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Water Quality Sensors:

Recommendations for Calibration, Maintenance & Storage

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Introduction

In-Situ's water quality monitoring instruments, the TROLL® 9000 and TROLL® 9500, may be configured with a custom suite of water quality sensors. Each individual sensor type has different capabilities and limitations that must be considered in order to achieve optimal performance.

Calibration and routine maintenance are required to maintain accuracy. To maximize the life of a sensor, it must be stored properly when not in use. The proper storage technique will vary depending upon the sensor and the amount of time which it will be stored.

For additional sensor information, in the form of Operator's Manuals, Quick-Start Guides, Information Sheets, Technical Notes, and Application Notes, please visit In-Situ's website: http://www.in-situ.com/In-Situ/Downloads/Downloads.html

This guide addresses each sensor type individually and provides recommendations for calibration, routine maintenance, storage, and suggestions for further reading.

Conductivity

Keys to Calibration:

- Calibrate every two to three months.
- Ensure Temperature sensor is fully submerged during calibration.
  - The High Range Sensor must be flooded above the level of the upper vent ports.
- See Calibration Report for K-Cell value.
  - Low Range Sensor: Ideal range is 0.33 to 0.39
  - High Range Sensor: Ideal range is 4.4 to 5.8

Routine Maintenance:

- Remove minerals or precipitates by soaking sensor in vinegar. Use a swab or tissue to remove the loosened materials.
- Do not scrub or brush or use anything that may scratch the sensing surface.

Storage:

- Rinse with water and store dry.

Suggested Further Reading:

- Tech Note: Specific Conductance as an Output Unit for Conductivity Readings

- Tech Note: Total Dissolved Solids from Conductivity
- Application Note: Using Multi-Parameter TROLL Data Loggers to Monitor Sea Water Intrusion During Pumping
- Application Note: Using In-Situ Inc. MP TROLL 9000 to Monitor Water Quality Parameters as an Indicator of Potential Volcanic Unrest
- TROLL 9500 Operator's Manual, Section 12

pH

NOTE: In-Situ Inc. has produced two different types of pH sensor. The newer model, PN 0059510 (pH only) or PN 0059520 (pH/ORP Combination), allows the user to replace the junction and the fill solution. The junction and fill solution are not replaceable for the older model, PN 0032000 (pH only) or PN 0032020 (pH/ORP Combination). The Part Number is stamped on the side of the sensor for easy identification.

Keys to Calibration:

- Calibrate every two to six weeks, depending upon site conditions.
- For newer model sensors, always recalibrate after replacing the reference junction and/or the filling solution.
- Resetting to Default Coefficients
  - The sensor's calibration may be reset to factory defaults at any time. This option is most effective when the sensor is new.
- See Calibration Report for mV response at pH =7.
  - Ideal value is 0 mV ± 20 mV.
- See Calibration Report for Slope.
  - Ideally, this value ranges from –54 to –62 (mV/pH).
- See Calibration Report for Offset.
  - Ideally, this value ranges from 390 to 450 (mV).

Routine Maintenance:

- Once the pH sensor is moistened it must be kept moist for the life of the sensor.
- For newer model sensors, replace the filling solution every five to six months or when:
  - The sensor fails to calibrate with a reasonable slope and offset.
  - Readings drift.
  - Readings during calibration at pH 7 are greater than +20 mV or less than –20 mV.
- For newer model sensors, replace the junction when the sensor fails to calibrate, even after replacing the fill solution.
- To clean the sensor, begin with a gentle stream of cold water. If further cleaning is required, consider the nature of the fouling.
  - Avoid wiping the glass sensing bulb.
- To remove Crystalline Deposits:
  - Clean sensor with warm water and mild soap.
  - Soak sensor in 5% HCl solution for 10-30 minutes.
  - If deposits persist, alternate soaking in 5% HCl and 5% NaOH solutions.
- To remove Oily or Greasy Residue:
  - Clean sensor with warm water and mild soap.
  - Methanol or isopropyl alcohol may be used for short soaking periods, up to one hour.
  - Avoid soaking in strong solvents, such as chlorinated solvents, ethers, or any ketones, including acetone.
- To remove Protein-like material or Slimy Films:
  - Clean sensor with warm water and mild soap.
  - Soak sensor in 0.1M HCl solution for 10 minutes and then rinse with DI water.
- To remedy a Clogged Reference Port:
  - Older sensors (PN 0032000, 0032020): Heat the electrode to 50° C in 3M KCl solution, then allow sensor to cool in same solution. Limit the immersion of sensor tip to two inches depth or less.

- Newer sensors (PN 0059510, 0059520): Replace the junction.

- After performing any of the above cleaning methods, rinse the sensor with water, then soak overnight in pH 4 buffer.

Short-Term Storage:

- Up to one week: Immerse the sensor tip in pH 4 buffer using the electrode storage bottle. Tighten the cap to prevent drying. Alternatively, pH 7 buffer can be used for up to a few days.

Long-Term Storage:

- Up to several weeks: Prepare a storage solution by mixing pH 4 buffer with a high concentration potassium chloride solution (for example, 58,670 µS/cm conductivity calibration solution) in a volume ratio of about 1:10. Immerse the sensor in this solution using the electrode storage bottle. Tighten the cap to prevent drying. Prior to use, condition the sensor by rinsing it with deionized water and soaking it for 15 minutes.

Storage Tips:

- Following Long-Term Storage and prior to use, rinse the sensor with DI water and then soak in pH 4 buffer for one to two hours.
  - Soaking in pH 4 buffer prior to use will prepare the glass bulb by saturating it with Hydrogen ions.
- Do not store the sensor in deionized water. Doing so will deplete the reference solution, thereby drastically shortening the life of the sensor.

Suggested Further Reading:

- Tech Note: Care of pH, ORP, and pH/ORP combination sensors
- TROLL 9500 Operator's Manual, Section 11

Oxidation-Reduction Potential (ORP)

Keys to Calibration:

- Calibrate every one to two months.
- See Calibration Report for Offset.
  - Ideally, this value is 0 mV ± 20 mV

Routine Maintenance:

- Follow the same cleaning procedures as listed above for the pH sensor.
- If platinum electrode appears dull or fouled, it may be cleaned with a swab and alcohol.
  - Rub gently until electrode is shiny.

Short-Term Storage:

- Same as for pH sensor

Long-Term Storage:

- Same as for pH sensor

Storage Tips:

- Same as for pH sensor

Suggested Further Reading:

- Tech Note: Care of pH, ORP, and pH/ORP combination sensors
- TROLL 9500 Operator's Manual, Section 14

Polarographic Dissolved Oxygen (Clark Cell D.O.)

Keys to Calibration:

- Calibrate every two to four weeks.
  - Calibrate every few days if deployed in a heavy biofouling environment.
- Ensure Temperature sensor is fully submerged during calibration.
- Perform calibration in a temperature stable environment.
- To minimize calibration time, ensure the software version of Win-Situ® 4 or Pocket-Situ 4 is the most current version available.
  - Software updates are always available at In-Situ's website:

    http://www.in-situ.com/In-Situ/Downloads/Downloads.html
- If using a bubbler system, keep sensor far from source of aeration and prevent bubbles from resting on the membrane.
- See Calibration Report for Slope.
  - Ideal range for 1-mil membrane is 30 to 67 [nA/(mg/L)].
  - Ideal range for 2-mil membrane is 15 to 34 [nA/(mg/L)].

- If slope is too high, sensor likely requires more conditioning time.
- If slope is too low, fill solution chamber may not be filled properly.

- See Calibration Report for Offset.
  - For one-point calibrations (Quick-Calibration), the default is 2 nA.
  - For two-point calibrations, should be less than or equal to 10 nA; Ideally this value will be close to 3 or 4 nA.

Routine Maintenance:

- Condition and calibrate sensor:
  - After cleaning the sensor
  - After replacing the membrane
  - When deploying senor at a different elevation from that which it was calibrated
- Replace membrane every three to six months, depending upon use and fouling.
- Clean and polish anode and cathode to remove Silver Chloride deposits
- Allow ample conditioning time following membrane replacement.
  - Following membrane replacement, connect the TROLL 9000/9500 to a computer via Win-Situ 4 or Pocket-Situ 4.
  - When "Dissolved Oxygen" is listed under "Parameters" in the navigation tree, the sensor conditioning begins.
  - Allow the sensor to condition for at least four hours, preferably overnight, before calibrating.

Short-Term Storage:

- Up to two weeks: Store assembled with membrane immersed in clean water. If a pH/ORP sensor is also present, a pH buffer of KCl solution may also be used.

Long-Term Storage:

- Longer than two weeks: Remove sensor from the TROLL, remove the membrane module from the sensor, rinse with deionized water, cap and store dry.

Suggested Further Reading:

- D.O. Sensor Maintenance Presentation
  - Great photos and step-by-step instructions for maintenance
- D.O. Clark Electrode Maintenance Kit Information Sheet
- TROLL 9500 Operator's Manual, Section 13

Optical Dissolved Oxygen (RDO®)

Keys to Calibration:

- Expect the RDO calibration to remain valid for six to twelve months. Many of today's field procedures were written when electro-chemical D.O. sensors were the norm, and therefore might direct the user to recalibrate before each deployment. It is good practice to at least check the calibration before deployment, recalibrating when the response falls outside of the procedure's acceptance window.
- Calibrate after changing the foil.
- Check the calibration after cleaning.
- The calibration of the RDO is extremely stable. Calibrations that are hastily per-formed will tend to degrade rather than enhance the performance. It is better to direct recalibration efforts toward quality rather than frequency.
- Use the bubbler accessory to perform field checks at the saturation point before deployments. Clean water will give best results. Avoid using field water that has significant demand or production of oxygen.
  - Saturation Point tips: Use freshly filled clean water (deionized or drinking water are both acceptable). Allow up to 15 minutes of sensor immersion time with bubbling to insure that the water and sensor have reached a full equilibrium. This is especially important if the water is under- or over-saturated to gases at the start, or when the water and sensor start at greatly differing temperatures.
  - Zero Point tips: Note that the drift of the zero point is even more gradual than the drift of the saturation point. Zero point checks and/or recalibrations are primarily advised when the field

conditions tend toward low oxygen levels. If the settling is sluggish the sulfite solution may be nearly spent - use a fresh solution.

- A one-point calibration at the saturation condition can be performed as follows: calibrate the saturation point normally, then use the [Next] button to move past the Zero Point screen, proceeding directly to the "Finish" screen.
- To perform a two-point calibration:
  - Use a bubbler system for 100% Oxygen saturation point. If not using the In-Situ bubbler accessory, do not introduce bubbles at a depth in excess of 4 inches (100mm).
  - Use Sodium Sulfite (Na_2SO_3) or bubbled Nitrogen gas for the 0% Oxygen point. Be aware that nitrogen bubbling is less efficient at removing oxygen from the water and may require high flow rates and longer settling times.
- Ensure that the RDO sensor is fully submerged during calibration.
  - Bubbler must be full or overflowing.
- See Calibration Report for Phase Angles.
  - Ideal phase angle for 100% Oxygen saturation point is 25 to 35 degrees.
  - Ideal phase angle for 0% Oxygen saturation point is 50 to 75 degrees.
- Always install Lithium D-Cell batteries in TROLL 9000/9500 when using RDO sensor.
  - Except in the case of the TROLL 9000E model with four D-cell power system. In this case, install four alkaline batteries.

Routine Maintenance:

- Pre-hydration of the sensing foil is not required of the RDO, in contrast to some other optical oxygen sensors.
- Clean at regular intervals, depending upon deployment conditions and biofouling.
- Wipe foil gently with damp cloth or swab.
- Mineral build-up/ fouling may be loosened by soaking in vinegar and removed by rinsing with water.
- Do not clean with organic solvents such as acetone, chloroform, or toluene.
  - These solvents will damage the foil.
- Only user-serviceable part is the foil.
  - Foil will last up to five years at 10-second sample intervals.
  - Replace foil approximately every five years or when damaged.
  - Update foil coefficients after foil replacement.
  - Data collected with incorrect foil coefficients is not able to be post-corrected.

Storage:

- May remain on TROLL 9000/9500 and stored according to storage needs of other sensors present.
- May be removed, rinsed with water and stored dry.

Suggested Further Reading:

- Tech Note: RDO Sensor Calibration
- Optical D.O. Specifications Sheet
- Optical D.O. Quick Start Guide
- TROLL 9500 Operator's Manual, Section 13
- Optical Dissolved Oxygen Presentation
- Lithium Battery Kit Information Sheet

Turbidity

Keys to Calibration:

- Factory Calibration is permanently stored on the TROLL 9000/9500.
  - Sensor arrives ready to use.
  - Calibration is referenced to AMCO-AEPA-1 Styrene Divinylbenzene copoly-mer primary standards.
  - May be restored at any time.
  - This calibration is strongly linear across full operating range: ± 5% or ± 2 NTU, whichever is greater, from 0 to 2000 NTU.
- Reasons to perform a User Calibration:
  - After cleaning

- To achieve a higher level of accuracy over a limited range
- To record measurements that are referenced to a specific calibration standard, such as Formazin
- If readings drift

- User Calibration
  - User may perform One-point to Four-point calibration.
  - Three most-commonly used standards are Diluted Stock Formazin, Stabilized Formazin, and Polymer Bead Suspensions
  - Begin with 0 NTU standard and progressively move up to more turbid solutions.
  - Limiting factor of accuracy is precision of turbidity standards used.
  - Restore Factory Calibration defaults if problems arise with User Calibration.

Routine Maintenance:

- Clean optical windows with swabs and water or ammonia.
- Remove fouling from inside sensor restrictor assembly.
- The optical windows are scratch-resistant sapphire and will only be damaged by severe shock.
- Deploy with the Turbidity Wiper to minimize fouling and bubble formation on optical windows.

Storage:

- Turbidity is an on-board sensor and cannot be removed from the TROLL 9000/9500.
- May be stored according to the needs of other sensors currently present on the TROLL 9000/9500.

Suggested Further Reading:

- Tech Note: Formazin Calibration of the TROLL 9000 Turbidity Sensor
- Tech Note: Accuracy & Precision of the TROLL 9000 Turbidity Sensor
- Tech Note: Total Suspended Solids from Turbidity
- Application Note: Construction Sites and Potential Impact: Using the In-Situ MP TROLL 9000 to Monitor Construction Runoff
- Application Note: Siltation from Construction Runoff: Using In-Situ Inc. MP TROLL 9000 to Monitor Silt Laden Runoff from Construction Activities
- Turbidity Wiper Installation and Maintenance Instruction Sheet
- TROLL 9500 Operator's Manual, Section 18

Temperature

Keys to Calibration:

- Factory calibrated
- No option for User Calibration

Routine Maintenance:

- Clean as needed with water, ammonia, or vinegar.

Storage:

- Temperature is an on-board sensor and cannot be removed from the TROLL 9000/9500.
- May be stored according to the needs of other sensors currently present on the TROLL 9000/9500.

Suggested Further Reading:

- TROLL 9500 Operator's Manual, Section 8

Pressure

Keys to Calibration:

- Factory calibrated
- No option for User Calibration
- Return to factory for re-calibration every 12 to 18 months, depending upon application and user's tolerance for drift.
  - Accuracy is compromised over time by normal drift in electronics, exceeding operating temperature or pressure limits, and improper care.

Routine Maintenance:

- Clean by swishing in water with mild soap.
- Do not poke or scrape the sensor.

Storage:

- Pressure is an on-board sensor and cannot be removed from the TROLL 9000/9500.
- May be stored according to the needs of other sensors currently present on the TROLL 9000/9500.

Suggested Further Reading:

- Tech Note: Water Level Accuracy – Correcting for Errors Due to Gravitational Acceleration and Liquid Density
- Tech Note: Absolute (Non-Vented) vs. Gauged (Vented) Sensors
- Tech Note: Manual Barometric Correction
- Tech Note: Instrument Calibration
- Application Note: Hydrology Project in India to Monitor Water Levels
- TROLL 9500 Operator's Manual, Section 7

Ion Selective Electrodes: Ammonium, Chloride, and Nitrate

Keys to Calibration:

- Prior to calibration, soak sensor for at least 15 minutes, up to several days, in the calibration fluid planned for the first calibration point; this will be the lowest concentration calibration standard.
- Use immediately following calibration.
  - Calibration will last approximately four to six hours.
- When the expected environmental water temperature range is known and variation is moderate, use a two-point calibration at the mid-point temperature.
- A 2-Point Isothermal Calibration will suffice if sensor is deployed in a relatively static temperature environment.
  - Calibrate with the lowest possible and the highest possible analyte concentrations to achieve the most accurate results across full range.
- Calibrate as close as possible to the expected deployment temperature.
- If the environmental water is expected to vary by more than 20 degrees C, a three-Point Bi-Thermal Calibration may be used.
  - First two calibration points must be at same temperature and different concentrations.
  - Third calibration point should be at least 10 degrees C (more is preferable) higher or lower than first two points, depending upon expected sampling conditions. Allow 15 minutes of stabilization time at this temperature.
  - All Ion Selective Electrode (ISE) sensors are highly susceptible to drift due to temperature changes; a 3-Point Bi-Thermal Calibration allows the sensor to compensate for temperature changes by determining the sensor's Isopotential Point, or the concentration at which changes in temperature don't cause a change in sensor response.
  - Sensor retains slope and temperature correction factor and all ensuing single point calibrations will adjust the only offset, not the slope.
  - Use a glass beaker for the ice bath, the thick plastic calibration cup will not equilibrate as quickly as glass.
- A 1-Point calibration is recommended only to re-adjust sensor offset following a 3-Point Bi-Thermal Calibration.
  - Perform daily or after using sensor for four to six hours.
- See Calibration Report for Slope.
  - Ideal slope for a new Ammonium sensor is approximately 54 to 58 (mV per decade of concentration)
  - Ideal slope for a new Chloride or Nitrate sensor is approximately 55 to 59 (mV per decade of concentration)

Ammonium Sensor Storage:

- When not in use, store the sensor in 14 or 140 ppm as N calibration solution
  - Use 14 or 140 ppm as N calibration solution, depending upon whether future deployment will be in low or high Ammonium range.
- Do NOT store dry.
- Do NOT store in deionized water.

Chloride Sensor Storage:

- Immerse in 35 or 355 ppm Chloride solution, depending upon whether future use will be in low or high Chloride range.
- For long-term storage, rinse with water and store dry.

Nitrate Sensor Storage:

- When not in use, store the sensor in 14 or 140 ppm as N calibration solution
  - Use 14 or 140 ppm as N calibration solution, depending upon whether future deployment will be in low or high Nitrate range.
- Do NOT store dry.
- Do NOT store in deionized water.

Suggested Further Reading for Ion Selective Electrodes:

- TROLL 9500 Operator's Manual
  - Contains very important information about usage recommendations and cautions related to Depth, pH, Conductivity, Temperature, and Potential Interfering Ions
  - See Section 15 for Ammonium Sensor
  - See Section 16 for Chloride Sensor
  - See Section 17 for Nitrate Sensor
- Tech Note: ISE Sensor Calibration, Performing a 3-Point Calibration Instructions for ISE Sensors
- "A Beginners Guide to Ion-Selective Electrode Measurements" by Chris C Rundle BSc, PhD. (Nico2000 Ltd, UK.)
  - Available for free download at http://www.nico2000.net/

Summary

Logging accurate water quality measurements with a TROLL 9000/9500 is wholly dependent upon the proper calibration and maintenance of the sensors. Achieve the highest possible accuracy and maximize the life of all water quality sensors by following the above guidelines for calibration, routine maintenance and storage.

For additional sensor information, such as Installation, Calibration Techniques, and Theory of Operation, please refer to the TROLL 9000 or TROLL 9500 Operator's Manual. For sensor specifications, such as Accuracy, Response Time, and Range of Operation, please refer to the Sensor Summary Information Sheet. All Operator's Manuals, Quick-Start Guides, Information Sheets, Technical Notes, and Application Notes may be accessed via In-Situ's website at: http://www.in-situ.com/In-Situ/Downloads/Downloads.html

Suggested Further Reading for General Information on Water Quality Sensors:

- TROLL 9500 Operator's Manual
- Tech Tip: MP TROLL 9000 Calibration Frequency
- Tech Note: Instrument Calibration
- Information Sheet: Sensor Summary

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