Installation, Operation, and Maintenance Manual

DOX

Optical Dissolved Oxygen Sensor with Digital Output

⚠ WARNING

Read this Manual BEFORE using this equipment.

Failure to read and follow all safety and use information can result in death, serious personal injury, property damage, or damage to the equipment.

Keep this Manual for future reference.

THINK SAFETY FIRST

scientific
A WATTS Brand

Table of Contents

1. **Introduction** **2**
2. Safety **2**
3. Getting Started **3**
4. DOX Sensor and Specifications **3**
4.1 System Description 3
4.2 Specifications 3
4.3 Dimensions 4
4.4 Dimensions 4
5. Installation **4**
6. Communication **4**
6.1 Digital 4
7. Calibration **5**
100% Sat (air) 5
0 ppm (0%) 5
Pressure 5
Salinity 5
8. Maintenance **6**
8.1 Cleaning 6
8.2 Replacing the Sensor Cap 6
9. Spare Parts **6**
10. Accessories **6**
10.1 Calibration Cap 6
10.2 Mounting 6
11. Troubleshooting **7**
12. Disposal **7**
13. Contact **7**
Appendix A: Dissolved Oxygen Equations **8**
Appendix C: Definitions **9**
Entering Calibration Registers **9**
HF scientific Municipal Market Products Limited Warranty **12**

1. Introduction

The DOX is one of the most compact, durable, and easy-to-use optical dissolved oxygen sensors on the market. It is an optical sensor that utilizes fluorescence quenching technology: The quenching of a fluorophore by dissolved oxygen molecules decreases the fluorescence intensity and lifetime, the latter of which is detected by a photodetector and allows the dissolved oxygen (DO) concentration to be quantified accurately and consistently. Unlike polarographic and galvanic electrochemical designs used for the measurement of dissolved oxygen, optical technology does not consume oxygen during measurement. Also, optical technology does not require electrolyte, a "warm-up" period, or sample flow. The measured dissolved oxygen concentration is automatically compensated for by integrating data from the temperature and pressure sensors coupled with sophisticated algorithms in the firmware.

The DOX sensor is a digital output sensor that communicates directly with the MPX controller communicating the Dissolved oxygen concentration in ppm units and temperature in Celsius or Fahrenheit. The sensor can be calibrated directly from the MPX controller or via an RS485 adapter to a computer. The sensor comes fully calibrated and can maintain this calibration for 1-2 years, depending on the environment it is installed in.

2. Safety

⚠ WARNING

Electrical hazard: Do not install the probe unless you have electrical training and you have read the instruction manual. The probe uses a 8-36V power supply and improper installation and handling can result in injury or damage to surrounding equipment including this probe.

NOTICE

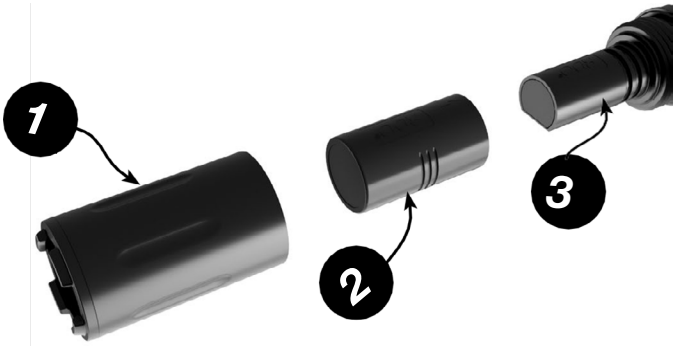
The probe should only be installed, stored and serviced in the manner described in this manual. Improper handling may result in damage to the unit and surrounding equipment and may void the warranty.

3. Getting Started

1. A temperature sensor is built into the probe body, close to the sensor cap. It should be completely immersed in the sample when taking measurements.
2. To maximize the working life of the sensor cap do not allow the sensor cap to be exposed to organic solvents, scratching, or impacts. Special care should be taken to clean the coating of cap, to dip probe and cap in fresh water, and then to tap dry the surface with a tissue. Do not wipe the coating surface.
3. Replace the sensor cap if the cap coating is faded or stripped away. **DO NOT touch the clear window on the probe tip after unscrewing the old cap.** If any contaminants or residue are present on the window or inside the cap, carefully remove them with a powder-free wipe. Then re-screw the new sensor cap onto the probe.

4. DOX Sensor and Specifications

4.1 System Description



Your DOX probe includes the following items:

1. The sensor guard cap protects and seals the sensor cap in place.
2. The membrane sensor cap (1000003931) has a luminescent foil that responds to oxygen molecules. This cap needs to be replaced periodically. The typical life is two years.
3. The optical system contains the optics and circuitry that enable the sensor to calculate the concentration of dissolved oxygen.

NOTICE

The membrane cap and sensor guard both need to be installed prior to operation. If these are not installed, the sensor will be damaged beyond repair and void the warranty.

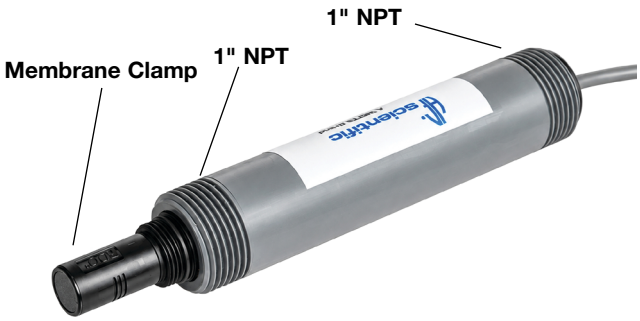
4.2 Specifications

Call customer service if you need assistance with technical details.

Probe Parameters	
Parameters	Optical Dissolved Oxygen Sensor
Data Transmission	RS485, Modbus
Range, DO	0 to 60 mg/L; 0 to 600% Saturation
Accuracy, DO	+/-0.1 mg/L (0-20 mg/L) +/-2% (20-60 mg/L)
Resolution, DO	0.01 mg/L
Response Time, Cap	T63<5s, T90<45s, T95<60s
Units, DO	mg/L, ppm, % saturation
Range, Temp	-5°C to 50°C (23°F to 122°F)
Accuracy, Temp	+/- 0.1°C
Resolution, Temp	0.01°C
Units, Temp	Celsius, Fahrenheit
Salinity Compensation	Fixed or real-time capable
Barometric Compensation	Fixed or real-time capable
Methods	EPA-approved methods 1002-8-2009, 1003-8-2009, 1004-8-2009 Standard Methods 4500-O
Calibration	1 or 2 points via MPX or RS485 Connection
Calibration Time	~1 min (for each point)
Calibration Frequency	1 to 2 years
Physical	
Wetted Material	cPVC Body, Cycoloy® (PC/ABS)[1], Ryton® (PPS), PC/PMMA[2] PVC, Santoprene® 101-55 when fully submerged
Reading Rate	1 second
Power Requirements	8 to 36 VDC
Power Consumption	Maximum (measurement): 50 mA at 12 VDC Idle (communication only): 2 mA at 12 VDC
IP Rating	IP-67 with sensor cap off; IP-68 with sensor cap installed
Compliance	EMC 2014/30/EU IEC 61000-6-2:2005 EN 55011:2009
Environmental	
Pressure	150 psi from 0° to 50°C
Depth	100 m (328 ft) @ 25°C
Operating Temperature (non-freezing)	-5°C to 50°C (23°F to 122°F)
Storage Temperature	-40°C to 65°C (-40°F to 149°F)
Interferences	Alcohols >5%; hydrogen peroxide > 3%; sodium hypochlorite (commercial bleach) > 3%; gaseous sulfur dioxide; gaseous chlorine. Do not use in organic solvents (e.g., acetone, chloroform, methylene chloride, etc.), which may swell the sensing element (foil matrix) and destroy it.

[1] Cycoloy is a registered trademark of SABIC GLOBAL Technologies B.V.;
[2] Ryton is a registered trademark of Solvay SA.

4.3 Dimensions

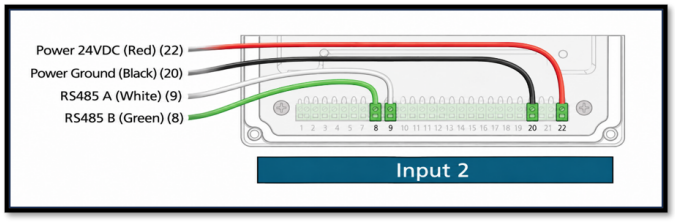


4.4 Dimensions

Wire Color	Description
Red	Power (8 to 36 VDC)
Black	Power GND
Green	RS 485 B (+)
White	RS 485 A (-)
1) Power supply: 8-36VDC. Make sure to follow the wiring instructions above and provide the proper power. Connecting the probe to any power outside the normal range may result in damage and may void the warranty.	

5. Installation

The DOX Sensor is designed to be connected to a MPX controller. The probe can output either a single output or dual outputs. As factory default, the DOX comes wired as such:



6. Communication

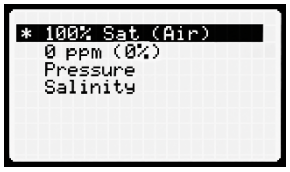
6.1 Digital

The standard output range for the DOX analog output is:

Output Parameter	Min	Max
Temperature	-5	50
Dissolved Oxygen (Concentration) ppm	0	60

7. Calibration

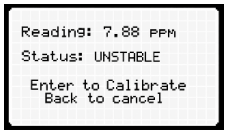
About Optical Dissolved Calibration

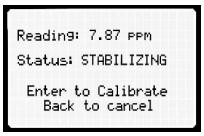


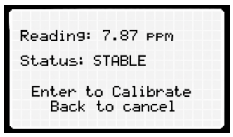
The calibration of the DOX sensors through the MPX UI actually saves and stores the calibration locally on the sensor. This allows users to leverage the factory calibration, calibrating offsite or simply calibrating on site. The DOX sensor has 4 calibration parameters: 100% Sat (often called Air), 0ppm (or 0%Sat), pressure and Salinity. Air and Zero are actual calibration methods where Pressure and Salinity are user adjustable values to adjust accuracy based on the installation method and location of the sensor's use.

100% Sat (air)

1. Saturate a sponge with deionized water and insert it into the calibration cup.
2. Gently dry the probe and sensor cap with a paper towel. Remove all water and debris.
3. Place the ODO-TX probe in the calibration cup so the sensor surface is about 2.5 cm (1") above the sponge.
4. Wait 5 to 10 minutes for temperature stabilization, but do not leave the probe in the calibration cup for more than 30 minutes. Condensation can form on the sensor surface, which may result in false readings after calibration. If condensation occurs, remove and thoroughly dry the probe.
5. To complete the calibration, simply press enter when the reading appears to be stable. The MPX will walk you through stability as shown below.



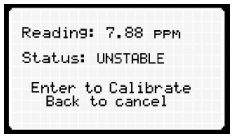


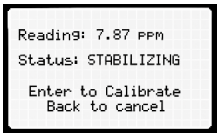


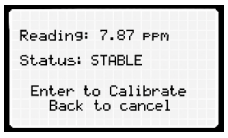
6. If successful you will get a screen depicting the new slope and offset saved to the sensor.

0 ppm (0%)

1. Remove the sponge from the calibration cup. Fill the cup with approximately 40 mL of fresh sodium sulfite solution. (This should be filled to about the bottom of the vented cap)
2. Place the instrument in the calibration cup. Leave at least 13 mm (1/2") between the tip of the sensor and the bottom of the cup.
3. Make sure the membrane cap is completely submerged in the solution.
4. Allow at least five minutes for the temperature to stabilize.
5. To complete the calibration simply press enter when the reading appears to be stable. The MPX will walk you through stability as shown below.





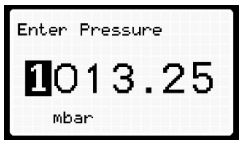


6. If successful you will get a screen depicting the new slope and offset saved to the sensor.

7. After calibration, remove the probe. Thoroughly rinse the probe the probe and sensor to remove all sodium sulfite solution.

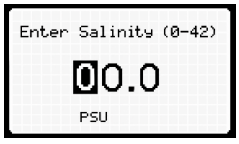
Pressure

As noted above, the pressure is a user entered value. The default value is 1013.25 mbar. The user can adjust this by toggling left or right to the desired unit and then toggling up or down to adjust. Simply press enter to save a back to reject.



Salinity

As noted above, the pressure is a user entered value. The default value is 0 PSU. The user can adjust this by toggling left or right to the desired unit and then toggling up or down to adjust. Simply press enter to save and back to reject.



8. Maintenance

8.1 Cleaning

Probe maintenance includes cleaning the sensor cap, as well as the proper conditioning, preparation, and storage of the test system. With the membrane sensor cap and guard cap installed on DOX, gently scrub the probe with a soft-bristled brush or nylon dish scrubber. Use Alconox or similar cleaning solution to remove grease or other matter. Soak in vinegar and DI water to remove mineral deposits or extensive fouling.

8.2 Replacing the Sensor Cap

The membrane Sensor Cap has a 2-year typical life after the sensor takes its first reading.

1. Remove the probe guard cap.
2. Use a lint-free cloth to remove any moisture from the probe.
3. Pull the used membrane sensor cap of the sensor, without twisting.
4. Remove the existing O-rings from the sensor.

NOTICE

Do not touch or clean the lens with anything other than the supplied lens wipe.

5. Use your finger to apply a very light layer of silicone-based lubricant around the O-ring grooves.
6. Place the O-rings on the sensor. Apply another thin layer of lubricant to the O-rings and grooves.

NOTICE

Do not transfer grease to the lens or sensor pins.

7. Remove the new cap from its sealed packaging and attach it to the sensor, being careful to press firmly, without twisting, until it seals over the lens. Make sure that the O-rings are not pinched or rolled between the cap and the sensor.
8. Replace the guard cap.
9. Each membrane cap comes factory calibrated, but for enhanced performance, perform a 1- or 2-point calibration to pair the new membrane sensor cap with the probe.

The DOX series does not consist of any user-serviceable parts. The membrane is a consumable item and thus should only be replaced. If the guard Cap is damaged, that should also be replaced. The optical system cannot be serviced and thus users/technicians must not attempt to open the prove beyond removing the membrane sensor cap and the guard cap.

9. Spare Parts

Part #	Description
AM-ODO-TX-CAP	AM-ODO-TX-Replacement Sensor Cap

Sensor Cap Storage

Prior to installation - Store in factory supplied container.

Installed - Store in the calibration chamber with the storage cap attached and a few drops of clean water.

10. Accessories

Part #	Description
1000003931	Calibration Cap
1000003708	Union tee with adapter - 2" NPT process connection - CPVC material with Viton o-rings
1000003709	Union tee with adapter - 2" socket process connection - PVC material with Viton o-rings
1000003720	Union tee with adapter - 3" socket process connection - PVC material with Viton o-rings

10.1 Calibration Cap

Calibrate the sensor with the Comm Kit Software or calibrate the sensor directly with your controller or PLC. The calibration cup (1000003931) comes with a tube and a vented cap, designed to fit with your DOX Sensor. The Calibration cap also comes with 3 dry sponged, cut to fit in the cap, for use of the 100% air calibration point.

For Calibration procedure, please refer to section 7.

10.2 Mounting

10.2.1. General Installation Requirements

Check the probe to ensure that no air bubbles have formed on the electrodes during submersion.

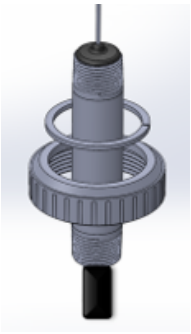
10.2.2. Inline Mounting

In-line measurements must be made with a 1" tee adapter. An off the shelf tee fitting will work. For mounting that allows quick removal of the probe without twisting the cable consider our Union Tee. This customized tee consists of a 1" FNPT compression fitting for the probe and a large lock nut for securing the probe.

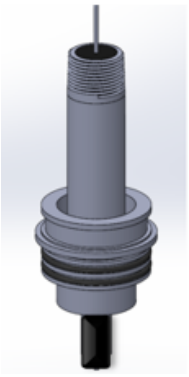
10.2 Mounting (Cont.)

To mount the DOX probe:

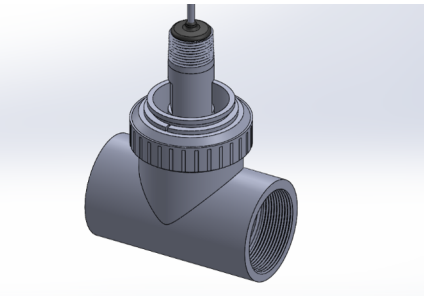
1. Insert the split ring and nut over the sensor.



2. Screw the DOX into the 1" insert bushing.



3. Slide the bushing assembly into the tee and screw on the compression nut. Install lock nut into a groove to keep the nut attached to the assembly.



11. Troubleshooting

To troubleshoot the DOX connect it directly to the MPX and assess readings. The expected reading in the air would be ≈100%sat (or ≈8ppm). If the output is stuck the sensor may not be working.

Ensure the membrane cap is on along with the protective cap.

Ensure the membrane cap is fully submerged.

The sensor can also be connected directly to a computer via RS-485 communication. Using the CommKit software, the user can establish a live connection and monitor real-time readings from the sensor.

If the user is unable to establish communication through CommKit, then the sensor is likely not functioning properly.

Please contact HF Scientific or call technical support 978-749-9949.

12. Disposal

In accordance with local regulations, please dispose of this product at specified locations for electrical and electronic equipment. Please contact the local government/authority or party responsible from which you purchased this device. Should this device be passed on to other parties (for private or professional use), the content of this regulation must also be related.

13. Contact

Please contact HF Scientific or call technical support 978-749-9949.

RDO® is a registered trademark of In-Situ®Inc., Fort Collins, Co USA.

Appendix A: Dissolved Oxygen Equations

Dissolved Oxygen Concentration

DO concentration is internally calculated in mg/L. Conversion to other units is as follows:

µg/L = 1000* mg/L

Oxygen concentration C_o (mg/L) is calculated as:

$C_o = 31.9988 \times 1E6 \times (\rho P_o / K_o M) (1 - O_o) \times S_c$

Where:

P_o is the partial pressure of O_2 in atmospheres.

$P_{torr} = 759.999876 \times P_{atm}$

S_c is the salinity correction:

$\ln S_c = S(B_0 + B_1 T_s + B_2 T_s^2 + B_3 T_s^3) + C_0 S^2$

$B_0 = -6.246090 \times 10^{-3}$

$B_1 = -7.423444 \times 10^{-3}$

$B_2 = -1.048635 \times 10^{-2}$

$B_3 = -7.987907 \times 10^{-3}$

$C_0 = -4.679983 \times 10^{-7}$

T_s is the scaled temperature:

$T_s = \ln [(298.15 - t) / (273.15 + t)]$

t is temperature in degrees C.

S is the salinity in PSU.

K_0 is Henry's constant:

$\ln K_o = 3.71814 + (5596.17/T) - (1{,}049{,}668/T^2)$

Θ_o is the negative of the second pressure coefficient:

$\Theta_o = 0.000975 - (1.426 \times 10^{-5} t) + (6.436 \times 10^{-8} t^2)$

t is temperature in degrees C.

ρ is the density of water in g/cm³

$\ln \rho = -0.589581 + (326.785/T) - (45{,}284.1/T^2)$

T is temperature in Kelvin.

Molar mass of water: M = 18.0152 g/mole

References:

Benson and Krause. Jr.. 1980. The concentration and isotopic fractionation of gases dissolved in freshwater in equilibrium with the atmosphere. Limnol, Oceanogr, 25(4), 662-671.

Gordon and Garcia. 1992. Oxygen Solubility in Seawater: Better Fitting Equations. Limnol, Oceaongr, 37(6), 1307-1312.

$O_2\%Sat = O_2 Reading / O_2 100\%Sat$

Where:

O_2 reading is the mg/L reading from the RDO Sensor.

O_2 100% Sat is the theoretical saturation value in mg/L and is derived as:

$$O_2 100\%Sat = 319988 \times 10^6 \times \rho [0.20946 \times (P - Pwv)] \times (1 - \Theta_o P) \times S_c \quad / \quad K_o M$$

Where:

ρ is the density of water in g/cm³

$\ln \rho = -0.589581 + (326.785/T) - (45{,}284.1/T^2)$

T is the temperature in Kelvin.

P is the atmospheric pressure in atm.

P_{wv} is the partial pressure of water vapor at saturation in atm:

$\ln P_{wv} = 11.8571 - (3{,}840.70/T) - (216{,}961/T^2)$

K_o is Henry's constant:

$\ln K_o = 3.71814 + (5596.17/T) - (1{,}049{,}668/T^2)$

T is the temperature in Kelvin.

Molar mass of water: M = 18.0152 g/mole

Θ_o is the negative of the second pressure coefficient:

$\Theta_o = 0.000975 - (1.426 \times 10^{-5} t) + (6.436 \times 10^{-8} t^2)$

t is temperature in degrees C.

S_c is the salinity correction:

$\ln S_c = S(B_0 + B_1 T_s + B_2 T_s^2 + B_3 T_s^3) + C_0 S^2$

$B_0 = -6.246090 \times 10^{-3}$

$B_1 = -7.423444 \times 10^{-3}$

$B_2 = -1.048635 \times 10^{-2}$

$B_3 = -7.987907 \times 10^{-3}$

$C_o = -4.679983 \times 10^{-7}$

T_s is the scaled temperature:

$T_s = \ln [(298.15 - t) / (273.15 + t)]$

Where t is temperature in °C

S is the salinity in PSU

References:

Benson and Krause. Jr.. 1980. The concentration and isotopic fractionation of gases dissolved in freshwater in equilibrium with the atmosphere. Limnol, Oceanogr, 25(4), 662-671.

Appendix C: Definitions

Live Salinity Value

The live salinity value is used to correct the oxygen concentration value for salinity. Values must be written in Practical Salinity Units (PSU) in the range 0 to 42 PSU. This is not a measured parameter.

Default Salinity Value

The default salinity value is loaded into the live salinity value register when power is first applied to the probe. The default salinity value is used in calculations until a live salinity value is written. This is not a measured parameter.

Live Barometric Pressure

The live barometric pressure is used in the calibration of percent saturation and to determine the theoretical saturation point during calibration. Values must be written in millibars in the range 506.625 to 1114.675 mbar. This is not a measured parameter.

Default Barometric Pressure

The default barometric pressure is loaded into the live barometric pressure register when power is applied to the probe. The default barometric pressure is used in calculations until a live barometric pressure is written. This is not a measured parameter.

100% Saturation Calibration Values

These values represent the sensor conditions while the probe is in a 100% saturation calibration environment. These are not measured values—they are written by the controller during the calibration process.

Writes to these registers are only accepted if the probe is in the calibration mode. The probe will return exception 0x85 (invalid device command sequence) if an attempt is made to write these registers when the calibration mode is off.

0% Saturation Calibration Values

These values represent the sensor conditions while the probe is in a 0% saturation calibration environment. These are not measured values—they are written by the controller during the calibration process.

Writes to these registers are only accepted if the probe is in the calibration mode. The probe will return exception 0x85 (invalid device command sequence) if an attempt is made to write these registers when the calibration mode is off.

Calibration Slope and Offset

These values represent the slope and offset that will be applied to the raw concentration reading from the sensor to generate the final values reported by the sensor parameters. These registers may be written independently of the normal internal calibration procedure.

Entering Calibration Registers

The sensor is calibrated using the following procedure.

1. Optional: Read the Sensor Data Cache Timeout register 9463 and store the value.
2. Write the Sensor Data Cache Timeout register 9463 to a value less than your intended sample rate and greater than 1000 milliseconds. This will ensure that you get new sensor readings during the stabilization process.
3. Optional: Read the temperature units register 0049 and saturation units register 0041 and store their values.
4. Write the temperature units register 0049 to its default value (1) and write the saturation units register 0041 to its default value (117).
5. Write the Calibration Mode On command (0xE000) to the sensor command register 9305.
6. Update the live salinity and barometric pressure registers if necessary/
7. Prompt the user to place the probe in a 100% saturation environment.
8. Read the oxygen concentration and temperature parameters. When these values have reached equilibrium, record them in their respective 100% saturation calibration registers. Write the current live salinity and barometric pressure readings to their respective calibration registers.
9. Place the sensor in a 0% saturation environment. When these registers have reached equilibrium, record them in their respective 0% saturation calibration registers. If a zero calibration is not to be performed, these registers can be set to zero or left at their previous values.
10. Write the Calibration Update command (0xE001) to the sensor command register. The sensor will calculate a new slope and offset, write the current time to the last user calibration time register, and set the next user calibration time register to zero (disabled). If the concentrations at 100% and 0% saturation are equal, the probe will return an exception response with code 0x97 (invalid calibration) and not attempt to compute a new slope and offset due to possible division by zero. If the slope does not calculate between 0.85 and 1.20 inclusive, or if the offset does not calculate between -0.2 and +0.2 inclusive, then the probe will return an exception response with code 0x97 (invalid calibration). The slope and offset will be available for read but will not be committed to flash.
11. Optional: Read the last user calibration time register, add the next calibration interval, and write the result to the next user calibration time register.
12. Write the Calibration Mode Off command (-xE002) to the sensor command register to place the sensor in normal operation. If the calibration mode is turned off without a calibration update command, or the calibration command returned an exception, the previous calibration shall be restored.
13. Optional: If you saved the temperature and saturation parameter units at the start of the process, write the original values back.
14. Optional: If you saved the Sensor Data Cache Timeout register 9463 at the start of the process, write the original value back.

Notes

Notes

HF scientific Municipal Market Products Limited Warranty

The online warranty for this product is located on the Watts website (https://www.watts.com/resources/warranty-information), and in the event that the terms or conditions of this manual conflict with the online warranty, the terms and conditions of the online warranty shall control. HF scientific, LLC (the "Company") warrants each municipal market instrument product to be free from defects in material and workmanship under normal usage for a period of one (1) year from first use or two (2) years from date of the Company's invoice from the original sale of the product, whichever occurs first. In the event of such defects within the warranty period, the Company will, at its option, replace or recondition the product without charge. Parts which by their nature are normally required to be replaced periodically, consistent with normal maintenance, specifically reagents, desiccant, sensors, electrodes and fuses, are excluded. Also excluded are accessories and supply-type items.

Proof of purchase from the Company (Company invoice or paid order confirmation) and/or first use (commissioning) must be provided when making a product warranty claim.

THE WARRANTY SET FORTH HEREIN IS GIVEN EXPRESSLY AND IS THE ONLY WARRANTY GIVEN BY THE COMPANY WITH RESPECT TO THE PRODUCT. THE COMPANY MAKES NO OTHER WARRANTIES, EXPRESSED OR IMPLIED. THE COMPANY HEREBY SPECIFICALLY DISCLAIMS ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OR MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

The remedy described in the first paragraph of this warranty shall constitute the sole and exclusive remedy for breach of warranty, and the Company shall not be responsible for any incidental, special or consequential damages, including without limitation, lost profits or the cost of repairing or replacing other property which is damaged if this product does not work properly, other costs resulting from labor charges, delays, vandalism, negligence, fouling caused by foreign material, damage from adverse water conditions, chemical, or any other circumstances over which the Company has no control. In addition, the Company shall not be responsible for any costs incidental to the Company's warranty response efforts, including, without limitation, costs associated with the removal and replacement of systems, structures or other parts of facilities, de-installation, decontamination and re-installation of products, or transportation of products to and from the Company. This warranty shall be invalidated by any abuse, misuse, misapplication, improper installation or improper maintenance of the product, alteration of the product or use of any parts or accessories (including but not limited to reagents) not provided by the Company.

Some states do not allow limitations on how long an implied warranty lasts, and some states do not allow the exclusion or limitation of incidental or consequential damages. Therefore the above limitations may not apply to you. This Limited Warranty gives you specific legal rights, and you may have other rights that vary from State to State. You should consult applicable state laws to determine your rights. **SO FAR AS IS CONSISTENT WITH APPLICABLE STATE LAW, ANY IMPLIED WARRANTIES THAT MAY NOT BE DISCLAIMED, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED IN DURATION TO ONE YEAR FROM THE DATE OF ORIGINAL SHIPMENT.**

A WATTS Brand

USA: T: (239) 337-2116 • Toll-Free (888) 203-7248 • F: (239) 454-0694 • HFscientific.com
Latin America: T: (52) 55-4122-0138 • HFscientific.com

© 2026 HF scientific