

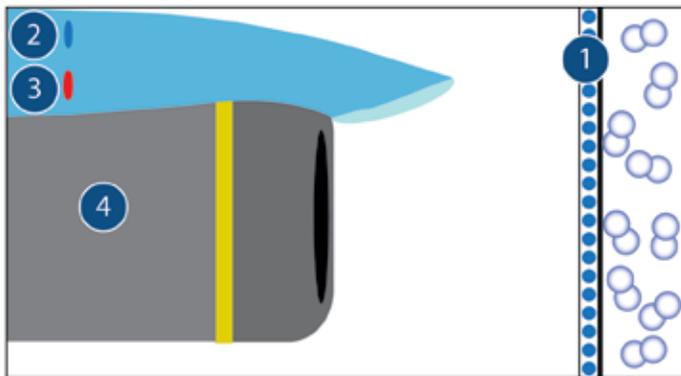
Frequently Asked Questions: EPA-Approved In-Situ® Inc. Optical Rugged Dissolved Oxygen (RDO®) Sensor

Answers to common questions about the RDO Sensor

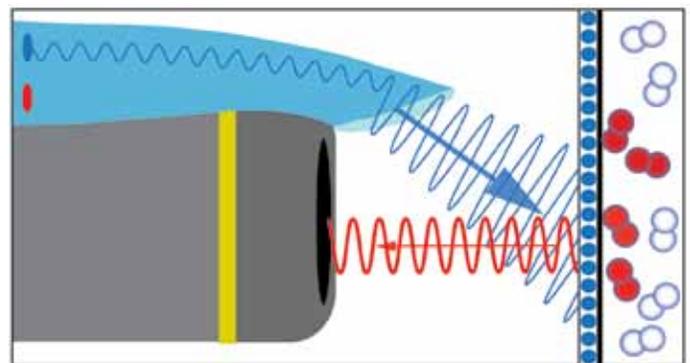
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Sensor Design



1. Oxygen-permeable sensing element contains lumiphore molecules
2. Blue LED
3. Red LED
4. Photodiode



The optical RDO Sensor initiates a reading by sequentially turning on the blue and red LEDs. The blue light excites lumiphore molecules in the sensing element. The red light provides a zero phase reference. Excited lumiphore molecules emit red light. The photodiode detects both red returned light from excited lumiphore molecules and red reference light from the red LED. Optical electronics report dissolved oxygen (DO) concentration in mg/L.

Q. How does the optical RDO Sensor work?

A. The low-maintenance RDO Sensor measures DO and provides extremely stable, accurate results.

1. The optical RDO Sensor initiates a reading by sequentially turning on the blue and red LEDs.
2. The blue light excites lumiphore molecules in the sensing element.
3. The red light provides a zero phase reference; it does not excite lumiphore molecules.
4. Excited lumiphore molecules emit red light.
5. The photodiode detects both red returned light from excited lumiphore molecules and red reference light from the red LED.
6. Optical electronics compute the luminescence lifetime value of the lumiphore molecules.

- The luminescence lifetime is based on the phase shift between red returned light from the excited lumiphore molecules and the red reference light from the red LED.
7. When DO is present, oxygen molecules quench the excited lumiphore molecules from returning red light to the photodiode. This “dynamic luminescence quenching” process prevents lumiphore molecules from returning red light to the photodiode.
 - DO concentration and red returned light are inversely proportional. For example, high DO concentration reduces red returned light. Determination of DO concentration by luminescence quenching has a linear response over a range of concentrations.
 8. Sensor electronics compute DO concentration as a function of phase and temperature.
 - Sensor electronics automatically compensate DO values for temperature. DO values can be compensated for salinity and barometric pressure.

Q. What is the purpose of the red LED?

A. The red LED provides a zero phase reference. The luminescence lifetime is based on the phase shift between red returned light from the excited lumiphore molecules and the red reference light from the red LED.

Q. How do optical technologies differ?

A. Typically, optical sensors use either a time domain method or a frequency domain method.

- **Time domain method**—Uses a pulsed measurement method to measure a series of exponential decay events. This method is susceptible to drift and interference from stray light.
- **Frequency domain method**—Measures the phase shift between the entire signal and references wave forms across a number of cycles. This method delivers the highest accuracy across the widest operating range. The RDO Sensor uses this method, which delivers accurate, stable results.

Q. What are the key advantages of the optical RDO method versus electrochemical (polarographic, galvanic) methods?

A. The RDO method offers the following advantages:

- **Accurate results**—Sensor operates with no drift over long-term deployments. Unlike membrane-based sensors, the RDO Sensor excels in hypoxic conditions. No sample flow or stirring is required.
- **Minimal maintenance**—No hydration, conditioning, or special storage is required. No membranes or electrolyte/filling solution need to be replaced. The RDO Cap requires annual replacement—simply pull off the cap and snap on a new one.
- **Long-lasting calibration**—The RDO Sensor can be deployed for several months if sample fouling is minimal and if the sensing element is not damaged. Membrane-based sensors typically require calibration every 2 weeks, depending on sample conditions.
- **Rugged performance**—Wiper-free design excels in demanding environments. Abrasion-resistant lumiphore withstands fouling, high sediment loads, and rapid flow rates. The sensing element is not affected by photobleaching or stray light.
- **Automatic setup**—The RDO Cap is pre-loaded with factory calibration coefficients, serial number, expiration clock, and manufacture date for traceability. Programming errors are eliminated.
- **Fast response**—The RDO Sensor responds quickly and maintains a stable response, which makes it ideal for dynamically changing conditions and vertical profiling.

Q. Does the RDO Sensor offer other advantages?



- **EPA approved**—The U.S. Environmental Protection Agency has granted nationwide approval to three RDO methods. These methods can be used to determine Biochemical Oxygen Demand (BOD), Carbonaceous

Biochemical Oxygen Demand (CBOD), and Dissolved Oxygen (DO) under the Clean Water Act.

- **Patented signal processing**—Proprietary design allows for stable, fast response and has low power requirements.
- **Minimal interferences**—Unlike membrane-based sensors, the RDO Sensor is unaffected by sulfides, sulfates, carbon dioxide, ammonia, pH, or chloride.

Q. Do I need to enter a long string of coefficients when I install a new cap?

A. No. Each RDO Cap comes pre-loaded with its specific calibration coefficients. These calibration coefficients are determined at the time of manufacturing and are lot-specific. Simply install a new cap on the sensor and all the calibration coefficients unique to that sensing element will be automatically uploaded into the sensor. This eliminates errors and allows caps to be switched from instrument to instrument without having to track coefficients or enter unwieldy coefficient strings.

Q. How does the RDO Sensor use salinity and barometric pressure readings?

A. The RDO Sensor has a salinity range of 0 to 42 PSU (fixed or real-time capable), a range of 2 to 10 pH, and barometric range of 507 to 1115 mbar (fixed or real-time capable). Smart sensor technology allows the sensor to incorporate values and compensate DO measurements for salinity and barometric pressure.

Q. Can the RDO Sensor be serviced?

A. The RDO Sensor does not contain user-serviceable parts, other than general cleaning of the body and yearly sensor cap replacement. The RDO Sensor has a 3-year warranty against defects. In-Situ Inc. will replace or repair any sensor that fails due to poor workmanship during its warranty period. The cable on the sensor can be repaired if it is damaged.

Q. What does a reading of -2.5 mg/L mean?

A. This is the default sentinel value and indicates that the sensor is not reading correctly. Check to make sure that the RDO Cap is installed correctly. If the problem persists, please contact In-Situ Technical Support.

Calibration

Q. Is an initial user calibration necessary?

A. No. The RDO Sensor is factory calibrated with an approximate “out-of-box” accuracy of $\pm 3\%$ at 100% saturation and $\pm 5\%$ at 200% saturation. In order to meet the stated accuracy specifications of the RDO Sensor, perform a user calibration near the measurement range.

Q. How often should I calibrate the RDO Sensor?

A. If you choose to calibrate the sensor, In-Situ Inc. recommends that you check the RDO Sensor calibration when a new cap is installed; when the sensor or cap have been cleaned; or when the sensor has been used in harsh environments. Follow your standard operating procedures for information on routine calibration.

Q. How do I calibrate the RDO Sensor, if desired?

A. The RDO Sensor can be calibrated at 100% saturation in water-saturated air using the cal cup provided with the sensor or in air-saturated water in a calibration bubbler. Use either sodium sulfite or bubbled nitrogen to determine the 0% saturation point.

Q. Can I perform a 2-point calibration?

A. Yes, a 2-point calibration is recommended if you are measuring throughout the entire range or at the low end of the range (anoxic conditions).

Q. What are the criteria for a good calibration?

A. A calibration slope between 0.9 and 1.1 is ideal. A calibration slope between 0.8 and 1.2 is acceptable. (For example, 100% saturation should read between 80% and 120%. A 0% saturation point should read between -0.2 and 0.2 mg/L.) Values outside these ranges can indicate problems with a sensor or sensing element and will cause a calibration error warning.

Q. Why am I getting negative mg/L readings?

A. The sodium sulfite solution used for the zero calibration could be old/bad or nitrogen bubbling was not completely saturated prior to calibration, which can cause a false-negative offset in the sample. When reading close to zero, slightly negative values should be interpreted as zero and may indicate that recalibration or cap replacement is necessary.

Hydration Effects

Q. Does the sensor show any hydration effects when used after dry storage?

A. All optical DO sensing elements show some hydration effects after dry storage—some to a much larger degree than others. The RDO Sensor shows negligible hydration effects across the majority of the testing range and will perform to its stated accuracy specification without recalibration.

Sensor Storage

Q. How should I store the sensor and cap when I am not using them?

A. Prior to installation, store the RDO Cap in its factory package until you are ready to install it. Sensor conditioning is not required prior to use. After installation, store the cap and other sensors (e.g., pH or pH/ORP) as required. A rehydration process is not required if the sensor dries out during deployment. Storage options are available, as required:

- Disposable/recyclable calibration and storage bags
- Sensor storage and calibration chamber for instruments with turbidity sensors
- Sensor storage and calibration chamber for instruments without turbidity sensors

Response Time

Q. What do the T90 and T95 times represent?

A. These represent the time that the sensor will take to span 90% or 95% of the change in reading. For example, moving a sensor from 0% saturation to 100% saturation, T90 is the time to get to 90% saturation.

Q. How does the system (instrument) response time differ from the T90 or T95 time?

A. The response time specification is based on what customers will experience in the field. It takes into account the time for the entire system to attain equilibrium when temperature and DO concentrations are changing. This is a more accurate estimation of a “wait time” in the field and is highly dependent on the design of the sonde. Compared to other DO sensors, the In-Situ RDO Sensor responds quickly to changing field conditions.

Fouling and Cleaning

Q. How quickly will my sensor foul?

A. Fouling is extremely site dependant. Some sites will show significant fouling within a week; other sites contribute minimal fouling with little to no impact on measurements. You may need to evaluate each site to determine how long it takes the sensor to foul. Then you can determine a site-specific maintenance schedule.

Q. How do I clean the RDO Cap?

1. Leave the cap on the sensor! If you must remove the cap from the sensor, plug the back end of the sensor cap with a rubber stopper so that no moisture enters the inside of the cap. Promptly install another cap on the sensor or replace the red rubber dust cap to protect the lens.
2. Rinse the sensor with clean water from a squirt bottle or spray bottle.
3. Gently wipe with a soft cloth or brush if biofouling is present.
4. If extensive fouling or mineral build-up is present, soak the cap end in vinegar for 15 minutes, then soak in deionized water for 15 minutes.
 - Do not use organic solvents; they will damage the sensing element. Do not remove the cap from the sensor prior to brushing.
 - After cleaning, perform a 2-point user calibration.

Q. How do I clean the RDO Sensor Body?

1. With the sensor cap installed on the sensor, gently scrub the sensor body with a soft brush.
2. Soak in vinegar and deionized water to remove mineral deposits or extensive fouling as in Step 4, above.

Q. How do I clean the optical lens?

A. In most cases, the RDO Cap should remain on the sensor, and therefore lens cleaning is not necessary. If the sensor cap is being replaced, gently wipe the lens with the lens wipe supplied in the RDO Sensor Cap Replacement Kit. Additional lens cloths are available from In-Situ Inc. See the RDO Sensor Cap Replacement Kit Instruction Sheet for details.



To start monitoring, simply snap on the RDO Cap.

Q. Are antifouling accessories available to extend deployment?

A. Yes, the following antifouling systems are available (call your In-Situ Sales Representative for more information):

- TROLL® Shield Antifouling Guard for the sub-4" TROLL 9500 Water Quality Instrument
- Antifouling Guard for the RDO PRO Probe and the RDO Titan Probe
- Airblast system for the RDO PRO Probe and the RDO Titan Probe

Chemical Compatibility and Interferences

Q. Are chemical compatibility recommendations available?

A. In-Situ has completed extensive chemical testing on the RDO Sensor and sensing element. Please contact In-Situ Technical Support for information on specific chemicals not addressed below.

Q. What are the known interferences?

A. Known interferences include: alcohols >5%; hydrogen peroxide >3%; sodium hypochlorite (commercial bleach) >3%; gaseous sulfur dioxide; gaseous chlorine; organic solvents (e.g., acetone, chloroform, methylene chloride, etc.), which may swell the sensing element and destroy it.

Q. Will strong oxidizers (e.g., sodium permanganate or potassium permanganate) that are used in remediation applications damage the sensing element?

A. All oxidizers will give false high readings; however, based on laboratory testing, they do not appear to damage the sensing element.

Q. Will bleach damage the sensor or the sensing element?

A. A > 6% bleach solution will severely damage the sensing element. More dilute concentrations (3 to 6%) will cause interference, however, readings appear to return to within 2% of initial readings after a 100-hour soak in deionized water. Commercial bleach solution diluted 10:1 with tap water for disinfecting purposes does not damage the sensor or sensing element.

Q. Will hydrogen peroxide damage the sensing element?

A. Following 100+ hours of exposure to a commercial 3% hydrogen peroxide solution, the sensing element continued to read within stated accuracy specifications and had no visible signs damage. A 6% hydrogen peroxide concentration caused slight interference to the readings following 24+ hours of exposure, but that damage was reversed following a recovery soak in deionized water.

Q. Is there any photobleaching effect from long-term exposure to ambient light?

A. No. In-Situ has performed extensive testing and the exclusive RDO Sensor is not affected by long-term exposure to light.

Cap Usage Life

Q. How long does the RDO Cap last?

A. The RDO Cap operates for 365 days or 12 months from its initial reading. After 12 months, you will need to replace the old cap with a new one. A 12-month working life ensures that results are within the specified accuracy range for the usable life of the cap.

Q. Why does the RDO Cap have a time-out feature?

A. The time-out feature ensures that with proper care and calibration, the cap will deliver accurate results for the duration of its usable life. To guarantee accuracy and a full 12-month working life, store the cap in its factory packaging prior to use and install by the date printed on the label.

The cap includes an expiration clock and software will notify you when it's time to replace the cap. In-Situ Software will begin warning you when 90 days of sensor cap life remain. You can then choose to be reminded again in a certain number of days (e.g., 30 days, 5 days, etc.).

Q. When does the 12-month clock start ticking?

A. As soon as the RDO Cap is installed and the water quality instrument or probe is powered up.

Q. How can the cap have a 24-month storage life, but only a 12-month working life?

A. The RDO Cap has a 24-month life from date of manufacture, or 12 months from the first reading, whichever comes first. After this point, the cap will not continue to take measurements. This ensures that with proper care and calibration, the cap will deliver accurate results for the duration of its usable life. To guarantee accuracy and a full 12-month working life, store the cap in its factory packaging prior to use and install by the date printed on the label.

Q. Should I stock some replacement caps and keep them with my instrument?

A. The RDO Cap is very robust and resistant to damage. A maximum storage time of 12 months prior to installation is recommended so that a full 12 months of cap usage is achieved. Under typical circumstances, we do not recommend stocking a large quantity of replacement caps.

Q. How long will it take to receive a new cap?

A. Caps are made-to-order. Typically, the cap will be delivered within 5 to 7 days from its manufacture date.

Additional References

For additional information about EPA-approved RDO methods and the RDO Sensor, visit www.in-situ.com/RDO_EPA_Approval.



For more information, contact In-Situ Inc.

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Rev 1.0, Jan. 2013

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