium sensor is soaked in 100 mg/L solution after field deployments. This process helps remove any interfering ions from the sensor membrane. After the activation process the sensor should be rinsed thoroughly and the following calibration precautions should be observed:

part #003841	1 mg/L
part #003842	10 mg/L
part #003843	100 mg/L

The ammonium sensor should be calibrated using solutions of known total ammonium-nitrogen content or YSI Standards.

If a two point calibration protocol is used, the temperature of the standards should be as close as possible to that of the environmental medium to be monitored. The recommended calibration procedure is one involving three solutions. Two of the solutions should be at ambient temperature while the third should be at least 10 degrees Celsius different from ambient temperature. This protocol minimizes the effects of taking readings at temperatures that are significantly different ambient laboratory temperatures.

Calibration Tip

Exposure to the high ionic content of pH buffers can cause a significant, but temporary, drift in the Ammonium, Nitrate, and Chloride sensors. Therefore, when calibrating the pH/ORP probe, YSI recommends that you use one of the following methods to minimize errors in the subsequent readings:

1. Calibrate pH first, immersing all of the probes in the pH buffers. After calibrating pH, place the probes in 100 mg/L nitrate or ammonium standard or 1000 mg/L chloride standard and monitor the reading. Usually, the reading starts low and may take as long as 30 minutes to reach a stable value. When it does, proceed with the calibration.

2. When calibrating pH, remove ISE modules from the sonde bulkhead and plug the ports. After pH calibration is complete, replace the ISE sensors and proceed with their calibration with no stabilization delay.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all interfering species produce an artificially high ammonium reading. Thus, if the sonde indicates the presence of only small quantities of ammonium, it is unlikely that the reading is erroneously low because of interference. Unusually high ammonium readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

Ammonium 3-point

NOTICE: Do not expose electrodes to high-conductivity solutions. Exposure will reduce data quality and response of the sensors. During calibration of other sensors, remove the ISEs to avoid exposing them to conductivity standards, Zobell solution, pH buffer, or any solution with significant conductivity.

In the Calibrate menu, select ISE, then select ammonium.

Click 3-point for the Calibration Points. Enter 1 mg/L as the value of the first standard, 100 mg/L as the value of the second standard, and 1 mg/L as the value of the third standard.

Click Start Calibration.

Pour a sufficient amount of 1 mg/L NH_4^+ -N calibration standard solution at ambient temperature in a clean and dry or pre-rinsed calibration cup. Carefully immerse the sensor end of the sonde into the solution, making sure the sensor's tip is in solution by at least 1 cm. Allow at least 1 minute for temperature equilibration before proceeding.

Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point. Confirm that the Pending data value is close to the Setpoint value. Click Proceed and wait for the software to prompt you to move the sensor to the next calibration standard solution.

Rinse the sensors in deionized water between changes of the calibration solutions. Pour a sufficient amount of 100 mg/L of NH_4^+ -N calibration standard solution at ambient temperature into a clean, dry or pre-rinsed calibration cup and carefully immerse the sensor end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point. Confirm that the Pending data value is close to the Setpoint value. Click Proceed and wait for the software to prompt you to move the sensor to the next calibration standard solution.

Rinse the sensors in deionized water between changes of the calibration solutions. Immerse the sensor end of the sonde in the pre-chilled 1 mg/L NH_4^+ -N calibration standard solution ensuring that the temperature is at least 10°C different than ambient. Allow at least 1 minute for temperature equilibration before proceeding.

Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Confirm that the Pending data value is close to the Setpoint value.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu

Rinse the sonde in tap or purified water.

Nitrate 3-point

The calibration procedure for nitrate is identical to the procedure for ammonium, except that the calibration standard solution values are in mg/L NO_3^- -N instead of NH4+ -N.

Chloride 3-point

The calibration procedure for chloride is identical to the procedure for ammonium and nitrate, except that the calibration standard solution values are in mg/L Cl^- instead of NH_4^+ -N or NO_3^- -N. YSI recommends that the user employ standards for chloride that are 10 times greater than for ammonium and nitrate and that span the expected deployment conditions. Typical calibration ranges are 10mg/L Cl^- and 1000mg/L Cl^- or 1000mg/L Cl^- and 18000mg/L Cl^-.

Chloride Standard for Chloride Sensor

⚠ **WARNING:** Read and follow all the safety instructions and MSDS documentation supplied with the chemical before proceeding. Remember that only trained personnel should handle hazardous chemicals.

Preparation

Use the following procedure to prepare 10 and 1000 mg/L chloride reagents for the EXO Chloride sensor. (Nitrate and Ammonium standards can be purchased from YSI or other laboratory supply companies.)

1000 mg/L Standard

1. Purchase solid sodium chloride from a supplier.
2. Accurately weigh 1.655 grams of anhydrous sodium chloride and transfer into a 1000 mL volumetric flask.
3. Add 0.5 grams of anhydrous magnesium sulfate to the flask.
4. Add 500 mL of water to the flask, swirl to dissolve all of the reagents. Dilute to the volumetric mark with water. Mix well by repeated inversion and then transfer the 1000 mg/L standard to a storage bottle.
5. Rinse the flask extensively with water prior to its use in the preparation of the 10 mg/L standard.

Alternatively, simply add 0.5 grams of magnesium sulfate to a liter of a 1000 mg/L chloride standard from a certified supplier.

10 mg/L Standard

1. Accurately measure 10 mL of the above 1000 mg/L standard solution into a 1000 mL volumetric flask.
2. Add 0.5 grams of anhydrous magnesium sulfate to the flask.
3. Add 500 mL of water, swirl to dissolve the solid reagents, and then dilute to the volumetric mark with water. Mix well by repeated inversion and then transfer the 10 mg/L standard to a storage bottle.

Sensor Drift

The ion-selective electrodes have the greatest tendency to exhibit calibration drift over time. This drift should not be a major issue for sampling studies where the instrument can be frequently calibrated. However, if the sensor is used in longer-term deployments, drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion-selective electrodes, the user should acquire a few grab samples during the deployment for analysis in the laboratory or with another sensor that has been recently calibrated.

Sensor Accuracy Specifications

The typical accuracy specification for the sensors (+/-10% of reading or 2mg/L which ever is greater for ammonium and nitrate and ±15% of reading or 5mg/L which ever is greater for chloride) refer to sampling applications where only minimal time has elapsed between calibration and field use.

To maintain accuracy specifications for EXO sensor, we recommend that users calibrate sensors in the lab in standards with temperatures as close to the ambient temperature of the field water as possible.

All ion-selective electrodes are subject to the interaction of species with the sensor membrane, which are similar in nature to the analyte. These interfering species thus include other halide ions (fluoride, bromide, and iodide) as well as other anions.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all-interfering species produce an artificially high reading. Thus, if the sensor indicates the presence of only small quantities, it is unlikely that the reading is erroneously low because of interference. Unusually high readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

ISE Precautions

Ion-selective electrodes may not stabilize as rapidly as pH sensors. Be sure to allow plenty of time for the readings to come to their final values during all calibration routines.

Ion-selective electrodes generally drift more than pH sensors. To check for this drift, read the sensor's value in a calibration standard solution at the end of each deployment.

Ammonium and nitrate standards are good growth media for a variety of organisms. This growth can significantly reduce the nitrogen content of your standards, an effect that is particularly important for the 1 mg/L solution. It is best to use new standards for each deployment, but if you decide to save your solutions for reuse, we recommend refrigerated storage to minimize the growth of these organisms.

Remember that the ammonium, nitrate, and chloride sensors will take longer to stabilize after exposure to high conductivity solutions such as a pH calibration. To accelerate the recovery process, soak the sensor in 100 mg/L (ammonium or nitrate standard solution) or 1000mg/L Cl- standard solution for a few minutes after exposure. In addition, be particularly careful that readings are stable during subsequent calibrations.

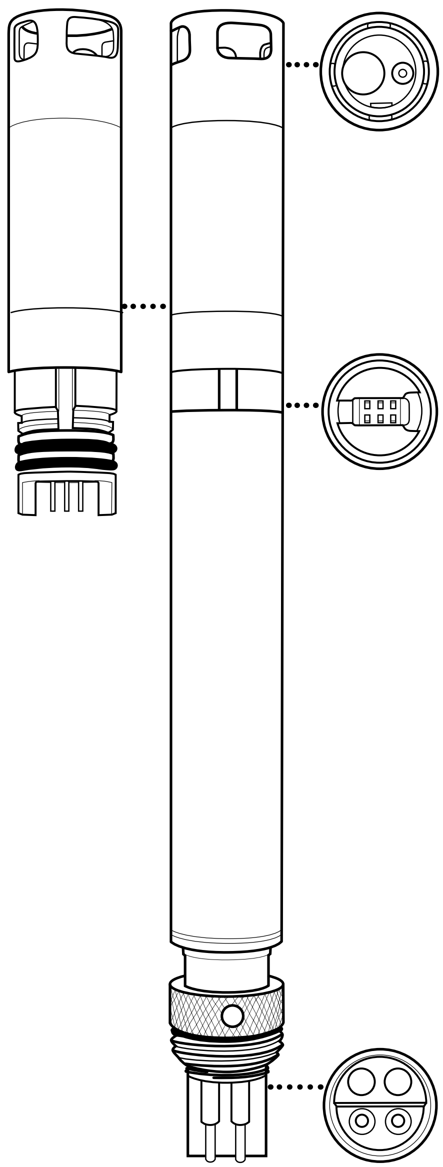
Of all the sensors available on the sonde, ion selective electrodes have the greatest tendency to exhibit calibration drift over time. This drift should not be a major problem for sampling studies where the instrument can be frequently calibrated. However, if an ammonium sensor is used in a longer-term deployment study with the sonde, the user should be aware that drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion selective electrodes, the user should acquire a few "grab samples" during the course of the deployment for analysis in the laboratory by chemical means or with another ammonium sensor which has been recently calibrated. Remember that the typical accuracy specification for the sensor (+/- 10 % of the reading or 2 mg/L, whichever is larger) refers to sampling applications where only minimal time has elapsed between calibration and field use.

Many users find it useful to swap Ammonium sensors after 30 days of deployment with freshly calibrated sensors. On the EXO platform the calibration is retained inside the sensor, so they can be removed from the lab and installed in the field.

4.17 pH and ORP Sensor Overview

Users can choose between a pH sensor or a combination pH/ORP sensor to measure these parameters. pH describes the acid and base characteristics of water. A pH of 7.0 is neutral; values below 7 are acidic; values above 7 are alkaline. ORP designates the oxidizing-reducing potential of a water sample and is useful for water which contains a high concentration of redox-active species, such as the salts of many metals and strong oxidizing (chlorine) and reducing (sulfite ion) agents. However, ORP is a non-specific measurement—the measured potential is reflective of a combination of the effects of all the dissolved species in the medium. Users should be careful not to overinterpret ORP data unless specific information about the site is known.

(continued)



599701, 599702, 599705, 599706; 599795-01, 599795-02, 599797-01, 599797-02 modules

Specifications

pH

Units	pH units
Temperature *Operating* *Storage*	 -5 to +50°C 0 to 60°C
Range	0 to 14 units
Accuracy	±0.1 pH units within ±10°C of calibration temperature; ±0.2 pH units for entire temp range
Response	T63<3 sec
Resolution	0.01 units
Sensor Type	Glass combination electrode

ORP

Units	millivolts
Temperature *Operating* *Storage*	 -5 to +50°C 0 to 60°C
Range	-999 to +999 mV
Accuracy	±20 mV in Redox standard solution
Response	T63<5 sec
Resolution	0.1 mV
Sensor Type	Platinum button

Replaceable Sensor Module

The EXO pH and pH/ORP sensors have a unique design that incorporates a user-replaceable sensor tip (module) and a reusable sensor base that houses the processing electronics, memory, and wet-mate connector. This allows users to reduce the costs associated with pH and pH/ORP sensors by only replacing the relatively inexpensive module periodically and not the more costly base.

The connection of the module to the sensor base is designed for one connection only and the procedure must be conducted in an indoor and dry environment. Once installed the module cannot be removed until you are prepared to replace it with a new module. *See section 5.16 for detailed instructions.*

Users must order either a pH or pH/ORP sensor. Once ordered the sensor is ***only*** compatible with like-model sensor modules. For example, if a pH sensor is purchased initially, then the user must order a replaceable pH sensor module in the future; it cannot be replaced with a pH/ORP module.

Electrodes

EXO measures pH with two electrodes combined in the same probe: one for hydrogen ions and one as a reference. The sensor is a glass bulb filled with a solution of stable pH (usually 7) and the inside of the glass surface experiences constant binding of H^+ ions. The outside of the bulb is exposed to the sample, where the concentration of hydrogen ions varies. The resulting differential creates a potential read by the meter versus the stable potential of the reference.

The ORP of the media is measured by the difference in potential between an electrode which is relatively chemically inert and a reference electrode. The ORP sensor consists of a platinum button found on the tip of the probe. The potential associated with this metal is read versus the Ag/AgCl reference electrode of the combination sensor that utilizes gelled electrolyte. ORP values are presented in millivolts and are not compensated for temperature.

Signal Quality

Signal conditioning electronics within the pH sensor module improve response, increase stability, and reduce proximal interference during calibration. Amplification (buffering) in the sensor head is used to eliminate any issue of humidity in the front-end circuitry and reduce noise.

4.18 pH Calibration

1-point

Select the 1-point option to calibrate the pH probe using one calibration standard.
NOTE: *While a 1-point pH calibration is possible, YSI recommends using a 2 or 3-point calibration for greater accuracy.*

2-point

Select the 2-point option to calibrate the pH probe using two calibration standards. In this procedure, the pH sensor is calibrated with a pH 7 buffer and a pH 10 or pH 4 buffer depending on your environmental water. A 2-point calibration can save time (versus a 3-point calibration) if the pH of the media to be monitored is known to be either basic or acidic.

3-point

Select the 3-point option to calibrate the pH probe using three calibration standards. In this procedure, the pH sensor is calibrated with a pH 7 buffer and two additional buffers. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated.

Review the basic calibration description in section 4.2.

Pour the correct amount of pH buffer in a clean and dry or pre-rinsed calibration cup. Carefully immerse the probe end of the sonde into the solution, making sure the sensor's glass bulb is in solution by at least 1 cm. Allow at least 1 minute for temperature equilibration before proceeding.

In the Calibrate menu, select pH or pH/ORP, then select pH.

Select the number of points desired for the calibration. Enter the value(s) of the pH buffer(s) that will be used for the calibration.

> **NOTE:** *Observe the temperature reading above the standard value.* The actual pH value of all buffers varies with temperature. Enter the correct value from the bottle label for your calibration temperature for maximum accuracy. For example, the pH of one manufacturer's pH 7 Buffer is 7.00 at 25˚C, but 7.02 at 20˚C.
> - If no temperature sensor is installed, user can manually update temperature by entering a value.

Click Start Calibration. Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point. Confirm that the Pending data value is close to the Setpoint value. Click Proceed and wait for the software to prompt you to move the sensor to the next standard solution.

Rinse the sensor in deionized water. Pour the correct amount of an additional pH buffer standard into a clean, dry or pre-rinsed calibration cup, and carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Repeat the calibration procedure and click Apply when the data are stable. Rinse the sensor and pour additional pH buffer, if necessary. Repeat calibration procedure for the third point and click Apply when data are stable.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

Rinse the sonde and sensors in tap or purified water and dry.

4.19 ORP Calibration

Review the basic calibration description in section 4.2.

Pour the correct amount of standard with a known oxidation reduction potential value (we recommend Zobell solution) in a clean and dry or pre-rinsed calibration cup. Carefully immerse the probe end of the sonde into the solution.

In the Calibrate menu, select pH/ORP, then select ORP mV.

Click Start Calibration. Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

NOTICE: Do not leave sensors in Zobell solution for a long time. A chemical reaction occurs with the copper on the sonde (sonde bulkhead, central wiper assembly, copper tape). While the reaction does not impact calibration, it will degrade the sonde materials over time. Discard the used standard.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

Rinse the sonde in tap or purified water and dry the sonde.

Effect of temperature on ORP

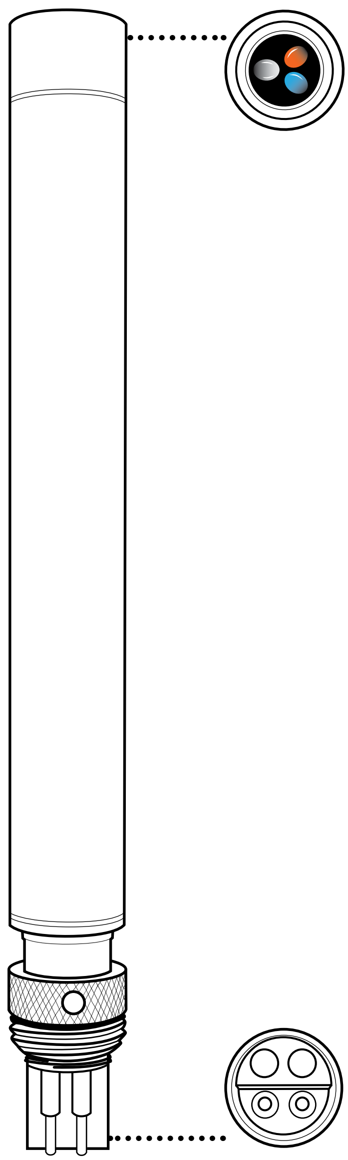
The oxidation reduction potential value shows an inverse relationship with temperature. This effect must be accounted for when calibrating the EXO ORP sensor with Zobell solution. Enter the mV value from the table below that corresponds to the temperature of the standard.

Temp (˚C)	mV	Temp (˚C)	mV
-5	270.0	25	231.0
0	263.5	30	224.5
5	257.0	35	218.0
10	250.5	40	211.5
15	244.0	45	205.0
20	237.5	50	198.5

4.20 Total Algae (Chl & BGA) Sensor Overview

The EXO total algae sensor is a dual-channel fluorescence sensor that generates two independent data sets; one resulting from a blue excitation beam that diexcites the chlorophyll ***a*** molecule, present in all photosynthetic cells, and a second from an orange excitation beam that excites the phycocyanin accessory pigment found in blue-green algae (cyanobacteria). This excitation triggers a transfer of energy from the phycocyanin to the central chlorophyll ***a***, where photosynthesis is initiated.

(continued)



599102-01 (Phycocyanin)
599103-01 (Phycoerythrin)

Specifications

Units *Chlorophyll* *BGA-PC* *BGA-PE*	 RFU, µg/L Chl RFU, µg/L PC RFU, µg/L PE
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	*Chl:* 0-100 RFU, 0-400 µg/L Chl*; *BGA-PC:* 0-100 RFU, 0-100 µg/L*; *BGA-PE:* 0-100 RFU, 0-280 µg/L*
Response	T63<2 sec
Resolution	*Chl:* 0.01 RFU, 0.01 µg/L Chl; *BGA-PC:* 0.01 RFU, 0.01 µg/L; *BGA-PE:* 0.01 RFU, 0.01 µg/L
Sensor Type	Optical, fluorescence
Linearity	*Chl:* R^2>0.999 for serial dilution of Rhodamine WT solution from 0-400 µg/L Chl equivalents *BGA-PC:* R^2>0.999 for serial dilution of Rhodamine WT solution from 0-100 µg/L PC equivalents; *BGA-PE:* R^2>0.999 for serial dilution of Rhodamine WT solution from 0-280 µg/L PE equivalents
Optics: Chl Excitation	470±15 nm
PC Excitation	590±15 nm
PE Excitation	525±15 nm
Emission	685±20 nm

*Pigment concentration ranges of algae sensors were determined in monocultures of specific algae species. This range will vary depending on algae assemblage and environmental conditions. For accurate pigment concentration estimates at particular sites or samples, the user must determine the RFU to pigment concentration relationship on a site-by-site basis.

Although blue-green algae contain chlorophyll ***a***, the chlorophyll fluorescence signal detected by ***in situ*** fluorometers is weaker than in eukaryotic phytoplankton. This results in an underestimate of algae biomass when using a single-channel chlorophyll sensor when blue-green algae are present. The EXO total algae sensor generates a more accurate total biomass estimate of the planktonic autotrophic community by exciting chlorophyll ***a***, phycocyanin or phycoerythrin.

The sensor generates data in three formats: RAW, RFU, and an estimate of the pigment concentration in µg/L.

The RAW value is a value unaffected by user calibrations and provides a range from 0-100, representing the per cent of full scale that the sensor detects in a sample. This parameter is typically used for diagnostic purposes only.

RFU stands for Relative Fluorescence Units and is used to set sensor output relative to a stable secondary standard, such as Rhodamine WT dye. This allows users to calibrate sensors identically; for example, calibrating all sensors in a network to read 100 RFU in a concentration of Rhodamine WT dye. The sensors can then be deployed and generate data that is relative to all other sensors. Once a sensor is retrieved, it can be checked against that same standard to assess sensor performance, drift, or the potential effects of biofouling.

The µg/L output generates an estimate of pigment concentration. The relationship between µg/L and sensor's RAW signal should be developed through following standard operating procedures of sampling the water body of interest, collecting sensor data from sample, and then extracting the pigment to establish a correlation. The higher the temporal and spatial resolution of the sampling, the more accurate this estimate will be.

Chlorophyll

The EXO chlorophyll sensor operates on the ***in vivo*** fluorescence principle with no disruption of the cells required to obtain either spot readings or long-term data. The EXO sensor has an excellent detection limit as determined under laboratory conditions and this advantage should be realized in many field applications.

EXO chlorophyll readings show excellent linearity on serial dilution of a surrogate solution of Rhodamine WT (R^2>0.9999) and this should ensure relative accuracy of field chlorophyll readings, i.e., a chlorophyll reading of 100 units will represent twice the algal content of water with a chlorophyll reading of 50 units. Also, EXO chlorophyll readings show very low interference from turbidity, allowing for more accurate determination of algal content during rainfall events which release both sediment and algae into the water. The EXO chlorophyll sensor also exhibits very low interference from dissolved organics, increasing data accuracy.

Blue-green Algae

The EXO BGA readings show excellent linearity on serial dilution of a surrogate solution of Rhodamine WT (R^2>0.9999) and this should ensure relative accuracy of field BGA readings, i.e., a BGA reading of 100 units will represent twice the algal content of water with a BGA reading of 50 units.

4.21 Total Algae (Chl & BGA) Calibration

Review the basic calibration description in section 4.2.
Before calibrating, be certain that the sensing window is clean *(see cleaning instructions, section 5.8)*.

Chlorophyll

This procedure calibrates Chlorophyll RFU or Chlorophyll µg/L. If the user has both units selected, then this procedure must be performed twice, once for each unit, to completely calibrate the parameter.

For 2-point calibrations, one standard must be clear water (0 µg/L), and this standard must be calibrated first. The other standard should be in the range of a known chlorophyll content of the water to be monitored. Two general types of standards can be used: (a) phytoplankton suspensions of known chlorophyll content, determined by employing the extractive analysis procedure described in *Standard Methods for the Examination of Water and Wastewater*, or by analyzing the suspension *in situ* using a laboratory fluorometer, and (b) dye solutions whose fluorescence can be correlated to that of chlorophyll.

For option (b), we recommend using a 625 µg/L Rhodamine WT dye solution *(for detailed instructions, see the end of this section)*, and the solution is used in the calibration steps below.

µg/L – 1- or 2-point

This procedure will zero your fluorescence sensor and use the default sensitivity for calculation of chlorophyll concentration in µg/L, allowing quick and easy fluorescence measurements that are only semi-quantitative with regard to chlorophyll. However, the readings will reflect changes in chlorophyll from site to site, or over time at a single site.

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select BGA-PC/Chlor, then select Chl µg/L. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 66 for second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Next place the sensors in the Rhodamine WT standard. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.
Rinse the sonde in tap or purified water and dry the sonde.

RFU – 1- or 2-point

RFU is a percent full scale output; it outputs relative fluorescence from 0-100%. This calibration procedure is recommended if you are also using grab samples to post-calibrate *in vivo* chlorophyll readings.

The sonde will report relative values of fluorescence in the sample being measured. These values can be converted into actual chlorophyll concentrations in µg/L by using a post-calibration procedure, after the chlorophyll content of grab-samples taken during a deployment has been analyzed in a laboratory. This determination can involve conducting the extractive analysis procedure described for chlorophyll in *Methods for the Examination of Water and Wastewater* or by carrying out an *in situ* measurement of chlorophyll using a commercial benchtop fluorometer.

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select BGA-PC/Chlor, then select Chl RFU. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 16.4 for second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Next place the sensors in the Rhodamine WT standard. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

Rinse the sonde in tap or purified water and dry the sonde.

Blue-green Algae Phycocyanin

This procedure calibrates BGA RFU or BGA µg/L. If the user has both units selected, then this procedure must be performed twice, once for each unit, to completely calibrate the parameter.

For the 2-point calibration, one of the standards must be clear water (0 µg/L), and this standard must be calibrated first. The other standard should be in the range of the suspected BGA-PC content at the environmental site. Two general types of standards can be used: (a) phytoplankton suspensions of known BGA-PC content, and (b) dye solutions whose fluorescence can be correlated to that of BGA-PC. The user is responsible for determining the BGA-PC content of algal suspensions by using standard cell counting techniques.

For option (b), we recommend using a 625 µg/L Rhodamine WT dye solution *(for detailed instructions, see the end of this section)*, and the solution is used in the calibration steps below.

µg/L – 1- or 2-point

This procedure will zero your fluorescence sensor and use the default sensitivity for calculation of phycocyanin-containing BGA in µg/L, allowing quick and easy fluorescence measurements that are only semi-quantitative with regard to BGA-PC. However, the readings will reflect changes in BGA-PC from site to site, or over time at a single site.

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select BGA-PC/Chlor, then select BGA µg/L. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 16 for second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Next place the sensors in the Rhodamine WT standard. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.
Rinse the sonde in tap or purified water and dry the sonde.

RFU – 1- or 2-point
RFU is a percent full scale output; it outputs relative fluorescence from 0-100%. This calibration procedure is recommended if you are also using grab samples to post-calibrate *in vivo* algae readings.

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select BGA-PC/Chlor, then select BGA RFU. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 16 for second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Next place the sensors in the Rhodamine WT standard. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

Rinse the sonde in tap or purified water and dry the sonde.

Blue-green Algae Phycoerythrin

This procedure calibrates BGA RFU or BGA µg/L. If the user has both units selected, then this procedure must be performed twice, once for each unit, to completely calibrate the parameter.

For the 2-point calibration, one of the standards must be clear water (0 µg/L), and this standard must be calibrated first. The other standard should be in the range of the suspected BGA-PE content at the environmental site. Two general types of standards can be used: (a) phytoplankton suspensions of known BGA-PE content, and (b) dye solutions whose fluorescence can be correlated to that of BGA-PE. The user is responsible for determining the BGA-PE content of algal suspensions by using standard cell counting techniques.

For option (b), we recommend using a 25 µg/L Rhodamine WT dye solution *(for detailed instructions, see the end of this section)*, and the solution is used in the calibration steps below.

µg/L – 1- or 2-point

This procedure will zero your fluorescence sensor and use the default sensitivity for calculation of phycoerythrin-containing BGA in µg/L, allowing quick and easy fluorescence measurements that are only semi-quantitative with regard to BGA-PE. However, the readings will reflect changes in BGA-PE from site to site, or over time at a single site.

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water. In the Calibrate menu, select BGA-PE/Chlor, then select BGA µg/L. Select either a 1- or 2-point calibration. When using Rhodamine WT enter 0 for the first standard value and 126 for the second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Next place the sensors in the Rhodamine WT standard. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu. Rinse the sonde in tap or purified water and dry the sonde.

RFU – 1- or 2-point

RFU is a percent full scale output; it outputs relative fluorescence from 0-100%. This calibration procedure is recommended if you are also using grab samples to post-calibrate *in vivo* algae readings.

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water. In the Calibrate menu, select BGA-PE/Chlor, then select BGA RFU. Select either a 1- or 2-point calibration. When using Rhodamine WT enter 0 for the first standard value and 45 for the second standard value.

Click Start Calibration. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Next place the sensors in the Rhodamine WT standard. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu. Rinse the sonde in tap or purified water and dry the sonde.

Effect of temperature on fluorescence

The intensity of the fluorescence of many dyes shows an inverse relationship with temperature. This effect must be accounted for when calibrating the EXO Total-Algae sensor with Rhodamine WT. Enter the µg/L or RFU value from the table below that corresponds to the temperature of the standard.

Temp (°C)	RFU Chl	µg/L Chl	RFU BGA-PC	µg/L BGA-PC	RFU BGA-PE	µg/L BGA-PE
30	14.0	56.5	11.4	11.4	37.3	104.0
28	14.6	58.7	13.1	13.1	39.1	109.0
26	15.2	61.3	14.1	14.1	41.0	115.0
24	15.8	63.5	15.0	15.0	43.0	120.0
22	16.4	66	16.0	16.0	45.0	126.0
20	17.0	68.4	17.1	17.1	47.0	132.0
18	17.6	70.8	17.5	17.5	49.2	138.0
16	18.3	73.5	19.1	19.1	51.4	144.0
14	18.9	76	20.1	20.1	53.6	150.0
12	19.5	78.6	21.2	21.2	55.9	157.0
10	20.2	81.2	22.2	22.2	58.2	163.0
8	20.8	83.8	22.6	22.6	60.6	170.0

Rhodamine WT Dye Solution for Total Algae Sensor

⚠ **WARNING:** Read and follow all the safety instructions and MSDS documentation supplied with the dye before proceeding. Remember that only trained personnel should handle chemicals.

Preparation

Use the following procedure to prepare a Rhodamine WT solution for use as a sensor stability check reagent for the EXO Total Algae (Chlorophyll and Blue-green Algae) sensor:

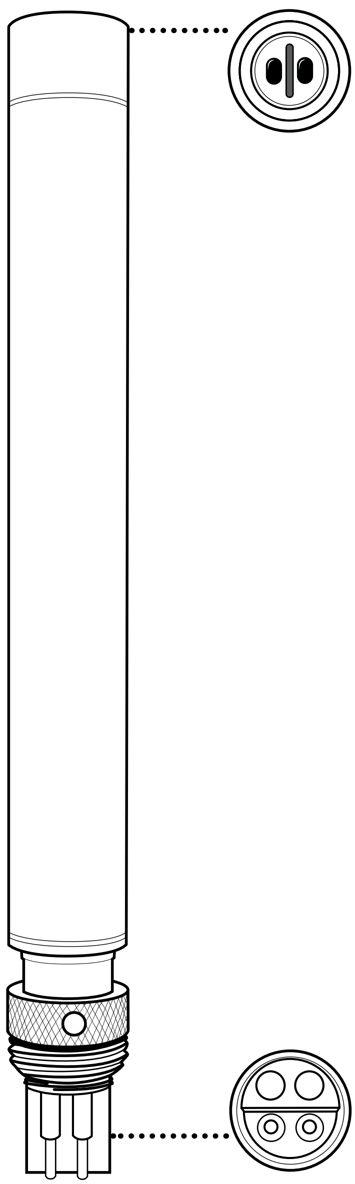
1. Purchase Rhodamine WT dye in solution form, which can vary somewhat in nominal concentration. Recommended supplier for a solution that is approximately 2.5% in Rhodamine WT:
   Fluorescent FWT Red Dye (item #106023)
   Kingscote Chemicals
   3334 South Tech Blvd., Miamisburg, OH 45342 USA
   1-800-394-0678
2. Accurately transfer 5.0 mL of the Rhodamine WT solution into a 1000 mL volumetric flask. Fill the flask to the volumetric mark with deionized or distilled water and mix well to produce a solution that is approximately 125 mg/L of Rhodamine WT. Transfer this standard to a glass bottle and retain it for future use.
3. Accurately transfer 5.0 mL of the solution prepared in the above step to a 1000 mL volumetric flask and then fill the flask to the volumetric mark with deionized or distilled water. Mix well to obtain a solution, which is 0.625 mg/L in water (a 200:1 dilution of the concentrated solution).
4. For BGA-PE calibration, accurately transfer 0.2 mL of the 125 mg/L solution prepared in step 2 to a 1000 mL volumetric flask and then fill the flask to the volumetric mark with deionized or distilled water. Mix well to obtain a solution that is 25 µg/L or 0.025 mg/L of Rhodamine WT.
5. Store the concentrated standard solution in a glass bottle in a refrigerator to retard decomposition. The dilute standard prepared in the previous step should be used within 24 hours of its preparation.

Discard the used standard. When Rhodamine standards are required in the future, perform another dilution of the concentrated Rhodamine WT solution after warming it to ambient temperature.

4.22 Turbidity Sensor Overview

Turbidity is the indirect measurement of the suspended solid concentration in water and is typically determined by shining a light beam into the sample solution and then measuring the light that is scattered off of the particles which are present. The suspended solid concentration is an important water quality factor and is a fundamental measure of environmental change. The source of the suspended solids varies in nature (examples include silt, clay, sand, algae, organic matter) but all particles will impact the light transmittance and result in a turbidity signal.

The EXO Turbidity sensor employs a near-infrared light source and detects scattering at 90 degrees of the incident light beam. According to ASTM D7315 method, this type of turbidity sensor has been characterized as a nephelometric near-IR turbidimeter, non-ratiometric[1]. This method calls for this sensor type to report values in formazin nephelometric units (FNU). FNU is the default calibration unit for the EXO sensor but users are able to change calibration units to nephelometric turbidity units (NTU), raw sensor signal (RAW), or total suspended solids (TSS) assuming the user enters the appropriate correlation data.



599101-01

The RAW value is a value unaffected by user calibrations and provides a range from 0-100, representing the per cent of full scale that the sensor detects in a sample.

While all turbidity sensors will read consistently in formazin, other calibration solutions and field readings will vary between different models of turbidity sensors. These differences are thought to be a result of differing optical components and geometries and the resulting detection of varying suspended sediment characteristics. This effect is inherent in the nature of every turbidity sensor, and as a result readings between different model turbidity sensors are likely to show different field values even after calibration in the same standards.

Specifications

Default Units	FNU
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 4000 FNU
Accuracy	0-999 FNU: 0.3 FNU or ±2% of reading, whichever is greater; 1000-4000 FNU: ±5% of reading[2]
Response	T63<2 sec
Resolution	0-999 FNU: 0.01 FNU 1000-4000 FNU: 0.1 FNU
Sensor Type	Optical, 90° scatter
Optics: Excitation	 860±15 nm

For long-term, ***in situ*** continuous monitoring of turbidity, the EXO2 sonde has a wiper to clean the turbidity sensor to avoid sensor fouling and maintain accuracy.

[1] *ASTM D7315-07a "Test Method for Determination of Turbidity Above 1 Turbidity Unit (TU) in Static Mode."*

[2] *Performance based on 3-point calibration done with YSI AMCO-AEPA standards of 0, 124, and 1010 FNU. The same type of standard must be used for all calibration points.*

4.23 Turbidity Calibration

Before calibrating, be certain that the probe is clean and free of debris. Solid particles, particularly those carried over from past deployments, will contaminate the standards during your calibration protocol and cause either calibration errors and/or inaccurate field data *(cleaning instructions, section 6.13)*. Use a clean, spare sonde guard. *Also, review the basic calibration description in section 4.2.*

For proper calibration, you must use standards that have been prepared according to details in *Standard Methods for the Treatment of Water and Wastewater* (Section 2130 B). Acceptable standards include (a) formazin prepared according to *Standard Methods,* especially for calibration points greater than 1010; (b) dilutions of 4000 NTU formazin concentrate purchased from Hach; (c) Hach StablCal™ standards in various NTU denominations; and (d) AMCO-AEPA standards prepared specifically for the EXO turbidity sensor by the manufacturer *(see table next page)*.

NOTE: *The use of standards other than those mentioned above will result in calibration errors and inaccurate field readings.* It is important to use the same type of standard for all calpoints. (i.e. do not mix formazine and AMCO-AEPA standard for different points in a multi-point cal).

2-point

Pour the correct amount of 0 NTU standard (clear deionized or distilled water) into the calibration cup. Immerse the probe end of the sonde into the water.

In the Calibrate menu, select Turbidity, then select Turbidity FNU.

Click 2 Point for the Calibration Points. Enter 0 FNU for first standard value and 124 FNU for second standard value. (0 must be calibrated first.)

- If the water to be evaluated is known to be low in turbidity, an appropriate choice of standards might be 0 and 12.4. However, for general purpose measurements an appropriate choice of standards is usually 0 and 124.
- If deploying with a copper anti-fouling guard, use this guard during calibration to calibrate for any offset; input 0.5 or 1 instead of 0. The guard must be clean and free of sediment and debris.

Click Start Calibration. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

- If the temperature of your field site is substantially different from the lab temperature, allow the sensor to sample for 3-5 minutes at each calibration point before accepting it. This step ensures the best possible temperature compensation when deployed.

Next place the sensors in the second calibration standard. Click Proceed on the pop-up window. Observe the readings under Current and Pending data points. While stabilizing, click the Wipe Sensors button to activate the wiper to remove any bubbles. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

Rinse the sonde in tap or purified water and dry the sonde.

3-point

Select the 3-point calibration option for maximum accuracy over a wider range. As for the 2-point procedure, the first standard must be 0 FNU. Because of the linearity characteristics of the sensors, we recommend that the other two standards have turbidity values of 124 and 1010 FNU. It is important to use a consistent type of standard for all calibration points. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to proceed to an additional solution to complete the
3-point procedure.

Calibration Limits

Due to the non-linear response of the turbidity sensor, calibration ranges may be limited. A 1-, 2-, or 3-point calibration may be completed, using the following limits:

First Point	Second Point	Thrid Point
0-1 FNU (or NTU)	5-199 FNU (or NTU)	200-4200 FNU (or NTU)

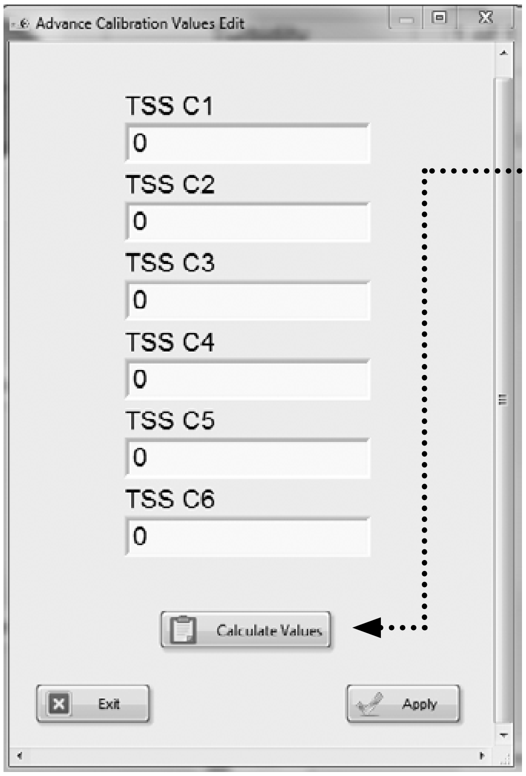
Calibration standards

The following standards are available for the EXO turbidity sensor:

608000	0 NTU (all turbidity sensors); 1 gallon
607200	12.4 FNU (EXO); 12.7 NTU (YSI 6-Series); 1 gallon
607300	124 FNU (EXO); 126 NTU (YSI 6-Series); 1 gallon
607400	1010 FNU (EXO); 1000 NTU (YSI 6-Series); 1 gallon

4.24 Total Suspended Solids Calculation

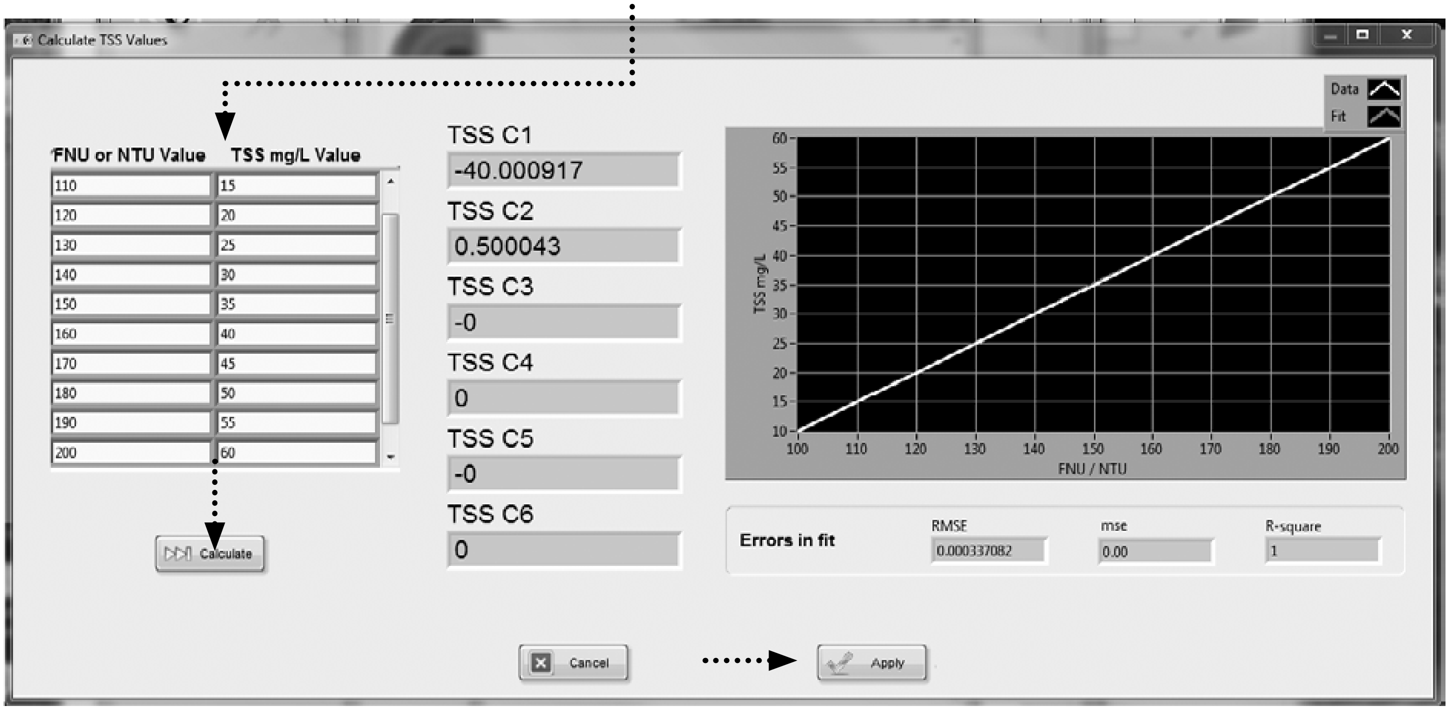
Please follow the process below to calculate TSS.
NOTE: *This process cannot be performed via the EXO handheld. It must be done using desktop KOR.*

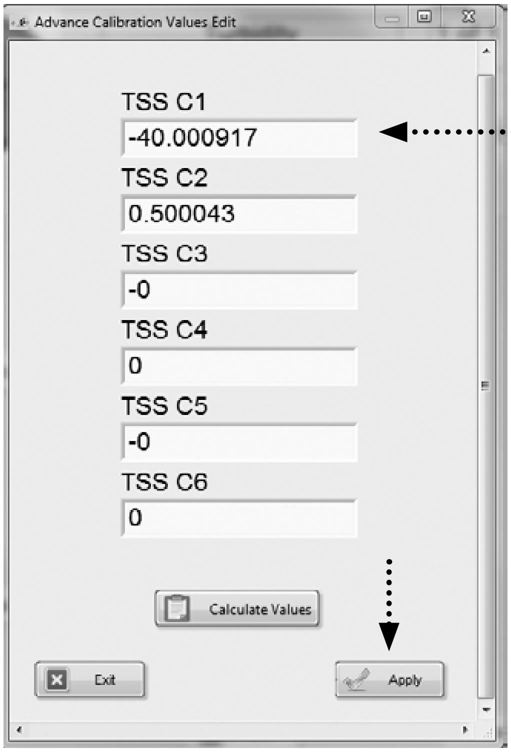


Step 1
Make sure the turbidity probe is installed in the sonde.

Step 2
Open KOR Desktop, connect to the sonde, and navigate to Ca librate>Turbidity>Advanced>Edit and click Calculate Values.

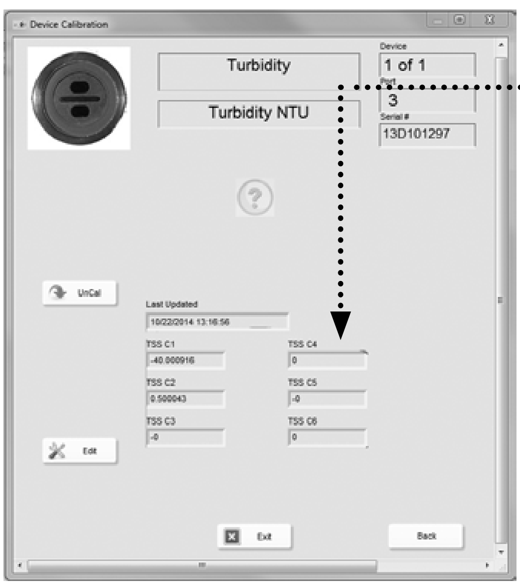
Step 3
Type in the turbidity NTU/FNU values and the corresponding TSS values obtained through lab analysis into the table on the left. Click Calculate. You will see the TSS coefficients populate and a graph generated. Click Apply.





Step 4
The values will appear on the previous screen.
Click Apply again.

Step 5
The message below will be displayed and the coefficients will be applied to the turbidity probe. Click OK.



Step 6
The coefficients will be displayed in the Advanced menu of the turbidity probe calibration. Click Exit or Back.

Step 7
TSS values will now be displayed on the Dashboard based on the values entered via KOR and saved to the turbidity probe.

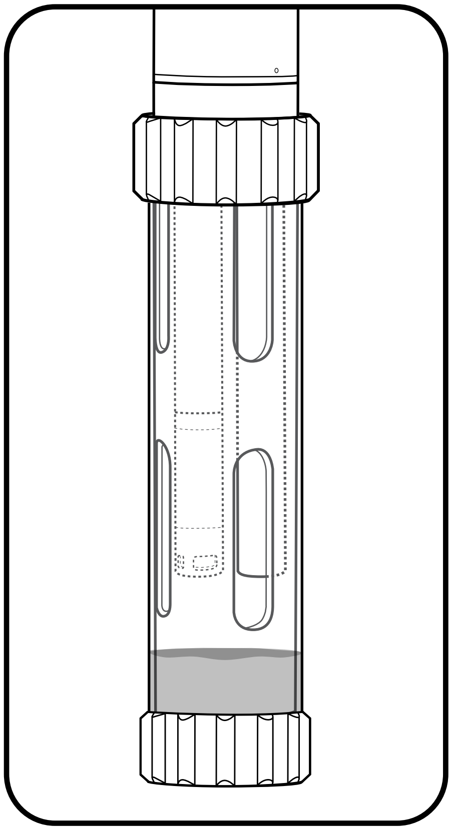
Step 8
If the TSS parameter is not displayed on the Dashboard, go to Options>Units>Turb to activate the TSS parameter. Click Apply and return to the Dashboard..

Step 9
The units to display TSS will need to be activated separately in the EXO handheld following the same path mentioned above.

Section 5
Maintenance

5.1 Sonde Storage

Proper sonde storage helps to ensure proper sonde operation. To keep sondes in their best working order, users must follow these instructions. This section will identify storage as "long-term" or "short-term." Long-term denotes storage during times of long inactivity (over winter, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.).



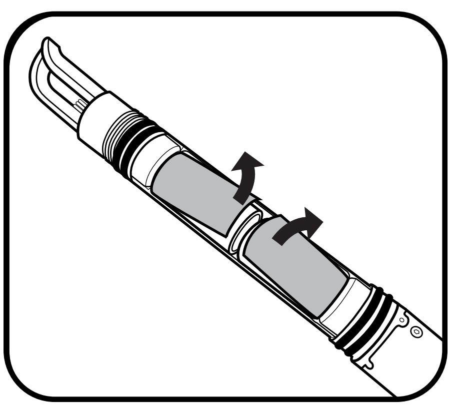
1 Short-term storage

For interim storage, users should keep sensors moist, but not submerged; submersion during storage may produce sensor drift. Users should aim for a storage environment of water-saturated air (100% humidity) for the sensors.

Place approximately 0.5 in (1 cm) of water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup. Then place the sonde with all of its sensors into the cup and close it tightly to prevent evaporation. Users can also use a moist sponge to create a humid environment.

Ensure that unused sensor ports are properly protected with port plugs. The sonde itself should be stored in dry air.

To protect the cable connector, either leave the cable installed on the connector, or install the port plug. This is especially important for sondes with level; users should always keep the cable connector of vented sondes dry. (*See section 6.5*)



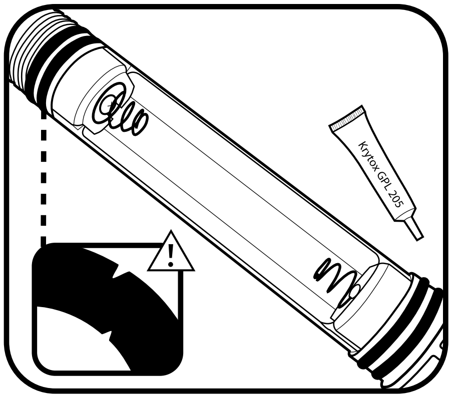
2 Long-term storage

Store all removed sensors according to the specific instructions in their sensor storage section. Plug all open ports, and store the sonde according the above instructions for short-term sonde storage.

NOTICE: Always remove batteries from sondes during long periods of inactivity to prevent potentially harmful battery leaks.

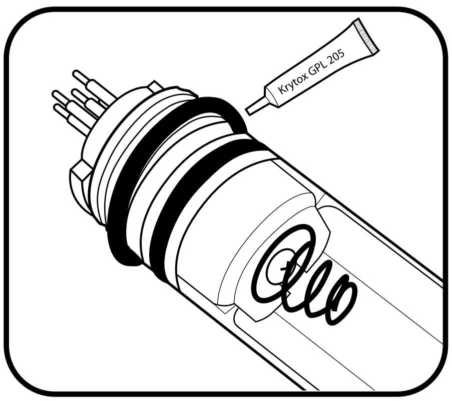
5.2 Sonde Maintenance

Like all precision equipment, EXO sondes work most reliably when users maintain them properly. A proper inspection and cleaning can prevent several issues, including leaks. When performing general maintenance on the sonde, also check this manual's depth and connector sections. Use only the recommended materials to service instruments. Each sonde comes with a maintenance kit, including proper lubricants and replacement o-rings. Users can order replacement o-ring kits (599680 or 599681) or tool kit (599594) from the manufacturer or an authorized distributor.



1 Inspect and service o-rings

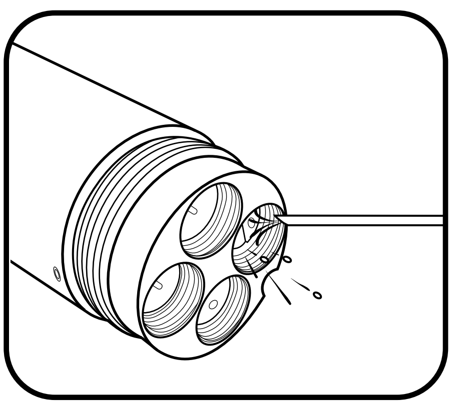
User-serviceable o-rings are located in the EXO sonde battery compartments. Perform a thorough visual inspection of o-rings each time they are exposed. Carefully look for grit, hair, etc. on the o-ring and mating surfaces and wipe away any contamination with a lint-free cloth. Without removing them from their grooves, *lightly* grease each o-ring with Krytox. Replace any damaged o-rings.



2 Replace o-rings

If the above inspection reveals a damaged (split, cracked, or misshapen) o-ring, remove it. Wipe the groove clean with alcohol and a lint-free cloth. Grease the o-ring by drawing it between your *lightly* greased thumb and index fingers. Place the o-ring in its groove, being careful to not roll or twist it, and lightly grease the surface. Inspect the o-ring for contamination.

NOTICE: Do not apply excess grease to the o-rings. This can cause contamination and seal failure.



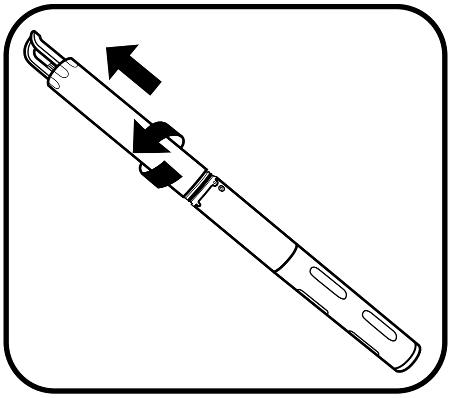
3 Inspect, clean, and grease ports

Visually inspect each port for contamination (grit, hair, etc.). Should the user detect contamination, remove it with a blast of compressed air. When the port's rubber appears dry, lightly grease the sensor connector before insertion.

NOTICE: Never insert solid objects into the sonde ports. This could permanently damage the connectors.

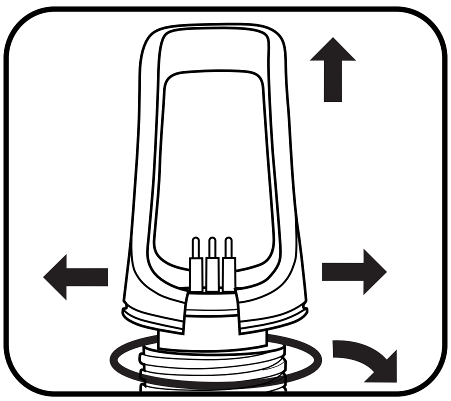
5.3 Sonde
Replace EXO1 Bail

Sonde bails provide users with a handle for convenient transport and an attachment point for cable strain reliefs. If an EXO1 bail breaks due to impact or standard wear and tear throughout the life of the sonde, a user can easily replace it. We also recommend attaching the cable's strain relief mechanism to the bail.



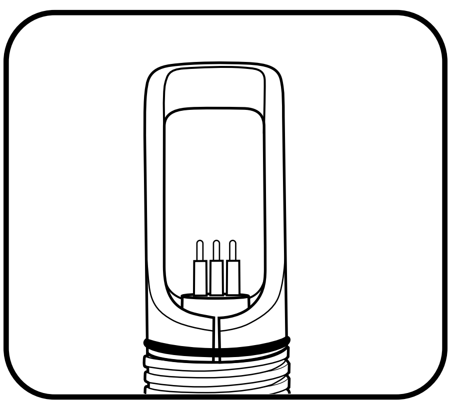
1 Remove battery cover

Twist the battery cover counterclockwise until free. Then slide off the battery cover.



2 Remove bail

Spread the sides of the bail away from the connector, pull the bail over the posts on top of the sonde, and remove the o-ring from its groove and discard.

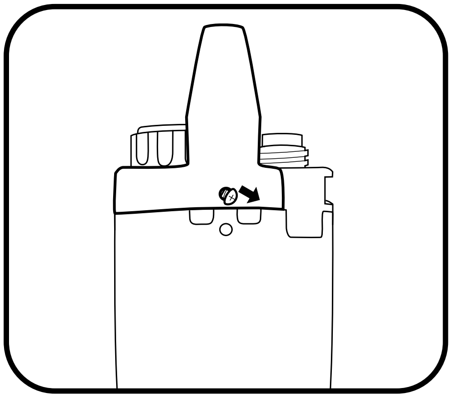


3 Install new bail

Install a new o-ring in the groove at the base of the bail. Then carefully spread the bail open and seat its sockets over the posts around the connector.

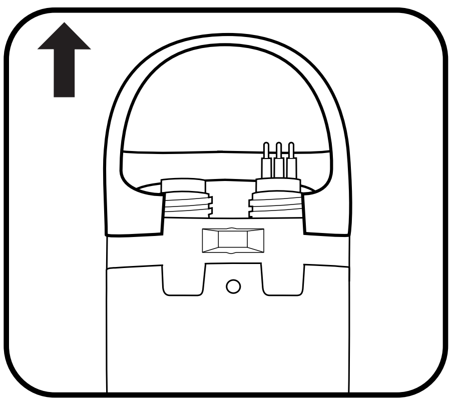
5.4 Sonde
Replace EXO2 Bail

Sonde bails provide users with a handle for convenient transport and an attachment point for cable strain reliefs. If an EXO2 bail breaks due to impact or standard wear and tear throughout the life of the sonde, a user can easily replace it. We also recommend attaching the cable's strain relief mechanism to the bail.

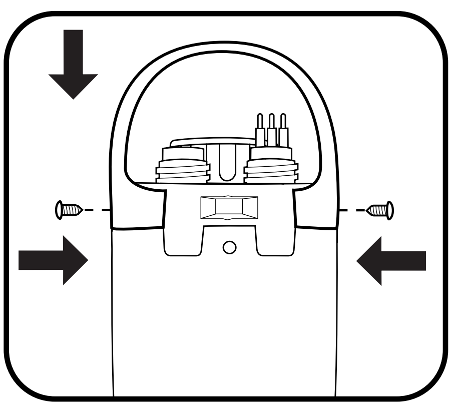


1 Remove bail

Use a small screwdriver to remove two screws on the sides of the bail.



Once screws are removed, lift the bail off the sonde.

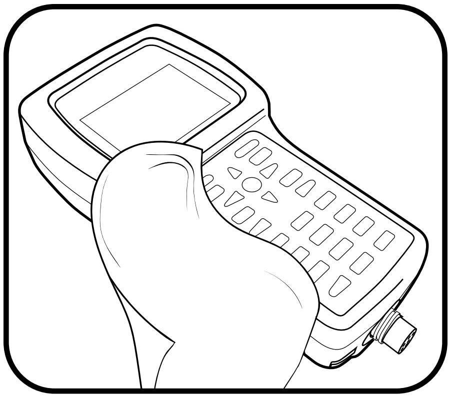


2 Install new bail

Place the new bail onto the sonde, aligning holes for the screws. With one side of the bail aligned, push on the other side to snap it into place. Use a small screwdriver to insert two screws on the sides of the bail. Tighten until snug.

5.5 Classic Handheld Maintenance and Storage

EXO Handhelds (HH) are rugged field instruments that are tested to a rating of IP-67 in the factory. Follow the instructions below for the most reliable performance from the HH. This section will identify storage as “long-term” or “short-term.” Long-term denotes storage during times of long inactivity (over winter, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.).

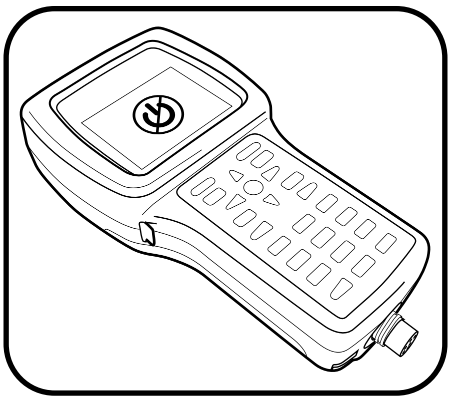


1 Clean handheld

If the HH’s USB connector is contaminated, rinse it with clean water and dry it.

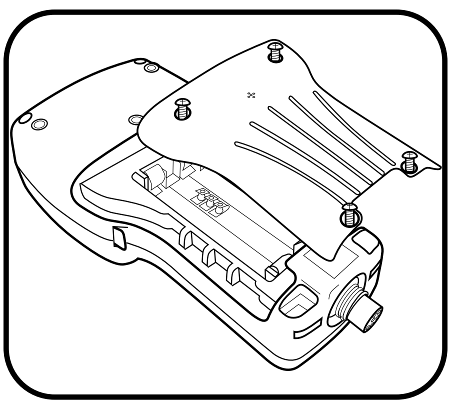
To clean the HH’s cable connector, follow directions in section 5.19 for Connector Maintenance.

Wipe clean the HH’s keypad, lens, and polymer case with a cloth soaked in clean water and a few drops of a dishwashing liquid that contains a degreaser. Take care not to scratch the lens.



2 Short-term storage

Keep the HH in a safe storage location and power it down by pressing and holding the power button for more than three seconds. Pressing the power button for less than three seconds does not entirely power down the instrument (Sleep mode) and may cause unnecessary battery drain.



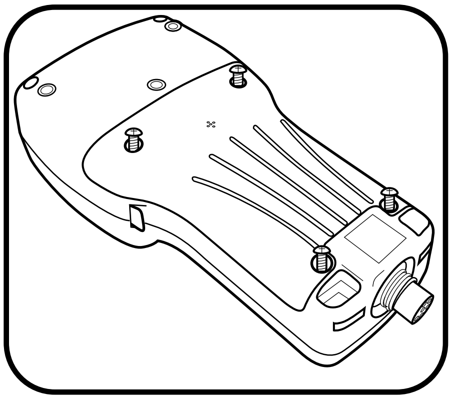
3 Long-term storage

Keep the HH in a safe location and remove the batteries (and reinstall the battery compartment panel) to prevent potentially harmful battery leaks.

NOTE: *If the HH is stored for more than several days without batteries, the GPS will take longer to obtain a location fix.*

5.6 Classic Handheld
Install or Replace Batteries

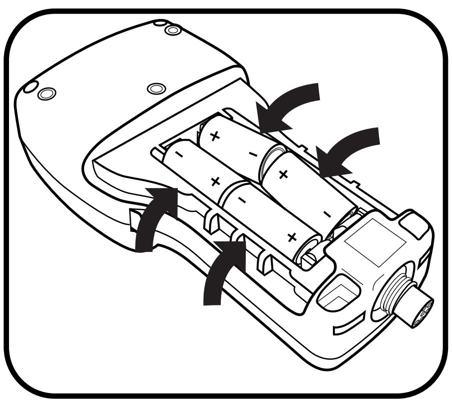
The EXO Handheld (HHs) uses four (4) C-cell alkaline batteries as a power source. Alternatively, a rechargeable Li-Ion battery pack is an available option (599622). Users can extend battery life by putting the HH in "Sleep" mode, when convenient, by pressing and holding the power button for less than three seconds. 1.5V Rechargeable Nickel Metal Hydride (NiMH) batteries can also be used. Battery life varies depending on GPS and Bluetooth wireless use. We recommend battery capacity of at least 5000 milliamp hours. *Do not use Ni-Cad rechargeable batteries in the Handheld.*



1 Remove battery cover panel

The battery cover panel is located on the back of the HH. To remove the panel, unscrew (counter-clockwise) the four screws with a flat or Phillips head screwdriver.

NOTE: *The retaining screws are captured into this panel and are not independently removable. If replacement is necessary, replace the entire assembly.*



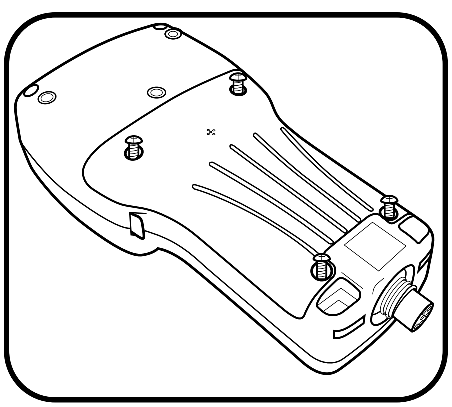
2 Insert/replace batteries

NOTICE: Do not use 3.6V Li batteries in the handheld.
Damage to the circuit board is not covered under warranty.

Remove the old batteries and dispose of them according to local ordinances and regulations. Install the new batteries between the battery clips with their polarity (+/-) oriented as shown on the bottom of the battery compartment.

If you use your own rechargeable batteries, they cannot be charged inside the handheld; they should be charged outside the handheld.

NOTE: *A rechargeable Li-Ion battery pack specifically for Classic EXO Handhelds is available from YSI (599622).*



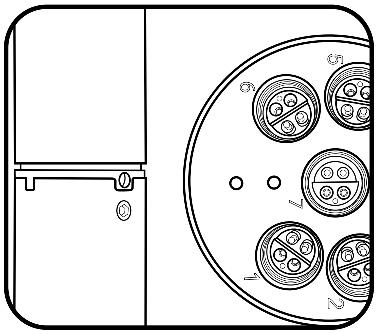
3 Reinstall battery cover panel

Ensure that the rubber battery cover gasket is seated properly, then replace the cover onto the back of the HH. Tighten the four retaining screws back into their holes.

NOTICE: Overtightening of the screws is likely to cause damage and require replacement of the battery pack.

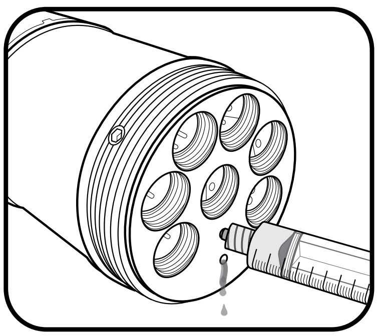
5.7 Depth and Level Sensor Maintenance and Storage

EXO depth and level sensors access the water through small holes (ports) located in the sonde body or bulkhead. Although users cannot access them directly, proper storage maintenance will help to ensure reliable operation. Depth sensors can be stored dry, in water-saturated air, or submerged in clean water. However, be sure that the water does not contain solutions that are corrosive. This can cause damage to the sensor's strain gauge.



1 Locate depth ports

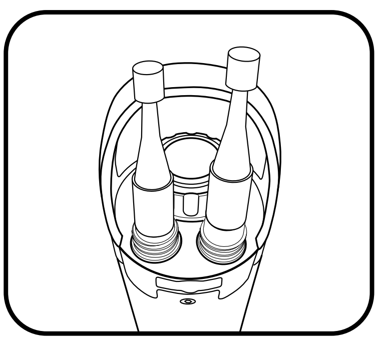
The two EXO1 depth ports are located in the yellow-plastic section between the bulkhead tube (labeled area) and the blue plastic battery cover. The EXO2 depth ports are located on the metal bulkhead face itself, in the largest open area between ports.



2 Clean depth ports

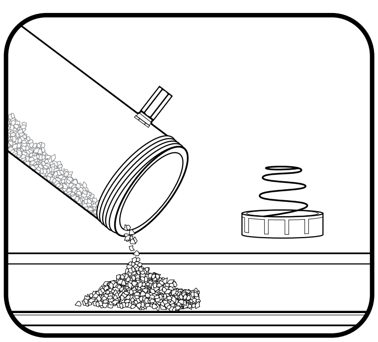
Although users cannot directly access the depth/level sensors, they should periodically clean them with the syringe included in the EXO tool kit (599594). Fill the syringe with clean water and gently force water through one of the ports. Ensure that water flows from the other hole. Continue flushing the port until the water comes out clean.

NOTICE: Do not insert objects in the EXO2 depth ports, as this may cause damage to the transducer not covered under the warranty.



3 Level sensor storage

Users can store these sensors either dry or submerged in clean water. However, regardless of storage method or length, ensure the vent tube remains dry. Always attach the port plug to the cable connector, or leave the cable installed with a cap over the desiccant's vent.

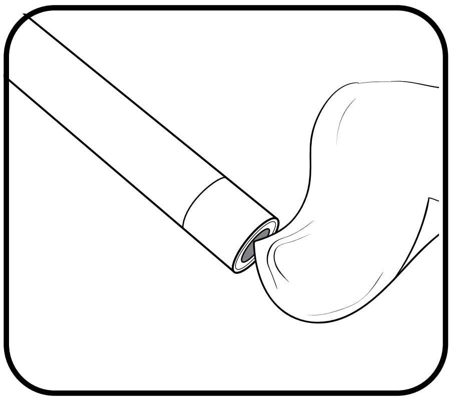


4 Level desiccant maintenance

Active desiccant is blue; saturated desiccant is pink. When the desiccant closest to the sonde begins to turn pink, you should replace (YSI 6108), or regenerate (YSI 6109) the desiccant cartridge. To regenerate desiccant, remove it from the cartridge and heat it for one hour at 200°C (about 400°F); then cool it in an airtight container before refilling. Also heat the felt filters at 100°C (about 200°F) for 30 minutes. The desiccant will turn blue following a successful recharge.

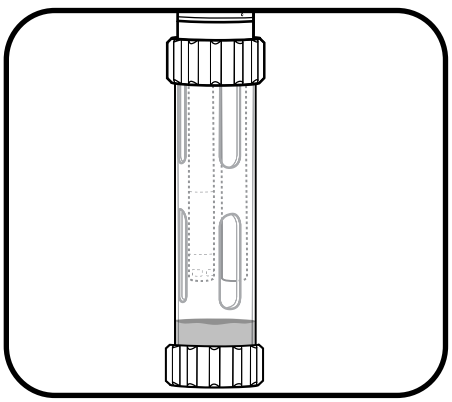
5.8 Standard Optical Sensor Maintenance and Storage

Standard optical sensors include Turbidity, Total Algae, and fDOM sensors; these optical sensors are very low maintenance. This section identifies storage as "long-term" or "short-term." Long-term denotes storage during times of long inactivity (over winter, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.). *Maintain connectors as instructed in section 5.19.*



1 Clean sensing window

Turbidity, Total Algae, and fDOM require minimal maintenance. Users should periodically inspect the optical surface at the tip of the sensor and wipe it clean with a non-abrasive, lint-free cloth if necessary. As much as possible, prevent scratches and damage to the sensing window.



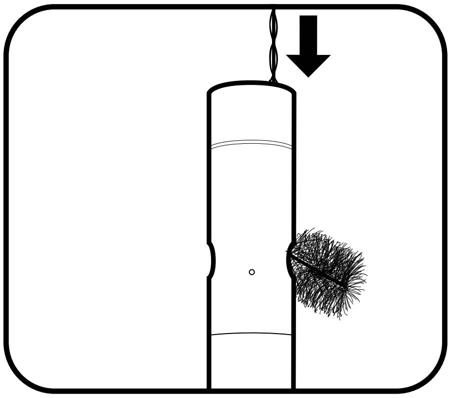
2 Long- and short-term storage

Turbidity, Total Algae, and fDOM require minimal precautions. Users can either remove the sensors or leave them installed in the sonde for long- and short-term storage. If left installed on the sonde, follow guidelines for sonde storage. If users remove them from the sonde, the sensors may be stored in dry air in their shipping cap (to protect against physical damage).

NOTICE: Do not store any sensor in quinine sulfate solution.

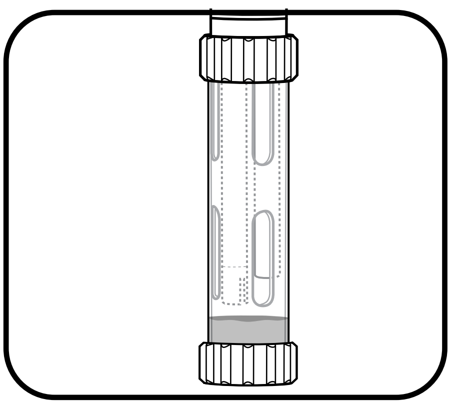
5.9 Conductivity/Temp Sensor Maintenance and Storage

EXO conductivity and temperature (CT) sensors require little maintenance or special attention for storage. As much as possible, prevent impact to the sensor's exposed thermistor. This section will identify storage as "long-term" or "short-term." Long-term denotes storage during times of long inactivity (over-wintering, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.). *Maintain connectors as instructed in section 5.19.*



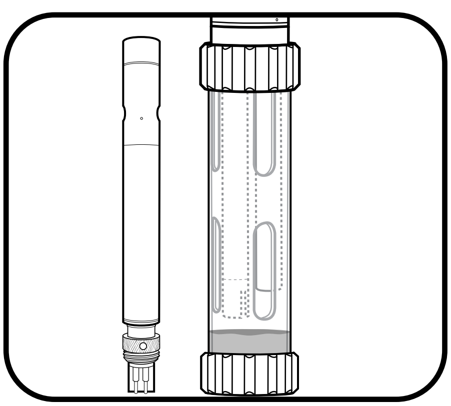
1 Clean electrode channels

The only parts of the CT sensor that require special maintenance are the channels leading to the internal electrodes. Dip the sensor's cleaning brush (included in the sonde maintenance kit) in clean water, insert at top of channels, and sweep the channels 15-20 times. If deposits have formed on the electrodes, use a mild solution of dish soap and water to brush the channels. If necessary, soak in white vinegar to aid cleaning. Rinse the channels with clean water following the sweepings or soak.



2 Short-term storage

When in regular field use, the sensor should remain installed on the sonde in an environment of water-saturated air. Place approximately 0.5 in (1 cm) of any water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup. Insert the sonde and sensor into the cup and screw it on tightly to prevent evaporation. (*More information in "Short-Term Sonde Storage" section 5.1.*)

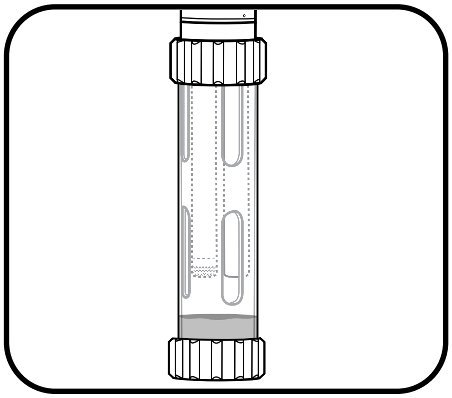


3 Long-term storage

Store the sensors either dry or wet, installed on the sonde or detached. However, before storage, perform the recommended maintenance (above) to ensure the sensor is in good working order for the next deployment season. If the sensor is submerged for storage, ensure that the liquid is not corrosive.

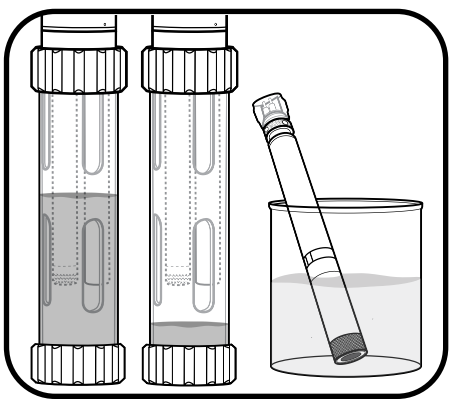
5.10 Dissolved Oxygen Sensor Storage

EXO DO sensors require separate storage instructions from other optical sensors due to their sensing membranes. This section will identify storage as "long-term" or "short-term." Long-term denotes storage during times of long inactivity (over winter, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.).



1 Short-term storage

When in regular field use, the ODO sensor should remain installed on the sonde. Place approximately 0.5 in (1 cm) of any water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup. Insert the sonde and sensor into the cup and screw it on tightly to prevent evaporation. (*More information in "Short-Term Sonde Storage" section 5.1*.)



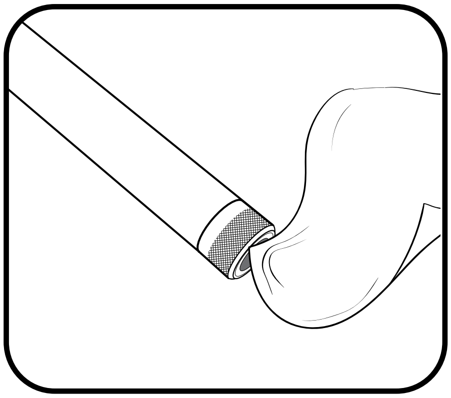
2 Long-term storage

Leave the sensor installed in the sonde, and submerge it in clean water in the calibration cup. Screw the cup on tightly to prevent evaporation. Users may also store the ODO sensor by itself in two ways. One, submerge the sensing end of the sensor in a container of water; occasionally check the level of the water to ensure that it does not evaporate. Two, store the sensor in water-saturated air.

We do not recommend storing the sensor with the connector end unmated or exposed. If unmated, cover with plastic connector cap.

5.11 Dissolved Oxygen Sensor Maintenance and Rehydration

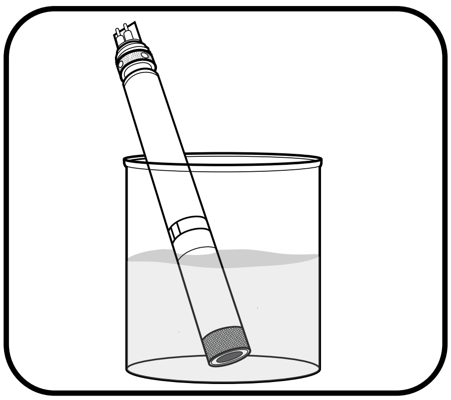
EXO optical Dissolved Oxygen (DO) sensors require unique maintenance instructions due to their sensing membranes. Users should routinely perform these instructions in order to achieve the highest levels of sensor accuracy. DO sensor caps have a typical life of 12 months. After this point, users should replace the DO membrane cap. As caps age, accuracy is reduced, ambient light rejection suffers, and response times can be affected. *Maintain connectors as instructed in section 5.19.*



1 DO membrane maintenance

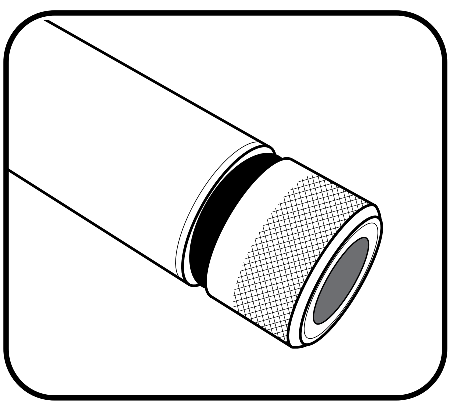
Users should periodically inspect the optical surface at the tip of the sensor and wipe it clean with a non-abrasive, lint-free cloth if necessary. Never use organic solvents to clean an EXO DO sensor.

As much as possible, prevent scratches and damage to the sapphire sensing window. Avoid getting fingerprints on the window. If necessary, wash with warm water and dish soap and rinse with DI water.



2 Sensor rehydration

Users should always store DO sensors in a moist or wet environment in order to prevent sensor drift. However, should DO sensors be left in dry air for longer than eight hours, they must be rehydrated. To rehydrate, soak the DO sensor cap in warm (room temperature) tap water for approximately 24 hours. Following this soak, calibrate the sensor and store it in a moist environment.

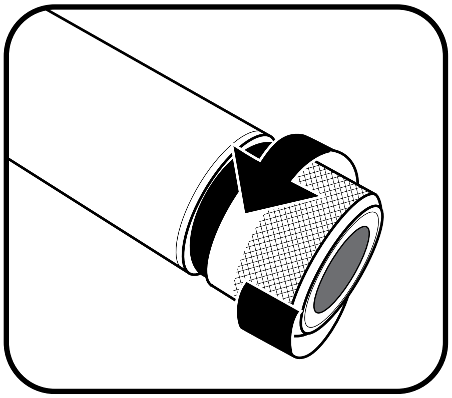


3 Sensor cap replacement

Due to restrictions inherent to all DO sensors, DO sensor caps have a typical life of 12 months. After this point, users should replace the DO membrane cap. To replace this cap, follow the directions in the "Sensor Cap Replacement" section found on the next page.

5.12 Dissolved Oxygen Sensor
Sensor Cap Replacement

Follow these instructions to replace the sensor cap on an EXO optical dissolved oxygen sensor once the previous cap has exhausted its usable life (typically about one year). The DO sensor cap (599110-01) is shipped in a humidified container, and should be stored in a 100% humid environment. If the sensor cap dries completely, follow instructions to rehydrate it.



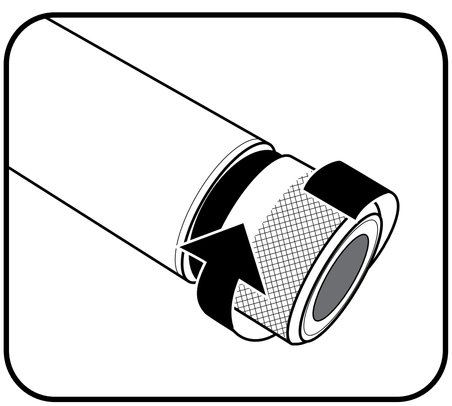
1 Remove current sensor cap

Rotate the sensor cap with your fingers counterclockwise until free.

If possible, do not use any tools during this process. However, should the cap be immovable after use, carefully twist the sensor cap with pliers until it breaks loose. **NOTICE:** Do not use pliers on the sensor body, and take great care not to damage the sensor threads.

2 Replace o-ring

Without using tools, remove the previous o-ring (pinch the o-ring out, then roll it upwards over the threads) and discard it. Visually inspect the new o-ring for nicks, tears, contaminants, or particles; discard damaged o-rings. Without twisting it, carefully install the new o-ring over the threads and into its groove, then apply a thin coat of Krytox lubricant to the o-ring only. Ensure the sensor cap's cavity is completely dry before installing the new cap.



3 Install new sensor cap

After the o-ring is installed and lubricated, wipe the clear window at end of sensor with a lint-free cloth until clean. Then dry the inside cavity of the sensor cap with a lint-free cloth. With a clockwise motion, thread the new sensor cap onto the sensor until it is finger-tight. The o-ring should now be compressed between the sensor cap and sensor, and not pinched. If pinched, remove and discard the o-ring and repeat procedure.

NOTICE: Do not over-tighten the sensor cap. Do not use any tools for the installation process.

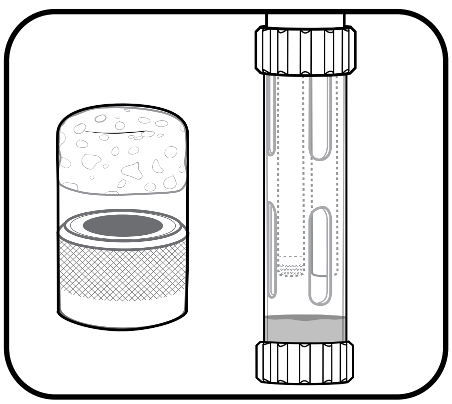
4 Configure sonde for new cap

In KOR software, configure the sonde for the new sensor cap. Click the Calibrate button and then click the ODO button. Next click the ODO % sat button, and in the DO calibration window click the Advanced button.

In the Advanced menu, click the Edit button and enter the unique membrane cap coefficients found on the instruction sheet shipped with the DO sensor cap.

NOTE: *Calibration coefficients are associated with specific individual sensor caps. They cannot be used for other ODO sensors.*

Although measures are taken at the factory to ensure this, please check that the serial number with the calibration coefficients on the instruction sheet matches the serial number engraved on the outside of the sensor cap.



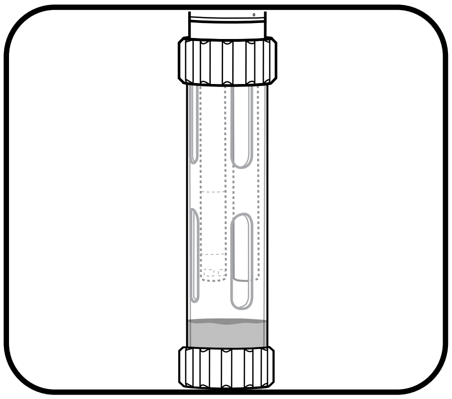
5 Store sensor cap

The sensor cap is shipped in a humidified container, and should be consistently stored in a 100% humid environment. Prior to installation, ensure the cap's container remains moist. Once the sensor cap is installed on the sensor, maintain this environment by placing approximately 0.5 in (1 cm) of water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup and screw it tightly onto the sonde to prevent evaporation. You may also store the sensor by submerging the cap end in water.

NOTICE: If pH sensor is also installed, do not submerge it in *distilled* water.

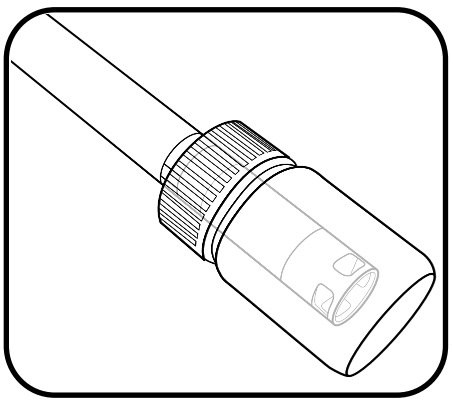
5.13 pH and pH/ORP Sensors
Storage and Rehydration

pH and pH/ORP sensors have two specific storage requirements: they should not be stored in distilled or deionized water and their reference electrode junction should never dry out. This section will identify storage as “long-term” or “short-term.” Long-term denotes storage during times of long inactivity (over-wintering, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.).



1 Short-term storage

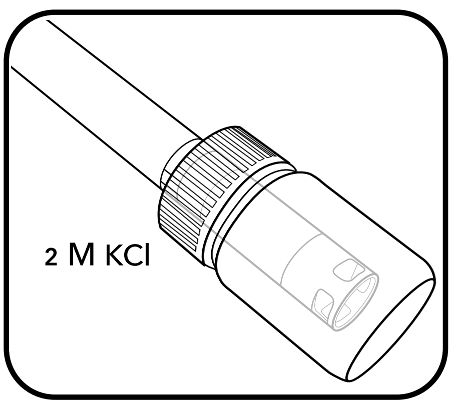
When in regular field use, the sensor should remain installed on the sonde in an environment of water-saturated air. Place approximately 0.5 in (1 cm) of any water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup. Insert the sonde and sensor into the cup and screw it on tightly to prevent evaporation. (*More information in “Short-Term Sonde Storage” section 5.1.*)



2 Long-term storage

Remove the sensor from the sonde and insert its sensing end into the bottle that the sensor was shipped in. Install the bottle’s o-ring and cap then tighten. This bottle contains a 2 molar solution of pH 4 buffer. If this solution is unavailable, users may store the sensor in tap water.

NOTICE: Do not store the pH or pH/ORP sensor in Zobell solution or DI water.

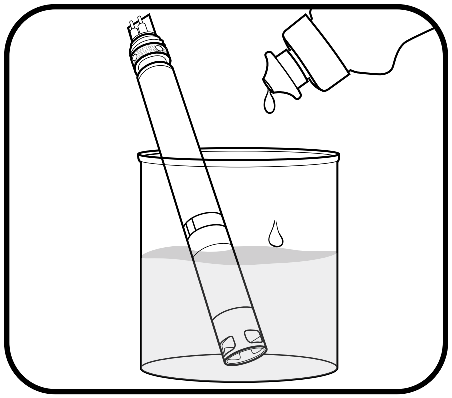


3 Rehydrate reference junction

If the pH sensor has been allowed to dry, soak the sensor for several hours (preferably overnight) in a 2 molar (2 M) solution of potassium chloride (KCl). In order to create a 2 M KCl solution, dissolve 74.6 g of KCl in 500 mL of distilled or deionized water. If KCl is unavailable, a tap water or pH 4 buffer soak may restore function. If the sensor is irreparably damaged, users must replace the sensor module.

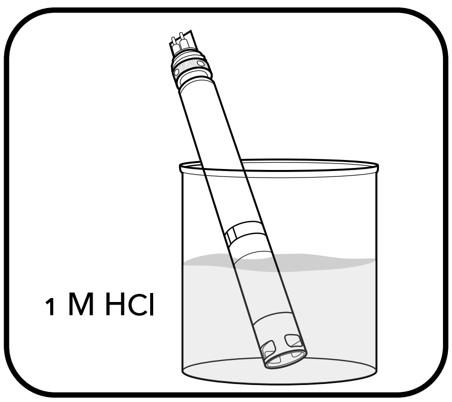
5.14 pH and pH/ORP Sensors Maintenance

pH and pH/ORP sensors will require occasional maintenance to clear contamination from the sensing elements. These contaminants can slow the sensor's response time. Clean the sensors whenever deposits, biofouling, or other contamination appear on the glass, or when the sensor's response time slows perceptibly. Remove the sensor from the sonde before performing the following cleaning steps. Do not attempt to physically scrub or swab the glass bulbs. The bulbs are very fragile and will break if pressed with sufficient force. *Maintain connectors as instructed in section 5.19. Replace depleted sensor module as instructed in section 5.16.*



1 Soak in dishwashing liquid solution

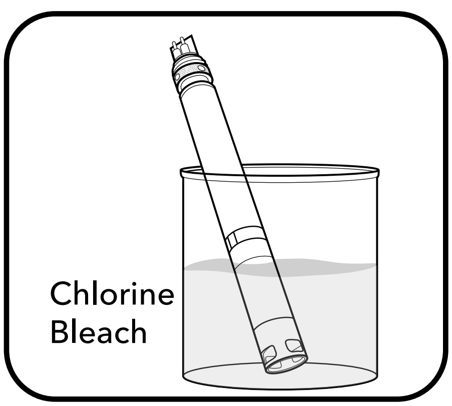
Soak the sensor for 10-15 minutes in a solution of clean water and a few drops of dishwashing liquid. Following the soak, rinse the sensor with clean water and inspect. If contaminants remain or response time does not improve, continue to the HCl soak.



2 Soak in HCl solution

Soak the sensor for 30-60 minutes in one molar (1 M) hydrochloric acid (HCl). This reagent can be purchased from most distributors. Following the HCl soak, rinse the sensor in clean tap water and allow it to soak for an hour in clean water. Stir the water occasionally. Then, rinse the sensor again in tap water and test response time. If response time does not improve or you suspect biological contamination of the reference junction, continue to the next soak. If HCl is not available, soak in white vinegar.

⚠ **WARNING:** Follow the HCl manufacturer's instructions carefully to avoid personal harm.

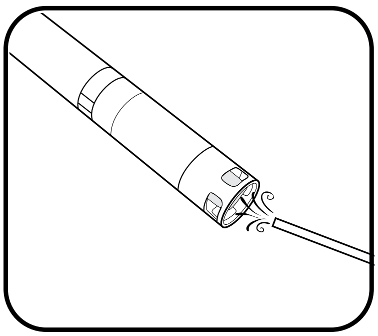


3 Soak in chlorine bleach solution

Soak the sensor for approximately one hour in a 1:1 dilution of chlorine bleach and tap water. Following the soak, rinse the sensor in clean tap water and allow it to soak for at least one hour in clean water (longer if possible). Then, rinse the sensor again in tap water and test response time.

5.15 ISE Sensors Maintenance and Storage

EXO ammonium, nitrate, and chloride sensors utilize ion-selective electrodes (ISEs) to monitor these parameters. One key requirement of storage, short or long-term, for these sensors is their reference electrode junctions should never dry out. This section will identify storage as “long-term” or “short-term.” Long-term denotes storage during times of long inactivity (over-wintering, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.). *Replace depleted sensor module as instructed in section 5.16.*

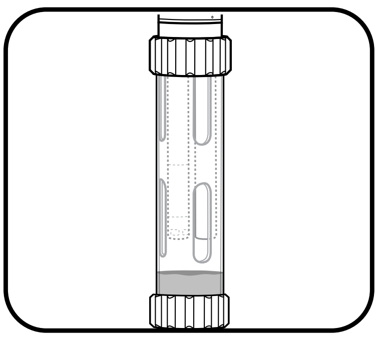


1 Sensor maintenance

Ammonium or Nitrate sensor: When deposits, biofouling, or other contamination appear on the membrane, users should *gently* remove them with a fine jet of deionized water or rinsing in alcohol followed by soaking in the high standard calibration solution. Gently dab dry with a lint-free tissue.

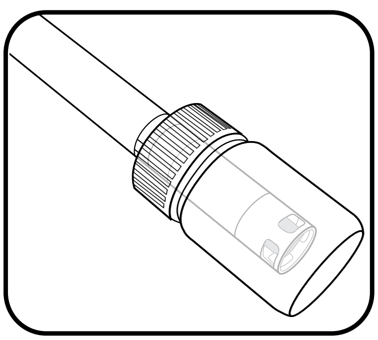
Chloride sensor: When deposits, biofouling, or other contamination appear on the membrane, users should *gently* remove them by washing with alcohol and/or gently polishing with fine emery paper in a circular motion to remove deposits or discoloration, then thoroughly washing with deionized water to remove any debris.

NOTICE: The ion-selective membranes are very fragile. Do not use coarse materials (e.g. paper towels) to clean the membranes, as these could permanently damage the sensor. The exception is fine emery paper for the chloride sensor, noted above.



2 Short-term storage

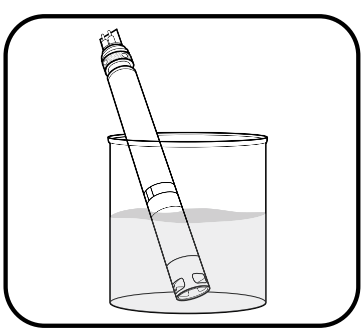
When in regular field use, the sensor should remain installed on the sonde in an environment of water-saturated air. Place approximately 0.5 in (1 cm) of any water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup. Insert the sonde and sensor into the cup and screw it on tightly to prevent evaporation. (*More information in “Short-Term Sonde Storage” section 5.1.*)



3 Long-term storage

Users should remove the sensors from the sonde and place them in their storage bottle (installed on sensor during shipping) with a small amount of tap water or calibration standard. The sensors should not be immersed in water.

NOTICE: Do not store the ISE sensors in conductivity standard, pH buffer, salt water, or any solution with significant conductivity.

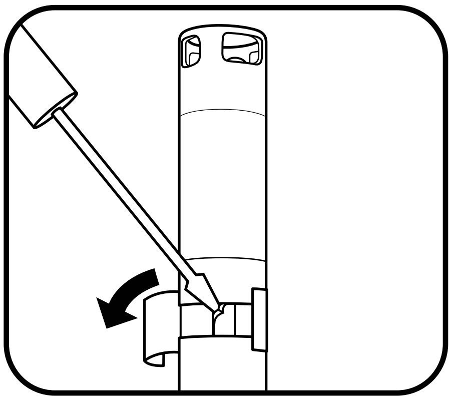


4 Rehydrate reference junction

If an ISE sensor has been allowed to dry, soak the sensor for several hours (preferably overnight) in the sensor’s high-calibration solution. If the sensor is irreparably damaged, users must replace the sensor module.

5.16 Sensor Module Replacement

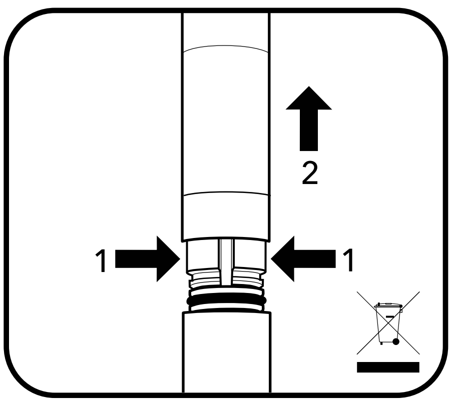
EXO pH, pH/ORP, ammonium, nitrate, and chloride sensors feature replaceable sensor modules (#599795, 599797, 599743-01, 599744-01, 599745-01) due to the electrolyte depleting characteristics necessary to make such measurements. We recommend that users replace these modules as necessary—typically 12 to 18 months for pH and ORP and three to six months for ISEs, if stored properly in a humid environment, wetting the sponge in the provided bottle when not in use. Working life will depend on the conditions of the deployment environment. Perform this procedure in a clean, dry laboratory environment.



1 Remove old sticker and plug

Peel off and discard the old sticker that covers the junction of the sensor body and the module. Then, with a small, flat-blade screwdriver, remove the small rubber plug from the gap in the hard plastic ring at the base of the sensor module.

⚠ **CAUTION:** Always exercise extra care when using sharp or potentially harmful instruments.

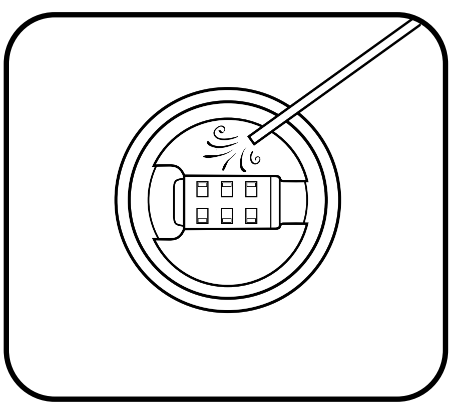


2 Remove and discard old sensor module

To remove, perform two motions simultaneously.

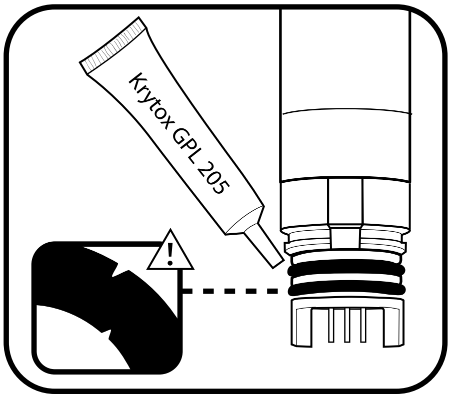
1. With your fingers, squeeze the sensor module's hard plastic ring so that it compresses the gap left by the rubber plug.
2. Steadily pull the sensor module straight back from the sensor body, rocking slightly if necessary.

NOTICE: The act of removing the old sensor module renders the o-rings on the module unusable. To prevent catastrophic leaks, do not attempt to reinstall a module with damaged o-rings. Discard the module according to your organization's guidelines, or return it to manufacturer for recycling.



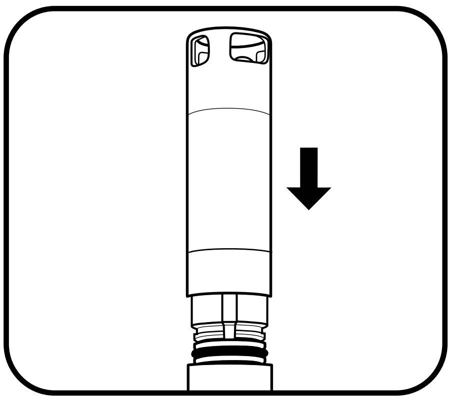
3 Inspect and service connector cavity

Inspect the connector cavity of the probe body for debris or moisture. If detected, remove it with a lint-free cloth or a gentle blast of compressed air.



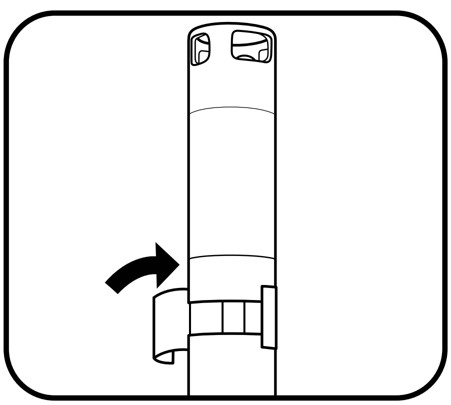
4 Inspect and service new sensor module's o-rings

Ensure that the two o-rings are not nicked or torn and have no contaminants or particles on them. If the user detects damage, carefully replace them with the extras included in the sensor module kit. Then apply a thin coat of Krytox® lubricant to each o-ring. If a user removes a sensor module that is in good working order, replace the o-rings before use.



5 Insert new sensor module

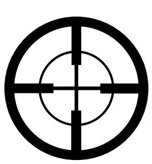
Align the prongs on the base of the module with the slots in the sensor body. The sensor module is keyed to insert in only one orientation. Once the module is aligned, press it firmly into position until it clicks. Wipe away any excess grease from the assembled components.



6 Apply new sticker

Wrap the junction of the sensor module and the body with the new sticker included in the sensor module kit. This sticker helps keep the sensor module junction clean and retains the rubber plug throughout deployment.

On the sticker, mark the date the replacement module was installed, as a reminder.

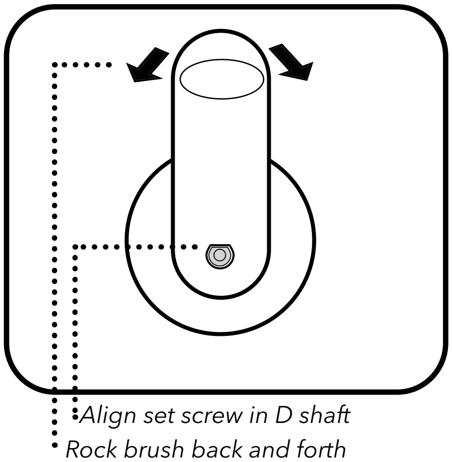


7 Re-calibrate the sensor

Using KOR software, calibrate the sensor following each sensor module replacement. After calibration, the sensor is ready for field use.

5.17 EXO2 Central Wiper Maintenance and Storage

Follow these instructions to replace the wiper brush assembly or brush guard component on the central wiper module on the EXO2 sonde. We recommend changing the wiper between deployments to avoid sediment carryover, which can compromise calibration and data collection. For long- and short-term storage, the wiper requires minimal precautions. Users can either remove the wiper or leave it installed in the sonde. If left installed on the sonde, follow guidelines for sonde storage. If users remove it from the sonde, the wiper may be stored in dry air in its shipping cap to protect against physical damage.



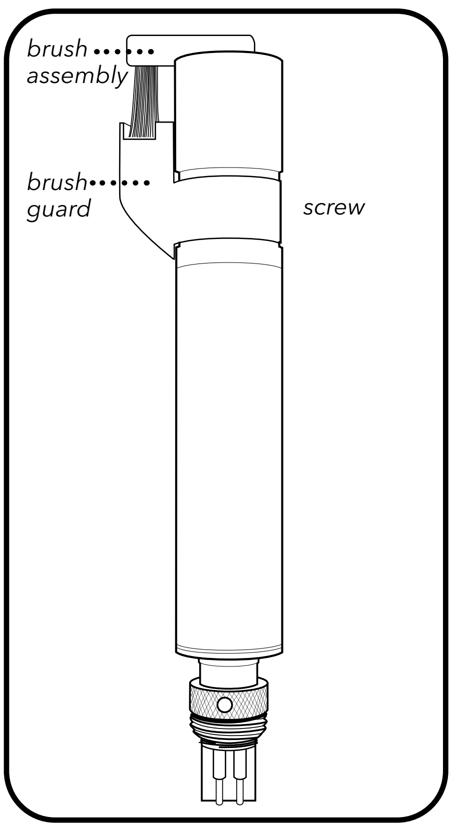
1 Replace wiper brush

Loosen set screw with 0.050 inch Allen wrench. Remove old brush assembly and clean any residue from wiper shaft and wiper end cap.

Install new brush assembly, gently pressing the wiper arm down against shoulder on wiper shaft.

Tighten set screw to a torque of 4 inch-pounds. While tightening, gently and slowly rock the brush to ensure a tight fit against the D shaft.

Check snugness of wiper by gently rocking 5 degrees in either direction.



2 Replace brush guard

In KOR software, go to Run > Dashboard. Click the Wipe Sensors button to ensure proper wiper park position.

Mark the position of the old guard with a marker.

Loosen the #6 screw with a 7/64 inch Allen wrench, remove the old guard and clean any residue from motor housing.

Remove cover on adhesive strip on the inside of the new brush guard.

Carefully install new brush guard in same position as old guard—with brush centered in well. Tighten screw until snug, but do not overtighten. (The adhesive helps to hold the guard in place.)

If necessary, calibrate the position of the new wiper in the KOR Calibrate menu.

NOTE: The adhesive on the guard strap, which facilitates installation, may make it difficult to re-position the wiper guard after it's been installed. Take caution to mark the position of the old guard before removing it and install the new one in the same location. Confirm that the new guard is aligned with the 4-pin connector at the bottom of the probe as shown, and properly centered between ports 1 and 6 after the wiper has been installed in the sonde.

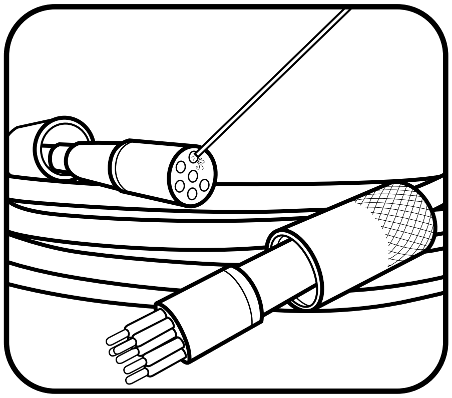
ANNUAL MAINTENANCE SPECIAL

[Download our Maintenance Brochure]

Central Wiper Seal Replacement:
A biennial (every two years) wiper shaft o-ring replacement is recommended to maintain optimum performance of the EXO2 wiper.
Contact us to learn more: repairs@ysi.com or +1 (800) 765-4974 (US)

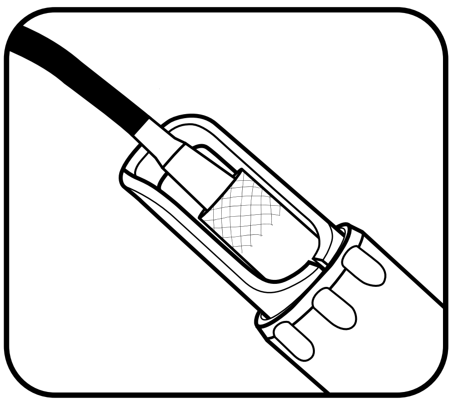
5.18 Field Cable Maintenance and Storage

EXO field cables are rugged and provide years of reliable service when properly maintained. As with all field cables, they are most vulnerable at their connectors. Take extra caution to protect the connectors from debris and physical harm.



1 Inspect and clean cables

Inspect the cable's connectors for contamination and remove any detected debris with a blast of compressed air. Users should also apply a thin coat of Krytox grease to the male pins of the connectors when they appear dried out. However, it is better to apply too little grease than too much. Too much grease can encourage contamination. Periodically inspect the cable for nicks and tears to ensure best performance.



2 Cable storage

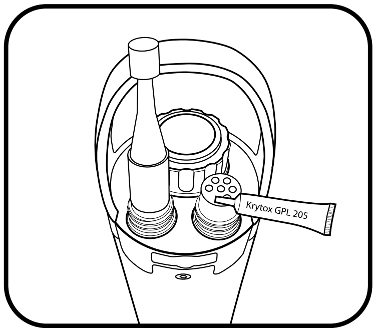
Users should leave the cable installed on the sonde to protect the connectors. If necessary users may remove it from the sonde, but extra care should be taken to protect the connectors. Store the cable in a safe location free from direct sunlight.

If the cable is vented, ensure the storage cap is affixed to the desiccant inlet. Store vented cables in a bag containing desiccant.

5.19 Connectors
Maintenance and Storage

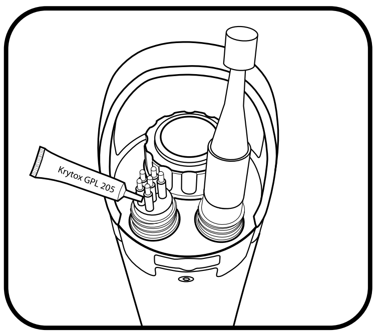
EXO sondes utilize wet-mate connectors that greatly reduce problems associated with traditional underwater connectors. However these connectors must be properly maintained to reap the full benefit of this design. Following these instructions will minimize most potential issues.

Never stick any foreign object into a female connector. Use only Krytox grease to lubricate the mating surfaces of the connectors.



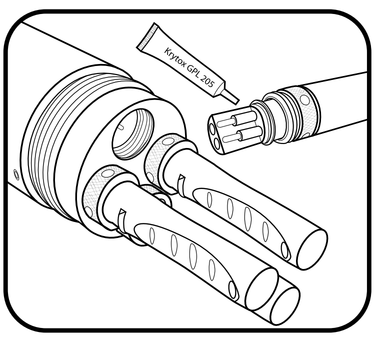
1 Female 6-pin connectors

These connectors are located on field cables, EXO2 accessory connector, and EXO Handheld. Periodically inspect the connectors for signs of contamination. If you detect debris, remove it with a gentle blast of compressed air. Prior to initial installation, or when dry, apply a light coat of Krytox grease to the flat rubber mating surface on top of the connector. When not in use, always install the connector's plug.



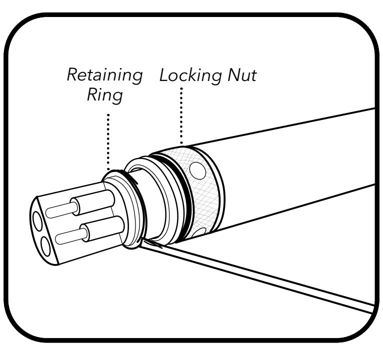
2 Male 6-pin connectors

These connectors are located on field cables and topside sonde connectors. Periodically inspect the connectors for signs of contamination. If you detect debris, carefully remove it. Prior to initial installation, or when dry, apply a light coat of Krytox grease to the rubber mating surfaces of the connector (including the rubber portions of the pins). When not in use, always install the connector's plug.



3 Sensor connectors (4-pin)

These connectors are located on sonde bulkheads (sockets) and sensors. Periodically inspect the female portions of these hermaphroditic connectors and the entire socket for contamination, and remove any debris with a gentle blast of compressed air. Prior to initial installation, or when dry, apply a light coat of Krytox grease to the rubber area of the sensor's connector.



4 Replace locking nut

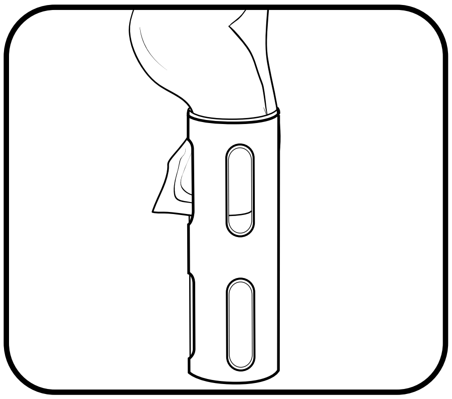
If the locking nut near the sensor connector wears out, users can replace it with 599668 (sensor) or 599669 (EXO2 central wiper).

First remove the retaining ring by inserting the tip of a small, flat-blade screwdriver under the lip of the ring and pry upward. Pull ring out of groove. Slide off locking nut and replace with new locking nut. Install new retaining ring by prying up one edge with screwdriver and fitting it into groove. Use the screwdriver to follow the diameter of the ring around the groove to seat it fully.

⚠ **CAUTION:** Wear eye protection when servicing the retaining ring.

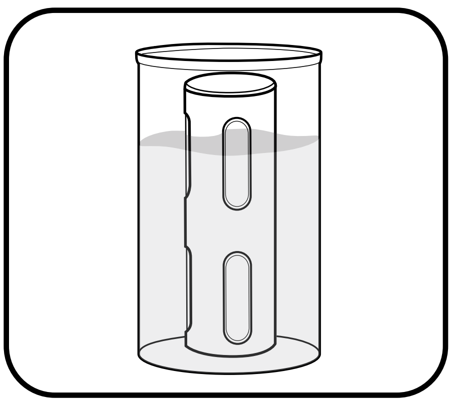
5.20 Antifouling Equipment Maintenance

Many components on EXO sondes are made of an anti-fouling copper-alloy material that discourages the growth of aquatic organisms. However, longer deployment intervals and highly productive waters can result in biofouling attachment to the equipment, which should be cleaned periodically.



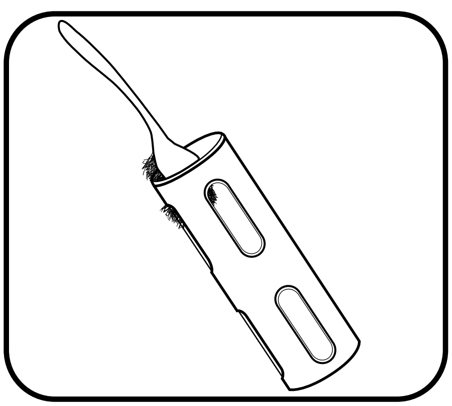
1 Remove minimal biofouling

Remove the antifouling sonde guard from the sonde. If the guard is covered in a thin layer of slime or filaments, wipe away the biofouling with a cloth soaked in clean water and a few drops of a dishwashing liquid that contains a degreaser. Rinse the guard with clean water and inspect.



2 Soak to remove heavy biofouling

Remove the antifouling sonde guard from the sonde. If the guard is covered in a thick layer of filaments or barnacles, soak the guard for 10-15 minutes in a solution of clean water and a few drops of a dishwashing liquid that contains a degreaser. Following the soak, rinse the guard with clean water and inspect.



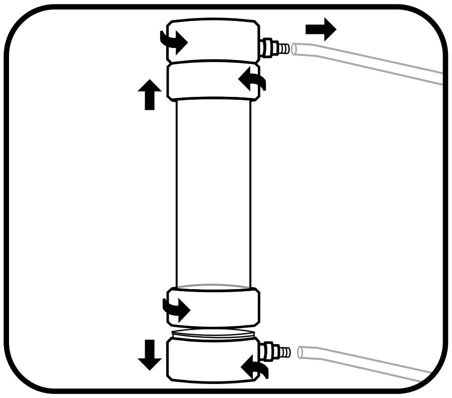
3 Scrub to remove heavy biofouling

If biofouling remains, use a small plastic scrub brush or plastic scraper to gently scrub the biofouling off the guard. Then wipe the guard with a wet, soapy cloth and rinse.

NOTICE: Do not sand or polish the inside of the guard bottom, as this may effect turbidity readings. (The guard bottom has a black coating that will eventually wear off.)

5.21 Flow Cell Maintenance

There are two versions of the EXO flow cell: EXO1 flow cell (599080) and EXO2 flow cell (599201). Flow rate of the flow cell is typically between 100 mL and 1 L per minute. Maximum flow rate depends on tubing type, size, and length. Maximum pressure for each is 25 psi.

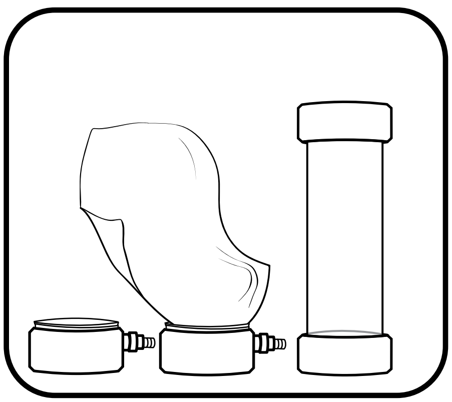


1 Disassemble flow cell

To clean the flow cell after use, unscrew and remove the sonde from the flow cell.

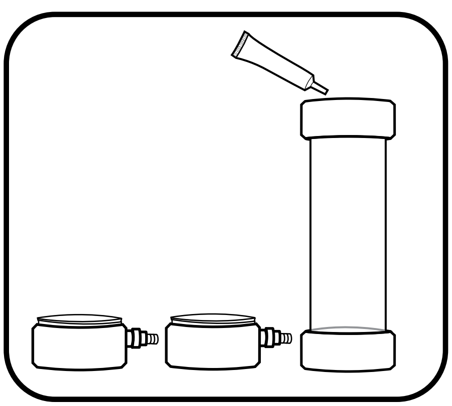
Take apart the flow cell by unscrewing the base from the locking ring. Remove the flow cell tube by gently pulling the base and the tube apart. The locking ring will remain on the tube due to the stainless steel retaining ring.

Repeat the same steps to remove the top of the flow cell from the flow cell tube.



2 Clean flow cell

Use water and a mild detergent and water to wipe clean the flow cell parts.



3 Reassemble flow cell

Make sure that the o-rings and threads are clean and free of any particles such as sand, grit, or debris. Apply a thin coat of Krytox grease to the two o-rings on the flow cell tube.

Make sure that the o-rings and stainless steel retaining rings are properly seated on the flow cell tube. Push the base of the flow cell onto the flow cell tube until it is firmly seated. This creates the watertight seal.

Screw the locking ring on to the base by turning it clockwise; do not use a tool and do not overtighten.

Repeat same steps to reconnect the top of the flow cell to the flow cell tube.

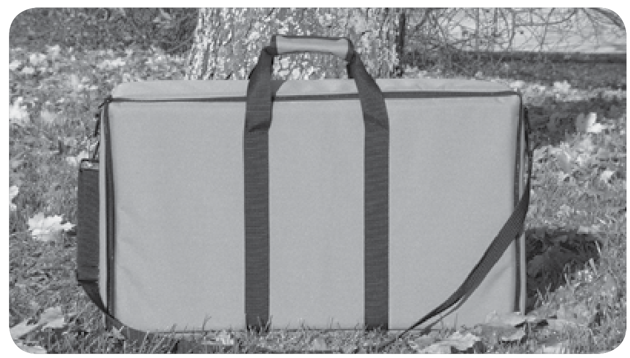
5.22 Storage Cases Packing Options

EXO sondes are built with the most rugged and durable materials to safeguard against the risks of water monitoring. Out of the water, the EXO Hard-Sided Carrying Case provides a secure manner in which to store your EXO equipment for travel or until the next trip into the field. As seen below, the EXO Hard-Case provides the perfect safe storage solution, though we do offer several case options.

EXO Hard-Sided Wheeled Carrying Case
#599020-01 (**EXO1**) and #599020-02 (**EXO2**)

EXO1 & EXO2 Storage Solutions

Within the heavy-grade plastic frame, protective foam form fits your EXO sondes. Additionally, the handheld and detached sensors rest safely within foam housing. The central portion of the case allows users to securely stow other miscellaneous items. There are two separate versions, one which will hold an EXO1 sonde, and another that holds an EXO2 sonde. Both versions include wheels for your convenience.



#696162 - 6-Series Soft-Sided Carrying Case

It is important to note, however, that with greater durability comes increased size and weight. The dimensions of the EXO Hard-Sided Carrying Case are larger than those of its 6-Series counterpart. Additionally, the new EXO case weighs approximately double that of the 6-Series cloth case.

Our EXO sondes are compatible with both YSI carrying cases however, and users should choose the storage solution that is tailored to their individual circumstances. In terms of carrying capacity, both cases are unable to hold multiple EXO2 sondes, and the cloth YSI case can hold up to two EXO1 sondes. Thus, EXO1 users may find it advantageous to utilize that storage option.

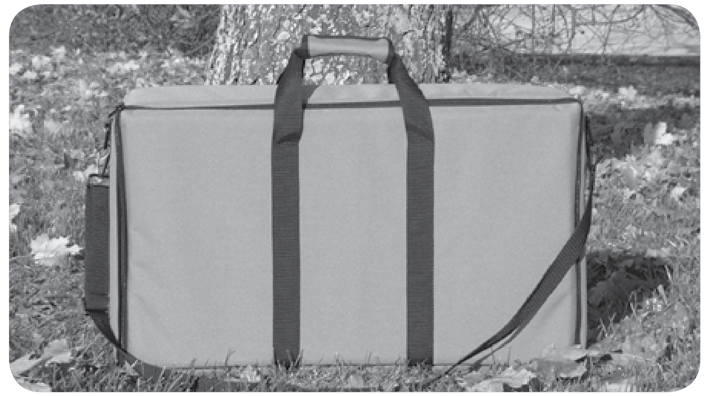
EXO1 configuration, Soft-Sided Case

While the EXO case is designed exclusively for EXO sondes and equipment, the cloth YSI case was originally intended for use with the 6-Series product line. It is important to note that the cloth case is versatile in nature – allowing users the ability to configure their own storage structure with its Velcro lining and interlocking padded strips. This flexibility enables both EXO1 & EXO2 equipment to fit inside using configurations as seen in the photos.

EXO2 configuration, Soft-Sided Case

Ultimately, while the EXO1 & EXO2 equipment is built to withstand harsh field environments, we recommend users take care to safely store their systems while not in use. Both the EXO Hard-Sided Carrying Case and the cloth YSI case are viable options, but other non-YSI products may better suit more specialized user needs.
(See Appendix below for more information.)

Item Description	Part #'s
EXO1 Wheeled Carrying Case, Black	#599020-01
EXO2 Wheeled Carrying Case, Black	#599020-02



Item Description	Part #
6-Series Carrying Case, Soft-Sided (EXO1 or EXO2 Sonde and equipment)	#696162

Appendix: Pelican Cases

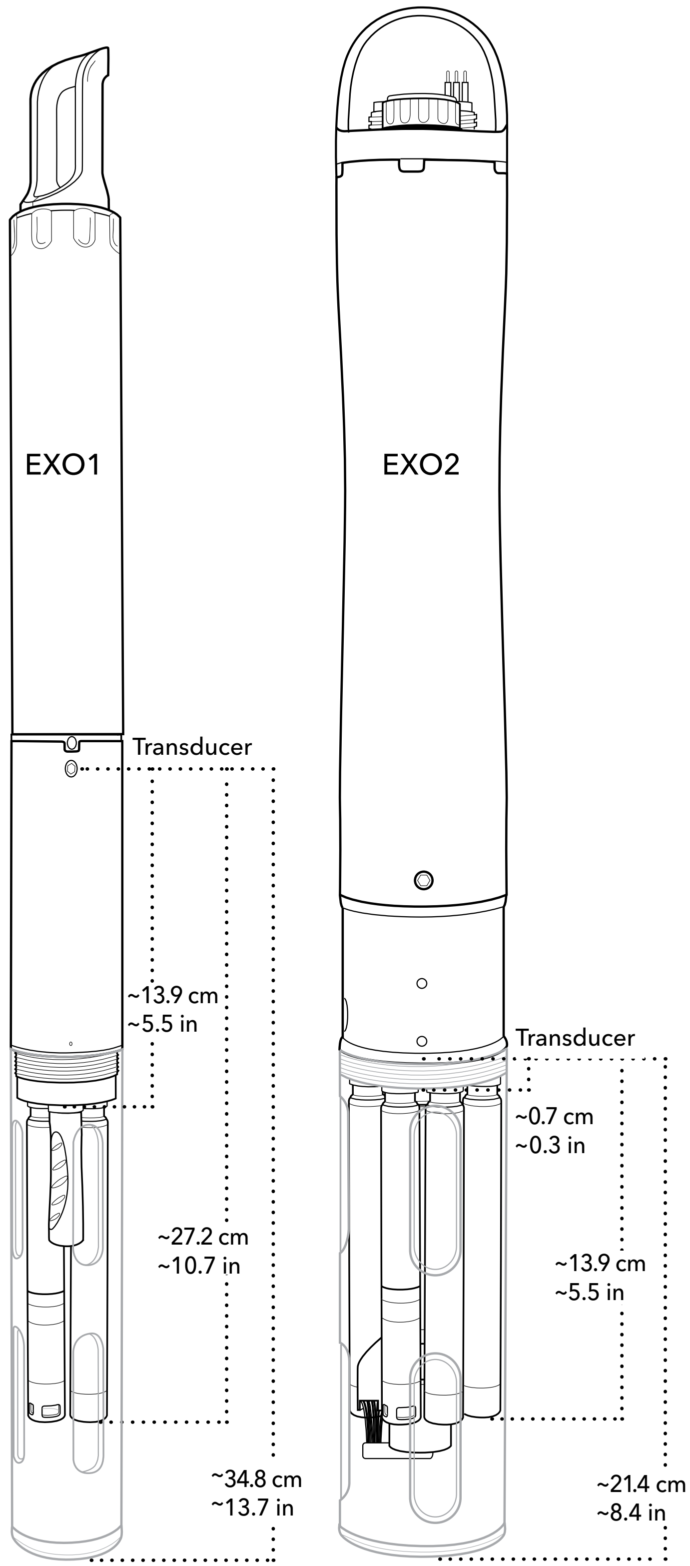
Pelican storage cases are another option for EXO users. This third party storage solution is an option for those that prefer to create their own cases for specific purposes. Two Pelican models work the best for storing EXO equipment, the Pelican 1600 and 1700. These cases can be purchased online through a number of portals but do require the user to personally customize the foam interior to fit our sondes and equipment.

Pelican-1600

Pelican-1700

Section 6
Vented Level Sonde

6.1 Vented Level Sonde
Overview



Like EXO depth sensors, level sensors use a differential transducer with one side exposed to the water. However, unlike the depth sensors which have their back side sealed in a vacuum, the other side of the level transducer is vented to the atmosphere.

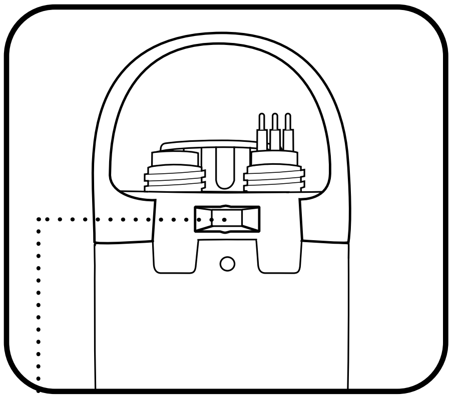
Because of this venting to the surface the transducer will only measure the water pressure exerted by the water column. Thus, the vented level option for depth measurement eliminates errors due to changes in barometric pressure because the barometric pressure is being seen on both sides of the pressure sensor. This is accomplished by using a special sensor that has been vented to the outside atmosphere by way of a tube that runs through the sonde and cable. This tube must remain open and vented to the outside atmosphere to function. No foreign objects can block the openings.

NOTICE: Never expose the sonde or the cable to the atmosphere for more than a few minutes without an active desiccant or connector dummy plug in place. Moisture or high humidity air entering the vent tubes can condense and block the tube, affecting accuracy; it could also cause damage to the transducer that is not covered by the warranty.

Special field cables are required for vented level measurements. These cables have a vent tube running through the center and connect to the EXO sonde at the connector near the bail. In the center of the sonde's connector is a matching vent hole. When attached, the vented cable allows the sonde to vent through the water column and thus gain a more accurate depth measurement.

6.2 Vented Level Sonde Installation

When installing a vented level sonde, users must ensure that the sonde never exceeds an operational depth of 10 meters. Provisions for floods, astronomical tides and severe storm events should be factored in. **NOTICE:** Exposing the depth sensor to depths greater than 10 meters could result in damage to the pressure sensor that is not covered by the warranty.



Indentation for location or positioning pin to ensure consistent horizontal orientation

Location of Depth Sensor

For best measurement accuracy when installing a sonde, the sonde's orientation and position must remain fixed.

When deploying the sonde vertically, take care to ensure the sonde is redeployed in the same position. Use a location pin or suspend the sonde using materials that cannot stretch (chain, wire rope) to ensure a fixed location.

Depth sensors on the EXO2 sondes are not on center. In horizontal deployments, take care to ensure the redeployments are always in the same orientation.

To assist with consistent horizontal orientation, the EXO2 sonde has an indentation at the top of the sonde for a location or positioning pin.

NOTICE: Never band clamp a sonde. This can lead to the sonde body becoming warped and taking on water.

EXO1 Depth Sensor Reference Points *(see diagram on previous page)*

- From bottom of sensor guard (metal or plastic) to transducer diaphragm: ~34.8 cm / ~13.7 inches
- From face of sensor endcap to transducer diaphragm: ~27.2 cm / ~10.7 inches
- From face of connector bulkhead to transducer diaphragm: ~13.9 cm / ~5.5 inches

EXO2 Depth Sensor Reference Points *(see diagram on previous page)*

- From bottom of sensor guard (plastic or metal) to transducer diaphragm: ~21.4 cm / ~8.4 inches
- From face of sensor endcap to transducer diaphragm: ~13.9 cm / ~5.5 inches
- From face of connector bulkhead to transducer diaphragm: ~0.7 cm / ~0.3 inches
- Horizontally positioned sonde, from outer case (location pin down) to transducer diaphragm: ~2.1 cm / ~0.8 inches

Ambient Light Interference

When deploying horizontally, it is best to keep the sonde's optical sensors out of direct sunlight. We suggest:

- Installing the sonde in a PVC pipe that has adequate openings for flow
- Aiming the sensors north in northern hemisphere or south in southern hemisphere
- Using a sun shield if the sonde is in the open

6.3 Vented Cables and Desiccants
Installation

Cables

Vented cables for EXO have a maximum length of 33 meters, so when connecting a sonde to a data logger, users should use a junction box to reach further distances. In the junction box, the EXO cable can connect to the desiccant, as well as another cable running to the data logger or DCP device.

- Avoid bending vented cables sharply to prevent the inner tube from kinking. (Min. bend radius 20.3 cm/8 in.)
- EXO vented cables have a reduced length to prevent tube damage from their own weight.
- EXO vented cables **do not** have wet-mate connectors—any water or humidity entering the vent tube will cause damage to the pressure sensor that is not covered by the warranty.
- EXO vented cables are not equipped with the barbed fitting for small desiccant cartridges.

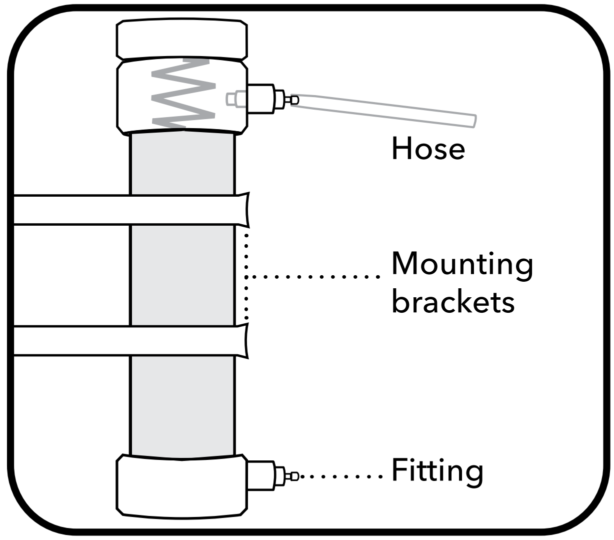
Dessicants

NOTICE: All EXO sondes with vented level require the use of a desiccant. Any damage to the sensor due to the lack of desiccant use is not covered under warranty.

Two desiccant systems are available, a cartridge kit (YSI 6108) and a canister kit (YSI 6109). *For all EXO sondes we strongly recommend the 6109 canister kit*. The 6109 desiccant canister contains a larger amount of desiccant and is intended for long-term deployments (can last up to 1 year in severe conditions). It also contains mounting brackets for mounting the canister to a nearby structure. The smaller 6108 kit requires replacement frequently in high humidity environments.

NOTICE: A desiccant or a connector dummy plug must always be attached to the sonde and cable to prevent moisture from entering into the vent tubes.

Users must also ensure that the desiccant always remains active. Active desiccant is a blue color, and when it can absorb no more moisture, it is a pink color. The end that is vented to the atmosphere will begin to change color first. As long as the desiccant closest to the sonde is blue, no maintenance is required. Local conditions will dictate how long the desiccant will last. In humid environments, the desiccant may need to be changed or regenerated before it is completely exhausted to ensure that it lasts the entire deployment.



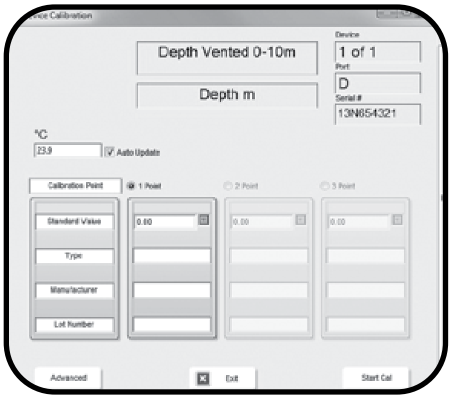
Installing YSI 6109 Desiccant Canister

- Remove the 1/8” NPT plugs from the stainless steel fittings on the canister.
- Install the 1/8” NPT to 1/8” hose fittings into the stainless steel fittings located on the side of the desiccant canister. Do not over-tighten.
- Place the plugs over the fittings on the canister until you are ready to use the canister.
- Using suitable screws fasten the canister mounting brackets to an appropriate support structure. The spacing between the brackets must accommodate the length of the canister. The canister must be located within a few feet of the cable end.
- Remove the plug from the top fitting of the canister. Remove the plug from the barbed fitting on the end of the cable. Using the tubing provided in the kit, connect the canister to the fitting on the end of the cable. Remember to remove the remaining plug from the canister when ready to begin sampling. When putting the sonde into service, remove the plug to ensure that the sensor in the sonde is vented to the atmosphere.

6.4 Calibration

NOTE: *This calibration option is available only if your sonde is equipped with a vented level sensor.*

For the calibration, make certain that the vented level sensor is in air and not immersed in any solution. Orient the sonde in the same position as it will be deployed. Also, never calibrate a vented level depth sensor with a non-vented cable.



In the desktop KOR Calibrate menu, select Port D-Depth, then select Depth m from the second menu. In the Device Calibration menu, you should see Depth Vented 0-10m as the device name. (In the handheld KOR Calibrate menu, select Port D Dep V 0-10m, then select Depth m from the next menu.)

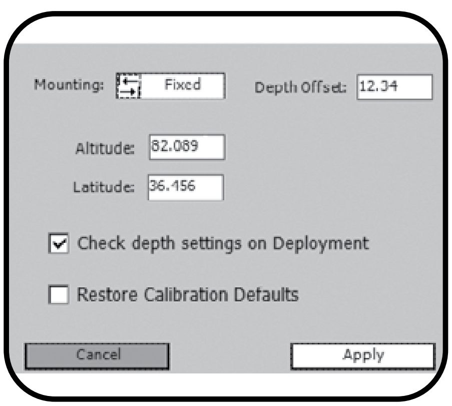
Click 1 Point for the Calibration Points. Enter 0 or go to the Advanced menu to enter a known sensor offset.

- If a depth offset is entered, the output value will shift by the value of the offset. Users may use an offset if referencing a water elevation against a known datum.

Click Start Calibration. Observe the readings under Current and Pending data points and when they are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point. This process zeros the depth sensor.

Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

For best performance of vented level measurements, users should ensure that the orientation of the sonde remains constant while taking readings. Keep the sonde still and in one position while calibrating.



Advanced

Mounting: Use the Advanced menu to select if a sonde will be mounted in a moving/profiling deployment instead of a fixed location.

Depth Offset: Enter a positive or negative depth offset value if the sonde has been surveyed into a geodetic reference.

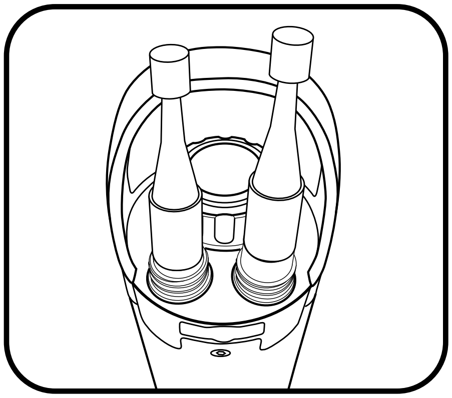
Altitude/Latitude: Enter the coordinates for the local altitude (in meters, relative to sea level) and latitude (in degrees) where the sonde is sampling. Latitude values are used in the calculation of depth and level to account for global variations in the gravitational field.

NOTE: *You must be within 500 feet (152.4 meters) and 1 degree, respectively.*

6.5 Maintenance and Storage

Short-term Storage

NOTICE: It is important that the air in a sonde's vent tube remains dry at all times.



Level Sensor Storage

Users can store these sensors either dry or submerged in clean water. However, regardless of storage method or length, ensure the vent tube remains dry. Always attach the port plug to the cable connector, or leave the cable installed with a cap over the desiccant's vent.

Level Desiccant Maintenance

Active desiccant is blue; saturated desiccant is pink or rose red. When the desiccant closest to the sonde begins to turn pink, you should replace (YSI 6108), or regenerate (YSI 6109) the desiccant cartridge.

To regenerate desiccant, remove it from the cartridge and heat it for one hour at 200°C (about 400°F); then cool it an airtight container before refilling. Also heat the felt filters at 100°C (about 200°F) for 30 minutes. The desiccant will turn blue following a successful recharge.

Connectors Maintenance

Connectors on vented level cables have five pins and a vent pin. Periodically inspect the connectors for signs of contamination. If you detect debris, carefully remove it. Prior to initial installation, or when dry, apply a *light* coat of Krytox grease to the rubber mating surfaces of the connector (including the rubber portions of the pins).

NOTICE: Do not allow grease to enter or block the vent tube on the cable connector or the vent opening on the sonde connector.

When not in use, always install the sonde and cable dummy plugs.

Cable Storage

Users should leave the cable installed on the sonde to protect the connectors. If necessary users may remove it from the sonde, but extra care should be taken to protect the connectors. For vented cables, ensure the storage cap is affixed to the desiccant inlet. Store vented cables in a bag containing desiccant.

NOTE: *Minimum bend radius for coiling cable is 8 inches (20.32 cm).*

Section 7
Accessories

7.1 Accessories Ordering

Telephone: 800 897 4151 (USA)
+1 937 767 7241 (Globally) Monday through Friday, 8:00 AM to 5:00 ET
Fax: +1 937 767 9353 (orders)
Email: info@ysi.com
Mail: YSI Incorporated 1725 Brannum Lane
Yellow Springs, OH 45387 USA
ysi.com

When placing an order please have the following available:

1. YSI account number (if available)
2. Name and phone number
3. Purchase Order or Credit Card number
4. Model Number or brief description
5. Billing and shipping addresses
6. Quantity

EXO1 Sondes

YSI Item #	Description
599501-00	EXO1 Sonde, No Depth, 4 Sensor Ports
599501-01	EXO1 Sonde, 10 meter Depth, 4 Sensor Ports
599501-02	EXO1 Sonde, 100 meter Depth, 4 Sensor Ports
599501-03	EXO1 Sonde, 250 meter depth, 4 Sensor Ports
599501-04	EXO1 Sonde, 10 meter vented level depth, 4 Sensor Ports

EXO2 Sondes

YSI Item #	Description
599502-00	EXO2 Sonde, No Depth, 6 Sensor Ports, 1 Wiper Port
599502-01	EXO2 Sonde, 10 meter depth, 6 Sensor Ports, 1 Wiper Port
599502-02	EXO2 Sonde, 100 meter Depth, 6 Sensor Ports, 1 Wiper Port
599502-03	EXO2 Sonde, 250 meter depth, 6 Sensor Ports, 1 Wiper Port
599502-04	EXO2 Sonde, 10 meter vented level depth, 6 Sensor Ports, 1 Wiper Port

EXO Handheld

YSI Item #	Description
599150	EXO Classic Handheld Display
599622	EXO Rechargeable Lithium-Ion Battery Pack
Coming 2016	New Updated EXO Handheld

EXO Signal Output Adapters

YSI Item #	Description
599820	EXO Signal Output Adapter - Data Collection Platform (DCP) 2.0
599825	EXO Signal Output Adapter - Modbus
599810	EXO Signal Output Adapter - USB (Necessary for firmware updates.)

EXO Antifouling

YSI Item #	Description
599867	EXO Anti Fouling C/T Screen
599563	EXO1 Anti-Fouling Guard
599564	EXO2 Anti Fouling Guard
599663	EXO2 Probe and Sonde protective sleeves
6189-AF	Copper tape kit
C-SPRAY	Protective probe solution, 100 mL bottle

EXO Cables

YSI Item #	Description
599040-2	EXO 2 meter Field Cable
599040-4	EXO 4 meter Field Cable
599040-10	EXO 10 meter Field Cable
599040-15	EXO 15 meter Field Cable
599040-33	EXO 33 meter Field Cable
599040-66	EXO 66 meter Field Cable
599040-100	EXO 100 meter Field Cable
599040-150	EXO 150 meter Field Cable
599040-200	EXO 200 meter Field Cable
599040-250	EXO 250 meter Field Cable
599040-300	EXO 300 meter Field Cable
599008-10	EXO 10 meter Flying Lead Cable
599008-15	EXO 15 meter Flying Lead Cable
599008-33	EXO 33 meter Flying Lead Cable
599008-66	EXO 66 meter Flying Lead Cable
599008-100	EXO 100 meter Flying Lead Cable
599210-4	EXO 4 meter VENTED Flying Lead Cable
599210-10	EXO 10 meter VENTED Flying Lead Cable
599210-15	EXO 15 meter VENTED Flying Lead Cable
599210-33	EXO 33 meter VENTED Flying Lead Cable

EXO Sensors & EXO2 Central Wiper

YSI Item #	Description
599870	EXO Conductivity/Temperature Sensor
599827	EXO Wiped Conductivity/Temperature Sensor
599701	EXO pH Sensor Assembly, Guarded
599705	EXO pH/ORP Sensor Assembly, Guarded
599702	EXO pH Sensor Assembly, Unguarded
599706	EXO pH/ORP Sensor Assembly, Unguarded
599710	EXO Ammonium Sensor Assembly,Guarded
599711	EXO Chloride Sensor Assembly, Guarded
599709	EXO Nitrate Sensor Assembly, Guarded
599100-01	EXO Optical DO Sensor
599101-01	EXO Turbidity Sensor
599102-01	EXO Total Algae - PC Sensor
599103-01	EXO Total Algae - PE Sensor
599104-01	EXO fDOM Sensor
599090-01	EXO2 Central Wiper

EXO Replaceable Sensor Tips

YSI Item #	Description
599795-01	EXO pH Sensor Replacement Module, Guarded (User replaceable tip for 599701)
599795-02	EXO pH Sensor Replacement Module, Un-Guarded (User replaceable tip for 599702)
599797-01	EXO pH/ORP Sensor Replacement Module, Guarded (User replaceable tip for 599705)
599797-02	EXO pH/ORP Sensor Replacement Module, Un-Guarded (User replaceable tip for 599706)
599744-01	EXO Ammonium Sensor Replacement Module, Guarded (User replaceable tip for 599710)
599743-01	EXO Nitrate Sensor Replacement Module, Guarded (User replaceable tip for 599709)
599745-01	EXO Chloride Sensor Replacement Module, Guarded (User replaceable tip for 599711)

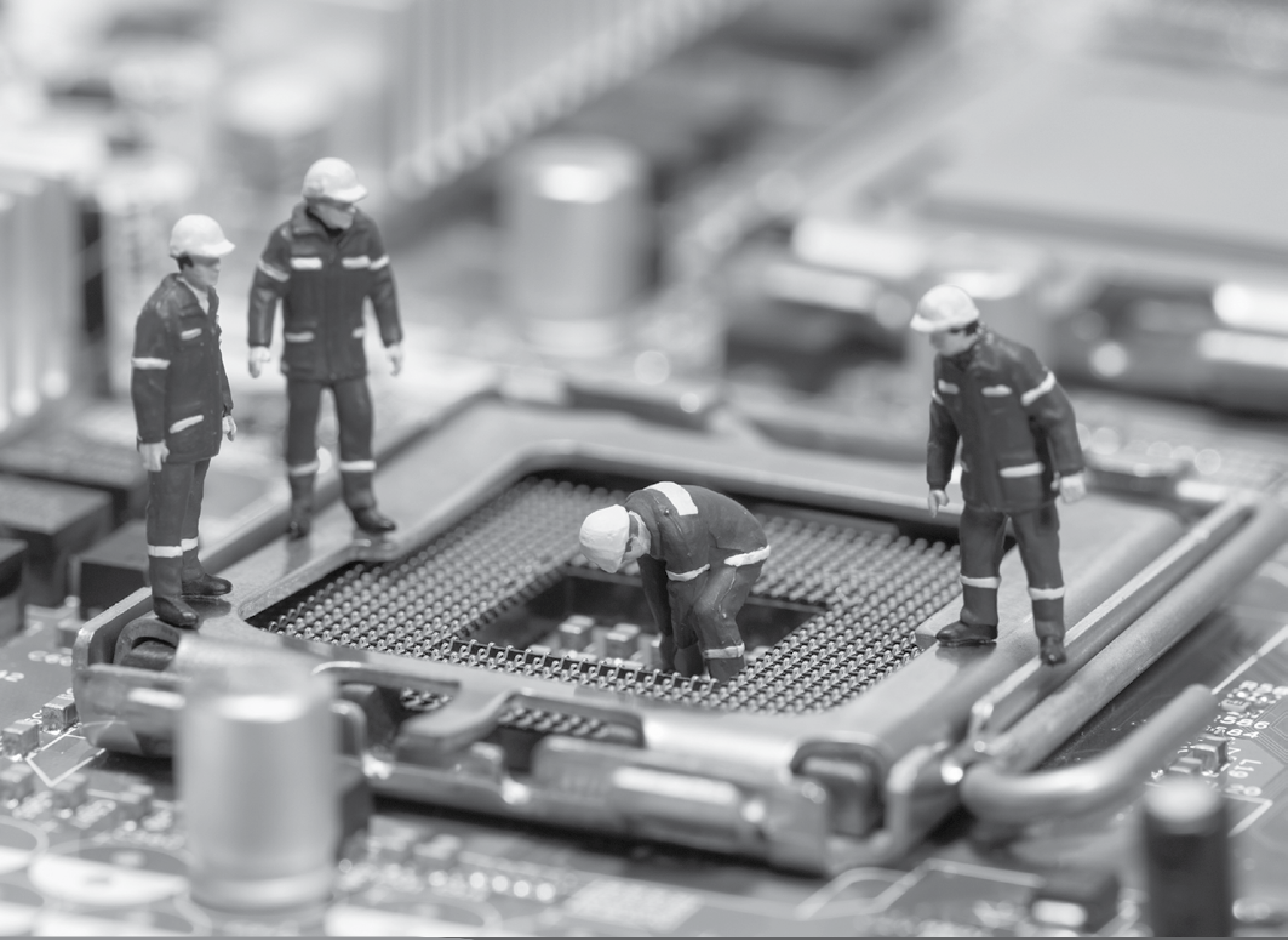
EXO General Accessories

YSI Item #	Description
599020-01	EXO1 Wheeled Carrying Case, Black
599020-02	EXO2 Wheeled Carrying Case, Black
599470	EXO C/T Sensor Cleaning Brush
599831	EXO Wiped C/T Sensor, Spacing Kit
599080	EXO1 Flow Cell
599201	EXO2 Flow Cell
599786	EXO1 Calibration/Storage Cup
599316	EXO2 Calibration/Storage Cup
599471	EXO1 Sonde Weight Kit
599472	EXO2 Sonde Weight Kit
599473	EXO1 Replacement Bail
599474	EXO2 Replacement Bail
599475	EXO 4-Pin Bulkhead Connector Port Plug
599594	EXO Tool Kit
599680	EXO1 Replacement O-Ring Kit
599681	EXO2 Replacement O-Ring Kit
599677	EXO Sensor O-Ring Kit

YSI Item #	Description
599110	DO Sensor Cap Replacement Kit
599595	EXO Coastal Anode Kit
599520	EXO1 Coastal Anode Guard Weight Kit
599521	EXO2 Coastal Anode Guard Weight Kit
599338	KOR User Interface Software USB
599668	EXO Sensor Retaining Nut Kit, Sensors
599669	EXO Sensor Retaining Nut Kit, Wiper
599666	EXO1 Guard Assembly Kit
599667	EXO2 Guard Assembly Kit
599673	EXO Central Wiper Brush Kit
599665	EXO Replacement 6-pin Female Dummy Plug
599664	EXO Replacement 6-pin Male Dummy Plug
599676	EXO Wiper Brush Guard replacement Kit
599469	EXO Sensor tool and magnet activation kit
599352	Krytox Lubricant
006109	Desiccant Canister Kit
006108	Desiccant Cartridge Kit

Calibration Standards and Solutions

YSI Item #	Description
065270	Conductivity Calibrator - 1,000 umhos/cm (quart)
065272	Conductivity Calibrator - 10,000 umhos/cm (quart)
065274	Conductivity Calibrator - 100,000 umhos/cm (quart)
060907	Conductivity Calibrator - 1,000 umhos/cm (8 ea, pint)
060911	Conductivity Calibrator - 10,000 umhos/cm (8 ea, pint)
060660	Conductivity Calibrator - 50,000 umhos/cm (8 ea, pint)
061320	Zobell Solution - For ORP cal. - 125 mL
061321	Zobell Solution - For ORP cal. - 250 mL
061322	Zobell Solution - For ORP cal. - 500 mL
003821	pH 4 Buffer - Box of 6 pints
003822	pH 7 Buffer - Box of 6 pints
003823	pH 10 Buffer - Box of 6 pints
603824	Assorted pH Buffers - 2 pints of 4 - 2 pints of 7 - 2 pints of 10"
003841	Ammonium Cal Solution - 1 mg/L (500mL)
003842	Ammonium Cal Solution - 10 mg/L (500mL)
003843	Ammonium Cal Solution - 100 mg/L (500mL)
003885	Nitrate Standard - 1 mg/L (500mL)
003886	Nitrate Standard - 10 mg/L (500mL)
003887	Nitrate Standard - 100 mg/L (500mL)
608000	Turbidity Std. - 0 NFU, 0 NTU - 1 Gallon
607200	Turbidity Std. - 12.4 FNU - 1 Gallon
607300	Turbidity Std. - 124 FNU - 1 Gallon
607400	Turbidity Std. - 1010 FNU - 1 Gallon



Section 8
Health and Safety, Warranty, Service

8.1 Health and Safety
Chemicals

NOTE: For additional health, safety, and disposal information about reagents, download the MSDS documents for the chemical in question from the EXO manufacturers' websites: www.ysi.com or www.wtw.de.

First Aid for all solutions

Inhalation	Move to fresh air. If breathing is difficult, give oxygen. If symptoms persist, seek medical attention.
Skin Contact	Remove contaminated clothing and wash. Wash exposed area with soap and water for at least 15 minutes. If irritation persists, seek medical attention.
Eye Contact	Rinse eyes immediately with large amounts of water, also under eyelids, for at least 15 minutes. If irritation persists, seek medical attention.
Ingestion	Wash out mouth with water and then drink plenty of water. If symptoms persist, seek medical attention.

Ammonium Solutions

3841, 3842, and 3843

Ingredients: Water, Ammonium Chloride, Lithium Acetate Dihydrate, Sodium Azide, Hydrochloric Acid

Nitrate Solutions

3885, 3886, and 3887

Ingredients: Water, Potassium Nitrate, Magnesium Sulfate Heptahydrate, Gentamycin Sulfate

Inhalation: Avoid breathing vapors or mists. Ensure adequate ventilation is available before handling.

Skin: Wear lightweight protective clothing, gloves, and apron.

Eyes: Wear safety glasses with side-shields or face shield. Contact lenses should not be worn when working with these solutions.

Ingestion: May be harmful if swallowed. Wear a mouth cover or face shield when there is splashing. Keep away from food and drink.

First Aid: See box at left.

Conductivity Solutions

3161, 3163, 3165, 3167, 3168, and 3169

Ingredients: Water, Potassium Chloride

Inhalation: Avoid breathing vapors or mists. Inhalation of dust may cause irritation of respiratory tissues. Ensure adequate ventilation is available before handling.

Skin: Exposure may cause irritation with repeated exposure. Wear lightweight protective clothing, gloves, boots, and apron.

Eyes: Can cause irritation and potential eye damage with repeated exposure. Wear safety glasses with side-shields or face shield.

Ingestion: May cause irritation of mouth, throat, and an upset stomach. Wear a mouth cover or face shield when there is splashing. Keep away from food and drink. Do not swallow.

First Aid: See box at left.

pH 4.00, 7.00, 10.00 Buffer Solutions

3821, 3822, and 3823

pH 4 Ingredients: Water, Potassium Hydrogen Phthalate, Red food coloring

pH 7 Ingredients: Water, Potassium Phosphate Monobasic, Sodium Hydroxide, Yellow food coloring

pH 10 Ingredients: Water, Potassium Hydroxide, Disodium EDTA dihydrate, Potassium Borate, Potassium Carbonate, Bromphenol Blue Sodium Salt, Bromphenol Green Sodium Salt

Inhalation: Avoid breathing vapors or mists. Inhalation of dust may cause irritation of respiratory tissues. Ensure adequate ventilation is available before handling.

Skin: Exposure may cause irritation with repeated exposure. Wear rubber or neoprene gloves.

Eyes: Can cause irritation and potential eye damage with repeated exposure. Wear safety glasses with side-shields or face shield. Contact lenses should not be worn when working with these solutions.

Ingestion: May cause nausea, vomiting, or diarrhea. Wear a mouth cover or face shield when there is splashing. Do not swallow. Do not induce vomiting.

First Aid: See box on previous page.

Zobell Solution

3682

Ingredients: Potassium Chloride, Potassium Ferrocyanide Trihydrate, Potassium Ferricyanide

Inhalation: Inhalation of dust may cause irritation of respiratory tissues. Ensure adequate ventilation is available before handling.

Skin: Exposure may cause irritation. Wear lightweight protective clothing, gloves, boots, and apron.

Eyes: May cause irritation. Wear safety glasses with side-shields or face shield.

Ingestion: May cause an upset stomach. Wear a mouth cover or face shield when there is splashing. Keep away from food and drink. Do not swallow. If large amount is ingested and person is conscious, induce vomiting.

First Aid: See box on previous page.

Turbidity Standard

6073

Ingredients: Water, Styrene divinyl Benzene copolymer beads

The material is not volatile and has no known ill effects on skin, eyes, inhalation or ingestion. Therefore, no special precautions are required when using the standards. However, general precautions should be adopted as required with all materials to minimize unnecessary contact.

First Aid: See box on previous page.

Ultraviolet Light

The fDOM sensor radiates ultraviolet light (UV light) which can be harmful to the eyes even during brief periods of exposure. Do not look into the light at the tip of the probe and wear protective eyewear when handling UV LEDs.

Lithium-Ion Battery Handling

⚠ **WARNING:** Failure to exercise care when handling this product and to comply with the following conditions and guidelines could result in product malfunction, excessive heat, fire, property damage, and ultimately injury.

- **DO NOT** alter, puncture, or impact battery or related components.
- **DO NOT** directly connect the terminals with metal objects.
- **DO NOT** expose the battery to extreme temperatures or direct extended exposure to sunlight.
- Always disconnect batteries when not in use and for long term storage.
- Store batteries in a non-conductive and fireproof container.
- For best results, store the battery at approximately 50% of the capacity.

If at any time the battery becomes damaged, hot, or begins to balloon or swell, discontinue charging (or discharging) immediately. Quickly and safely disconnect the charger. Then place the battery and/or charger in a safe, open area way from flammable materials. After one hour of observation, remove the battery from service. **DO NOT** continue to handle, attempt to use, or ship the battery. Failure to follow these procedures can cause damage to the battery, personal property or cause serious injury.

Damaged or swollen batteries can be unstable and very hot. **DO NOT** touch batteries until they have cooled. In the event of a fire use a Class A, B, or C fire extinguisher. **DO NOT** use water.

If the internal battery fluid comes into contact with your skin, wash the affected area(s) with soap and water immediately. If it comes into contact with your eye(s), flush them with generous amounts of water for 15 minutes and seek immediate medical attention.

8.2 Radio Frequency

Xylem certifies that the EXO product line has been tested and complies with the following radio frequency (RF) interference standards and are approved for use in the following countries:

• United States: FCC Part 15 compliant
• Canada: RSS compliant
• European Union (EU): CE compliant
• Australia: CISPR 11 compliant
• New Zealand: CISPR 11 compliant
• Republic of Korea: Radio Waves Act compliant
• People's Republic of China: Radio regulations compliant
• Japan: TELEC Radio Law compliant
• Brazil: Anatel certification compliant

Reference the Declaration of Conformity in the next section for further details.

Bluetooth wireless technology and similar approvals and regulations can be country-specific. Check local laws and regulations to insure that the use of wireless products purchased from Xylem or its subsidiaries are in full compliance.

8.3 Declarations of Conformity

The undersigned hereby declares that the products listed below conform with all applicable requirements of FCC Part 15 for the U.S. and Industry Canada (IC) ICES-003 for Canada, for intentional radiators.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1 and EXO2) and EXO Handheld Systems
Model numbers:	599501-xx, 599511-xx, 599502-xx, 599512-xx, 599150
Intentional Radiators:	EXO Sondes (EXO1 and EXO2) contain the LMX Bluetooth module: FCC ID ED9LMX9838; IC 1520A-LMX9838. Nemko certified body ID #CE 2302. EXO Handheld (599150) contains a Wi-Fi/Bluetooth module: FCC ID U9R-W2CBW003; IC 7089A-W2CBW003. Nemko certified body ID #CE 2302.
Regulations:	• FCC 47 CFR Part 15-2011, Radio Frequency Devices. • IC ICES-003-2004, Digital Apparatus.

Lisa M. Abel, Director, Quality
June 7, 2012

The undersigned hereby declares that the products listed below conform with all applicable Essential Requirements of the listed Directives and Standards and carry the CE mark accordingly.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1 and EXO2) and EXO Handheld Systems
Model numbers:	599501-xx, 599511-xx, 599502-xx, 599512-xx, 599150
Accessories/Sensors:	599090-xx, 599100-xx, 599101-xx, 599102-xx, 599104-xx, 599118-xx, 599800, 599810, 599870-xx, 599040-xx, 599008-xx, EXOISE0x
Intentional Radiators:	EXO Sondes (EXO1 and EXO2) contain the LMX Bluetooth module. EXO Handheld (599150) contains a Wi-Fi/Bluetooth module. Nemko certified body ID#CE 2302.

Directives:
- EMC 2004/108/EC
- R&TTE 1999/5/EC
- ROHS
- WEEE

Harmonized Standards:
- EN61326-1:2006, Electrical equipment for measurement, control, and laboratory use – EMC requirements – Part 1: General Requirements.
- EN61326-2-3:2006, Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-3: Particular Requirements – Test configuration, operational conditions, and performance criteria for transducers with integrated or remote signal conditioning.
- EN61000-3-2:2006+A1:2009+A2:2009, Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current <16A per phase).
- EN61000-3-3:2008, Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems for equipment with rated current < 16A per phase and not subject to conditional connection.
- EN 300 328, V1.7.1, Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz ISM band and using wide band modulation techniques; Harmonized EN covering essential requirements under article 3.2 of the R&TTE Directive.
- EN 301 489-1, V1.8.1, Electromagnetic compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements.
- EN 301 489-17, V2.1.1, Electromagnetic compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment; Part 17: Specific conditions for Broadband Data Transmission Systems.
- EN 60950-1: Information technology equipment – Safety – Part 1: General requirements.

Lisa M. Abel, Director, Quality
June 7, 2012

The undersigned hereby declares that the products listed below conform with the Australian and New Zealand Electromagnetic Compatibility (EMC) requirements for generic products to be used in residential, commercial, and light industrial environments, and carry the C-Tick mark accordingly.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA

Equipment name:	EXO Sondes (EXO1 and EXO2) and EXO Handheld Systems
Model numbers:	599501-xx, 599511-xx, 599502-xx, 599512-xx, 599150
Accessories/Sensors:	599090-xx, 599100-xx, 599101-xx, 599102-xx, 599104-xx, 599118-xx, 599800, 599810, 599870-xx, 599040-xx, 599008-xx, EXOISE0x
Intentional Radiators:	EXO Sondes (EXO1 and EXO2) contain the LMX Bluetooth module. Nemko certified body ID #CE 2302. C-Tick number N136. EXO Handheld (599150) contains a Wi-Fi/Bluetooth module. Nemko certified body ID #CE 2302. C-Tick number N136.

Directives:
- EMC 2004/108/EC
- Australian ACMA Standards for C-Tick mark, Section 182 of the Radiocommunications Act 1992.
- New Zealand RSM Standards, Radiocommunications Act 1992.
- Telecommunications Labeling, Notice 2001 under section 407 of the Australian Telecommunications Act 1997.

Standards:
- EN61326-1:2006, Electrical equipment for measurement, control, and laboratory use – EMC requirements – Part 1: General Requirements.
- ACMA Radio Communications (Short Range Devices), 2004.
- AS/NZ 4268, 2008.
- Radio Communications (Electromagnetic Radiation - Human Exposure) Standard, March 2003.

Lisa M. Abel, Director, Quality
June 7, 2012

The undersigned hereby declares that the products listed below conform with all applicable requirements of the Radio Waves Act of Korea, for intentional radiators.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1 and EXO2) and EXO Handheld Systems
Model numbers:	599501-xx, 599511-xx, 599502-xx, 599512-xx, 599150
Intentional Radiators:	EXO Sondes (EXO1 and EXO2) contain the LMX Bluetooth module. Broadcasting and certification number KCC-CRM-XYL-EXOSonde1 (for EXO1) and KCC-CRM-XYL-EXOSonde2 (for EXO2). EXO Handheld (599150) contains a Wi-Fi/Bluetooth module. Broadcasting and certification number KCC-CRM-XYL-EXOHANDHELD (for EXO Handheld).
Type Identification:	LARN8-IO2Y2402/2480TR0.000003F1D79 (EXO1) LARN8-IO2Y2402/2480TR0.00001F1D79 (EXO2) LARN8-IO2Y2402/2480TR0.00003F1DG1D79 (EXO Handheld)
Regulation:	Radio Waves Act of the Republic of Korea.

A급 기기 (업무용 방송통신 기자재)
이 기기는 업무용 (A급) 전자파 적합기기로서
판매자 또는 사용자는 이 점을 주의하시기 바라
며, 가정 외의 지역에서 사용하는 것을 목적으 로 합니다.

Class A device (Broadcasting and communication equipment for office work).

Seller and user shall be noticed that this equipment is suitable for electromagnetic equipment for office work (Class A) and it can be used outside the home.

KCC notice 2012-12. Radio device using 2400-2483.5 MHz and 5725-5825 MHz.
해당 무선설비는 전파혼신
가능성이 있으므로 인명안전과
관련된 서비스는 할 수 없음.
Service related to human safety is not allowed because this device may have the possibility of the radio interference.

Lisa M. Abel, Director, Quality
December 13, 2012

The undersigned hereby declares that the products listed below conform with all applicable requirements of the Radio Regulations of China, for intentional radiators.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1 and EXO2) and EXO Handheld Systems
Model numbers:	599501-xx, 599511-xx, 599502-xx, 599512-xx, 599150
Intentional Radiators:	EXO Sondes (EXO1 and EXO2) contain the LMX Bluetooth module. EXO Handheld (599150) contains a Wi-Fi/Bluetooth module.
CMIIT ID:	CMIIT ID: 2012DJ7503 (EXO1) CMIIT ID: 2012DJ7504 (EXO2) CMIIT ID: 2012DJ7505 (EXO Handheld)
Regulation:	Radio Regulations of the People's Republic of China.

A级设备（办公用广播和通讯设备）
销售商和使用者应注意本设备适用于办公条件下的电磁环境（A级）并可以在室外使用。
Class A device (Broadcasting and communication equipment for office work).
Seller and user shall be noticed that this equipment is suitable for electromagnetic equipment for office work (Class A) and it can be used outside the home.

Lisa M. Abel, Director, Quality
December 13, 2012

The undersigned hereby declares that the products listed below conform with all applicable requirements of TELEC and Radio Law of Japan for intentional radiators.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1 and EXO2) and EXO Handheld Systems
Model numbers:	599501-xx, 599511-xx, 599502-xx, 599512-xx, 599150
Intentional Radiators:	Intentional radiators: EXO Sondes (Exo1 and Exo2) contain the LMX Bluetooth module. Exo1 TELEC certificate number 001-A00577. Exo2 TELEC certificate number 001-A00578. EXO Handheld contains a Wi-Fi/Bluetooth module; certificate number 001-A00579.
Regulations:	TELEC; Article 38-24 Paragraph 1 of the Radio Law.

Lisa M. Abel, Director, Quality
June 7, 2012

The undersigned hereby declares that the products listed below conform with all applicable requirements of the Anatel Regulations of Brazil for intentional radiators.

Manufacturer: YSI Incorporated, a Xylem brand
1725 Brannum Lane
Yellow Springs, OH 45387 USA

Equipment name: EXO Sondes (EXO1 and EXO2) and EXO Handheld Systems

Model numbers: 599501-xx, 599511-xx, 599502-xx, 599512-xx, 599150

Intentional Radiators: Intentional Radiators: EXO Sondes (EXO1 and EXO2) contain the LMX Bluetooth module: Certificate of Homologation No. 0657-13-8838; Certificate of Conformity No. 07473/13. EXO Handheld (599150) contains a Wi-Fi/Bluetooth module: Certificate of Homologation No. 1281-13-8838; Certificate of Conformity No. 07769/13.

Regulations: Anatel; Transceptor de Radiacao Restrita - Categoria II

Lisa M. Abel, Director, Quality
June 7, 2012

8.4 Instrument Warranty

Warranty Card

Register your product with the online warranty card: www.EXOwater.com/warranty

Warranted against defects in workmanship and materials when used for their intended purposes and maintained according to instructions and exclusive of batteries and any damage caused by defective batteries.

Two years: cables; sondes (bulkheads); handheld; conductivity, temperature, depth, and optical sensors; electronics base for pH, pH/ORP, ammonium, chloride, and nitrate sensors; and accessories.

One year: optical DO membranes and replaceable reagent modules for pH and pH/ORP.

Three months: replaceable reagent modules for ammonium, chloride, and nitrate.

Regular maintenance of sondes and sensors, such as replacing damaged o-rings, is described in the Maintenance section of this manual. Users are expected to follow these guidelines to keep their equipment in good and proper working order and to protect the warranty on the product. Damage due to accidents, misuse, tampering, or failure to perform prescribed maintenance is not covered.

This warranty does not include batteries or damage resulting from defective batteries. As documented in the Maintenance section of this manual, batteries should be removed from all sondes and handheld when the product is not in use. Since many battery manufacturers will repair or replace any equipment that has been damaged by their batteries, it is essential that leaky or defective batteries be retained with the damaged product until the manufacturer has evaluated the claim.

The warranty period for chemicals and reagents is determined by the expiration date printed on their labels. Within the warranty period, we will repair or replace, at our sole discretion, free of charge, any product that we determine to be covered by this warranty.

To exercise this warranty, write or call your local representative, or contact Technical Support. Send the product and proof of purchase, transportation prepaid, to the Authorized Service Center selected by the manufacturer. Repair or replacement will be made and the product returned transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days from date of repair or replacement.

Limitation of Warranty

This Warranty does not apply to any EXO product damage or failure caused by (i) failure to install, operate or use the product in accordance with the written instructions, (ii) abuse or misuse of the product, (iii) failure to maintain the product in accordance with the written instructions or standard industry procedure, (iv) any improper repairs to the product, (v) use by you of defective or improper components or parts in servicing or repairing the product, or (vi) modification of the product in any way not expressly authorized by the manufacturer.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. YSI's LIABILITY UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AND THIS SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY. IN NO EVENT SHALL YSI BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY.

EXO Authorized Service Centers are located in the United States and around the world. Please refer to the EXO website (**EXOwater.com**) for your nearest Authorized Service Center.

8.5 Instrument Service
Cleaning and Packing

Product Return Form

Find the product return form online:
www.EXOwater.com/return

Cleaning Certificate

Find the cleaning certificate on the back of the online product return form:
www.EXOwater.com/return

Cleaning Instructions

Before they can be serviced, equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected. Biological contamination is presumed for any instrument, probe, or other device that has been used with body fluids or tissues, or with wastewater. Radioactive contamination is presumed for any instrument, probe or other device that has been used near any radioactive source.

If an instrument, probe, or other part is returned or presented for service without a Cleaning Certificate, and if in our opinion it represents a potential biological or radioactive hazard, our service personnel reserve the right to withhold service until appropriate cleaning, decontamination, and certification has been completed. We will contact the sender for instructions as to the disposition of the equipment. Disposition costs will be the responsibility of the sender.

When service is required, either at the user's facility or at the manufacturer, the following steps must be taken to insure the safety of our service personnel:

- In a manner appropriate to each device, decontaminate all exposed surfaces, including any containers. 70% isopropyl alcohol or a solution of 1/4 cup bleach to 1 gallon tap water are suitable for most disinfecting. Instruments used with wastewater may be disinfected with .5% Lysol® if this is more convenient to the user.

- The user shall take normal precautions to prevent radioactive contamination and must use appropriate decontamination procedures should exposure occur.

- If exposure has occurred, the customer must certify that decontamination has been accomplished and that no radioactivity is detectable by survey equipment.

- Cleaning must be completed and certified on any product before returning.

Packing Instructions

- Clean and decontaminate items to insure the safety of the handler.
- Complete and include the Product Return Form, found online.
- Place the product in a plastic bag to keep out dirt and packing material.
- Use a large carton, preferably the original, and surround the product completely with packing material.

ANNUAL MAINTENANCE SPECIAL

Download our Maintenance Brochure

Preventive Maintenance Note
A biennial (every two years) wiper shaft o-ring replacement is recommended to maintain optimum performance of the EXO2 wiper.
Contact us to learn more: repairs@ysi.com or +1 (800) 765-4974 (US)

8.6 Instrument Service
Recycling

Batteries

The user must remove and dispose of alkaline batteries when they no longer power the EXO1 sonde, EXO2 sonde, or EXO Handheld. Disposal requirements vary by country and region, and users are expected to understand and follow the battery disposal requirements for their specific locale.

The circuit board in these instruments may contain a manganese dioxide lithium “coin cell” battery that must be in place for continuity of power to memory devices on the board. This battery is not user serviceable or replaceable. When appropriate, an authorized service center will remove this battery and properly dispose of it, per service and repair policies.

Rechargeable Li-Battery Pack

(1)When the battery is worn out, insulate the terminals with adhesive tape or similar materials before disposal.

(2)Dispose of batteries in the manner required by your city, county, state or country. For details on recycling lithium-ion batteries, please contact a government recycling agency, your waste-disposal service, or visit reputable online recycling sources such as **www.batteryrecycling.com.**

This product must not be disposed of with other waste. Instead, it is the user’s responsibility to dispose of their waste equipment by handing it over to a designated collection point for the recycling of waste electrical and electronic equipment. The separate collection and recycling of your waste equipment at the time of disposal will help to conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment.

For more information about where you can drop off your waste equipment for recycling, please contact your local city office, or your household waste disposal service. **DO NOT ship batteries to YSI.**

Manufacturer

We are committed to reducing the environmental footprint of our products. While materials reduction is the ultimate goal, we also make a concerted effort to responsibly deal with materials after a long, productive life-cycle. Our recycling program ensures that old equipment is processed in an environmentally responsible way, reducing the amount of materials going to landfills.

- Printed circuit boards are sent to facilities that process and reclaim as much material for recycling as possible.
- Plastics enter a material recycling process and are not incinerated or sent to landfills.
- Batteries are removed and sent to battery recyclers for dedicated metals.

xylem
Let's Solve Water

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