RBR STANDARD INSTRUMENTS

RBR*virtuoso*³

RBR*duo*³

RBR*brevio*³

RBR*concerto*³

RBR*maestro*³

INSTRUMENT GUIDE

rbr-global.com

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1 RBR standard instruments

RBR offers a variety of standard instruments that measure up to ten parameters:

- RBR*virtuoso*^{3} - one channel
- RBR*duo*^{3} - two channels
- RBR*brevio*^{3} - three channels (C.T.D only)
- RBR*concerto*^{3} - three to five channels
- RBR*maestro*^{3} - five to ten channels

All RBR standard instruments support the following features:

- High accuracy
- Extended deployments
- Large memory
- Flexible schedules
- Twist activation
- USB-C download
- Realtime communication
- Wi-Fi

RBR standard instruments can integrate one to ten sensors, including third-party sensors, and thus meet any of your unique requirements, be it acoustic surveys, coastal and deep ocean studies, tide and wave studies, hydrography, water quality, or profiling applications.

Some of the supported sensors are:

- Conductivity - RBR
- Temperature - RBR
- Pressure - RBR
- Thermistor string - RBR
- Dissolved oxygen - RBR, OxyGuard®, Rinko®, Aanderaa®
- Photosynthetically active radiation - RBR, LI-COR®
- Narrow-band light radiation - RBR
- Turbidity - RBR, Seapoint®, Turner®, Sequoia®
- Fluorescence - RBR, Seapoint®, Sea-Bird®, Turner®
- pH - Idronaut®
- Oxidation-reduction potential - Idronaut®
- Methane - Franatech®
- Carbon dioxide - Turner®
- Transmittance - Sea-Bird®
- Voltage - RBR

Select a configuration that fits your needs and enjoy stable, accurate measurements during long deployments.

ⓘ RBR is constantly updating the list of supported sensors. Please contact the RBR sales team for an updated list.

Variants with pressure, temperature, conductivity, radiometer, PAR, and turbidity sensors are also available in titanium housing for deep applications (| deep), designed to endure harsh conditions. Titanium housing resists all forms of marine corrosion. All RBR instruments within the | deep family provide accurate and stable measurements in the most challenging environments. Some configurations are rated for the full ocean depth, thus being deployable as deep as the bottom of the Marianas Trench.

RBR standard instruments facilitate optimal measurement schedules, whether moored, towed, or profiling. Select from several | fast sampling variants, such as | fast8, | fast16, | fast32, | tide16, and | wave16, depending on your needs.

The instruments come with a Wi-Fi module and twist activation. Large storage capacity and reliable battery power facilitate long deployments with higher sampling rates. Downloads are quick with USB-C. A dedicated holder makes it simple to replace desiccant before each deployment. The calibration coefficients are stored on the instrument, and only one software tool, Ruskin, is required to operate it. Datasets can be read directly in Matlab, or exported to Excel, OceanDataView®, or text files.

For a detailed description of using the Ruskin software, see Ruskin User Guide: Standard Instruments[3].

Explore the RBR*quartz*[3] family of instruments featuring an advanced pressure sensor with enhanced stability and exceptionally low drift. Refer to individual instrument guides, available at the RBR website or with Ruskin software.

1.1 RBR*virtuoso³*

The RBR*virtuoso³* is a flexible single-channel instrument that can integrate any one of the following sensors:

- Temperature (T)
- Depth (D)
- Dissolved oxygen (DO, ODO)
- Photosynthetically active radiation (PAR)
- Radiometer (rad)
- Turbidity (Tu)
- Fluorescence (Fl)
- pH
- Oxidation-reduction potential (ORP/redOx)
- Methane
- Carbon dioxide
- Transmittance
- Voltage

RBR*virtuoso³* Tu | deep, RBR*virtuoso³* D, and RBR*virtuoso³* rad

> ⓘ *RBRvirtuoso³* D | tide16 and RBR*virtuoso³* D | wave16 take averages of pressure readings over extended periods of time, providing accurate tide level data and obtaining wave characteristics. They are also capable of detecting infrequent phenomena, like boat wakes.

1.2 RBR*duo*[3]

The RBR*duo*[3] is a flexible dual-channel instrument that can integrate any two of the following sensors:

- Conductivity (C)
- Temperature (T)
- Pressure (D)
- Dissolved oxygen (DO, ODO)
- Photosynthetically active radiation (PAR)
- Radiometer (rad)
- Turbidity (Tu)
- Fluorescence (Fl)
- pH
- Oxidation-reduction potential (ORP/redOx)
- Methane
- Carbon dioxide
- Transmittance
- Voltage

RBR*duo*[3] T.D and RBR*duo*[3] C.T | deep

> ⓘ RBR*duo*[3] T.D | tide16 and RBR*duo*[3] T.D | wave16 take averages of pressure readings over extended periods of time, providing accurate tide level data and obtaining wave characteristics. They are also capable of detecting infrequent phenomena, like boat wakes.

1.3 RBR*brevio*³

The RBR*brevio*³ C.T.D is a small instrument with the following three sensors:

- Conductivity (C)
- Temperature (T)
- Depth (D)

The RBR*brevio*³ C.T.D is the shortest of RBR standard instruments and may be used to derive salinity, density anomaly, and sound velocity. When mounted on a stationary subsea vehicle, the pressure sensor can measure high-frequency waves. The CFD-optimised conductivity cell is self-flushing and does not require a pump. Its silent operation facilitates stealth missions and passive acoustic listening. For profiling applications, the co-located thermistor reduces salinity spiking, thus increasing data accuracy.

The RBR*brevio*³ C.T.D has all of the same features as the RBR*concerto*³ C.T.D, just in a smaller form factor, thus best suited for applications where size and weight are critical.

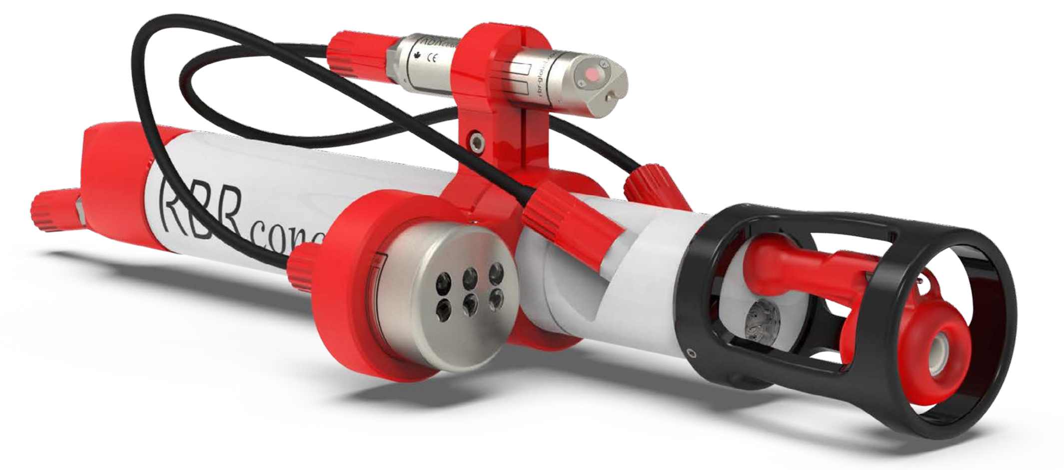
RBR*brevio*³ C.T.D and RBR*brevio*³ C.T.D | deep

1.4 RBR*concerto*^{3}

The RBR*concerto*^{3} is a flexible multi-channel instrument that can integrate three to five of the following sensors:

- Conductivity (C)
- Temperature (T)
- Pressure (D)
- Thermistor string (Tx)
- Dissolved oxygen (DO, ODO)
- Photosynthetically active radiation (PAR)
- Radiometer (rad)
- RBR*quadrante* (quad)
- Turbidity (Tu)
- Fluorescence (Fl)
- RBR*tridente* (tri)
- pH
- Oxidation-reduction potential (ORP/redOx)
- Methane
- Carbon dioxide
- Transmittance
- Voltage

The RBR*concerto*^{3} C.T.D is the most popular instrument in this family, uniquely designed to determine salinity of seawater via measuring the conductivity, temperature, and pressure. Use the RBR*concerto*^{3} C.T.D for moored, towed, and profiling applications; shallow and deep deployments; fast, averaging, and burst sampling. It is also available in an extended body with more battery power for longer deployments and space for additional one or two sensors.



RBR*concerto*^{3} C.T.D.ODO.tri

> ⓘ RBR*concerto*^{3} configurations support moored, towed, and profiling applications, shallow and deep deployments, standard and fast sampling.

1.5 RBR*maestro*³

The RBR*maestro*³ is a flexible multi-channel instrument that can integrate up to ten of the following sensors:

- Conductivity (C)
- Temperature (T)
- Pressure (D)
- Dissolved oxygen (DO, ODO)
- Photosynthetically active radiation (PAR)
- Radiometer (rad)
- RBR*quadrante* (quad)
- Turbidity (Tu)
- Fluorescence (Fl)
- RBR*tridente* (tri)
- pH
- Oxidation-reduction potential (ORP/redOx)
- Methane
- Carbon dioxide
- Transmittance
- Voltage

RBR*maestro*³ C.T.D.DO.Fl.pH.Tu

> ⓘ RBR*maestro*³ configurations support moored, towed, and profiling applications, shallow and deep deployments, standard and fast sampling.

2 Physical specifications

Instrument

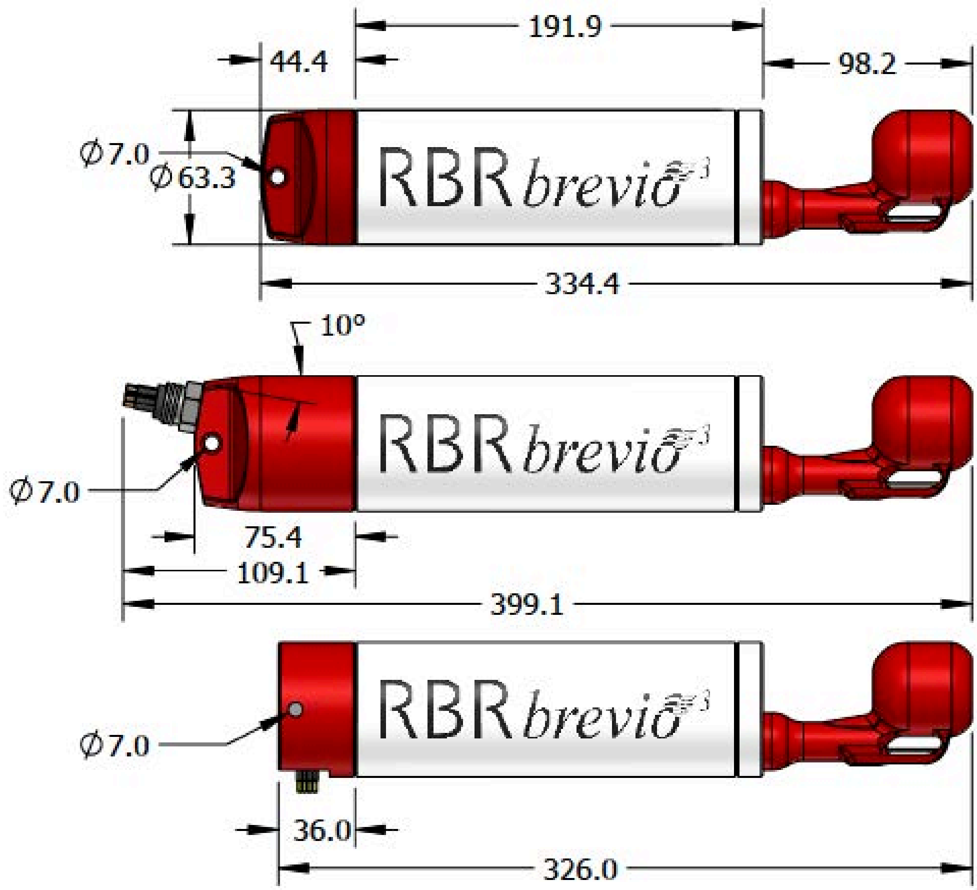
Specification	Description
Max number of readings	240 million
Power	8 AA-type cells*
External power	4.5 to 30V
Communications	Internal: USB-C External: USB and RS-232 / RS-485
Clock drift	±60 seconds/year
Housing	Plastic or titanium
Diameter	63.3mm (plastic), 60.3mm (Ti)
Depth rating	Configuration dependent
Sampling rate	2Hz; options up to 32Hz (configuration dependent)

*Lithium thionyl chloride batteries are only recommended for T, D, T.D, and C.T.D instruments. Instruments with any additional sensors will not work correctly on this type of battery. See Ruskin User Guide: Standard Instruments[3] for suitable battery chemistries.

Length and weight

Instrument	Length*	Weight in air*
RBR*virtuoso*[3]	~340-400mm	~1-1.5kg (plastic) ~2-3kg (titanium)
RBR*duo*[3]	~370-500mm	~0.9-1.5kg (plastic) ~2-3kg (titanium)
RBR*brevio*[3]	~330-400mm	~0.9kg (plastic) ~ 1.7kg (titanium)
RBR*concerto*[3]	~440-500mm	~1.5-2kg (plastic) ~2.8-4kg (titanium)
RBR*maestro*[3]	~600mm	~3-5kg (plastic) ~5.5-8kg (titanium)

*Configuration dependent. The total length and weight of an instrument depend on the sensors and battery end-cap type.



RBR*brevio*3 dimensions with three different battery end-caps

Power supply selection

If connected, an external power supply will be used preferentially over the internal batteries as long as the voltage remains 4.5V or greater. If it drops below 4.5V or complete disconnection occurs, the system automatically switches to the internal batteries.

Clock

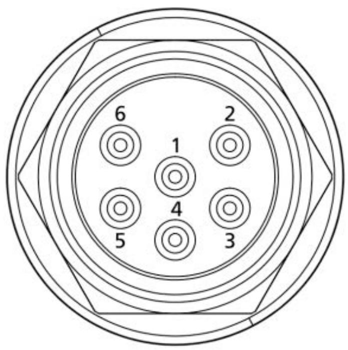
The instrument clock is maintained during brief disconnections. This time is usually sufficient to change batteries. If the clock is lost, the time will revert to January 2000. In this case, check the power supply and synchronise with the computer again.

USB-C power

The USB-C cable provides power sufficient for configuration or data download. However, the instrument requires an internal or external power supply to perform sampling.

RBR standard instruments with connectorised battery end-caps (BEC12 and BEC13) have **MCBH-6-MP** connectors. These connectors facilitate communication out of the instrument to your computer via USB, RS-232, or RS-485 cables, depending on the wiring selected at the time of purchase.

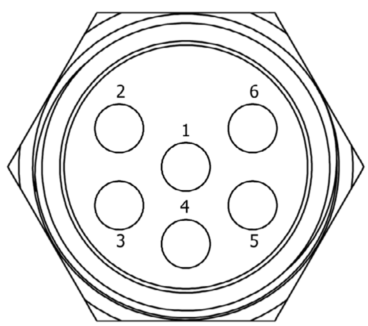
External MCBH-6-MP connector pinout



Pin No.	USB	RS-232	RS-485
1	Ground		
2	Power +4.5 to +30V		
3	N/C	From the instrument (Tx)	From the instrument (Tx-)
4	+5V	Into the instrument (Rx)	Into the instrument (Rx+)
5	D-	N/C	Into the instrument (Rx-)
6	D+	N/C	From the instrument (Tx+)

Additionally, the RBR*concerto*^{3} variants with an elongated body and RBR*maestro*^{3} instruments have **MCBH-6-FS** connectors. Use them to install raw voltage sensors (voltage kit, 0-5V general analogue input) and to communicate the data from these sensors to the instrument.

MCBH-6-FS connector pinout



Pin No.	RS-232
1	Ground
2	Sensor power
3	Serial data output from the sensor
4	Serial data input into the sensor
5	N/C
6	N/C

RBR properly installs all sensors included with your instruments. The MCBH-6-FS pinout will only be needed when installing an additional sensor.

For deployment estimates specific for your instrument configuration and sampling options:

- Go to Ruskin and click the "Instruments" tab
- Select "Simulate an instrument...", find your logger under "Standard instruments", and click "OK"
- Adjust variable parameters under "Configuration" to match your needs
- Ruskin autonomy engine will calculate the **End** date and indicate when your deployment is likely to stop

Note that deployment estimates are the same for shallow and deep variants.

3 Sensor specifications

RBR instruments can integrate a wide variety of sensors, including third-party units. While conductivity, temperature, and pressure remain the most popular choices, specialised sensors are available to meet any requirement. Refer to the following subsections for more information.

> RBR is constantly updating the list of supported sensors. Please contact the RBR sales team to discuss your needs and to select the perfect configuration for your applications.

3.1 Conductivity (C)

RBR standard instruments with a "C" in the name, such as RBR*duo*^{3} C.T, or RBR*concerto*^{3} C.T.D.ODO.Tu, use integrated inductive conductivity sensors which measure the ability of seawater to conduct electric current.

RBR manufactures four variants of inductive conductivity cells:

- 750m-rated black C cell
- 750m-, 2000m-, and 6000m-rated CFD-optimised red CT cells, with temperature and conductivity sensors integrated as a single unit.

750m-, 2000m-, and 6000m-rated conductivity cells

Parameter	Value
Range	0 to 85mS/cm
Initial accuracy	±0.003mS/cm
Resolution	<0.001mS/cm
Typical stability	0.010mS/cm/year
Max depth rating	750m, 2000m, or 6000m (depending on the variant)

The three red CT cells are rugged and durable. They are not affected by surface contaminants or freezing conditions, and can be frozen into ice. RBR used computational fluid dynamics (CFD) to optimise their design.

The black C cell has a simpler design which makes it easier to clean and maintain. This variant is perfect for moored applications.

The conductivity sensor is streamlined for hydrodynamic flushing through and around it, and does not require a pump, thus ensuring totally silent operation. While 80% of its volumetric measurements happens inside the cell, they also extend up to 15cm away and thus may be affected by conductive and non-conductive objects within this distance. RBR calibrates conductivity sensors to account for static objects, such as cages, guards, and other sensors.

> To maintain optimal accuracy, deploy your instrument with the same cage or guard as used during calibration and at least 15cm away from other objects.

Conductivity measurements are temperature compensated.

RBR*brevio*³ C.T.D with a conductivity sensor

Derived parameters: salinity, density anomaly, specific conductivity, speed of sound, oxygen concentration, oxygen saturation

3.2 Temperature (T)

RBR standard instruments with a "T" in the name, such as RBR*duo*³ T.D, RBR*brevio*³ C.T.D, or RBR*concerto*³ C.T.D.ODO.Tu, use the thermistor-type temperature sensors, rated for depths of up to 10km.

> ⚠ The depth rating of each instrument as a whole takes into account all integrated sensors and thus could be lower than 10km.

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

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

RBR*duo*³ T.D and RBR*concerto*³ C.T.D | deep with temperature sensors

Derived parameters: salinity, density anomaly, specific conductivity, speed of sound, oxygen concentration, oxygen saturation

3.3 Pressure (D)

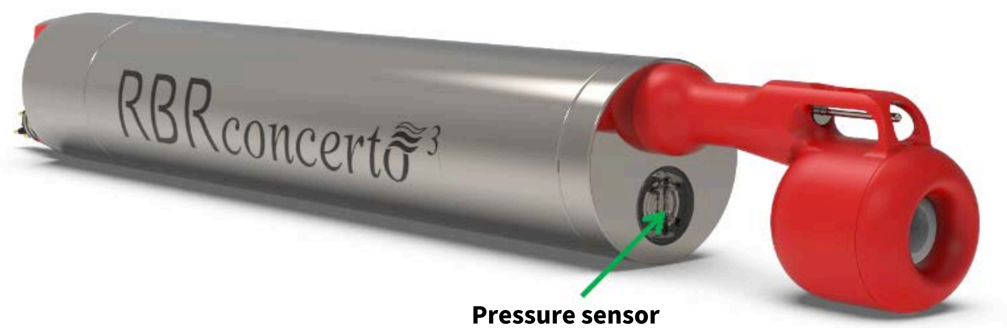
RBR standard instruments with a "D" in the name, such as RBR*virtuoso³* D, RBR*duo³* T.D, RBR*brevio³* C.T.D, or RBR*concerto³* C.T.D.ODO.Tu, use piezoresistive pressure (depth) sensors.

The sensor is protected by a clear plastic guard. During deployments, always orient it downwards to reduce debris collecting on the housing.

Parameter	Value
Range*	20 / 50 / 100 / 200 / 500 / 1000dbar (plastic) 1000 / 2000 / 4000 / 6000 / 10000dbar (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.

* The pressure rating of 10000dbar is only available for RBR*virtuoso³* T | deep, RBR*virtuoso³* D | deep, and RBR*duo³* T.D | deep.



RBR*concerto³* C.T.D | deep with a pressure sensor

Derived parameters: depth, sea pressure, salinity, density anomaly, speed of sound

3.4 Thermistor string (Tx)

The RBR*concerto*^{3} Tx is a unique instrument within the standard instrument family as it integrates multiple (12 or 24) temperature sensors in a single chain. The multi-node thermistor strings are made to order and are available in plastic and titanium housings.

To extend the life of your RBR*concerto*^{3} Tx and prevent failures, deploy this instrument over the side of your vessel and never via a winch. Avoid stretching the chain, placing any items on the chain, or bending the chain at radii smaller than 15cm.

Specification	Description
Nodes	12- or 24-node configuration
Depth rating	750m (plastic), 8000m (Ti)
Length	400m maximum
Load	250kg maximum
Clevis pin	12.7mm
Node diameter	22mm
Cable diameter	11.6mm
Node spacing	150mm centre-to-centre minimum

RBR*concerto*^{3} Tx with a thermistor string

3.5 RBR*coda*³ T.ODO (ODO)

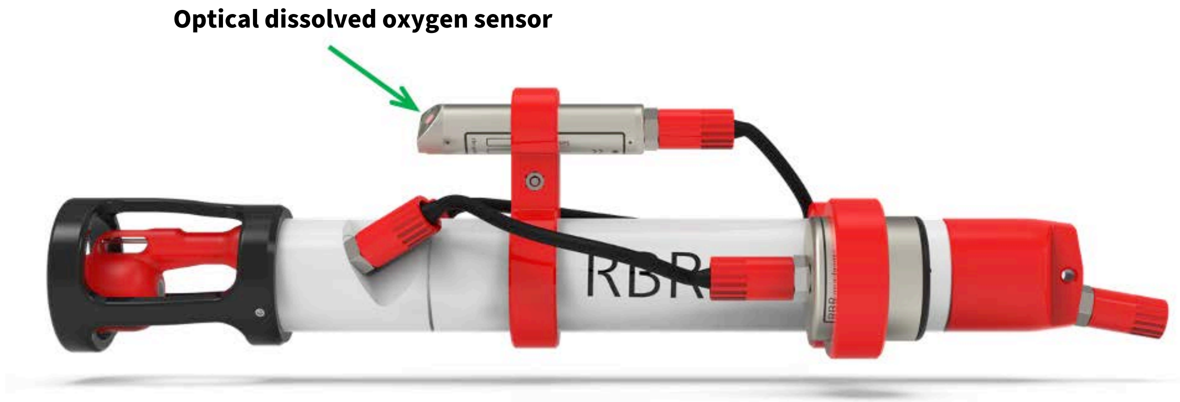
RBR standard instruments with an "ODO" in the name, such as RBR*concerto*³ C.T.D.ODO.Tu, use our RBR*coda*³ T.ODO integrated sensors, deployable at depths up to 6000m.

Optical dissolved oxygen sensors measure the drop in luminescence of a chemical dye in the sensor cap, caused by interacting with the oxygen dissolved in seawater.

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. Rehydrate for five days before deployment. See RBR ODO sensor care and maintenance for more information.

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)



RBR*concerto*³ C.T.D.ODO.quad with an ODO sensor (RBR*coda*³ T.ODO)

Derived parameters: oxygen saturation

3.6 Dissolved oxygen (DO)

RBR standard instruments with a "DO" in the name, such as RBR*concerto*[3] C.T.D.DO.PAR, use third-party dissolved oxygen sensors.
Galvanic dissolved oxygen sensors sensors (OxyGuard) generate an electrical current proportional to the amount of oxygen dissolved in seawater and are rated for depths of up to 1700m.
Optical dissolved oxygen sensors (Rinko®, Aanderaa®) measure the drop in luminescence of a chemical dye in the sensor cap, caused by interacting with the oxygen dissolved in seawater. Being based on phosphorescence, their scientific concept is similar to the ODO sensor manufactured by RBR.

OxyGuard

During deployments, always orient the sensor downwards to reduce debris collecting at the aperture.
Store the DO sensor in the dedicated storage cap, included with the instrument.

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

RBR*concerto*[3] C.T.D.DO.PAR with a DO sensor (OxyGuard)

⚠ Galvanic dissolved oxygen sensors need refurbishment if you observe any of the following:
- There is salt build-up around the aperture
- Protective membrane is damaged
- Electrolyte solution inside the storage cap is cloudy
- Sensor readings are out of range

Derived parameters: oxygen concentration

Rinko

RBR standard instruments support the Rinko optical dissolved oxygen sensor (Rinko III).

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.

Parameter	Value
Range	0-200% O_2 saturation
Resolution	0.01-0.04%
Accuracy	Non-linearity ±2% full scale
Depth rating	7000m

Optical dissolved oxygen sensor (Rinko)

Derived parameters: oxygen concentration

Aanderaa

RBR standard instruments support the Aanderaa optical dissolved oxygen sensors (Optode 4531 and Optode 4831F).

Parameter	O_2 concentration	O_2 saturation
Measurement range	0-1000µmol/L	0-300%
Resolution	<0.1µmol/L	0.05%
Accuracy Optode 4531 Optode 4831F	 <8µmol/L <2µmol/L	 <5% <1.5%
Depth rating Optode 4531 Optode 4831F	 100m 300m / 3000m/ 6000m	

Optical dissolved oxygen sensors (Aanderaa)

Derived parameters: oxygen saturation or oxygen concentration

3.7 Radiometers (PAR, rad, quad)

RBR offers PAR radiometers and narrow-band radiometers with a fixed channel width. Additionally, we support PAR sensors from LI-COR.
PAR sensors measure intensity of visible light at frequencies associated with photosynthesis. Narrow-band radiometers are available in a variety of wavebands.

RBR radiometers

The RBR*coda*[3] PAR and RBR*coda*[3] rad integrated sensors are cosine sensors which can measure light within one hemisphere.
The RBR*quadrante* (quad) is a four-channel radiometer which supports multiple radiation measurements (combinations of PAR and rad sensors) within the same sensor package.
Maximum depth rating of RBR radiometers is 2000m.

RBR*quadrante*

Optical radiometry

Parameter	Value
Dynamic range	>5.5 decades (nominal)
Absolute calibration*	±5%
Linearity	±1%
Operating temperature range	-5°C to 35°C
Cosine response error (water)	±5% at 0-60°C, ±10% at 61-82°C
Azimuth error (water)	±1.5% at 45°C
Out-of-band rejection**	>25dB (typical), OD 2.5

* RBR calibrates radiometers with NIST traceable references.
** Out-of-band rejection is wavelength-dependent for narrow-band radiometers.

PAR

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

* Dark offset is internally temperature-compensated.

Narrow-band channels

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

* Dark offset is internally temperature-compensated.
** Resolution is wavelength-dependent for narrow-band radiometers.

RBR*concerto*^{3} C.T.D.PAR with a cosine PAR sensor (RBR*coda*^{3} PAR)

LI-COR

PAR sensors options from LI-COR include cosine (one hemisphere, depth rating 560m) or spherical (omnidirectional, depth rating 350m) PAR sensors.

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

RBR*concerto*³ C.T.D.DO.PAR with a spherical PAR sensor (LI-COR)

3.8 Turbidity (Tu)

Turbidity

RBR standard instruments with a "Tu" in the name, such as RBR*virtuoso*³ Tu or RBR*concerto*³ C.T.D.ODO.Tu, use turbidity sensors from third-party manufacturers: Seapoint, Turner, and Sequoia.

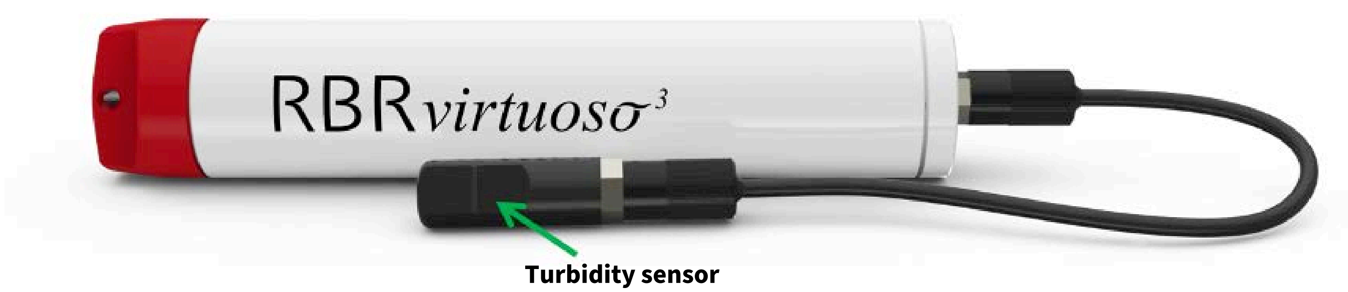
The RBR*concerto*³ and RBR*maestro*³ can integrate the RBR*tridente* three-channel sensor, capable of making multiple fluorescence and backscatter or turbidity measurements simultaneously.

Turbidity sensors detect light scattered by solid particles suspended in water. During deployments, minimise direct sunlight.

Seapoint

Parameter	**Value**
Light source wavelength	880nm
Sensing distance	<5cm from windows
Time constant	0.1s
Measurement range	0-4000FTU
Linearity	<2% deviation for 0-1250FTU range*
Depth rating	6000m

* Response becomes non-linear above 1250FTU.



RBR*virtuoso*³ Tu with a turbidity sensor (Seapoint)

Turner

Parameter	Value
Light source wavelength	260-900nm
Minimum detection limit	0.05FTU
Range	0-1500FTU
Depth rating	600m

Turbidity sensor (Turner)

Sequoia

Parameter	Value
Light source wavelength	850nm
Acoustic backscatter	8MHz
Range	0-3000FTU
Depth rating	100m

Turbidity sensor (Sequoia)

3.9 Fluorescence (fl)

RBR standard instruments support a variety of fluorescence sensors from third-party manufacturers: Seapoint, Sea-Bird, and Turner.

The RBR*concerto*³ and RBR*maestro*³ can integrate the RBR*tridente* three-channel sensor, capable of making multiple fluorescence and backscatter or turbidity measurements simultaneously.

Fluorometers operate by transmitting a beam of light and then detecting the light emitted by the excited particles of organic matter suspended or dissolved in seawater. They can measure chlorophyll concentration, crude oil, chromophoric dissolved organic matter (cDOM), fluorescent dissolved organic matter (fDOM), and a variety of synthetic dyes.

Seapoint

Parameter	**Value**
Output time constant	0.1s
Wavelength, excitation/emission	470nm / 685nm (chlorophyll *a*) 370nm / 440nm (cDOM)
Sensing volume	$340mm^3$
Depth rating	6000m

Fluorescence sensor (Seapoint)

Seabird

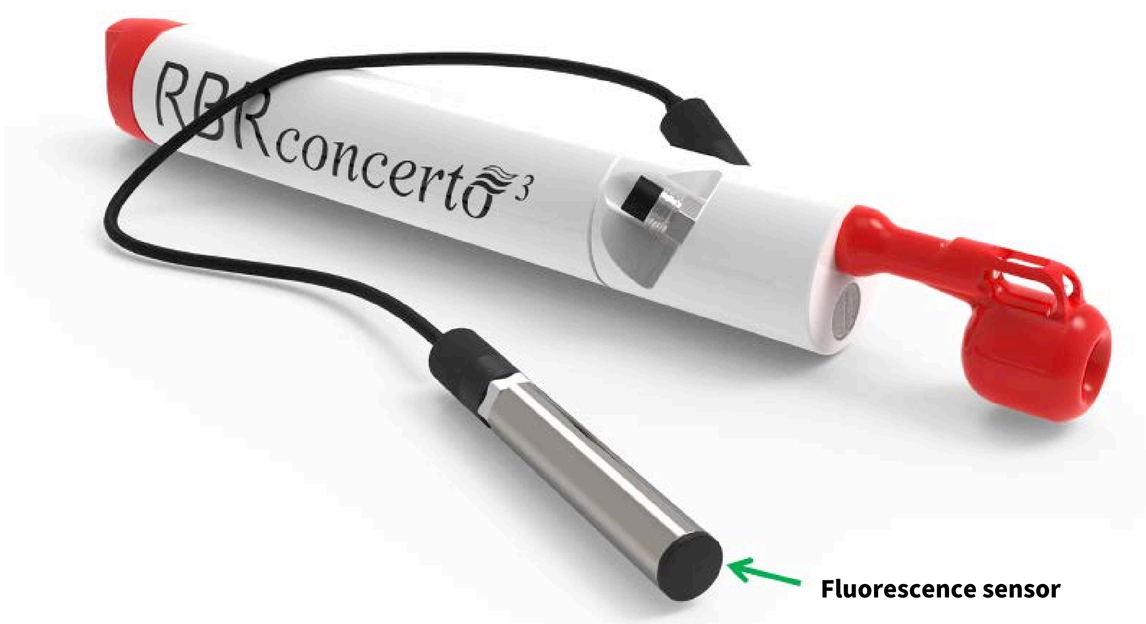
Parameter	**Value**
Wavelength, excitation/emission	470nm / 695nm (chlorophyll *a*) 370nm / 460nm (fDOM)
Sensitivity	0.025 µg/L
Depth rating	300m / 600m

Fluorescence sensor (Sea-Bird)

Turner

Parameter	Value
Wavelength, excitation/emission	440nm / 680nm (chlorophyll *a*) 370nm / 440nm (cDOM)
Minimum detection limit Chlorophyll *a* (blue excitation) Chlorophyll *a* (red excitation) cDOM/fDOM Crude oil Rhodamine dye	 0.03µg/L 0.3µg/L 0.1-0.5ppb 0.2ppb 0.01ppb
Depth rating	600m

Fluorescence sensors (Turner)



RBR*concerto*^{3} CTD.Fl with a Cyclops-7F fluorometer

3.10 RBR*tridente* (tri)

The RBR*tridente* is an optical sensor with three channels, capable of making multiple fluorescence and backscatter or turbidity measurements simultaneously. Its standard depth rating is 2000m, but a 6000m variant is available upon request. Contact RBR for more information.

Optical

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

RBR*tridente*

Chlorophyll *a*

Parameter	Value
Channel wavelength (excitation/emission)	470nm/695nm
Calibrated range*	0-100µg/L
Detection limit*	0.01µg/L

* Scaled to the fluorescence response from a monoculture of *Thalassiosira weissflogii*.

fDOM

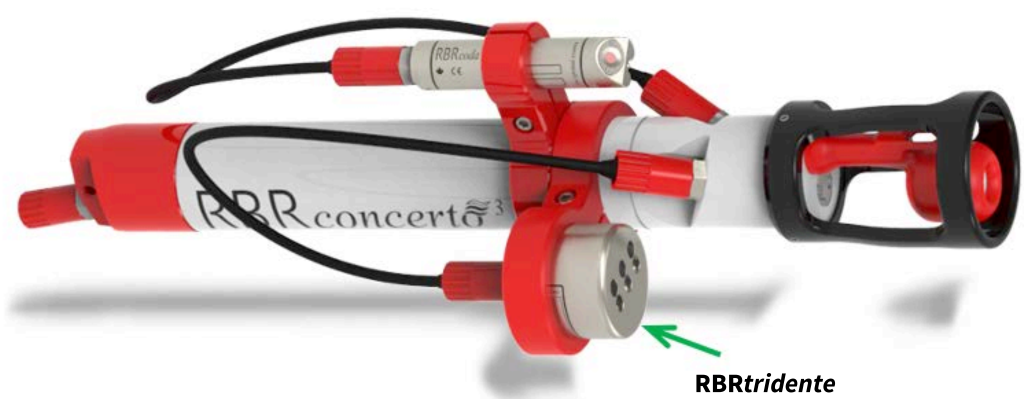
Parameter	Value
Channel wavelength (excitation/emission)	365nm/450nm
Calibrated range	0-500ppb
Detection limit	0.004ppb

Backscatter

Parameter	Value
Channel wavelength	700nm
Calibrated range	0-0.05$m^{-1}sr^{-1}$
Detection limit	1x$10^{-6}m^{-1}sr^{-1}$

Turbidity

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



RBR*concerto*^{3} C.T.D.ODO.tri with RBR*tridente*

3.11 pH

RBR standard instruments support the Idronaut pH sensors.

These sensors measure hydrogen ion concentration in environmental water, yielding its relative acidity or alkalinity, and thus evaluating water quality. RBR recommends to deploy the pH sensor together with the ORP sensor.

Parameter	Value
Membrane type	Blue glass membrane (<50MOhm at 20C°)
Range	pH 1 to pH 13
Null point	pH 7.0
Drift	0.05 pH units / month
Response time	3s
Maximum pressure	7000dbar

pH sensor (Idronaut)

3.12 Oxidation reduction potential (ORP/redOx)

RBR standard instruments support the Idronaut oxidation-reduction potential (ORP/redOx) sensors.

These sensors measure the ability of water to gain or lose electrons, and can track contamination levels in environmental water when used over extended periods of time. RBR recommends to deploy the ORP sensor together with the pH sensor.

Parameter	Value
Type	Platinum electrode, Ø0.3mm
Maximum pressure	7000dbar

ORP sensor (Idronaut)

3.13 Methane

RBR standard instruments support the Franatech methane sensors.

These sensors have a semi-conductor with an active layer that absorbs methane. A change in conductivity of the active layer is proportional to the amount of dissolved methane in seawater.

Parameter	Value
Range	50nM to 10µM
Sensitivity	1nM to 500nM (pumped flow-through mode)
Low range	20nM – 1µM
High range	1µM – 40µM
Response time	several seconds
Depth rating	4000m

Methane sensor (Franatech)

3.14 Carbon dioxide

RBR standard instruments support the carbon dioxide sensors (C-sense) from Turner.

These sensors measure absorption of the wavelength specific to carbon dioxide and generate voltage output proportional to the partial concentration of CO_2 gas in seawater. They operate through the diffusion of gas across a hydrophobic membrane into an isolated headspace. A copper antifouling guard minimises biofouling and protects the membrane.

Parameter	Value
Ranges	0 to 1000ppm 0 to 2000ppm 0 to 4000ppm 0 to 10000ppm
Initial accuracy	±3% full scale
Depth rating	600m

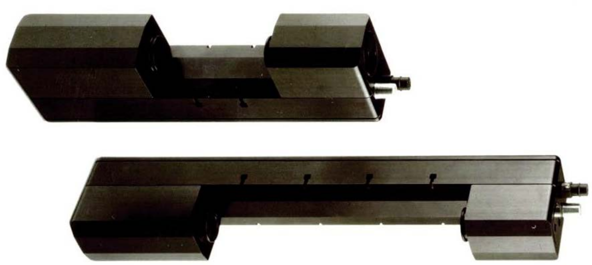
CO_2 sensor (Turner)

3.15 Transmittance

RBR standard instruments support the Sea-Bird transmissometers (C-Star).

These sensors measure underwater light transmittance by projecting a collimated beam through an optical flow tube and quantifying its attenuation. As the loss of light occurs due to scattering and absorption, the resulting value reflects the concentration of organic matter suspended and dissolved in seawater.

Parameter	Value
Wavelengths	410 / 465 / 520 / 650nm
Bandwidth	~10-12nm for 370nm ~20nm for all other wavelengths
Pathlength	25 or 10cm
Acceptance angle	~1°
Bandwidth	~10-12nm for 370nm ~20nm for all other wavelengths
Linearity	99% R^2
Depth rating	600m (plastic), 6000m (aluminium)



Transmissometers (Sea-Bird)

4 Derived parameters

Calculate derive parameters using Ruskin software or on the RBR instrument itself, depending on how it is configured. Both routes use the same equations and produce identical results.

Calculation on Ruskin

All derived parameters will be calculated on Ruskin:

- when the data storage format is set to **Desktop** and **Realtime** is set to **None**

As a result, the RSK file will only store raw data. This option enables post-processing on Ruskin, with the flexibility of changing the variables.

To obtain derived parameters, download the dataset to your laptop and open it on Ruskin, then input physical parameters into the **Parameters** tab. Furthermore, Ruskin has alternative derivation options for some parameters, which you can also select in the **Parameters** tab. See Ruskin User Guide: Standard Instruments[3] for details.

> The **Desktop** storage format is a preferred option. Having the raw data keeps more options open in the long term.
> However, when you are managing your deployments using a smartphone, it is more efficient to derive parameters in realtime than post-process a large RSK file with raw data, due to limited capabilities of mobile devices.

Calculation on the instrument

All derived parameters will be calculated on the instrument:

- when the data storage format is set to **Mobile**
  or
- when the data storage format is set to **Desktop** and **Realtime** is set to **Serial** or **USB**

As a result, the RSK file will store the data with calibration coefficients already applied and derived parameters already calculated.

4.1 Salinity

Salinity is defined as the ratio of the mass of dissolved material to the mass of seawater. It is impossible to measure absolute salinity directly. However, we can derive practical salinity from measurable properties: electrical conductivity, temperature, and pressure, obtained by your RBR CTD instrument, such as RBR*concerto*[3] C.T.D. The units of measurement are **PSU** (dimensionless Practical Salinity Units).

RBR uses the algorithm recommended by PSS78, the world standard for practical salinity calculation. It enables calculation of practical salinity in a range 2 to 42PSU from conductivity S (mS/cm) measured at temperature T (ºC) and hydrostatic pressure p (dBar). Refer to Practical Salinity Scale of 1978 (PSS78) for more details.

RBR CT instruments (such as RBR*duo*[3] C.T, without a pressure sensor) can still calculate salinity if you enter depth in the table under the **Parameters** tab in Ruskin. See Ruskin User Guide: Standard Instruments[3].

> ⚠ If the PSS78 calculation generates an error, the instrument will report a salinity of 0. This might occur when, in air, the conductivity report a small negative value. This does not apply if one of the measured parameters is already flagged as an error.

4.2 Specific conductivity

Specific conductivity is a function of conductivity and temperature. This parameter is mostly applicable in studies of freshwater and brackish water. The units of measurement are **µS/cm** (microsiemens per centimetre).

RBR uses the algorithm described in Standard Methods for the Examination of Water and Wastewater by L.S. Clesceri et al, which yields specific conductivity normalised to 25°C.

$$Specific\,conductivity = \frac{0.001 \cdot conductivity}{1 + 0.0191(temperature - 25)}$$

where conductivity in mS/cm and temperature in °C are values measured by your RBR instrument, and 0.0191 is the default specific conductivity coefficient.

The specific conductivity coefficient is defined as the change in conductivity (in %) per 1°C. Its default value corresponds to an increase in conductivity of 1.91%. However, it depends on temperature and ionic composition of the water, ranging between 0.0175 and 0.0214 for natural lakes and rivers. You may be able to find the value specific to your body of water in literature or experimentally. In this case, adjust the specific conductivity coefficient manually in the table under the **Parameters** tab in Ruskin. See Ruskin User Guide: Standard Instruments[3].

This method enables calculation of specific conductivity in a range 0 to 6000µS/cm and is valid in the temperature range -2°C to +35°C.

4.3 Speed of sound

Speed of sound in seawater is a function of salinity, temperature and pressure. The units of measurement are **m/s** (metres per second).

It is not always possible to measure the speed of sound in seawater directly. However, we can derive it from measurable properties: electrical conductivity, temperature, and pressure, obtained by your RBR instrument, such as RBR*concerto*^{3} C.T.D. RBR CT instruments (such as RBR*duo*^{3} C.T, without a pressure sensor) will calculate the speed of sound if you enter depth in the table under the **Parameters** tab in Ruskin. See Ruskin User Guide: Standard Instruments[3].

We derive salinity first, via the PSS78 method, and then use it in the algorithm, often referred to as the UNESCO equation. See Speed of sound in seawater as a function of salinity, temperature, and pressure by G.S.K. Wong and S. Zhu for more details.

In the oceans, the speed of sound varies between 1450 and 1570m/s. It increases about 1.3m/s per each 1PSU increase in salinity, 4.5m/s per each 1°C increase in temperature, and 1.7m/s per each 1dbar increase in pressure.

4.4 Density anomaly

Density anomaly, or negative thermal expansion, is the paradoxical tendency of water to expand during cooling. This behaviour manifests in anomalous decrease in water density when the temperature drops below 4°C. The units of measurement are **kg/cm^3** (kilograms per cubic centimetre).
It is not possible to measure the density anomaly directly. However, we can derive it from measurable properties: electrical conductivity, temperature, and pressure, obtained by your RBR CTD instrument, such as RBR*concerto*^{3} C.T.D. RBR CT instruments (such as RBR*duo*^{3} C.T, without a pressure sensor) will calculate density anomaly if you enter depth in the table under the **Parameters** tab in Ruskin. See Ruskin User Guide: Standard Instruments[3].

We derive salinity first, via the PSS78 method, and then use it in the algorithm, often referred to as the UNESCO equation of state:

$$Density\ anomaly = \left(\frac{1}{V(S,t,p)}\right) - 1000kg/m^3$$

where V (S, t, p) is specific volume of seawater derived from salinity, temperature and pressure and 1000kg/m^3 is density of freshwater.

See UNESCO (1981), Tenth report of the joint panel on oceanographic tables and standards for details.

> ⚠ The UNESCO equation of state is applicable within these ranges: 2 < practical salinity < 42, −2°C< temperature < 35°C.
> If salinity values are lower than 2PSU (freshwater), density anomaly values will not be accurate.

4.5 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: Standard Instruments[3]. If not entered, a default value of 10.1325dbar will be used.

4.6 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: Standard Instruments[3]. If not entered, default values of 10.1325dbar and 1.0281g/cm^3 will be used.

4.7 Oxygen concentration

RBR standard instruments support several third-party DO sensors from Rinko, OxyGuard, and Aanderaa*, which measure dissolved oxygen saturation.

* Aanderaa sensors report either oxygen saturation or oxygen concentration, depending on the RBR instrument.

When a sensor measures oxygen saturation, we 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** for the Oxyguard DO and Rinko DO sensors; and **mg/L** or **mL/L** for the Aanderaa Optode DO sensors.

The Weiss equation requires values for absolute temperature (in °K) and salinity, which are derived from measured temperature and conductivity. If your instrument does not measure these, default values of 0°C (273.15°K) and 35PSU will be used. Alternatively, enter temperature and conductivity manually in the table under the **Parameter** tab in Ruskin. See Ruskin User Guide: Standard Instruments[3].

4.8 Oxygen saturation

RBR standard instruments support several sensors which measure dissolved oxygen concentration, including our own RBR*coda*[3] T.ODO and Aanderaa* Optode DO sensors.

* Aanderaa sensors report either oxygen saturation or oxygen concentration, depending on the RBR instrument.

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. If your instrument does not measure these, default values of 0°C (273.15°K) and 35PSU will be used. Alternatively, enter temperature and conductivity manually in the table under the **Parameter** tab in Ruskin. See Ruskin User Guide: Standard Instruments[3].

5 Hardware

5.1 Opening and closing the instrument

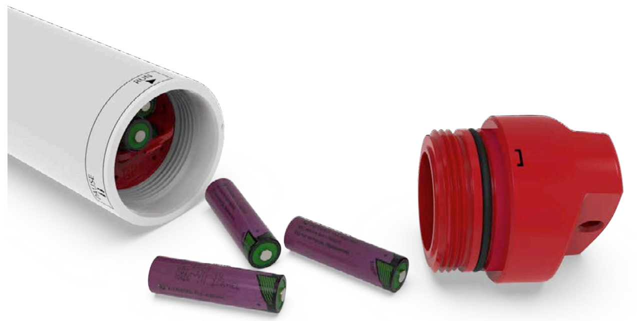
> ⚠ Remember to keep the O-ring clean and avoid scratching the O-ring mating surfaces. Carefully inspect the O-ring before deploying the instrument.

Opening the instrument with a standard end-cap

1. Twist the battery end-cap counterclockwise.
2. Once fully unscrewed, pull the end-cap away from the housing.

Closing the instrument with a standard end-cap

1. Place the end-cap back on the instrument until almost fully closed.
2. Twist the end-cap clockwise until aligned with **PAUSE**.



Open instrument with a standard end-cap

Opening the instrument with a connectorised end-cap

1. Twist the battery end-cap counterclockwise.
2. Once fully unscrewed, pull the end-cap away from the housing.
3. Unplug the umbilical cable.

Closing the instrument with a connectorised end-cap

1. Plug the mini-display port connector into the instrument as shown.
2. Twist the end-cap counterclockwise two full rotations to unwind the umbilical cable.
3. Twist the end-cap clockwise back on the instrument until aligned with **PAUSE**.

Open instrument with a connectorised end-cap

5.2 Instrument interface

The RBR standard instruments provide an internal USB-C port and, depending on the end-cap type, an external MCBH-6-MP connector.

> Refer to Opening and closing the instrument for details on accessing connection ports.
> Refer to Physical specifications for the external MCBH-6-MP connector pinout diagram.

USB-C connection

Remove the battery end-cap to access the USB-C port located inside the instrument body.

A USB-C desktop cable is supplied in the instrument support kit. Use this cable to download data from the instrument to your computer.

Mini-display port

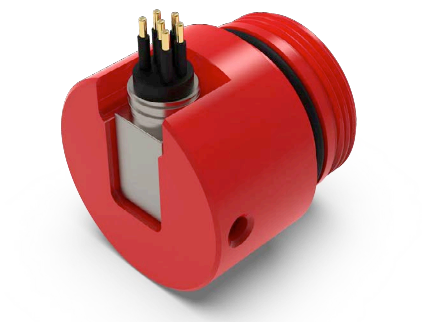
The mini-display port is located next to the USB-C port. This is the port to use for the umbilical cable from the connectorised end-cap.

End-cap types

RBR standard instruments are compatible with three different end-caps. These end-caps are interchangeable between instruments.

Standard end-cap

Connectorised end-cap



Right-angle connectorised end-cap

MCBH connectors

Only connectorised battery end-caps have the external MCBH-6-MP connector. Depending on your needs, they may be wired to support the USB, RS-232, or RS-485 communication (selected at the time of order).

.

MCBH connector

ⓘ Patch cables and underwater extension cables are sold separately. See RBR Cable Guide for details.

5.3 Twist activation

Sampling

Twist activation allows you to start or pause the instrument without the need to connect to a computer. All RBR Generation[3] standard instruments are equipped with twist activation as a standard feature. See Ruskin User Guide: Standard Instruments[3].

When you select "Twist activation" in Ruskin, the instrument starts to sample based on the twist **PAUSE**/**RUN** position rather than a schedule. To start sampling, first click "Enable" in Ruskin to enable logging. The status will then become "Paused". Turn the battery end-cap to the **RUN** position. The instrument will vibrate with one long pulse and start sampling. To pause it, turn the battery end-cap to the **PAUSE** position. The instrument will vibrate with three short pulses to indicate it has paused logging.

Twist activation mode

Wi-Fi

Twist activation allows you to connect to the instrument over the Wi-Fi when using a mobile device. Instruments equipped with a Wi-Fi module have the **WI-FI READY** icon on the end-cap. This module needs to be enabled at the time of purchase. Contact RBR if you have any question about this feature.

You can activate the Wi-Fi by twisting the end-cap in either direction. The WI-Fi will stay on for 60 seconds, waiting for you to connect. See Ruskin User Guide: Standard Instruments[3] for the required steps.

The Wi-Fi is disabled after 60 seconds of inactivity. Twist the end-cap to **RUN** or **PAUSE** to re-activate the Wi-Fi.

Twisting the end-cap to the **RUN** or **PAUSE** position will activate the Wi-Fi. However, twisting to the **PAUSE** position will also pause the instrument, as described above.

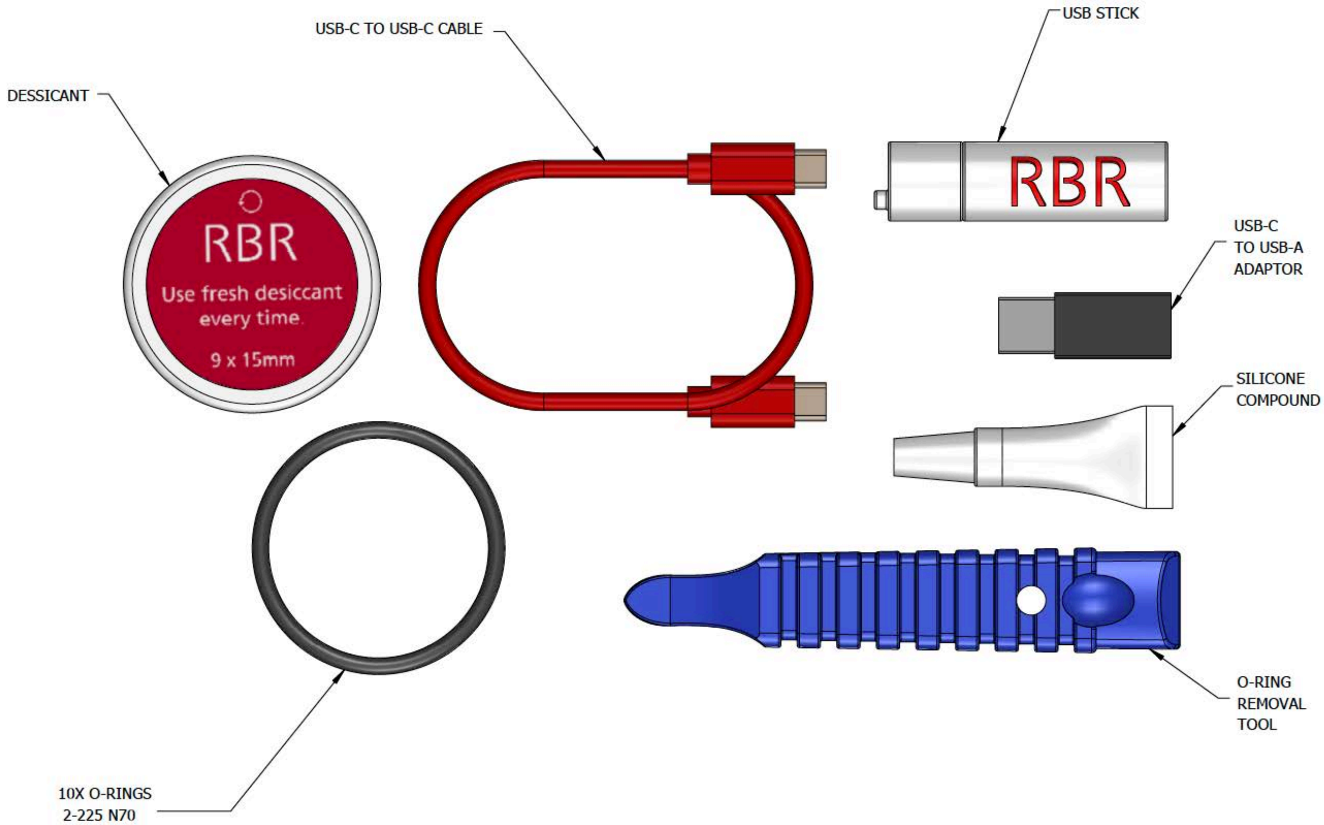
6 Maintenance

6.1 Support kits

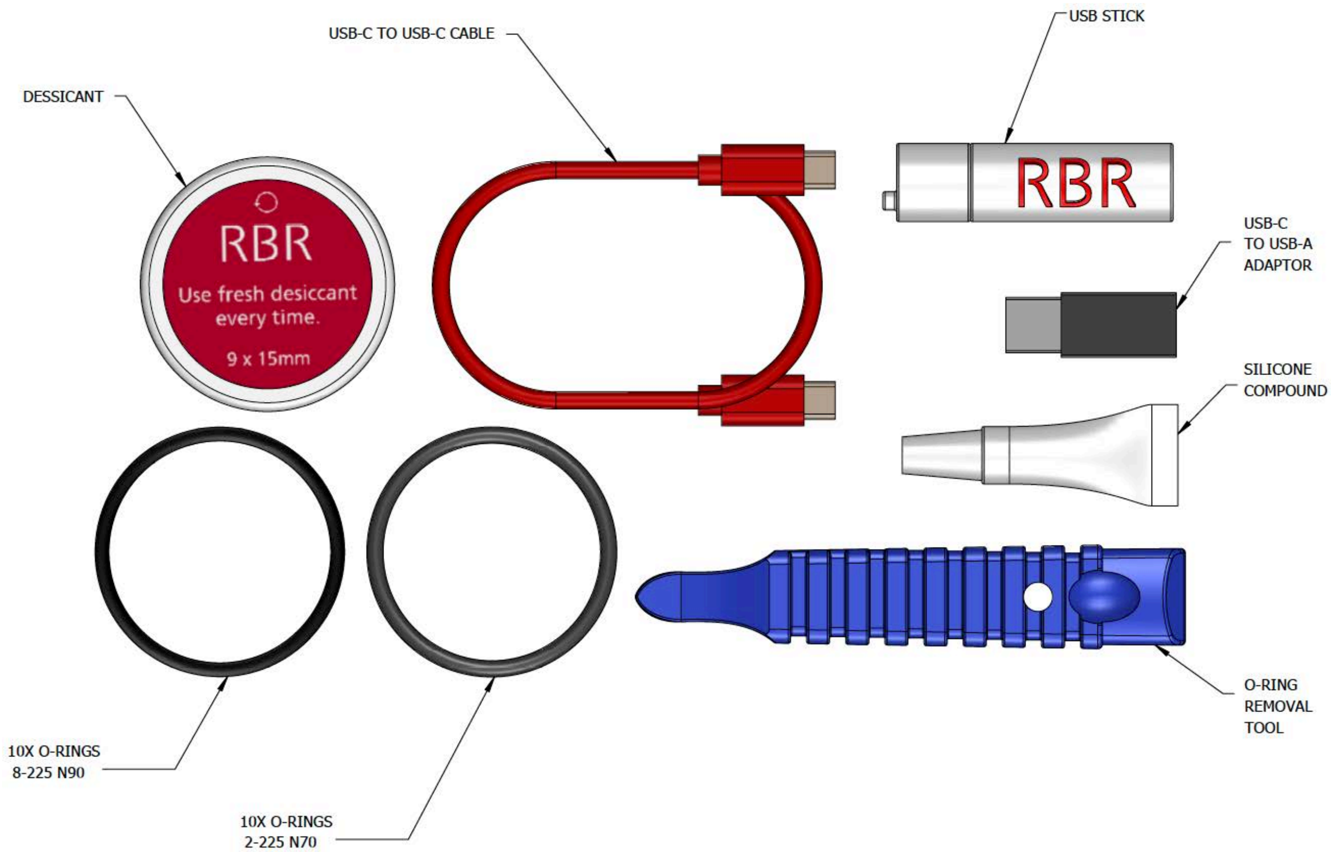
RBR provides one support kit per every three instruments ordered. If you need more units, contact RBR.

There are two types of RBR support kits for standard instruments, for the ones in plastic housing and for those in titanium. The difference is the O-rings included in the support kit. Instruments in titanium housing are used for deep deployments and must endure harsher conditions. An additional O-ring serves as a backup protection from flooding.

The RBR support kits contain an assortment of basic accessories and spare parts, as presented below.



RBR support kit diagram (for plastic)



RBR support kit diagram (for titanium)

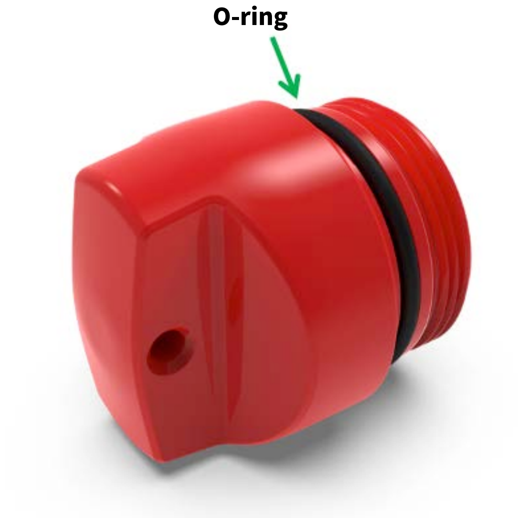
See Replacing the O-rings for more information on the | deep variants.

6.2 Replacing the O-rings

ⓘ Refer to Opening and closing the instrument for details on accessing the O-rings.
The O-ring removal tool and silicone compound are available in the support kits.

Care for the O-ring is the single most important item of maintenance on any submersible RBR instrument. A water leak can damage the circuit board beyond repair and cause complete data loss. Every instrument's seal depends upon its O-ring, not the end-cap tightness. Therefore, proper O-ring maintenance is crucial.

ⓘ The O-ring may lose elasticity over time, even when the instrument is not deployed. RBR strongly recommends replacing the O-ring regularly.



Location of the O-ring

To access the O-ring, open the instrument.

Inspecting the O-ring

Visually inspect the new O-ring for nicks and scratches before installing it. Pay attention to the following areas:

- The surface of the O-ring itself
- The mating surface on the inside of the case between the threads and the open end
- The groove in the end-cap where the O-ring sits

⚠ When handling the O-rings:

- Avoid using any object that could scratch the O-ring or any of its mating surfaces.
- If dirt is present in the O-ring groove, remove the O-ring as described below and thoroughly clean the groove.
- Do not return this old O-ring to the instrument! If you remove the O-ring from the instrument for any reason, always replace it with a new one.
- If the surfaces of the O-ring groove are scratched, pitted, or damaged, contact RBR for advice.

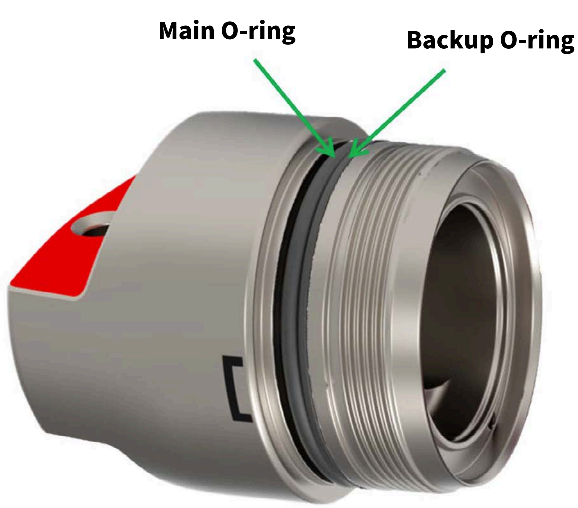
Replacing the O-ring

> Do not use metal screwdrivers or any other metal tool! They may scratch the O-ring groove and render the end-cap useless.

1. Use the plastic O-ring removal tool (included in the support kit) to remove the old O-ring from its groove. The O-ring may need to stretch quite a bit as it is pushed off. This requires some effort, but can be done by hand.
2. Clean the groove thoroughly with a soft, lint-free cloth and compressed air, if necessary.
3. Select a new O-ring and inspect it for damage.
4. Lubricate with a very light film of silicone compound (included in the support kit).
5. Install the new O-ring by pushing it into place and popping it into its groove.
6. Once in place, inspect it once more for scratches and debris, and wipe away any silicone compound deposited on the end-cap.
7. Close the instrument.

O-rings on | deep variants

The | deep variants of standard instruments use two O-rings. One is the main O-ring, and the other is the backup. Both are required to protect the instrument from flooding. To access the O-rings, open the instrument.



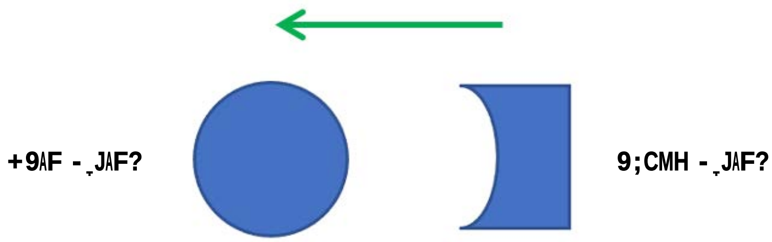
Location of the O-rings, | deep

Orienting the O-rings on | deep variants

Correct placement and orientation of the two O-rings are critical to maintaining depth rating integrity.

The main O-ring has a round profile. It must be installed first.

The backup O-ring is flat on one side, and concave on the other. When installed, the concave side must face the main O-ring.



-JA=FL9LAGF G> L@= -.JAF?K, A deep (Main O-ring, Backup O-ring)

6.3 Replacing the batteries

RBR ships new instruments with fresh, highest capacity batteries included. Replace the batteries before each deployment to maximise the operational time and prevent data loss.

Ruskin software estimates the remaining battery life during deployment by tracking power consumption in mAh. When setting up your deployment on Ruskin, check "Fresh" to indicate that new batteries are installed.

If using the same batteries for a subsequent deployment, do not check "Fresh" and continue power tracking from the previously recorded level.

See Ruskin User Guide: Standard Instruments[3] for more information on predicting battery life.

0 0 KL9F<9J< AFKLJM E=FL OAL@ :9LL=JA=K J=EGN=<

0=HD9;AF? L@= :9LL=JA=K

1. Remove the battery end-cap.
2. Using both thumbs, press down on the "+" symbols on the battery cover and slide in the direction of the arrow.
3. Remove the eight old batteries from the battery carriage.
4. Insert eight new batteries.
5. Check for correct battery polarity.
6. Put the end-cap back on the instrument and twist clockwise until aligned with **. 31#**.

> Always remove the batteries from your instrument during long-term storage!
> Doing so will prevent internal damage due to battery leakage and/or corrosion.

6.4 Replacing the desiccant capsules

Replace desiccant capsules before each deployment.

Fresh desiccant will keep the instrument compartment dry and prevent malfunction. Water damage may occur if condensation forms inside the instrument.

As a preventative measure, RBR recommends servicing the instrument in a cool, dry place (when possible).

Replacing desiccant capsules

1. Remove the battery end-cap.
2. Remove the used desiccant capsules from their sockets.
3. Insert fresh desiccant capsules into their sockets, face out.
4. Once all the capsules are secured, place the battery end-cap back in its place.
5. Put the end-cap back on the instrument and twist clockwise until aligned with **PAUSE**.

Location of the desiccant capsules

Direction of insertion

All instruments ship with fresh reusable desiccant capsules. They use a cobalt-free colour changing indicator dye. Orange indicates fresh desiccant, while green indicates it is saturated (about 15% water by weight). Once exhausted, the capsules can be replaced with new ones (available from RBR), or refreshed.

Fresh (orange) and saturated (green) desiccant capsules

Refreshing the desiccant

Follow the steps below to refresh the desiccant.

1. Remove the saturated silica beads from their capsule.
2. Place them in the oven and heat at 120°C (250°F) for about two hours.

> Always remove the beads from their capsule before refreshing!
> The capsule will deform if heated to 120°C.

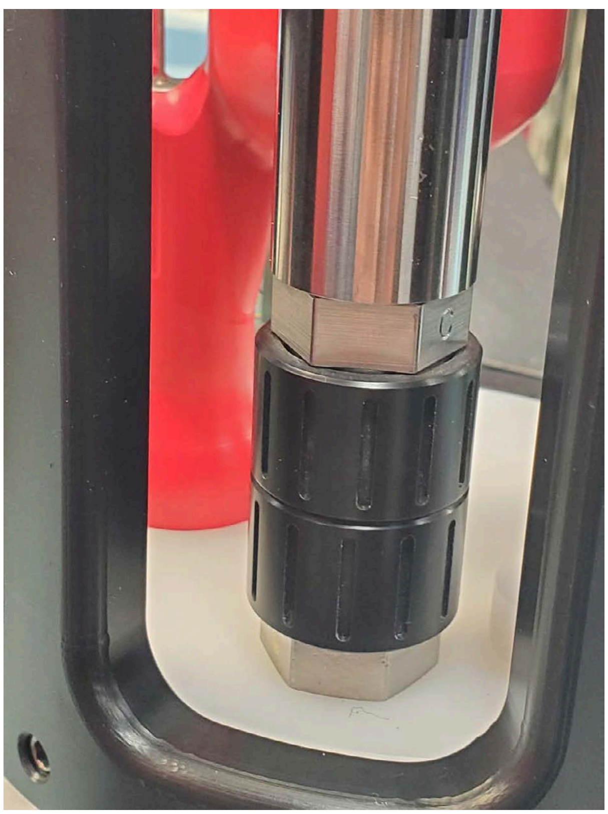
3. Take the refreshed beads out of the oven and return them to the capsule.

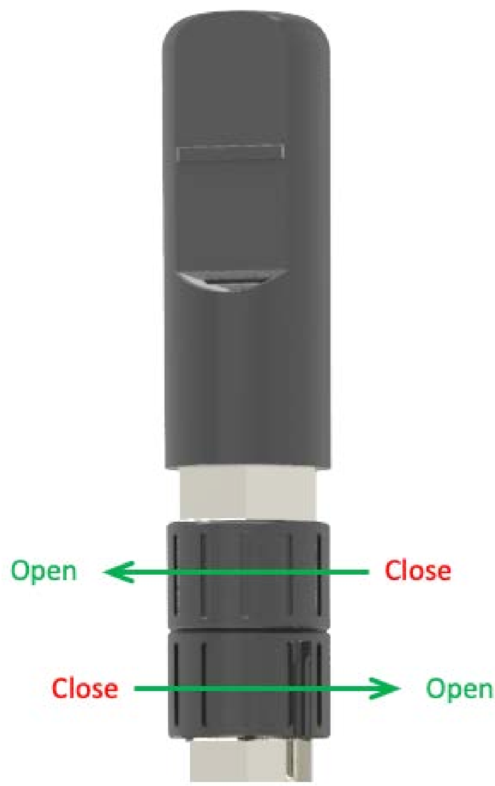
> Return the refreshed beads to the capsule immediately after reheating!
> If left outside the capsule, the desiccant will trap moisture and go back to green.

4. Wait until the silica beads cool down. Once cool, the desiccant is ready to be reused.

6.5 Using a coupler for bulkhead-mounted sensors

RBR standard instruments can use bulkhead-mounted sensors, some of which are connected via a coupler with two free-spinning flanges designed to tighten and hold the mating MCBH pairs together. Examples include Turner turbidity, Turner fluorometer, and Seapoint turbidity sensors.





Follow the steps outlined below to remove and replace the coupler.

Steps to disconnect and reconnect a sensor

Step	Description
1	Disconnect the sensor 1. Position the instrument vertically, with the sensor end-cap up. 2. Press the sensor down firmly with your right hand to prevent it from moving and to secure the instrument in its position. 3. With your left index finger and thumb, twist the flange closest to the instrument counterclockwise until loose. 4. Remove the disconnected sensor with your right hand.
2	Access the female connector 1. Twist the flange on the sensor counterclockwise. 2. Remove the coupler.
3	Lubricate the female connector (see Cables and connectors)
4	Reconnect the sensor 1. Place the coupler back on the instrument. 2. Twist clockwise until tight. 3. Very carefully mate the sensor to the instrument (the pins on the sensor must be aligned with the corresponding holes). 4. Press the sensor into the instrument to make sure the pins are inserted. 5. With your right index finger and thumb, twist the right flange counterclockwise while slightly pushing the sensor in with your palm. 6. Verify the tightness of both flanges. Occasionally, one of the flanges may begin to loosen while you are tightening the other one. It usually means that the pins did not mate properly. Carefully align the pins again and press harder. Wiggle the sensor gently to make sure the pins are inserted.

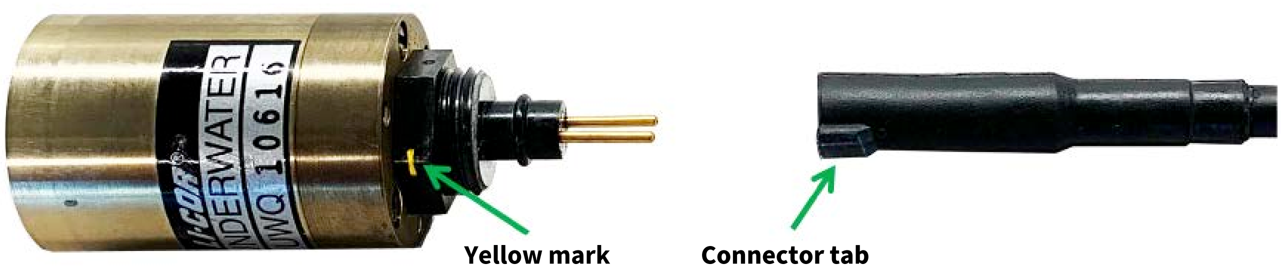
The same coupler connects the Seapoint turbidity sensor in the RBR*solo*³ Tu. See Ruskin Instrument Guide: Compact Instruments³ for instructions on coupling the turbidity sensor.

6.6 Connecting the cabled PAR sensor (LI-COR)

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.



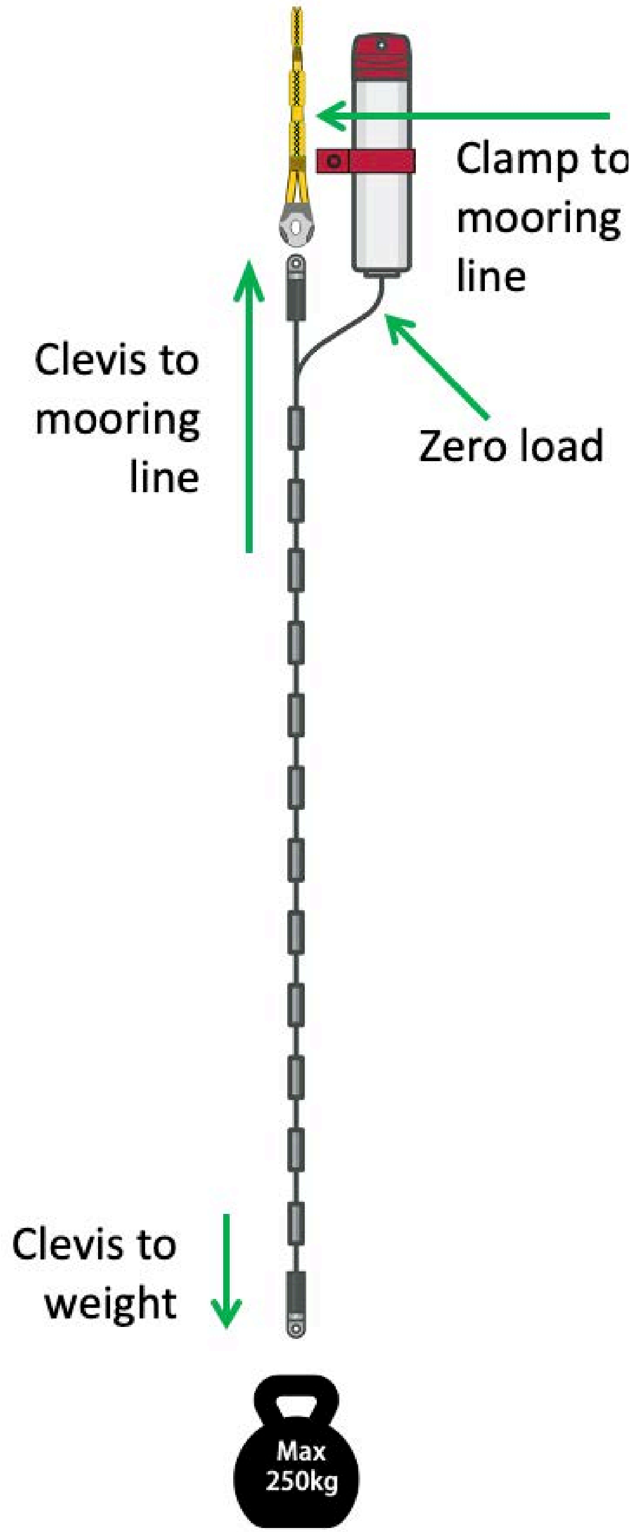
Orientation

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.

6.6.1 Thermistor string care and maintenance

> Do not place any items on the T-string.
> Do not step on the T-string.
> Do not exceed a load of 250kg clevis to clevis.



Storage

Store the T-string in its shipping crate or a dedicated box, loosely coiled. The smallest bend radius for the T-string cables is 15cm.

Deployment

1. Remove the T-string out of the box.
2. Attach the shackle of the mooring line to the clevis of the T-string closest to the instrument.
3. Attach the instrument to the mooring line with a clamp.
4. Attach the weight to the clevis at the free end of the string (the opposite of the instrument).
5. Carefully unspool the T-string on the side of your vessel, weight first.

> The T-string must be supported by the clevis, never by the instrument connector.

Cleaning

After each deployment, clean the cables of the T-string with soapy water.

6.7 Idronaut pH and ORP sensor care and maintenance

Storage

Store the Idronaut pH sensors in the dedicated storage cap half-filled with pH 7 buffer solution or distilled water.

Store the reference sensors in the dedicated storage cap half-filled with KCl or NaCl solution.

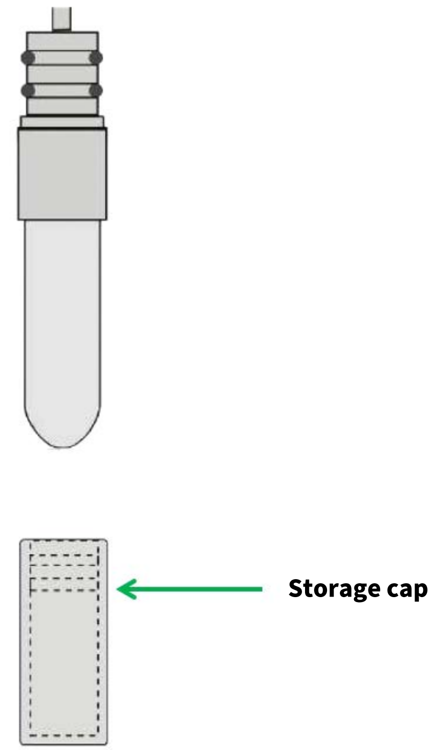
Storage caps are provided with the instrument. Contact RBR if a replacement is needed.

> ⚠ The reference sensor and the glass membrane of the Idronaut pH sensor must always be hydrated. Any period of dry storage longer than 24 hours will affect performance.

Check the sensor performance after any extended period of storage.

Remove the storage cap before using the sensors.

> ❗ Exercise care when removing the storage cap to avoid damaging the sensor or its connector.



Cleaning

Over long term deployments, a buildup of deposits can block the ion-sensitive glass membrane. This would prevent the electrode from detecting any hydrogen ions and the readings would stay at ~pH 7. If this happens, contact RBR for support.

Calibration

Calibrate the Idronaut pH sensor before each deployment, using three buffer fluids. Repeat every day that the electrode is used, for optimum accuracy. See Ruskin User Guide: Standard Instruments[3] for details.

6.8 OxyGuard DO sensor care and maintenance

Storage

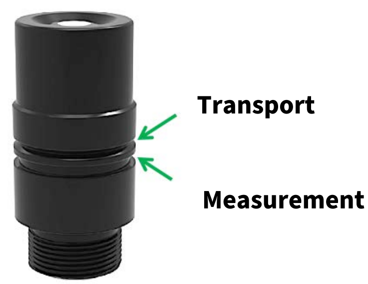
Store the OxyGuard dissolved oxygen sensor in the dedicated storage cap to minimise fluid loss. Storage caps are provided with the instrument. Contact RBR if a replacement is needed.

O-ring

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

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

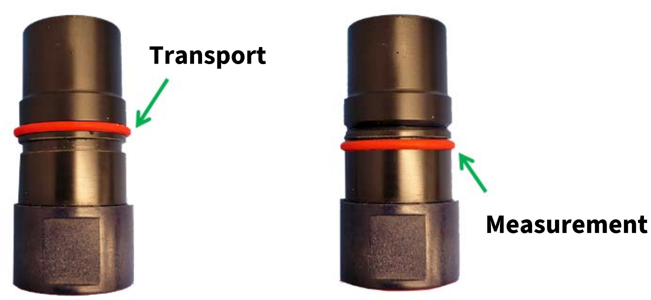
There are two positions for O-ring on the OxyGuard sensor, "Transport" and "Measurement".



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 recalibrate 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: Standard Instruments[3] for instructions on calibration.

6.9 RBR ODO sensor care and maintenance

The RBR optical dissolved oxygen sensors have an oxygen-sensitive substrate that requires special care. Any damage will permanently affect performance.

> Avoid direct sunlight.
> Never touch the sensitive element while cleaning or handling.
> Use the storage cap when the sensor is not in use.

Storage

Store the RBR optical dissolved oxygen sensor in the dedicated storage cap to protect it from damage.

Storage caps are provided with the instrument. Contact RBR if a replacement is needed.

- ***Short-term storage (three weeks or less)***

1. Fill the storage cap with clean water until about 50% full.
2. Place the cap on the sensor and gently push it past the locking pin.
3. Refill the water periodically during storage. The cap is semi-watertight and will leak overtime.

Push the storage cap past the locking pin

- ***Long-term storage (more than three weeks)***

> For longer storage periods, store your sensor dry. Rehydrate for **five** days before deployment.

1. Place an empty cap on the sensor and gently push it past the locking pin.
2. Before deployment, fill the storage cap with clean water like for short-term storage, place it on the sensor, and rehydrate for **five** days.

> It takes up to five days for a dry ODO sensor to equilibrate after being placed in water. Insufficient hydrating time before deployment may lead to unreliable data.

RBR*coda*³ T.ODO ready for storage

First deployment

RBR ships the RBR*coda*³ T.ODO instruments with a hydrated storage cap on, so that the instrument is ready for its first deployment.

However, long transportation times and low cabin pressure may cause the water to evaporate. Verify that the storage cap is still wet. If not, rehydrate the sensor for **five days** before deployment.

Calibration

Check your sensor calibration before each deployment in saturated fresh water. If the readings are not within 1% of 100% saturation, recalibrate the instrument using a one-point calibration. Typically, | fast instruments may need recalibration more often than standard or | slow. See Ruskin User Guide: Standard Instruments³ for user calibration instructions.

6.10 Fluorescence sensors safety precautions

RBR standard instruments support a variety of fluorescence sensors, including the RBR*tridente* and third-party sensors from Seapoint, Sea-Bird, and Turner.

For fDOM measurements, fluorometers use 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

When the fluorometer does not need to be active, disable sampling on Ruskin by selecting "Stop". See Ruskin User Guide: Standard Instruments[3].

6.11 Cables and connectors

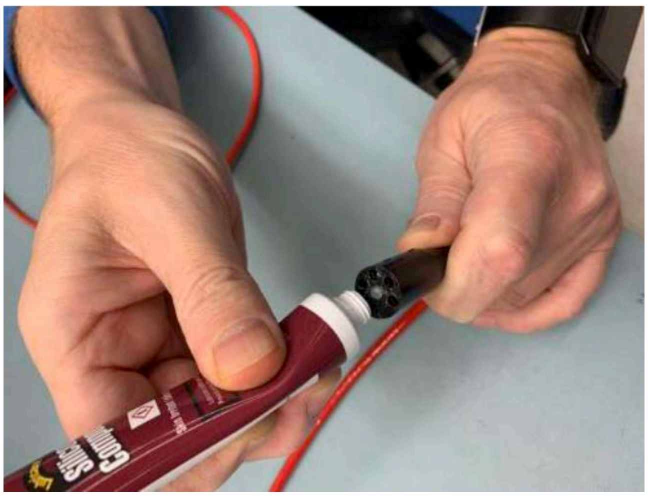
Cable bend radius

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

6.12 Cleaning the instrument

Clean the instrument after each extended deployment to remove deposits that may have accumulated.

Type	Procedure	Notes
General/biofouling	To clean the exterior, soak in a mild detergent, then scrub the instrument with a soft brush.	Avoid scratching the plastic (scratches make future cleaning more difficult).
Calcification	Soak in vinegar for six hours, then scrub the surface using a soft brush.	Soaking in vinegar for more than 24 hours may damage the O-ring and increase the chances of a leak.
Encrustation	Ultrasound bath	Do not use ultrasound on pressure transducers <50dbar.

Cleaning the pressure sensor

Avoid touching the diaphragm when cleaning the sensor! Any deformation will permanently affect performance.

1. Unscrew the sensor guard using a coin or a large flat head screwdriver. Do not apply excessive force, especially when using the screwdriver.
2. Rinse the area under running water. If this fails to remove the deposits, try soaking in vinegar or immersing in an ultrasound bath. Do not use ultrasound on pressure transducers <50dbar.
3. If unsuccessful, contact RBR.

Cleaning PAR, rad, ODO, turbidity, and third-party fluorescence sensors

When dirty, carefully wipe the sensors with a soft cloth. To remove encrustation, soak in water until soft. It may take hours or days, depending on the severity.

Do not use abrasive cloths as scratched faces can affect calibration.
Do not use solvents or cleaners as these could affect optical properties of the window.

Cleaning RBR*tridente*

RBR*tridente* design makes it resilient to corrosion and thus allows for more rigorous handling than other fluorometers.

See the table above for cleaning procedures.

Cleaning pH sensors

Over long term deployments, a buildup of deposits can block the ion-sensitive glass membrane. If this happens, contact RBR for support.

6.13 Calibrating the instrument

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 recalibrated.

Please contact RBR for our current calibration fees.

6.14 Repair

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	31-August-2022	Original
B	31-October-2022	Added depth rating and sampling rate to Physical specifications. Enhanced description of the conductivity cell in Sensor specifications. Added RBR*tridente* and RBR*quadrante* to sensor lists and Sensor specifications. Updated instructions for refreshing the desiccant. Added Fluorescence sensors safety precautions to Maintenance.
C	30-April-2023	Added a note on battery chemistries and the MCBH-6-FS pinout to Physical specifications. Updated the Conductivity, ODO, Radiometers, and RBR*tridente* sections in Sensor specifications. Added instructions on using a coupler for bulkhead-mounted sensors and RBR ODO sensor storage instructions to Maintenance. Updated cleaning instructions for optical sensors and added RBR*tridente* to Cleaning. Updated images for RBR*concerto*^{3}, RBR*coda*^{3} T.ODO, RBR*tridente,* and RBR*quadrante* pages.
D	31-July-2023	Updated the specifications for RBR radiometers. Added a warning to the Replacing the batteries section.