RBR*legato*[4]
INSTRUMENT GUIDE

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1 RBRlegato^4

The RBR*legato*^{4} is a small CTD instrument optimised for gliders and autonomous underwater vehicles, as shown in Fig. 1. Designed to determine salinity by measuring the conductivity, temperature, and pressure, it can also incorporate a variety of sensors, such as optical dissolved oxygen, photosynthetically active radiation, turbidity, backscatter, and more. Its rugged inductive cell is not affected by surface contaminants or freezing conditions. The co-located thermistor reduces salinity spiking, thus increasing data accuracy. Equipped with a piezoresistive pressure channel, the RBR*legato*^{4} provides more accurate salinity data when the instrument is sampling at varying depths. The instrument ensures totally silent operation for passive acoustic listening and turbulence measurements, and is rated to the depth of 1250m.

Fig. 1 . An RBRlegato^4 installed in a glider.

The RBR*legato*^{4} comes in two variants:

- RBR*legato*^{4} C.T.D - 2Hz, standard thermistor response, realtime data output
- RBR*legato*^{4} C.T.D | fast16 - 16Hz, fast thermistor response, realtime data output

Key features of the RBR*legato*^{4} C.T.D:

- High accuracy
  - Unaffected by surface contaminants
  - Pre-calibrated to account for static elements
  - Sampling rate up to 16Hz
- Low power
  - 90% less power than pumped CTD
  - Longer mission and more samples
  - Multi-rate sampling support
- Silent operation
  - No pump or moving parts
  - Reduced noise for acoustic measurements
  - Reduced vibration for turbulence studies

2 Physical specifications

Instrument

Parameter	Value
Maximum number of readings*	240 million
External power	4.5V to 30V
Communications	RS-232
Clock drift**	±60 seconds per year
Depth rating	1250m
Housing material	Plastic
Dimensions	195.8mm x 63.8mm x 78.6mm
Top curvature, selectable	Ø220mm or Ø124mm
Weight (in air)	0.8kg
Weight (in water)	0.17kg
Displacement	$600 cm^3$

*Each sample can include multiple readings.

**The realtime clock is not maintained when there is no power.

Power consumption

Parameter	Value
≤1Hz sampling	22.8mJ per sample
≥2Hz sampling	46mW
Sleep power	180µW
Typical peak inrush current	6.6A (15µs duration)

Startup time

Generally, there is no need to power off RBR instruments. The RBR*legato*[4] will go to sleep after inactivity, consume virtually no power while on standby, and then wake up instantly when required.

If you turn off the instrument, there will be a delay starting up. Furthermore, you will have to wait for at least two minutes before turning it back on.

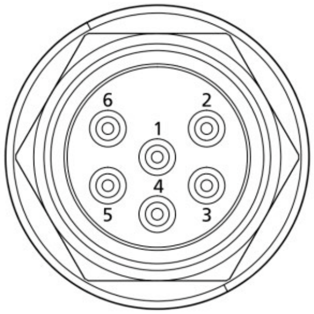
- Elapsed startup time from fully discharged state to functional command interpreter: 4s maximum
- Elapsed power downtime to complete discharge: 120s minimum

> ⚠ Ensure that the instrument is fully discharged before resuming the measurements. Power-cycling the unit for less than 120s may leave the board in an unknown state. In addition, the realtime clock may not be maintained over a power cycle.

External port

The RBR*legato*[4] uses an external MCBH-6-MP connector. It can be used for connecting to an RS-232 underwater extension cable.

External MCBH-6-MP connector pinout



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

3 Sensor specifications

The RBR*legato*[4] C.T.D is a multi-channel instrument with conductivity, temperature, and pressure sensors installed by default. Additionally, it supports several optional sensors:

- Optical dissolved oxygen (ODO): RBR*coda* T.ODO
- Turbidity (Tu): RBRcoda Tu
- Photosynthetically active radiation (PAR), narrow-band radiometers (rad): RBR*quadrante*
- Backscatter (bb), chlorophyll *a*, fluorescence (Fl): RBR*tridente*

3.1 Conductivity, temperature, and pressure

The RBR*legato*[4] C.T.D integrates conductivity, temperature, and pressure sensors, as shown in Fig. 2. Its unique body design is optimised for flow dynamics.

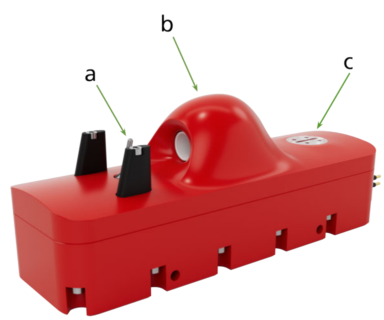


Fig. 2 . Side view of the an RBRlegato[4] C.T.D. (a) Temperature sensor. (b) Conductivity sensor. (c) Pressure sensor.

⚠ Accuracy of conductivity measurements is affected by objects within 15cm of the sensor, especially if they are conductive. Metal deployment frames are a good example. This proximity effect decreases with distance. Calibration procedure uses the predetermined k-factor to take into account static elements, such as other sensors or glider body.

Conductivity sensor

Parameter	Value
Range	0 to 85mS/cm
Initial accuracy	±0.003mS/cm
Resolution	<0.0001 mS/cm
Typical stability	±0.010mS/cm per year

Temperature sensor

Parameter	Value
Range	-5°C to 42°C
Initial accuracy	±0.002°C (-5 to +35°C) ±0.004 °C (+35 to +42 °C)
Resolution	0.00005°C
Typical stability	±0.002°C/year
Time constant	<1s (standard) <0.1s (| fast16)

Pressure sensor

Parameter	Value
Range	1250dbar
Initial accuracy	±0.01% full scale
Resolution	<0.001% full scale
Typical stability	±0.01% full scale
Time constant	<0.01s

3.2 RBRcoda T.ODO

The RBR*legato*^{4} can integrate the RBR*coda* T.ODO sensors, shown in Fig. 3. The measurement principle of optical dissolved oxygen sensors is based on the luminescence quenching by oxygen.

Fig. 3 . Side view of the RBRcoda T.ODO.

Parameter	**Value**
Measurement range	0-1000µmol/L
Calibrated range Concentration Saturation Temperature	 0-500µmol/L 0-120% 1.5°C to 30°C
Initial accuracy For | fast For standard, | slow	 Maximum of ±8µmol/L or ±5% Maximum of ±2µmol/L or ±1.5%
Resolution For | fast For standard For | slow	 <1µmol/L (saturation 0.4%) <0.5µmol/L (saturation 0.2%) <0.1µmol/L (saturation 0.04%)
Time constant	<1s | fast, <8s standard, or <30s | slow

> ⚠ Optical dissolved oxygen measurements require pressure correction for highest accuracy. When installed on an instrument with a pressure sensor, this correction is done automatically.

Store the sensor in the dedicated storage cap, included with the instrument. Rehydrate for five days before deployment. See RBRcoda T.ODO care and maintenance for more information.

3.3 RBRcoda Tu

The RBR*legato*[4] can integrate the RBR*coda* Tu sensors (Fig. 4). This realtime turbidity sensor has two independent optical channels for optimising linearity and sensitivity.

Fig. 4 . Side view of an RBRcoda Tu.

Turbidity

Parameter	Value
Channel wavelength	880nm
Centroid angle	90°
Linearity, R^2	0.99
Initial accuracy	5%
Calibrated range	0 - 1000FTU
Measurement range*	0 - 1500FTU
Detection limit	0.005FTU

* Response becomes non-linear above 1000FTU.

Turbidity (optical backscatter)

Parameter	Value
Channel wavelength	880nm
Centroid angle	135°
Linearity, R^2	0.99
Initial accuracy	5%
Calibrated range	1000 - 4000FTU
Measurement range*	0 - 20000FTU
Detection limit	2.0FTU

* Response becomes non-linear below 500FTU and above 15000FTU.

3.4 RBRtridente

The RBR*legato*[4] can integrate the RBR*tridente* sensors.

The RBR*tridente* is an optical sensor with three channels, capable of making multiple fluorescence and backscatter or turbidity measurements simultaneously. A dry-bay variant (Fig. 5), designed specifically for OEM users, is compatible with existing vehicle payload bays and offers the same channel options as the standard, wet-bay version (Fig. 6). Integrate the dry-bay RBR*tridente* on AUVs, gliders, floats, or any other underwater vehicle, and stream your RS-232 data via a Micro-Fit connector.

Fig. 5 . RBRtridente (dry-bay variant, OEM).

Fig. 6 . RBRtridente (standard wet-bay variant).

The RBR*tridente* uses multiple gains, allowing exposure to full sunlight. However, when exposed to high background ambient light, the resolution of some channels may decrease. For this reason, during deployments, orient the RBR*tridente* facing downwards. If you have to deploy it horizontally (e.g., on a glider), ensure that the machined mark is on top, so that the detectors are facing down into the water column. Fig. 7 shows an RBR*tridente* installed horizontally in a glider hull.

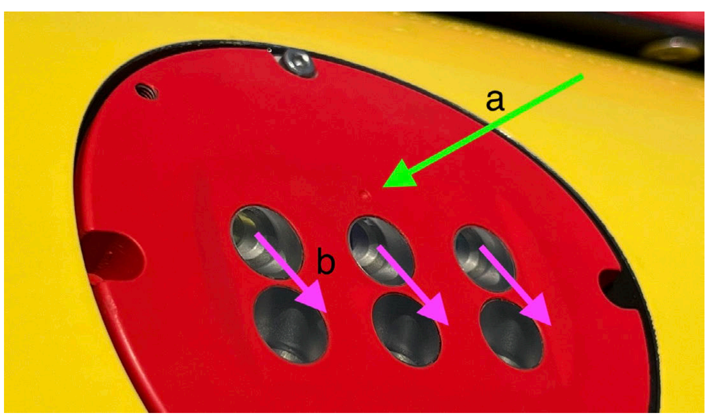


Fig. 7 . An RBRtridente mounted horizontally. (a) Machined mark. (b) The downward direction of the detectors.

Optical

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

Chlorophyll *a*

Parameter	Value
Channel wavelength (excitation/emission)	470nm/695nm or 435nm/695nm
Calibrated range*	0-50µg/L
Measurement range	0-500µg/L
Detection limit*	0.010µg/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
Measurement range	0-1500ppb
Detection limit	0.030ppb

* fDOM can be used as a proxy for cDOM.

Phycocyanin

Parameter	Value
Channel wavelength (excitation/emission)	590nm/654nm
Calibrated range	0-500µg/L
Measurement range	0-10000µg/L
Detection limit	0.200µg/L

Phycoerythrin

Parameter	Value
Channel wavelength (excitation/emission)	525nm/600nm
Calibrated range	0-6000µg/L
Measurement range	0-10000µg/L
Detection limit	2.0µg/L

Rhodamine

Parameter	Value
Channel wavelength (excitation/emission)	550nm/600nm
Calibrated range	0-1000µg/L
Measurement range	0-1000µg/L
Detection limit	0.015µg/L

Fluorescein

Parameter	Value
Channel wavelength (excitation/emission)	470nm/550nm
Calibrated range	0-500µg/L
Measurement range	0-1500µg/L
Detection limit	0.010µg/L

Backscatter

Parameter	Value
Channel wavelength	470nm, 525nm, 650nm, or 700nm
Calibrated range*	0-0.05$m^{-1}sr^{-1}$
Measurement range	0-1.5$m^{-1}sr^{-1}$
Detection limit	1x$10^{-6}m^{-1}sr^{-1}$

* Response becomes non-linear above 0.05$m^{-1}sr^{-1}$.

Turbidity

Parameter	Value
Channel wavelength	650nm or 700nm
Calibrated range*	0-500FTU
Measurement range	0-1500FTU
Detection limit	0.001FTU

* Response becomes non-linear above 500FTU.

3.5 RBRquadrante

The RBR*legato*[4] can integrate the RBR*quadrante* sensors (Fig. 8). This four-channel radiometer supports multiple radiation measurements (combinations of PAR and rad sensors) within the same sensor package.

Fig. 8 . An RBRquadrante.

Optical radiometry

Parameter	Value
Dynamic range	>5.5 decades (nominal)
Initial accuracy*	±2%
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/m²/s (minimum)
Resolution	±0.010µ mol/m²/s

Narrow-band channels

Parameter	Value
Centre wavelengths (CWL)*	380 / 413 / 445 / 475 / 488 / 508 / 532 / 560nm
Full width at half-maximum (FWHM)	10nm (25nm for CWL 475nm)
Full scale range	0 to ≥200µW/cm²/nm (full sun)
Resolution**	±0.001µW/cm²/nm

* Other CWL options within the 300-1100nm range are available upon request. Contact RBR for more information.

** Resolution is wavelength-dependent for narrow-band radiometers.

Dark offset is internally temperature-compensated.

4 Derived parameters

All derived parameters will be calculated on the instrument. 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*legato*^{4} 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.

> ⚠ If the PSS78 calculation generates an error, the instrument will report a salinity of 0. This might occur when, in air, the conductivity sensor reports 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.

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

where conductivity in mS/cm and temperature in °C are values measured by your RBR*legato*^{4}, 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. 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*legato*^{4}.

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 Sea pressure

Sea pressure is the difference between the pressure measured underwater by your RBR*legato*[4] and atmospheric pressure. The units of measurement are dbar (decibars).

$$\text{Sea pressure} = \text{absolute pressure - atmospheric pressure}$$

where absolute pressure (in dbar) is the value measured directly by your RBR*legato*[4], and $\text{atmospheric pressure}$ is a default value of 10.1325dbar.

4.5 Depth

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

$$\text{Depth} = \frac{\text{absolute pressure - atmospheric pressure}}{\text{density} \cdot \text{g}}$$

where absolute pressure (in dbar) is the value measured directly by your RBR*legato*[4], $\text{atmospheric pressure}$ is a default value of 10.1325dbar, seawater density is a default value of 1.0281g/cm^3, and g is the acceleration of gravity and equals 9.8m/s^2.

4.6 Oxygen saturation

The RBR*legato*[4] supports the option of integrating the RBR*coda* T.ODO sensor, which measures oxygen concentration. From this measured value, 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.

5 Maintenance

5.1 RBRtridente 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 to the eyes.

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

Storage cap

Whenever possible, keep the storage cap on your fluorometers.

Fig. 9 . RBRtridente with a 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.

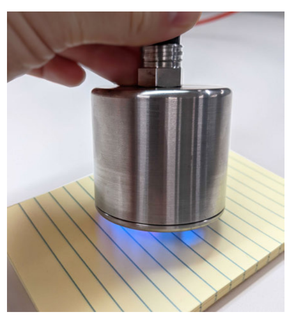


Fig. 10 . RBRtridente facing down.

When the fluorometer does not need to be active, disable sampling.

5.2 RBRcoda T.ODO 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 cap

Your RBR*coda* T.ODO instrument comes with a specialised storage cap (see Fig. 11), designed for a sensor mounted inside the glider. This storage cap has an opening for refilling the water with a syringe.

Fig. 11 . An RBRcoda T.ODO with storage cap.

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.

<u>Short-term storage (three weeks or less)</u>

1. Place the storage cap on the sensor, aligning its slanted shape with the angled optode, and gently push down until it stops. See Fig. 12.

> There is a ridge inside the storage cap which prevents it from going too far and ensures there is space left for water.

2. Unscrew the luer lock cap and put it aside.
3. Fill the syringe with distilled water.
4. Insert the syringe tip in the orifice.
5. Gently push down the piston to inject until full. See Fig. 13.
6. Remove the syringe.
7. Replace the luer lock cap.
8. Refill the water once a week during storage.

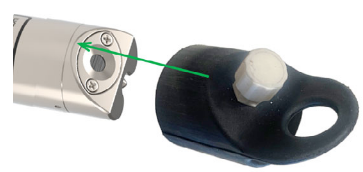


Fig. 12 . Push the storage cap until it stops.

Fig. 13 . Gently push down the piston to inject until full.

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 down until it stops.
2. Before deployment, refill the cap with distilled water following the same steps as for short-term storage (above) 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.

First deployment

RBR ships the RBR*coda* 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.

Do not exceed the maximum depth rating (6000m).
Do not apply physical stress to the housing.
Do not attempt to open the sensor.

For mooring or mounting applications, contact RBR for proper clamps and brackets. Improper mounting may damage the sensor.

Before any subsequent deployment, rehydrate the optode for at least **five** days.

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 Instruments[3] for user calibration instructions.

5.3 Cleaning

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

Do not use an ultrasonic bath to clean your instruments! Ultrasonic vibrations can break the wire bonding inside the transducers.

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, encrustation	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.

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 flathead 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.
3. If unsuccessful, contact RBR.

Fig. 14 . Pressure sensor of the RBRlegato[4], with the guard removed

Cleaning ODO and RBR*quadrante* 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.

5.4 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.

Calibration certificates are available for download:

- If using Ruskin, connect your instrument and go to **Information**, then click the **Download** button at the bottom
- For OEM instruments, go to https://oem-lookup.RBR-global.com, select **OEM lookup by serial number**, and search by the serial number and authorisation key

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.

5.5 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

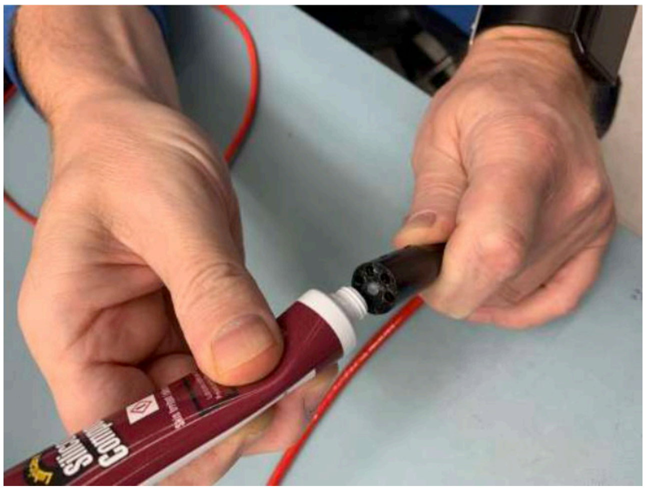


Fig. 15 . Applying silicone compound to the female connectors.

Fig. 16 . Cross section of a connector with 30% lubricant fill.

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

5.6 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.

6 Revision history

Revision No.	Release date	Notes
A	18-September-2025	Original