C1000-200 Nitrate & Phosphate Sensor Operation and Maintenance Manual

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Revision History

Rev.	Release Date	Prepared	Approved	Revision Description
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1 Safety & Specifications

1.1 Safety Information

⚠ WARNING

Phosphate Reagent 1, Nitrate Reagent, and the final waste solution are **hazardous fluids**. Avoid contact with exposed skin. Spills or leaks should be immediately cleaned with a wipe while wearing the required Personal Protective Equipment (PPE).

There are four (4) different fluids that are used to operate the DOT C1000-200 NP Sensor. A fifth (5^{th}) reservoir is used to collect waste and is empty on installation. During standard operation, the waste reservoir will fill with a mixture of each of the four (4) fluids and sample water. The resultant waste will consist mostly of sample water and is therefore quite diluted. To determine the waste contents by percentage, refer to the scripts used to operate the sensor for your application.

The five (5) fluid reservoirs required to operate the sensor (including waste) are listed below:

1) (RG1) Reagent Solution 1 – **may be hazardous** (acidic, < 1 % sulfuric acid)
2) (RG2) Reagent Solution 2
3) (RG3) Nitrate Reagent – **hazardous**
4) (ST) Combined Nitrate & Phosphate On-Board Standard
5) (WS) Waste – **treat contents as hazardous**

Each fluid is contained in its own reservoir and must be connected to the sensor via tubing before use. A label can be found on each fluid reservoir detailing the contained fluid and the relevant safety information. When handling the fluid reservoirs, wear all listed PPE. Inspect all lines carefully for leaks.

Required PPE includes:

1) Protective gloves
2) Safety glasses
3) Long-sleeved clothing (recommended)

Fluids disposal must comply with the requirements of all applicable local, regional, or national/federal regulations. Refer to the SDS for each fluid (included digitally on the DOT NP Sensor USB Drive and available by email from Aftersales@DartmouthOcean.com.)

⚠ WARNING

Exercise caution when replacing fluid bags. Replace or drain waste reservoirs when fluids are serviced.

1.2 Identification

Every Sensor Housing, Reagent Housing, and Battery Pack is assigned a model number and a unique serial number. The model number and serial number are written on ID tags attached to the relevant component. The Model and Serial Number of the sensor is also recorded electronically and can be accessed through the operating software. Please refer to the Model and Serial Number of your unit when communicating with DOT about warranty, servicing, or technical issues.

1.3 Specifications

1.3.1 Mechanical

Table 1: Mechanical specifications

Parameter	Specification
Maximum Depth Rating	200 m
Operating Temperature Range	4 °C – 35 °C
Weight	
In Air (empty reagent reservoirs)	5 kg
In Water	2.2 kg
Dimensions	
Sensor	Length = 20”, ϕ = 4.5” (Largest)
Reagent Case	Length = 14”, ϕ = 4.5”

1.3.2 Electrical

Table 2: Electrical specifications

Parameter	Specification
Input Voltage	7 V (Battery or Supply) or 9 V to 24 V (Supply)
Power Draw (Sleep, Idle, Peak)	0.22 W, 1 W, ~12 W
Communication	RS-232: 115200 Baud, 8n1 (Programming) Ethernet (File Upload/Download)
Data Storage	1 GB Micro SD Card

1.3.3 Optical

Table 3: Optical specifications

Parameter	Optical Cell #1	Optical Cell #2
Peak Wavelength	527 nm	880 nm
Spectral Line Half Width	35 nm	60 nm
Optical Path Length	10.4 mm	25.4 mm

1.3.4 Analytical

Table 4: Analytic specifications at T = 25 °C

Parameter	Nitrate Specification	Phosphate Specification
Dynamic Concentration Range	2 – 100 µM NO_3^-	0.2 – 10 µM PO_4^{3-}
Limit of Detection (LOD)	97 nM NO_3^-	15 nM PO_4^{3-}
Limit of Quantification (LOQ)	324 nM NO_3^-	50 nM PO_4^{3-}

2 Parts and Equipment

The following tables list the required parts needed to operate the C1000-200 Nitrate Phosphate Sensor.

Table 5: Manufacturer-supplied equipment

Part no.	Description
DOT-0164	C1000-200 NP Sensor
DOT-0166	Reagent Case
DOT-1277	NP Reagent Kit
DOT-1309	DOT NP Sensor USB Flash Drive
DOT-0356	Control Pendant with Ethernet and DB9 to USB
DOT-1290	Universal Power Adapter (for Wall Outlet Power)
DOT-0947	8-Pin Dummy Plug (Male)
DOT-0949	6-Pin Dummy Plug (Female)
DOT-0950	5-Pin dummy Plug (Male)

Table 6: Required user-supplied equipment

Equipment
Laptop or PC
External power supply with 7V or 9-24 V DC output, or wall outlet power with DOT Power Adapter
Hex (Allen) Key, 4 mm
Hex (Allen) Key, 3 mm
Hex (Allen) Key, 2 mm
(*Recommended*) Lint-free wipes, such as Kimtech Kimwipes™

Table 7: Miscellaneous / replacement equipment (sold-separately)

Part no.	Description
DOT-1277	NP Reagent Kit
N/A	Inlet Filter, 0.45 µm Pore Size
DOT-0200	DOT Battery Pack, twelve (12) D-cell size, 7 V DC, 80.2 Ah (batteries not incl.)
DOT-0635	D cell Battery, Li-$SOCl_2$, 3.6V, (twelve cells required per DOT Battery Pack)

3 Physical Setup

3.1 System Description

The DOT C1000-200 Nitrate Phosphate Sensor (NP Sensor) provides real-time measurement of nitrate and dissolved orthophosphate using an optimized wet-chemistry approach. Reagent consumption, reaction time, and power draw are reduced using microfluidic Inlaid Optical Technology™. On-board standards are used to correct for drift and maximize measurement accuracy during long-term deployments. The sensor is compatible with many deployment configurations including platform-mounted, towed, or in autonomous underwater vehicles. The sensor may also be used as a benchtop analyzer for laboratory or environmental samples.

Each nutrient is measured using a different colourimetric assay using two parallel inlaid optical cells. Nitrate measurements are performed by mixing sample with one reagent to produce a purple-coloured complex that is measured in Optical Cell #1. Similarly, phosphate measurements are performed by mixing sample with two reagents to produce a blue-coloured complex that is measured in Optical Cell #2. The speed of the nitrate reaction is heavily influenced by external temperature, where warmer environmental conditions lead to higher sensitivity and improved limits of detection (LOD).

Optical measurements are highly susceptible to errors from air bubbles entering the optical channel(s). Air bubbles may produce one or several erroneous measurements until the air has cleared the system.

⚠ WARNING
Always avoid introducing air into the system. Ensure the Sensor is fully submerged underwater before pumping using the Sample port. Orient fluid reservoirs to minimize air transfer from bag to sensor.

The protocol outlined above requires four (4) fluids. RG1 and RG2 are two reagents used for phosphate detection, and are named Phosphate Reagent 1 and Phosphate Reagent 2. RG3 is the colour-developing reagent of Nitrate, also referred to as Nitrate Reagent. Finally, ST is an on-board standard used to check analytical performance *in situ* – useful when checking that each reagent has not expired. Each fluid is contained in a flexible bag located in the Reagent Housing. The spent fluids are collected in an onboard waste reservoir (WS), also found in the Reagent Housing. **Before operating, ensure tubing connected to each fluid port are not capped with plugs. Tubing must be attached to fluid reservoirs before operating scripts.**

⚠ WARNING
NEVER operate the Nitrate & Phosphate Sensor with capped tubing lines.

Table 8 lists the major components of the C1000-200 Nitrate & Phosphate Sensor with optional mounting bracket (depicted in Figure 1).

Table 8: List of major system components (sensor, reagent cannister, and optional dual-cannister mounting bracket)

Schematic number	Part name	Description
1	Sensor housing	Contains syringe pumps, motors, microfluidic chip, optical sources, and detectors.
2	Reagent housing	Contains fluid reservoirs for reagents, standards, and waste collection.
3	Mounting bracket assembly	Secures sensor and reagent bulkheads in place and to an external platform. Optional accessory.
6	Fluid ports (reagent housing)	Supplies fluids from reagent housing to sensor
11	Subsea connector	Provides power and communication to valve manifold.

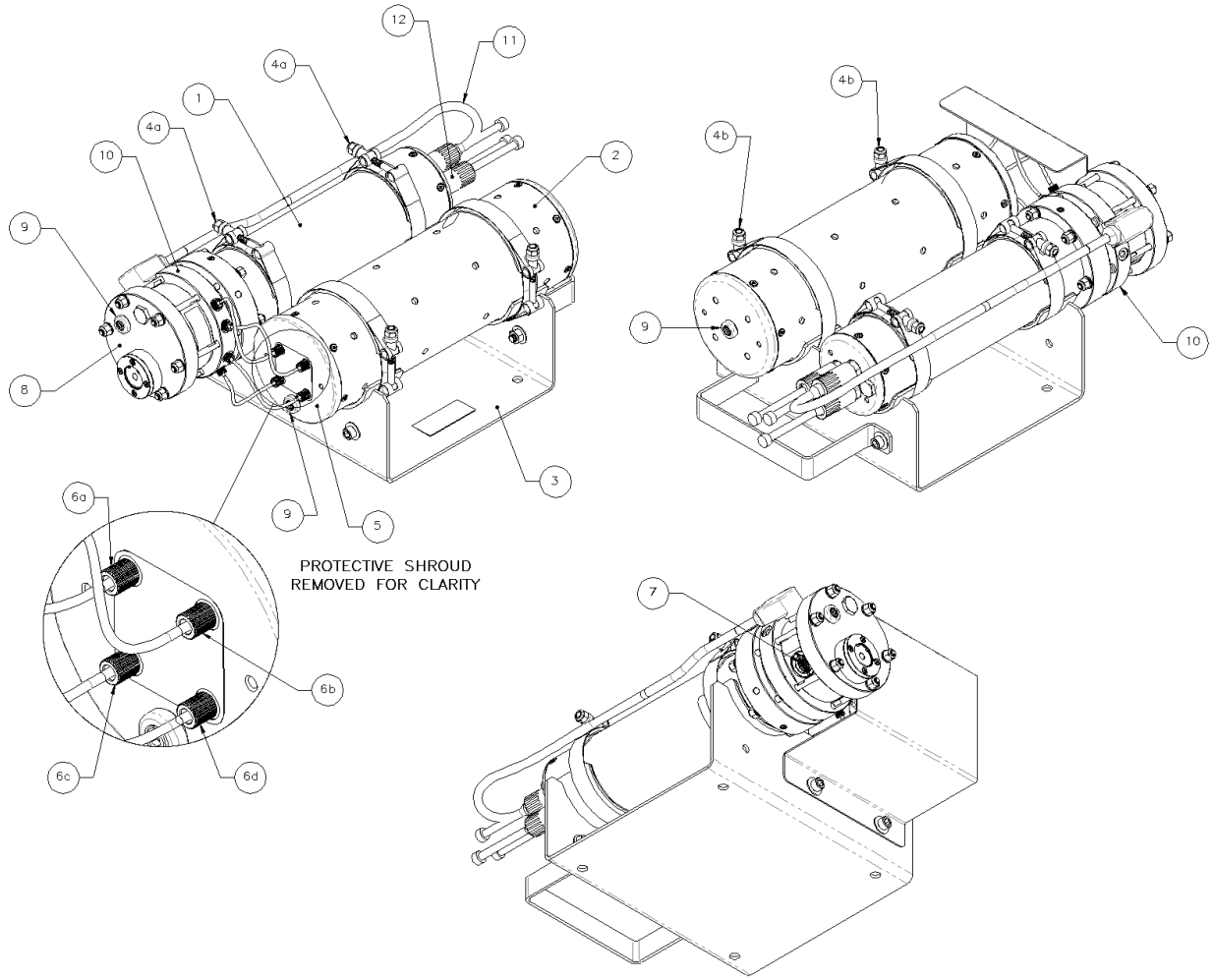


Figure 1: Overview of major system components

3.2 Assembly Instructions

3.2.1 Installation and Removal of Reagent Reservoirs

⚠ WARNING

The waste reservoir will burst if overfilled. Do not fill beyond the size of the supplied waste reservoir.

The DOT NP Reagent Kit contains the various fluids needed for sensor operation. Each kit contains five (5) fluid reservoirs that must be connected to the sensor before use. The kit includes four (4) flexible bags filled with chemical reagent and one (1) empty bag used to collect waste. The fluid reservoirs are listed below with typical volumes:

1) RG1 – Phosphate Reagent 1 Reservoir, 100 mL (filled)
2) RG2 – Phosphate Reagent 2 Reservoir, 100 mL (filled)
3) RG3 – Nitrate Reagent Reservoir, 250 mL (filled)
4) ST – On-Board Standard Reservoir, 100 mL (filled)
5) WS – Waste Reservoir, 1 L (empty upon delivery)

The volume each fluid reservoir is filled to upon delivery is listed on its respective label. In the case of the waste reservoir, the maximum filling capacity is listed on its label. **NEVER fill waste reservoirs beyond their stated volume limits.** Users must take care to replace fluid reservoirs when needed.

Figure 2 provides an installation guide for each reservoir. Four ports can be located on the sensor as shown with labels “WS”, “RG1”, “RG2”, and “ST”. **A fifth port for RG3 (Nitrate Reagent) is located on the reverse side of the sensor.**

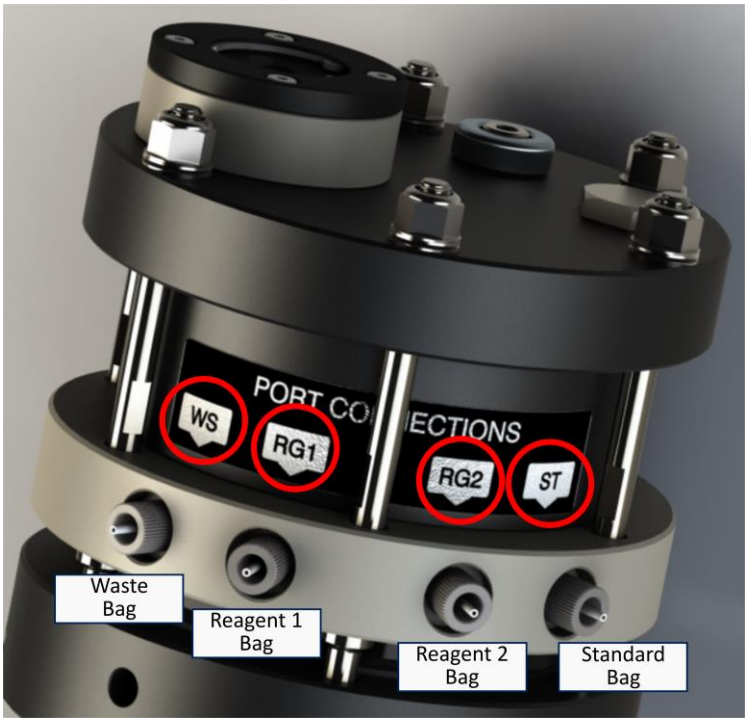


Figure 2: Labelled fluid port connections. RG3 is located on the back side.

⚠ WARNING

Ensure that the correct reagent reservoir is connected to the correct port on Sensor. Incorrect connections will result in improper measurement of nutrients.

Each fluid reservoir contains two (2) tubes. One (1) tube is connected to the Sensor; the second tube is used during the reservoir filling operation only. Two colour-coded caps are applied to the ends of each tube.

- Black covered tube – not used.
- Green covered tube – connects to Sensor. Remove green cover and plastic cap. **NEVER remove purple Luer valve (bag will spill fluid)**.

The reservoir connection tube employs a purple coloured Luer shut-off valve. The valve threads onto a female Luer tubing fitting. This valve is passively closed, and only opens the fluid path when connected to a fitting on both sides of the valve. This seals the reservoir when not connected to Sensor and allows for easy, drip free installation. The valve also minimizes air that enters the fluid system during reservoir connection, as air in the system can be detrimental to Sensor function.

Figure 3: Fluid reservoirs. Connect green-capped tube to Sensor. NEVER remove purple valve.

⚠ WARNING

Always wear the required PPE when removing or installing reagent reservoirs. Wipe up all fluid leaks and spills immediately.

Removal of Depleted Reagents / Filled Waste Reservoirs & Installation of New Reservoirs

Required Tools / Equipment

- (PPE) Protective gloves / clothing / eye and face protection
- Hex (Allen) Key – 3 mm
- Five (5) Luer fluid Port Caps (to cap tubes, only for disconnecting fluids for long term sensor storage)

To remove spent reservoirs from Sensor, perform the following procedures:

1) Disconnect Sensor from external power supply (optional but recommended).
2) Remove Reagent Housing from bracket. Place on a horizontal surface nearby. Give yourself as much space as allowed by the tubing.
3) Remove Reagent Housing lid (see Figure 4) using a 3 mm Hex Key:
    a. **Partially** unscrew each of the three (3) screws until the larger shoulder clears the reagent housing. The screws should not come out.
    b. Rotate the lid to move the three screws from the locked to unlocked position – see Figure 4.
    c. Pull lid straight away from housing until lid is removed from housing. The lid cannot be fully removed until the bags are disconnected from the Sensor tubes. Pull lid away from housing as needed to access bags.
4) With lid removed, slide spent fluid reservoirs out of the reagent housing.
5) For each fluid reservoir to replace:
    a. Disconnect fluid reservoir from Sensor tubing. The disconnect point is between the purple Luer shutoff valve and the Idex Fitting of the tubing (see Figure 5).
    b. Wipe away any excess fluid using a lint free wipe (optional).
    c. Install new fluid reservoir to Sensor tubing by connecting to the purple Luer shutoff valve. Tighten connection using black ring on Idex fitting.
    d. Repeat for all bags.
6) Dispose of spent reservoirs. For long term sensor storage, plug each of the five (5) tubes.

Note: the Waste reservoir may be reused if desired after emptying. Take care to inspect fluid reservoirs of kinks, cracks, or potential leaks before (re)installation.

Figure 4: Reagent housing – lid removal

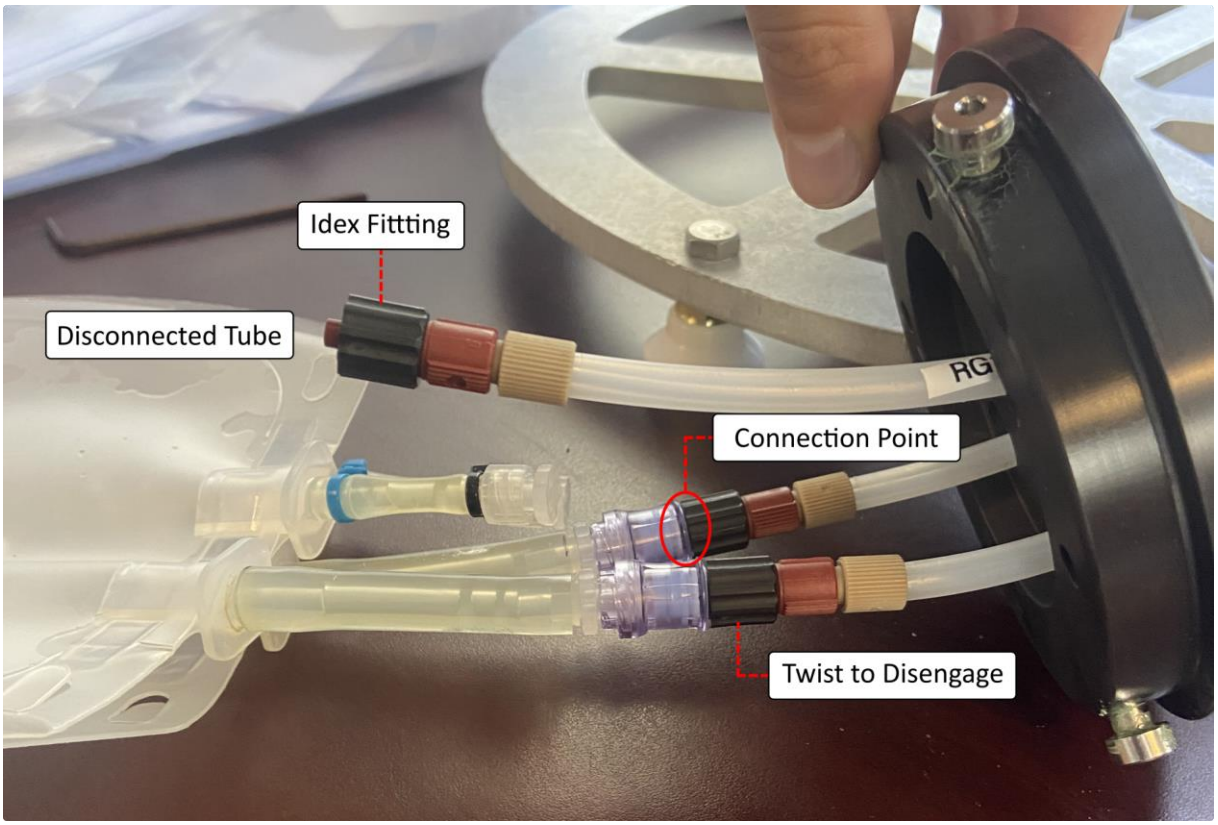


Figure 5: Fluid reservoir removal

3.2.2 Tri-Bracket Assembly and Removal of Sensor and Reagent Housings

The Tri-Bracket is typically shipping with its base disassembled; to re-assemble, slide the base of the bracket onto the bottom of the pole of the main assembly such that the three feet of the base face down. Tighten the base onto the assembly using the provided nut with an adjustable wrench.

For each housing, there are two metal clasps used to secure the housing to each of the two plastic cradles of the Tri-Bracket. When installing a Sensor or Reagent Housing onto the bracket, be sure to align each cannister such that there is an appropriate amount of tension placed on the fluidic tubing running between cannisters.

3.2.3 Inlet Filter Installation and Removal

Inlet Filter Installation

Required Tools / Equipment

- Fresh 0.45 µm inlet filter
- Disposable gloves
- Lint free wipes (if inlet is wet or dirty)
- Isopropyl alcohol (if inlet noticably dirty)

To install a fresh inlet filter:

1) Put on fresh disposable gloves.
2) (If applicable) Remove used inlet filter from sample inlet. Refer to **Inlet Filter Removal** for instructions.
3) Inspect sample inlet and surrounding surfaces for residual fluid, dirt, and/or other particulates.
    a. If visibly fouled to the point where it may affect pulling fluid through the sample inlet, clean surfaces with isopropyl alcohol and a lint free wipe.
    b. If surfaces are wet, gently pat-dry with a lint-free wipe. Do not dry the inlet port itself.
4) Locate package containing a fresh 0.45 µm filter.
5) Open filter package and remove 0.45 µm filter for installation.
6) Locate the male Luer fitting on the orange side of the filter.
7) Locate the female Luer fitting on the sample inlet.
8) Mate the male Luer fitting on the orange side of the filter to the female Luer fitting on the sample inlet. Rotate filter clockwise until finger tight. When assembled, the inlet filter should feel fixed in place.

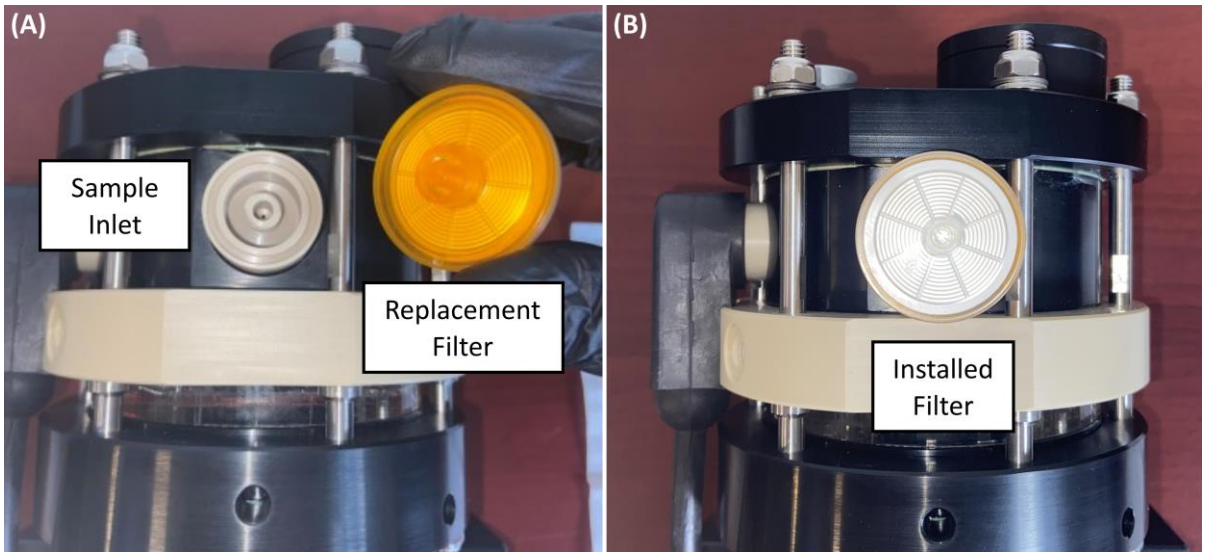


Figure 6: (A) Exposed inlet port (beige) and replacement filter (orange). (B) Installed filter.

Inlet Filter Removal

Required Tools / Equipment

- Disposable gloves
- Lint free wipes (if inlet is wet or dirty)
- Isopropyl alcohol (if inlet noticably dirty)

To remove the inlet filter:

1) Put on fresh disposable gloves.
2) Inspect inlet filter and surrounding surfaces for residual fluid, dirt, and/or other particulates.
    a. If visibly fouled, clean surfaces with isopropyl alcohol and a lint free wipe.
3) Using your dominant hand, grab the inlet filter around the rim using your thumb and 1—2 fingers.
4) Unscrew inlet filter counter-clockwise to remove. Do not twist the beige base underneath.

Note: dust and particulates may drift into the inlet port if left exposed for extended periods. After removing the sample inlet, promptly cover the inlet port using a fresh filter or a Luer cap.

⚠ WARNING

Do not leave the sample inlet exposed for extended periods. Install a new sample inlet filter, or plug the port with a Luer cap.

4 Electrical & Software

⚠ WARNING
Do not bend electrical cables beyond their natural bend radius, r = 10 x cable OD. Excessive bending can ruin cable integrity.

4.1 Power and Communications Connections

Before connecting any cables & connectors, ensure pins are well-lubricated and free from corrosion – refer to Section **7.1 Electrical Connections** for guidance on maintaining electrical connectors. There are three (3) electrical connections on the Sensor: an 8-Pin male bulkhead connector, used for communications, a 6-pin female bulkhead connector, used to supply power to the sensor, and a 5-pin female bulkhead connector. **The 5-pin female bulkhead is used for communications from top to the bottom of the sensor and shouldn't be unplugged.**

Figure 7 is a schematic diagram of the electrical connections required to provide power and communications to the Sensor. Communications are enabled through the DOT Control Pendant, with Serial communication over RS-232 and ethernet connection to a PC.

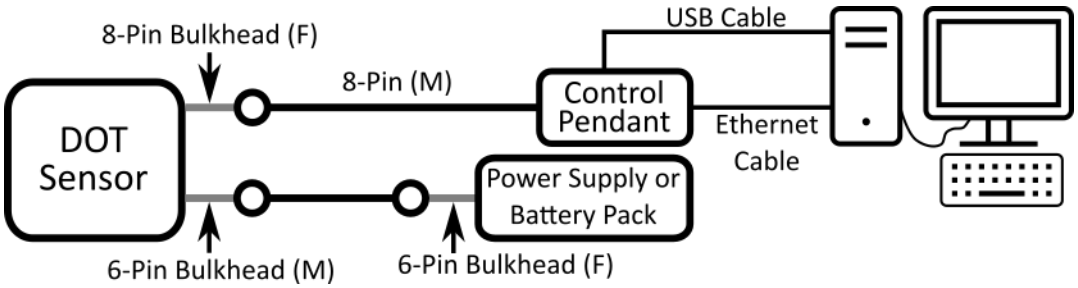


Figure 7: Electrical connections schematic diagram (power & communications)

4.1.1 Powering the Sensor Using Wall Outlet

Required Tools / Equipment

- Power Cord: Wall to Power Adapter
- DOT 24 V Power Adapter: 6-Pin Female to AC/DC External Power Adapter

Powering the Sensor using a DOT 24V Power Adapter is recommended during in-house use (*e.g.* configuration, bench testing). The DOT 24V Power Adapter can accept an input voltage of 100 - 264 VAC (47 – 67 Hz) from a wall outlet. The following instructions detail powering the Sensor from a wall outlet. The power cord is swappable and will depend on the region and type of wall outlet available.

1) (If applicable) Remove dummy plug from 6-Pin (M) power bulkhead.
    a. Rotate locking sleeve counter-clockwise until loose
    b. Pull plug and locking sleeve from 6-Pin (M) bulkhead to expose pins.

c. Store dummy plug and locking sleeve.

2) Connect the 6-Pin (F) of the DOT 24V Power Adapter to the 6-Pin (M) power bulkhead of the sensor.
3) Attach a Power cord to the Power Adapter.
4) Plug Power cord into a wall outlet.
5) Verify that the power adapter's indicator is green.

4.1.2 Powering the Sensor Using DOT Battery Pack

Required Tools / Equipment

- DOT Battery Pack loaded with twelve (12) non-depleted batteries
- 6-pin Male to Female Power Cable

The DOT Battery Pack can be used to power the Nitrate & Phosphate Sensor when an external power supply is not available and is applicable for benchtop use or field deployments.

1) (If applicable) Remove dummy plug from 6-Pin power bulkhead
    a. Rotate locking sleeve counter-clockwise until loose
    b. Pull plug and locking sleeve from 6-Pin cable to expose pins.
    c. Store dummy plugs and locking sleeves
2) Retrieve DOT Battery Pack
3) Remove dummy plug from 6-Pin female bulkhead connector on DOT Battery Pack
    a. Rotate locking sleeve counter-clockwise until loose
    b. Pull plug and locking sleeve from 6-Pin connector
    c. Store dummy plug and locking sleeve
4) Plug female end of 6-pin power cable into 6-pin male bulkhead on Sensor.
5) Plug male end of 6-Pin power cable into 6-Pin female bulkhead of Battery. Push cable into bulkhead until there is no gap visible between the two mating faces. The Sensor is now powered and on.
6) Retrieve locking sleeve on 6-Pin male power cable. Slide locking sleeve on cable to battery pack bulkhead. Rotate locking sleeve clockwise to seal cable to battery can bulkhead.

4.1.3 PC to Sensor Communications

Required Tools / Equipment

- DOT Control Pendant
- Powered Sensor
- Laptop / PC with at least one (1) available USB port and one (1) available ethernet port

The following steps detail the method to connect communications (comms.) between a PC and the Sensor. Refer to **Figure 7** for a detailed Electrical Connections schematic. Your Sensor should already be powered according to the procedures outlined in the previous Sections.

1) (If applicable) Remove dummy plug from 8-Pin Female bulkhead connector.
    a. Rotate locking sleeve counter-clockwise until loose
    b. Pull plug and locking sleeve from 8-Pin cable to expose holes
    c. Store dummy plug and locking sleeve

2) Connect 8-Pin (M) Comms cable from Control Pendant to 8-Pin (F) bulkhead connector on sensor.
3) Plug USB cable from DOT Control Pendant into an available PC USB port.
4) Plug Ethernet cable from DOT Control Pendant into an available PC ethernet port.
5) Open DOT Suite application to communicate with Sensor. Sensor might be in 'sleep mode' on initial connection; if this is the case power cycle the Sensor by disconnecting from power, waiting 5 seconds, and reconnecting to power.

⚠ WARNING

Serial communications over long cables may accrue errors in transmitted/received information. The use of longer communication cables than that of the DOT Control Pendant should always be done with caution.

4.2 DOT Suite (Software) Application Sensor Programming

An RS-232 serial connection is used to send communications between user and sensor. This connection is used to operate the sensor. A separate ethernet connection is used for file transfer between the sensor and a connected PC. *Ethernet connection may be skipped for sensor programming only.*

Through the DOT Suite application, users can:

- Review and modify the status of the Sensor:
  - Reagent and Waste Levels (in Development)
  - Sensor on-board Clock
  - Unit serial number, hardware, and firmware version
  - Measurement schedule / frequency
- Download data files:
  - Raw photodiode voltages, calculated absorbance, and calculated sample concentrations.
  - Calibration settings used in calculations
- Download instrument engineering and log data files from previous Sensor use:
  - Time-stamped orientation (pitch, roll) and power data
  - Full log of sensor activity with raw script commands
  - Warnings or error messages (if applicable)

For users that wish to operate their Sensor through an external controller without use of DOT Suite, contact DOT through email at Aftersales@DartmouthOcean.com for instructions on Serial Connectivity.

4.2.1 DOT Suite Installation

DOT Suite is an application provided by DOT to operate the Nitrate & Phosphate Sensor. DOT Suite combines sensor programming (Serial Communications) and file upload/download (FTP) in one convenient application. Refer to the Nitrate & Phosphate Sensor Software Manual for installation and user instructions.

4.2.2 Connecting to Instrument through DOT Suite

1) Power the Sensor – refer to Section **4.1 Power and Communications Connections.**
2) Connect Communications between Sensor and PC – refer to Section **4.1.3 PC to Sensor Communications.**
3) Open DOT Suite application.
4) Establish Serial Connection
    a. In **Serial Connection** window, click Configure.
    b. Select the COM Port from dropdown menu associated with your Sensor. If multiple COM Ports are available:
        i. Open Device Manager in Windows
        ii. Expand Ports and note the list of currently active ports
        iii. Unplug the Sensor from your PC and note which port disappears – this is your COM port
        iv. Re-plug the Sensor to the same USB port.
        v. Select COM port from dropdown menu
    c. Click Save to proceed
    d. Click Connect. If you have selected the correct COM Port and with the sensor powered, an auto refresh should occur to update the application.
5) Successful serial connection is shown by the green indicator in the top right corner. Instrument information is shown in the top left corner.
    a. If serial connection fails, there could be an error in the serial configuration. Click Configure in the Serial Connection panel and select the correct COM port. Baud rate is 115200 and shouldn't be changed.
6) To setup the FTP connection, go to the **Configure tab. Refer to Section 6.2.2 Ethernet (Configure) for full FTP instructions.**

5 Sensor Operation

This Section contains the information and procedures to operate the Sensor and set various configuration parameters, such as measurement frequency, update reagent volumes, set Sensor on-board clock, etc.

Sensor operation usually follows the generalized workflow described below:

1) Power Sensor using DOT battery pack or wall outlet.
2) Connect PC to Sensor using DOT Control Pendant and DOT Suite
3) Interrupt Sensor if it is in 'Autorun' mode by clicking **Stop Logging** in DOT Suite
4) Download files from the Sensor for archiving, backup, and later analysis.
5) Review Sensor status in Status tab of DOT Suite
    a. Verify that there are sufficient reagents for the planned deployment (feature in development). Verify fluid consumption from previous use to determine whether fluids reservoirs must be replaced.
6) Refer to **Appendix C: Fluids Record** and verify that fluids won't expire before the end of the planned deployment.
7) If reagents need to be replaced, follow procedures outlined in **Section 3.2.1 Installation and Removal of Reagent Reservoirs** to replace reagents. Update reagent volumes in DOT Suite.
8) Replace depleted batteries in battery pack (if applicable).
9) Check Sensor clock to verify synchronized date & time between user and instrument timing. There is also the possibility of synchronising to a user-set time to account for time zones, daylight savings time, or other instruments or platforms.
10) Configure Sensor for next deployment in DOT Suite (Configure tab).
11) Reboot the Sensor when it is in the field to operate in 'Autorun' mode or acquire samples manually through the **Run Script** function.

5.1.1 Electrical Connections

Before connecting any subsea connectors, ensure pins are well-lubricated and free from corrosion (Section 7.1). There are three (3) electrical connections. Connections 1 – 2 are required for sensor operation. Connection 3 provides communications to the sensor and is optional. For each electrical connection, firmly tighten the associated locking sleeve after mating cable and bulkhead.

1) Between the bottom and top of the sensor housing (5-pin connection).
2) Between the bottom of the sensor housing and power supply / battery (6-pin connection)
3) Between the bottom of the sensor housing and the communications pendant (8-pin connection)

The natural bend radius of each cable must be followed. Excessive bending/kinking of any electrical cable can ruin the integrity of the connection. *Replacement of damaged cables through misuse will not be covered under warranty.*

5.2 Sensor Deployment

The C1000-200 Nitrate / Phosphate Sensor is capable of deployments on many different platforms, including floating drifts, stationary buoys or fixed seabed systems, as a payload on an underwater autonomous vehicle (UAV), or as a towed or hull-mounted system.

5.2.1 Length of Deployment

The maximum deployment duration is limited by three components: (1) fluids, (2) power source, and (3) intake filter.

1) Refer to the fluid volumes of each fluid reservoir, along with the consumption of each fluid per script execution, to determine the number of sample and/or standard measurements possible before fluids must be replenished.
2) Battery lifetime will depend on the sampling protocol. A faster sampling frequency will drain a battery pack faster. Contact DOT at Aftersales@DartmouthOcean.com to discuss battery-powered solutions.
3) The intake filter will become clogged with material when filtering sample water. We recommend replacing the intake filter every 3000 mL of drawn Seawater; however, more foul environments may require more frequent replacement.

5.3 Sensor Retrieval

Inspect sensor and reagent housings for biofouling and inspect tubes and connections for fit and integrity. Rinse copiously with fresh water and remove any biofouling with a soft rag.

5.4 Disposal of Used Fluids

Fluids disposal must comply with the requirements of all applicable local, regional, or national/federal regulations. Refer to the SDS for each fluid: included digitally with each Sensor purchase and available by email from Aftersales@DartmouthOcean.com.

6 Software & Analysis

This section describes communication protocols between the sensor and the user. Protocols for sampling settings are defined and procedures for data analysis are described.

6.1 Sensor Communication via Control Pendant

To communicate with the phosphate sensor, a computer with an ethernet and a USB port is required. The supplied Control Pendant is used to connect between PC and sensor.

1) Connect the DB9 end of an RS232 to USB cable to the RS232 port on the electrical communications pendant shown in Figure 8.
2) Connect the USB end to a USB port on the PC.
3) Connect one end of the ethernet cable to the ethernet port of pendant, shown in Figure 8.
4) Connect the other end of the ethernet cable to the ethernet port of the PC.
5) Connect the 8-Pin cable from sensor port of interface pendant to comms. bulkhead on sensor.

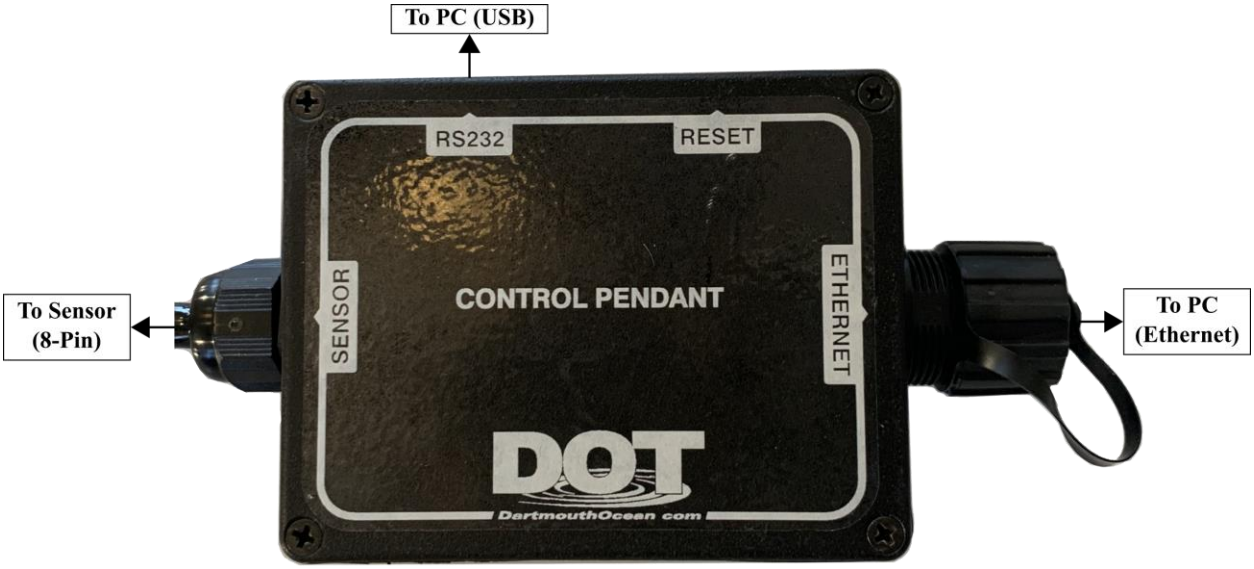


Figure 8: Nitrate & Phosphate Sensor Control Pendant.

6.2 Communication Protocols

Communications to and from the sensor go through two channels: RS-232 connection, and a network connection through Ethernet. RS-232 is used for sensor programming and general communication. Ethernet is used for file upload & download purposes, which primarily includes downloading data & log files from the Sensor to PC.

6.2.1 RS-232

The sensor uses a 115200 baud 8N1 Serial connection for general use. The Sensor can also be operated using an external controller without using DOT Suite through direct serial commands; users can request a list of base commands from DOT through email: Aftersales@DartmouthOcean.com. However, this is **not** recommended due to the safeguards built into DOT Suite that ensure proper operation.

6.2.2 Ethernet (Configure)

The sensor uses a 10Mbps 4-wire Ethernet connection for file transfer. File transfer can be done through DOT Suite or any FTP software[1]. Sensor IP address is obtained on startup using DHCP; however, the Ethernet port of your PC must first be configured correctly.

Before establishing an FTP connection between PC and Sensor, users must configure the IP Address of the Ethernet port of their PC. This process should only need to be performed once per PC. To configure the IP Address of your PC's Ethernet port:

1. In Windows, open the windows menu and search for "Command Prompt". **Run as Administrator**.
    a. When prompted, click "Yes" to allow changes to your device.
2. In Command Prompt, copy the following line and press enter:
    netsh interface ipv4 set address "Ethernet" static 192.168.137.10 255.255.255.0
3. The Ethernet port of your PC is now configured to 192.168.137.10. Verify by typing "ipconfig" into Command Prompt – see **Figure 9**.

When establishing FTP sessions between PC and Sensor, the sensor can be set to any available address "192.168.137.xxx" where "xxx" can be any value from 1 -- 255 **except 10 (**192.168.137.10 is the address taken by your Ethernet port). For example, an IP address of 192.168.137.200 is a valid address for your sensor, which can be set in the application DOT Suite.

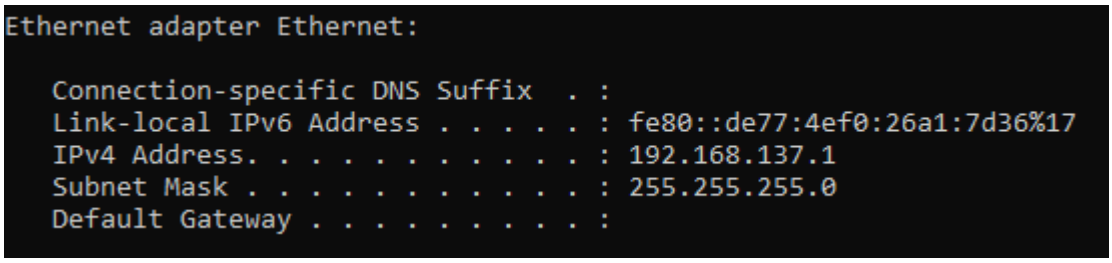


Figure 9: Ethernet IP Address configured in Command Prompt. In this example, the IPv4 Address was set to 192.168.137.1.

[1] If using FTP software, use the following login details: User – root; No Password

7 Maintenance & Care

7.1 Electrical Connections

The bulkhead connectors must be cleaned, inspected, and lubricated at regular intervals. Lubrication prevents damage to the rubber that seals the connector contacts. Faulty connectors can cause failures. Underwater electrical connections are sensitive, expensive equipment that require proper maintenance.

⚠ WARNING

Do not use WD-40 or petroleum-based lubricants on subsea connectors. These will erode the rubber. Use ONLY silicone-based lubricants.

1) Apply isopropyl alcohol (IPA) as a spray or with a brush or cloth to clean the contacts.
2) Flush with additional IPA
3) Shake the socket ends and wipe away any excess IPA
4) Blow air into the sockets and on the pins to ensure they are dry
5) Use a flashlight and magnifying glass to inspect for:
    a. Cracks, scratches, or damage to the rubber pins or in the sockets
    b. Any corrosion
    c. Separation of the rubber from the pins
    d. Swelled or bulging rubber pins
6) Use a silicone-based lubricant on the pins and in the sockets. Apply lubricant to the sockets with by putting a small quantity on your finger and pushing as much as possible into each of the sockets.
   Recommended lubricants include:
    - 3M™ Spray Silicone Lubricant (3M ID# 62-4678-4930-3). Make sure to let it dry.
    - Dow Corning Molykote® III Compound (DC III)
    - Dow Corning High Vacuum Grease® (DC 976 V)
    - Dow Corning 4 Electrical Insulating Compound® (DC 4)
    - Dow Corning Molykote 44 High Temperature Grease® (DC 44)

7) Connect the connectors and wipe away any excess lubricant with a lint-free wipe.

7.2 Sensor and Fluids Storage

The C1000-200 Nitrate & Phosphate Sensor should be kept out of direct sunlight in a cool, dry area when possible. **Reagents and standard should be stored in a refrigerator set to 4 °C when not in use to preserve their shelf-life. Fluids are susceptible to light and heat degradation and will expire faster when not stored properly.**

Before long term storage, the Nitrate & Phosphate Sensor should be cleaned thoroughly of any biofouling from previous deployment(s). We recommend the use of a pressure washer for the main body of the sensor, followed by scrubbing with water and a rag near fluid ports. Do not blast near the fluid ports with a pressure washer.

7.3 Anode Replacement

The water-facing metal components are made of anodized aluminum. The anodization is important in preventing corrosion in marine environments. Any scratch in the anodized metal parts will compromise corrosion resistance. Significant corrosion will make the part unusable, so great care should always be taken in handling anodized metal pieces, such as the sensor and reagent housings and end caps. Contact Aftersales@DartmouthOcean.com to discuss servicing of housings.

The Nitrate and Phosphate Sensor employs two sacrificial anodes, each located on opposite ends of the sensor. One anode is located on the top of the sensor near the serial number. The second anode is located on the bottom end cap of the sensor near the electrical bulkheads. Users should inspect both anodes before every deployment. Anodes should be replaced when most of the sacrificial material is gone.

Anode corrosion rates may vary with deployment conditions. For short-term deployments, replace each sacrificial anode when less than 25 % of the original mass remains; for long-term deployments, replace when less than 50 % remains. Contact Aftersales@DartmouthOcean.com to purchase more Anodes.

Replacing Anodes

Required Tools / Equipment

- Replacement Anode
- Hex (Allen) key – 4 mm

The Anode is mounted to a surface with a screw through its center.

1) Using a 4 mm Hex key, loosen screw holding the Anode in place by rotating counter-clockwise until the screw is disengaged from the threaded bore.
2) Remove Anode from Sensor.
3) Locate replacement Anode from Spares kit. The threads of the new Anode screw are coated with a conductive paste – do not wipe paste away.
4) Install new Anode using 4 mm Allen key. Screw clockwise to tighten until snug.
5) Dispose of used Anode.

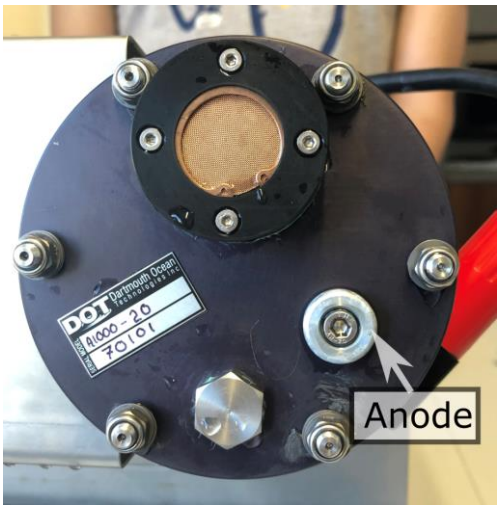


Figure 10: Anode placement on top of sensor housing

7.4 Warranty

Any personalized warranty agreement issued between DOT and the client overrules the following general agreement. The contents of this section apply only if no other warranty agreement between DOT and the customer has been issued.

Dartmouth Ocean Technologies warrants that the DOT C1000-200 Nitrate & Phosphate Sensor will be free from defects of workmanship and materials for a period of **one (1) year**. The warranty period begins on the date issued by the DOT Certificate of Conformance (COC).

This warranty does not apply to the following:

- Phosphate Sensor is modified without written consent from the manufacturer.
- Opening the pressure-compensated canister.
- Removing tubing connections to the valve manifold
- Opening the Phosphate Sensor.
- Recommended maintenance procedures are not followed.
- Damage due to misuse or abuse.
- Damage due to accidental collision.
- Surface corrosion of stainless components.
- Loss to the environment

7.5 Troubleshooting

Please contact the manufacturer with questions, concerns, or troubleshooting issues at Aftersales@DartmouthOcean.com or (902) 442-4010.

8 Appendices

8.1 Appendix A: Mechanical Drawings

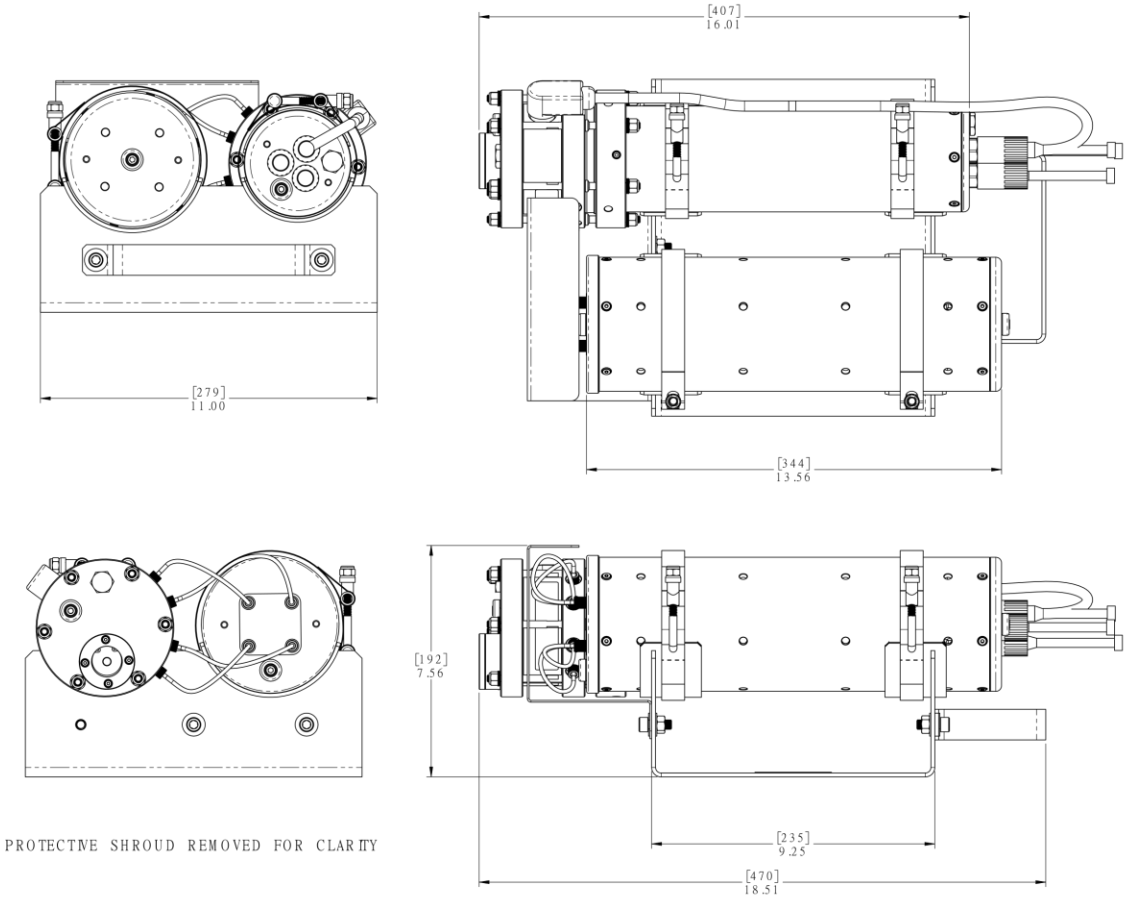


Figure 11: Mechanical drawings and dimensions – dual bracket (sensor and reagent housing)

8.2 Appendix B: Electrical Pinouts

Table 9: Power connector pinout: 6-pin male bulkhead

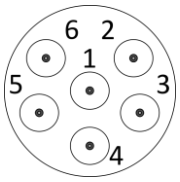
Pin	Function	Face View (Male)
1	Ground	
2	Ground	
3	Battery Voltage (7 V)	
4	Battery Voltage (7 V)	
5	9 – 24 VDC	
6	9 – 24 VDC	

Table 10: Communications connector pinout: 8-pin female bulkhead

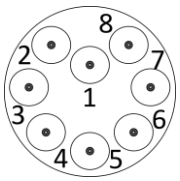
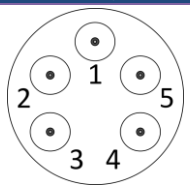
Pin	Function	Face View (Female)
1	Ground	
2	RS232 RX_In	
3	RS232 TX_Out	
4	Reset / Wake	
5	TX+ (Ethernet)	
6	TX- (Ethernet)	
7	RX+ (Ethernet)	
8	RX- (Ethernet)	

Table 11: Solenoid housing connector pinout: 5-pin female bulkhead

Pin	Function	Face View (Female)
1	Ground	
2	7 V	
3	NC – No Connection	
4	RS232_RX_In	
5	RS232_TX_Out	

8.3 Appendix C: Fluids Record

Reagent 1 (RG1)		Reagent 2 (RG2)		Reagent 3 (RG3)		Standard (ST)	
Installed	Expiry	Installed	Expiry	Installed	Expiry	Installed	Expiry

8.4 Description of Select Scripts

The following section describes some of the more useful scripts pre-loaded onto each C1000-200 Nitrate & Phosphate Sensor. Users may open script files in any standard text editor to obtain further insight into the function of any particular script.

sample_triplicate

This script acquires three blank measurements, followed by three sample measurements (environment). This is the typical script to run when sampling from environments.

Note: users may wish to delay the start of sampling from power-up. Users may add a delay to the start of this script in the following location:

```
#Obtain a triplicate blank and sample measure
RECENG,ON
PAUSE,600          [change 600 to any time in seconds less than 7200]
LED,SP,DEFAULT
LED,LP,DEFAULT
```

standard_triplicate

This script acquires three blank measurements (using standard fluid), followed by three standard measurements (on-board standard). This is the typical script to run under “Standard File Name” to obtain periodic *in situ* calibrations of your system using an on-board standard, but may be skipped if desired.

filter prime

Users may find that dry inlet filters struggle to pull sample water. This script backflows on-board standard out the Sample port to wet the filter.

prime_all

This script is used to purge air from the tubing lines when new fluid reservoirs are installed, and should be used to minimize air-induced errors at the start of deployments. This priming script includes the sample inlet, and should thus only be used if the sample inlet can pull fluid.

prime_bags

This script acts the same as prime_all but does not include the sample inlet port. This script is preferred when priming the tubing lines on the bench where the sample inlet cannot pull fluid.

8.5 User Notes