RBR*coda*^{3}
INSTRUMENT GUIDE

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1 RBR*coda*^{3}

The RBR*coda*^{3} small smart sensors are a family of cabled instruments with high accuracy, low power consumption, and ability to endure harsh conditions. These realtime streaming sensors are easy to integrate into any RBR multi-parameter instrument, or connect directly via RS-232.

The RBR*coda*^{3} instruments are are a perfect choice for many oceanographic and limnology applications where realtime steaming of data is desired, such as borehole monitoring, remotely operated underwater vehicles, stream gauging, or harbour water levels. These completely sealed units are available in plastic or titanium housings to accommodate shallow or deep deployments. Attach an MCIL connector with serial and power lines, and the data will stream.

Shallow variants

- RBR*coda*^{3} D - depth
- RBR*coda*^{3} T - temperature
- RBR*coda*^{3} T.D - temperature and depth
- RBR*coda*^{3} DO (OxyGuard®) - dissolved oxygen
- RBR*coda*^{3} PAR - photosynthetically active radiation
- RBR*coda*^{3} rad - narrow-band light radiation
- RBR*coda*^{3} PAR (LI-COR®) - photosynthetically active radiation

Deep variants

- RBR*coda*^{3} D | deep - depth
- RBR*coda*^{3} T | deep - temperature
- RBR*coda*^{3} T.D | deep - temperature and depth
- RBR*coda*^{3} T.ODO | deep - temperature and optical dissolved oxygen
- RBR*coda*^{3} PAR | deep - photosynthetically active radiation
- RBR*coda*^{3} rad | deep - narrow-band light radiation

Multi-channel sensor packages

- RBR*tridente* - chlorophyll *a*, fDOM, and backscatter or turbidity
- RBR*quadrante* - photosynthetically active radiation, narrow-band light radiation

2 Physical specifications

Specifications

Parameter	Value
Storage	No onboard memory
Power	7-15V, 3mA (RBR*coda*^{3} T.ODO) 4.5-30V, 32mA (RBR*tridente*) 6-18V, 3mA (all other sensors)
Communications	RS-232
Sampling rate	24hr to 1Hz (RBR*coda*^{3} T.ODO) up to 16Hz (RBR*coda*^{3} D | tide16, RBR*coda*^{3} T.D | tide16) up to 32Hz (all other sensors)

Dimensions, weight, and depth rating

Instrument	Diameter	Length*	Weight	Depth rating
RBR*coda*^{3} D RBR*coda*^{3} D | deep	~25mm	~235mm	170g in air, 70g in water 370g in air, 270g in water	1000m 6000m
RBR*coda*^{3} T RBR*coda*^{3} T | deep	~25mm	~244mm	160g in air, 60g in water 390g in air, 280g in water	1700m 6000m
RBR*coda*^{3} DO	~25mm	~290mm	190g in air, 70g in water	1700m
RBR*coda*^{3} T.ODO | deep	~28mm	~160mm	180g in air, 100g in water	6000m
RBR*coda*^{3} PAR, RBR*coda*^{3} rad RBR*coda*^{3} PAR | deep, RBR*coda*^{3} rad | deep	~25mm	~271mm	140g in air, 15g in water 320g in air, 195g in water	1000m 2000m
RBR*coda*^{3} T.D RBR*coda*^{3} T.D | deep	~25mm	~300mm	190g in air, 70g in water 390g in air, 280g in water	1000m 6000m
RBR*coda*^{3} PAR (LI-COR), cosine RBR*coda*^{3} PAR (LI-COR), spherical	~25mm	~300mm, cable 0.6m	460g in air, 240g in water 400g in air, 100g in water	560m 350m
RBR*tridente*	~63mm	~93mm	400g in air, 210g in water	6000m
RBR*quadrante*	~63mm	~93mm	400g in air, 210g in water	2000m

*Total length of the instrument, including the connector.

3 Sensor specifications

Most RBR smart realtime sensors have only one channel, but some include two, three, or four. Please contact the RBR sales team to discuss your needs and to select the perfect configuration for your applications.

3.1 Pressure (D)

The RBR*coda*^{3} D, RBR*coda*^{3} D | deep, RBR*coda*^{3} T.D, and RBR*coda*^{3} T.D | deep use the same piezoresistive pressure sensor. It is protected by a clear plastic guard. During deployments, always orient the sensor downwards to reduce debris collecting in the housing.

RBR*coda*^{3} D

Parameter	Value
Range*	20 / 50 / 100 / 200 / 500 / 1000dbar (plastic) 1000 / 2000 / 4000 / 6000dbar (Ti)
Initial accuracy	±0.05% full scale
Resolution	<0.001% full scale
Typical stability	±0.05% full scale / year
Time constant	<10ms

*Recommended depth for wave measurements is less than 50m.

3.2 Temperature (T)

The RBR*coda*^{3} T, RBR*coda*^{3} T | deep, RBR*coda*^{3} T.D, RBR*coda*^{3} T.D | deep, and RBR*coda*^{3} T.ODO | deep use the same thermistor-type temperature sensor.

RBR*coda*^{3} T

Parameter	Value
Range*	-5°C to 35°C
Initial accuracy	±0.002°C
Resolution	<0.00005°C
Typical stability	±0.002°C / year
Time constant	<0.1s | fast, <1s standard, <15s | slow

*A wider temperature range is available upon request. Contact RBR for more information.

3.3 Dissolved oxygen (DO, ODO)

Optical dissolved oxygen (ODO)

The RBR*coda*^{3} T.ODO | deep uses the optical dissolved oxygen sensor. During deployments, always orient the sensor downwards to reduce debris collecting at the aperture and minimise direct sunlight. Store the sensor in the dedicated storage cap, included with the instrument.

RBR*coda*^{3} T.ODO

Parameter	Value
Calibrated range Concentration Saturation Temperature	 0-500µmol/L 0-120% 1.5°C to 30°C
Initial accuracy	Maximum of ±8µmol/L or ±5%
Resolution	<1µmol/L (saturation 0.4%)
Time constant	~1s (|fast), ~8s (standard), ~30s (|slow)

Dissolved oxygen (DO)

The RBR*coda*^{3} DO uses the OxyGuard galvanic dissolved oxygen sensor. The sensor consumes oxygen from the environment and thus produces most accurate measurements when in a stirred environment. During deployments, always orient the sensor downwards to reduce debris collecting at the aperture and minimise direct sunlight. Store the sensor in the dedicated storage cap, included with the instrument.

RBR*coda*^{3} DO

Parameter	Value
Range	0 to 600%
Initial accuracy	±2% oxygen saturation
Resolution	1% of saturation
Response time	~10s, 90% step change at 20°C

3.4 Radiometers (PAR, rad, RBR*quadrante*)

PAR and narrow-band radiometers

The RBR*coda*^{3} PAR and RBR*coda*^{3} rad instruments look identical and share several specifications.
The RBR*coda*^{3} PAR and RBR*coda*^{3} PAR | deep use the cosine photosynthetically active radiation sensors.
The RBR*coda*^{3} rad and RBR*coda*^{3} rad | deep use radiometers measuring narrow-band light with a fixed channel width, available in various 10nm- and 25nm-wide channels. Both centre wavelength and channel width are factory-configured.

RBR*coda*^{3} PAR

The RBR*quadrante* is a four-channel radiometer, capable of measuring multiple wavebands simultaneously, including PAR. It uses the same cosine PAR sensors and narrow-band radiometers as the RBR*coda*^{3} PAR and RBR*coda*^{3} rad instruments.

RBR*quadrante*

Optical radiometry

Parameter	Value
Initial offset error*	±0.0025% full scale
Resolution**	±0.0002% full scale
Dynamic range	>5.5 decades (nominal)
Absolute calibration***	±5%
Linearity	±1%
Time constant	<5ms
Operating temperature range	-5°C to 35°C
Gain temperature dependence	0.15% / °C
Cosine response error (water)	±5% at 0-60°, ±10% at 61-82°
Azimuth error (water)	±1.5% at 45°
Out-of-band rejection**	>25dB (typical), OD 2.5

* Dark offset is internally temperature-compensated.
** Out-of-band rejection and resolution are wavelength dependent for narrow-band radiometers.
*** RBR calibrates radiometers with NIST traceable references.

PAR

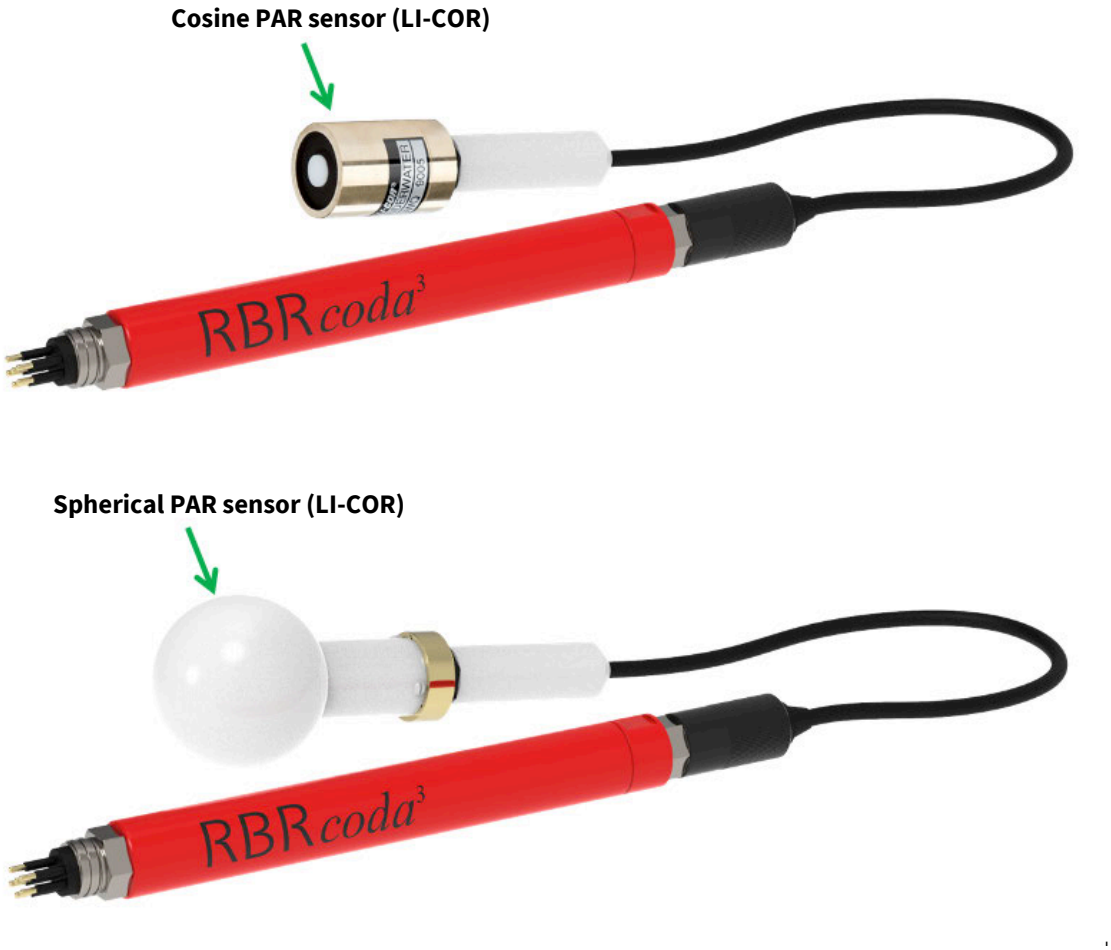
Parameter	Value
Wavelength range	400 to 700nm
Full scale range	0 to 5000µmol/m^2/s (minimum)
Initial offset error*	±0.125umol/m^2/s
Resolution	±0.010umol/m^2/s

Narrow-band channels

Parameter	Value
Centre wavelengths (CWL)	413/ 445/ 475/ 488/ 508/ 532/ 560nm
Accuracy (for CWL)	±3nm (for all CWLs except 475nm) ±5nm (for CWL 475nm only)
Full width at half-maximum (FWHM)	10nm (for all CWLs except 475nm) 25nm (for CWL 475nm only)
Accuracy (for FWHM)	±3nm
Full scale range	0 to 400µW/cm^2/nm (minimum)
Initial offset error*	±0.010µW/cm^2/nm
Resolution**	±0.001µW/cm^2/nm

PAR sensor (LI-COR)

The RBR*coda*^{3} PAR (LI-COR) instruments use cabled cosine (one hemisphere, LI-192) or spherical (omnidirectional, LI-193) PAR sensors.



RBR*coda*^{3} PAR variants

Parameter	Value
Wavelength range	400 to 700nm
Calibrated range	0 to 10000µmol/m^2/s
Initial accuracy	±2%

3.5 RBR*tridente*

The RBR*tridente* is an optical sensor with three channels, capable of making multiple fluorescence and backscatter or turbidity measurements simultaneously.

RBR*tridente*

Optical

Parameter	Value
Centroid angle	120°
Sensing volume	~1.3mL
Linearity, R^2	0.99
Calibration accuracy	5%

Chlorophyll *a*

Parameter	Value
Channel wavelength (excitation/emission)	470nm/695nm
Range	0-250µg/L
Detection limit	0.01µg/L

fDOM

Parameter	Value
Channel wavelength (excitation/emission)	365nm/450nm
Range	0-500ppb
Detection limit	0.004ppb

Backscatter

Parameter	Value
Channel wavelength	700nm
Range	0-5m^{-1}
Detection limit	1x10^{-4}m^{-1}

Turbidity

Parameter	Value
Channel wavelength	700nm
Range	0-500FTU
Detection limit	0.001FTU

4 Derived parameters

Ruskin software and the RBR instrument itself have the ability to calculate the derived parameters. Depending on how the instrument is configured in Ruskin for a particular deployment, the calculations will be routed through either one or the other option.

For example, when **Options > Realtime** is set to **Serial** or **USB**, all derived parameters will be calculated on the instrument.

When **Options > Realtime** is set to **None**, all derived parameters will be calculated on Ruskin.

Both routes use the same equations and produce identical results.

Ruskin has alternative derivation options for some parameters, which can be selected in the **Parameters** tab.

See Ruskin User Guide: RBRcoda[3] for instructions on configuring your instrument.

4.1 Sea pressure

Sea pressure is the difference between the pressure measured underwater by your RBR instrument and atmospheric pressure. The units of measurement are **dbar** (decibars).

$$Sea\,pressure = absolute\,pressure - atmospheric\,pressure$$

where pressure (in dbar) is the value measured directly by your RBR instrument.

Enter atmospheric pressure (in dbar) manually in the table under the **Parameter** tab in Ruskin. See Ruskin User Guide: RBRcoda[3]. If not entered, a default value of 10.1325dbar will be used.

4.2 Depth

Depth is a function of sea pressure and seawater density. The units of measurement are **m** (metres).

$$Depth = \frac{sea\,pressure}{density \cdot g}$$

where seawater density is in g/cm^3 and sea pressure is in dbar, and g is the acceleration of gravity and equals 9.8m/s^2 .

Sea pressure is also a derived parameter:

$$Sea\,pressure = absolute\,pressure - atmospheric\,pressure$$

Enter atmospheric pressure (in dbar) and seawater density (in g/cm^3) manually in the table under the **Parameter** tab in Ruskin. See Ruskin User Guide: RBRcoda[3]. If not entered, default values of 10.1325dbar and 1.0281g/cm^3 will be used.

4.3 Oxygen concentration

The RBR*coda*^{3} DO supports a third-party DO sensor from OxyGuard, which measures dissolved oxygen saturation.

When a sensor measures oxygen saturation, we can derive oxygen concentration using the Weiss equation. See The solubility of nitrogen, oxygen and argon in water and seawater by R.F. Weiss for details.

The units of measurement may be **µMol/L, mg/L,** or **mL/L**.

The Weiss equation requires values for absolute temperature (in °K) and salinity, which are derived from measured temperature and conductivity. As your instrument does not measure conductivity, a default value of 35PSU will be used. Alternatively, enter conductivity manually in the table under the **Parameter** tab in Ruskin. See Ruskin User Guide: RBRcoda^3.

4.4 Oxygen saturation

The RBR*coda*^{3} T.ODO measures dissolved oxygen concentration.

When a sensor measures oxygen concentration, we derive oxygen saturation using the Garcia and Gordon equation. See Oxygen solubility in seawater: better fitting equations by F. H. Garcia and I. I. Gordon for details.

The units of measurement are **%**.

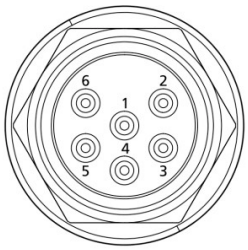
The Garcia and Gordon equation requires values for absolute temperature (in °K) and salinity, which are derived from measured temperature and conductivity. As your instrument does not measure conductivity, a default value of 35PSU will be used. Alternatively, enter conductivity manually in the table under the **Parameter** tab in Ruskin. See Ruskin User Guide: RBRcoda^3.

5 Cables and connectors

5.1 MCBH and DB9 connectors

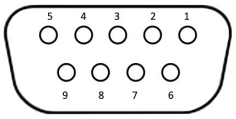
RBR*coda*^{3} has an external MCBH-6-MP connector on the instrument. The data will stream to your computer via a patch cable (ordered separately). Depending on the ordered configuration, your patch cable may have either an embedded converter and USB connector, or a DB9-F connector.

External MCBH-6-MP connector pinout



Pin No.	RS-232
1	Ground
2	Power +4.5 to +30V
3	Data output from the instrument (Tx)
4	Data input into the instrument (Rx)
5	N/C
6	N/C

DB9-F connector pinout



Pin No.	RS-232
1	N/C
2	Data output from the instrument (Tx)
3	Data input into the instrument (Rx)
4	N/C
5	Ground
6-9	N/C

5.2 RS-232 cables

The RBR*coda*^{3} sensors use RS-232 patch cables to connect to power supplies and computers. Patch cables and underwater extension cables are sold separately and not included with the sensors. Refer to the RBR Cable Guide or contact our support team for the list of available cables.

RBR*coda*^{3} D with an RS-232 cable

6 Maintenance

6.1 Deployment

The RBR*coda*^{3} smart sensors are robust and reliable, but there are several things to keep in mind when deploying them. Proper deployment will ensure faultless operation and preserve your data.

Precautions

1. Do not exceed the maximum depth rating.

> ⚠ All RBR*coda*^{3} instruments are individually rated to a maximum depth in meters, as indicated on the label.

Maximum depth rating

2. Do not apply physical stress to the housing.

> ⚠ Stress due to improper mounting may cause the RBR*coda*^{3} instruments to leak, resulting in the loss of valuable data or permanent damage to the electronics.
> Any type of clamp or bracket which concentrates the stress on the housing is not recommended for use in mooring, mounting, and/or other deployment.
> Contact RBR for proper mooring and mounting clamps suited to your specific application.

3. Do not attempt to open the sensor.

> ⚠ The RBR*coda*^{3} instruments are sealed and cannot be opened by the user. Any attempt to do so will damage the sensor.

6.2 Cable maintenance

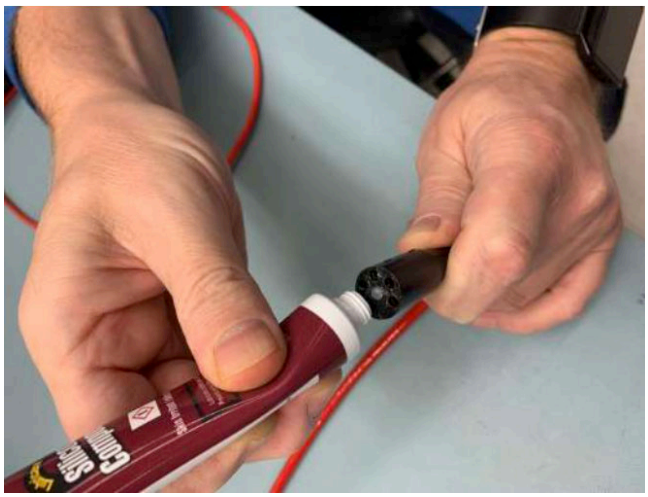
Cable bend radius

The smallest bend radius for RBR supplied cables is 15cm.

Lubricating the connectors

Lubrication improves watertight sealing, prevents corrosion, and reduces the force required to de-mate the connector. Use the silicone compound provided with your instrument.

- Apply the silicone compound to all female connectors before every mating
- Ensure each connector hole is filled with approximately 30% lubricant



Lubricating a connector

Reducing mechanical stress

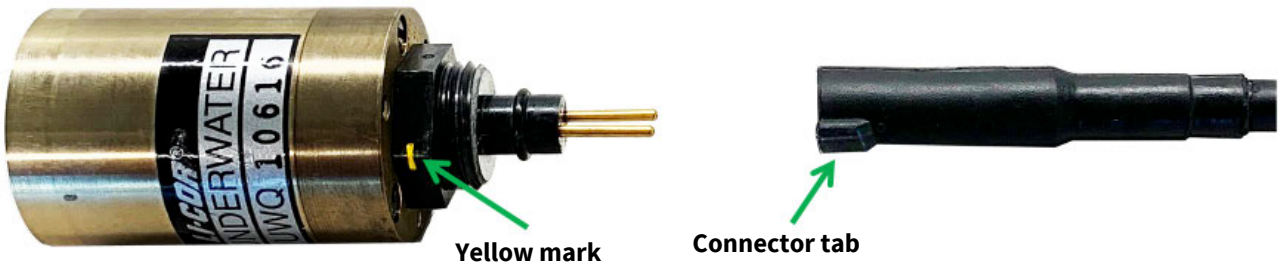
- Do not pull on the cable
- Hold onto the connector to pull out the cable
- Disconnect by pulling straight out, not at an angle
- Avoid sharp bends at the point where the cable enters the connector
- Avoid angular loads on the connector

6.3 PAR sensor (LI-COR) connector alignment

Proper connection between the PAR sensors (LI-COR) and their cable is crucial for deployment success.

Both LI-192 and LI-193 have a two-pin connector with a small yellow mark on the side.

Always align this yellow mark with the tab on the side of the cable connector when connecting the sensor to its cable.



Orientation

After connecting the cable to the PAR sensor, confirm that the yellow mark and the connector tab are aligned, and then put the white locking sleeve in place. The sensor is ready for deployment.

> Ensure proper orientation of the yellow mark and the tab before each deployment. Inverted connection of your PAR sensor will result in incorrect or lost data.

6.4 DO sensor (OxyGuard) care and maintenance

Storage

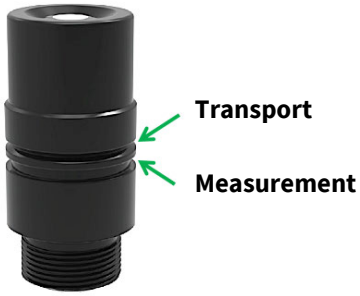
Store the OxyGuard dissolved oxygen sensor in the dedicated storage cap to minimize fluid loss. Storage caps are provided with the instrument. Contact RBR if a replacement is needed.

O-ring

The red O-ring of the OxyGuard sensor serves two purposes:

- To retain the electrolyte during storage
- To balance pressure during deployments

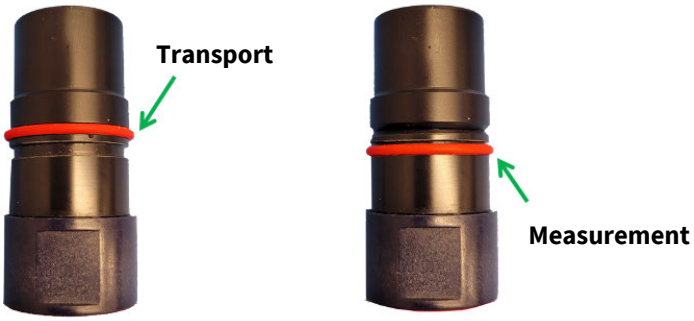
There are two positions for O-ring on the OxyGuard sensor, "Transport" and "Measurement".



During transportation or storage, move the red O-ring of the Oxyguard sensor to the "Transport" position, closing off the port on the side of the cell.

Before deployment, move the O-ring to the "Measurement" position to maintain the pressure balance.

After deployment, return the O-ring to the "Transport" position.



Support kit

RBR offers an OxyGuard sensor support kit that includes:

- Membrane tool
- Electrolyte solution (250ml)
- Fast response membranes
- Replacement O-rings
- Oxyguard Support Kit and Refurbishment Guide

Check the state of your DO sensor before deployment. Look for any damage to the membrane, cloudiness of the electrode, and buildup on the anode. If you find any damage, refurbish and re-calibrate the sensor.

Refer to Oxyguard Support Kit and Refurbishment Guide, included with the support kit, for instructions on refurbishing your sensor. See Ruskin User Guide for instructions on calibration.

6.5 RBR*tridente* sensor safety precautions

For fDOM measurements, the RBR*tridente* uses UV LEDs (ultraviolet light emitting diodes) and should be handled with care.

Ultraviolet radiation is invisible so it may not be obvious when the instrument is active. Exercise caution to avoid any associated health risks for the eyes.

> Wear approved safety glasses with side protection and UV filter lenses.
> Avoid looking at the LEDs.

Storage cap

Whenever possible, keep the storage cap on your fluorometers.

RBR*tridente* with its storage cap on

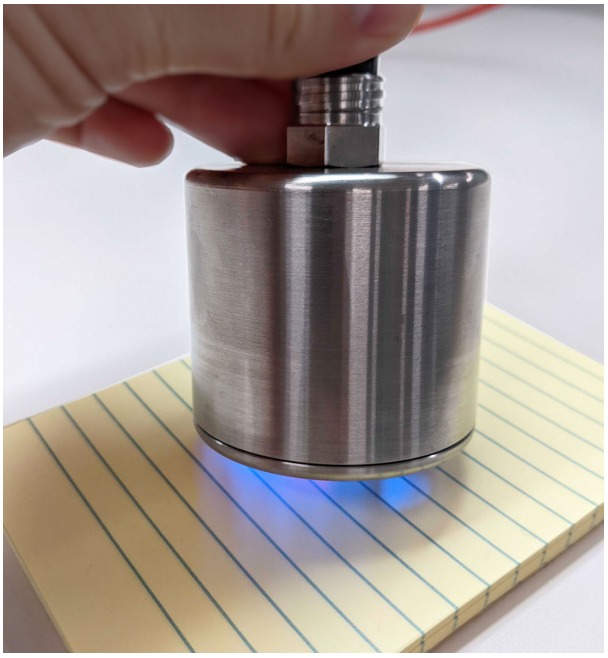
Eye protection

If the storage cap is removed, use protective eyewear. RBR recommends UV-blocking safety glasses of the highest available rating.

Safe operation

Never look at the LEDs as their optical power (ultraviolet and visible) can be hazardous to eyes.

Whenever handling an active fluorometer, place the unit face down on a non-abrasive surface to avoid shining the light into the eyes.



RBR*tridente* facing down

RBR realtime sensors continue streaming data as long as power is provided. When the fluorometer does not need to be active, disconnect it from the power supply.

6.6 Calibration

Factory calibration coefficients are calculated for each sensor, and the coefficients are stored on the instrument.

RBR calibration certificates contain calibration equations, coefficients, and residuals for each sensor. Hard copies are provided with each shipment. RBR can replace lost or misplaced calibration certificates upon request.

RBR recommends calibrating your instrument before any critical deployment, periodically once a year, or if you suspect the readings to be out of specifications.

Discuss your calibration requirements with RBR. In some cases, the instrument will need to be returned to RBR to have it checked and re-calibrated.

Please contact RBR for our current calibration fees.

6.7 Repairs

RBR supports all our products. Contact us immediately at support@rbr-global.com or via the RBR website if there are any issues with your instrument. Please have the model and the serial number of the unit ready. Our support team will work to resolve the issue remotely. In some cases, you may have to return your instrument to RBR for further servicing.

> There are no user-repairable parts of the instrument. Any attempt to repair without prior authorisation from RBR will void the warranty. Refer to the RBR warranty statement.

To return a product to RBR for an upgrade, repair, or calibration, please contact our support team to obtain a return merchandise authorisation code (RMA) and review the detailed shipping information on the RBR website.

7 Revision history

Revision No.	Release date	Notes
A	30-November-2021	Original
B	28-February-2022	Corrected pressure rating (from 10000dbar to 6000dbar), added maintenance instructions for the OxyGuard DO sensor.
C	15-March-2022	Added MCBH pinout and description of the PAR sensor (LI-COR) connector to Specifications.
D	15-September-2022	Added RBR*tridente* to the list of sensors and Specifications. Added sampling rates to Specifications. Moved description of the PAR sensor (LI-COR) connector to Maintenance. Added Deployment to Maintenance.
E	31-October-2022	Improved page hierarchy for Specifications. Added RBR*quadrante* to the list of sensors and Specifications. Added the Derived parameters section. Added RBR*tridente* sensors safety precautions to Maintenance.