

Standard Operating Procedures for Measuring Dissolved Oxygen

A Guide to Field Measurements Using an Optical Dissolved Oxygen Meter and other Handheld Meters



Wastewater Management Program, wastewatmgmt@doh.wa.gov, 360-236-3330

DOH 337-160 June 2018

For people with disabilities, this document is available on request in other formats. To submit a request, please call 1-800-525-0127 (TDD/TTY call 711)

1. Purpose and Scope

- 1.1. This document is for the Washington State Department of Health (WSDOH) Standard Operating Procedure (SOP) for dissolved oxygen (DO) measurements.
- 1.2. This document describes the procedure for using a handheld optical dissolved oxygen meter to measure the DO of wastewater. The optical dissolved oxygen meter uses luminescence technology to measure the dissolved oxygen concentration of water. Dissolved oxygen is a useful indicator of water treatment efficiency. This procedure is performed in accordance with Luminescent Method ASTM D888-12.

2. Applicability

- 2.1. This procedure was developed for field measurements of dissolved oxygen in wastewater using the handheld YSI ProODO, Digital Optical Dissolve Oxygen Meter. This document is intended for measuring DO in the 0-50 mg/L range.

3. Definitions

- 3.1. Calibration- To standardize or correct sensor after determining, by measurement or comparison with a standard, the correct value.
- 3.2. DO- Dissolved Oxygen, the relative amount of oxygen which is dissolved or carried in water.
- 3.3. Field Log- A standard document for recording field measurements. See Appendix.
- 3.4. MSDS- Material Safety Data Sheets
- 3.5. PPM- Part Per Million (equal to mg/L for DO meter application)
- 3.6. True (uncorrected) Barometric Pressure - a barometric pressure value that has NOT been corrected to sea level.
- 3.7. WSDOH- Washington State Department of Health

4. Personnel Qualifications/Responsibilities

- 4.1. All field measurements will be performed by WSDOH personnel with lab experience and a professional background in wastewater treatment.
- 4.2. Review appropriate Material Safety Data Sheets before calibration.

5. Equipment, Reagents, and Supplies

- 5.1. Optical Dissolved Oxygen Meter, YSI Model: ProODO, Part #: 626281
- 5.2. Probe storage sleeve with moist sponge
- 5.3. Replacement Sensor Cap, Part #626320
- 5.4. Soft bristle brush to clean temperature sensor
- 5.5. Distilled Water
- 5.6. Lens Cleaning Tissue
- 5.7. Spare sponge for storage sleeve
- 5.8. At least 2 spare C-cell alkaline batteries
- 5.9. Disposable Rubber Gloves
- 5.10. YSI ProODO User Manual
- 5.11. Back-up Equipment: YSI DO200 Meter, Sensor and User Manual, YSI # 5908 Membrane kit, and YSI #5238 Probe Reconditioning Kit

6. Summary of Procedures

6.1. Dissolved Oxygen Calibration

Calibration Frequency: The ProODO should be calibrated prior to each usage using the DO% in watersaturated air 1-point calibration method.

1. Moisten the sponge in the storage sleeve with a small amount of distilled water. The sponge should be clean since bacterial growth may consume oxygen and interfere with the calibration process.
2. Make sure that there are no excess water droplets on the sensor cap or temperature sensor. Install the storage sleeve over the probe. Confirm that the DO and temperature sensors are not immersed in water.
3. Connect the sensor to the meter so that is turned and locked into place.
4. Turn meter on by holding the  button for two seconds.
5. Wait approximately 5 to 10 minutes for the storage container to become completely saturated and to allow the temperature and dissolved oxygen sensors to stabilize.
6. Press Calibration . Select the Probe ID and/or User ID if appropriate, highlight DO and press enter.
7. Highlight DO% and press enter to confirm.
8. Confirm that the “true” barometric pressure reading is acceptable, and wait for the DO and temperature readings to stabilize then highlight “Accept Calibration” and press enter. Note: If the barometer value is incorrect, it must be re-calibrated. Refer to the ProODO User Manual for barometer calibration instructions.
9. Wait until “Calibration Successful” appears. Press Esc to exit calibration mode.
10. Record calibration on the **CALIBRATION LOG**.
11. Verify Calibration Value for Current Barometric Pressure. To verify the YSI ProODO’s calibration, check to see that the meter is reading its calibration value for the current barometric pressure. Refer to Appendix A, “DO% Calibration Values”. Meter startup readings and confirmation that D.O. measured in calibration-cup is within 1% of True D.O. True (water-saturated) D.O. = Barometric Pressure inches Hg (measured by meter) / 29.92 inches Hg x 100. If D.O. measured is not within 1% of True D.O. then calibration is necessary. A post-check can also be performed with this value in mind. If, for example, you calibrate the meter to 98% and then conduct your DO testing, you can place the sensor back into the same calibration environment and it should read $\pm 1\%$ of 98% once stable.

1.1. Direct DO Grab Sample Bottle Measurement

1. Turn meter on by holding the  button for two seconds.
2. Insert the probe into the wastewater sample water bottle. Move the probe in the water to release any air bubbles and to provide a fresh sample to the sensor cap. Continuous stirring is not required using the ProODO sensor.
3. Allow the temperature to stabilize and wait approximately 25-35 seconds for the DO readings to stabilize.
4. Record the reading in mg/L in the field logbook.
5. Clean the sensor using distilled water.
6. At the end of data collection, verify the instrument's calibration, place the sensor in its calibration environment and check to see that the DO% is reading its calibration value based on the current barometric pressure. Refer to Appendix A for a list of DO% calibration values and corresponding barometric pressure readings. Record this verification in the Field Data Log.
7. To clean the Sensor Cap, gently wipe away any fouling with a lens cleaning tissue that has been moistened with water. Do not use organic solvents to clean the Sensor Cap. Using an organic solvent to clean the cap may cause permanent damage to the cap. For example, alcohol will dissolve the outer paint layer and other organic solvents will likely dissolve the dye in the cap. Keep the sensor in 100% humid environment. Store the sensor in the grey calibration/storage sleeve with sponge moistened for storage <30 days.
8. For storage >30 days, remove the batteries from the instrument. Moisten the sponge in the red protective plastic cap that was provided with the sensor and place it over the sensor with the sensor cap installed. Inspect the sponge every 30 days to make sure it is still moist. Alternately, you can place the sensor, with the cap on, directly in a beaker of water, making sure that the water does not evaporate over time.

2. **Records Management**

- 2.1. All hardcopy documentation of the data, such as the completed Field Log will be reviewed, verified, and entered into a database after being approved by the project's designated QA/QC Lead.
- 2.2. All calibration and field records should include: the instrument manufacturer, model number, the standards used to calibrate the instruments (including source), the calibration date and time, instrument readings, the post-calibration check and the name of the person (s) who performed the calibration.

3. **Quality Control and Quality Assurance Section**

- 3.1. The Sensor and Meter should be calibrated before each use and the calibration should be verified using the procedure described in 6.2.7 following data collection.
- 3.2. Although field instruments are robust, they should still be handled carefully.
- 3.3. All procedures should be completed in accordance with the project Quality Assurance Project Plan.

4. Safety

- 4.1. Wear gloves when exposed to wastewater.
- 4.2. Wear goggles when testing wastewater.
- 4.3. Wash hands after calibration and exposure to wastewater.
- 4.4. When using equipment in the field, be aware of your surroundings. Select an area in which you feel safe and secure from hazards.

5. References

American Public Health Association (APHA) (2005). *Standard Methods for the Examination of Water and Wastewater*. 21st ed. A.D. Eaton, L.S. Clesceri, E.W. Rice, and A. E. Greenberg, eds. APHA-AWWA-WEF, Washington D.C.

YSI Incorporated (2009) *ProODO User Manual*

<https://www.y.si.com/media/pdfs/626279-YSI-ProODO-User-Manual-RevC.pdf>

YSI Incorporated (2009) *Dissolved Oxygen Measurement Frequently Asked Questions (FAQS)*

<https://www.y.si.com/media/pdfs/FAQs-Dissolved-Oxygen-Measurement.pdf>

YSI Incorporated (2009) *Model 55 Handheld Dissolved Oxygen and Temperature System Operations Manual*

<http://www.y.si.com/media/pdfs/055207-YSI-Model-55-Operations-Manual-RevD.pdf>

YSI Incorporated (2008) *Operations Manual EcoSense DO200*

<http://www.y.si.com/media/pdfs/605368-YSI-DO200-Operations-Manual-English-Deutsch-Espanol-Francais-Italiano-RevE.pdf>

Appendix A: Calibration Check According to Current Barometric Pressure

- The local (station) barometric pressure (BP) at the DOH Lab is available at: <http://www.wrh.noaa.gov/mesowest/getobext.php?wfo=sew&sid=KOLM&num=48&raw=0>
The “**Station Pressure (inches)**” column on the webpage provides the true (uncorrected) barometric pressure needed for the DO meter calibration. The “Sea Level Pressure (mb)” and “Altimeter Setting (inches)” columns provide corrected to sea level readings, and therefore cannot be used unless they are “uncorrected”.
- Verify Calibration Value for Current Barometric Pressure:
(Local BP in ‘inches Hg’/ 29.92 inches Hg) *100 = Expected Calibration Value (in __ %)

DO% Calibration Values

Calibration Value		Pressure		
D.O. %	in Hg	mmHg	kPa	mbar
101%	30.22	767.6	102.34	1023.38
100%	29.92	760.0	101.33	1013.25
99%	29.62	752.4	100.31	1003.12
98%	29.32	744.8	99.30	992.99
97%	29.02	737.2	98.29	982.85
96%	28.72	729.6	97.27	972.72
95%	28.43	722.0	96.26	962.59
94%	28.13	714.4	95.25	952.46
93%	27.83	706.8	94.23	942.32
92%	27.53	699.2	93.22	932.19
91%	27.23	691.6	92.21	922.06
90%	26.93	684.0	91.19	911.93
89%	26.63	676.4	90.18	901.79
88%	26.33	668.8	89.17	891.66
87%	26.03	661.2	88.15	881.53
86%	25.73	653.6	87.14	871.40
85%	25.43	646.0	86.13	861.26
84%	25.13	638.4	85.11	851.13
83%	24.83	630.8	84.10	841.00
82%	24.54	623.2	83.09	830.87
81%	24.24	615.6	82.07	820.73
80%	23.94	608.0	81.06	810.60
79%	23.64	600.4	80.05	800.47
78%	23.34	592.8	79.03	790.34
77%	23.04	585.2	78.02	780.20
76%	22.74	577.6	77.01	770.07
75%	22.44	570.0	75.99	759.94
74%	22.14	562.4	74.98	749.81
73%	21.84	554.8	73.97	739.67
72%	21.54	547.2	72.95	729.54

Appendix B: Back-up Meter Standards of Procedure

YSI DO200 (Back-up) Calibration

Calibration Frequency: The YSI DO200 should be calibrated prior to each usage.

1. Moisten the sponge in the calibration bottle with a small amount of distilled water. The sponge should be clean since bacterial growth may consume oxygen and interfere with the calibration process.
2. Make sure that there are no excess water droplets on the sensor cap or temperature sensor. Install the probe into the calibration bottle. Confirm that the membrane does not touch the sponge.
3. Connect the sensor to the meter so that is turned and locked into place.
4. Turn meter on by pressing the  button. Wait 10 to 15 minutes for the dissolved oxygen and temperature readings to stabilize.
5. Press Calibration .
6. The LCD prompts for the local pressure in milliBar. Use the Δ and ∇ keys to increase or decrease the pressure value respectively.
7. When the proper pressure displays, press the enter arrow once to view the calibration value in the lower right of the display. Once the value in the main display stabilizes, press enter again to move to the salinity compensation procedure.
8. The display prompts for the approximate salinity of the water to be analyzed. Use the Δ and ∇ keys to increase or decrease the salinity compensation value to the value of your sample (between 0 to 40 parts per thousand [ppt]). When the correct salinity displays, press the enter button.
9. The unit holds calibration even if it is powered off. However, it is recommended to check calibration with each use and recalibrate as necessary to prevent drift. Dissolved oxygen readings are only as good as the calibration.
10. Record calibration in the calibration data log.

YSI DO200 (Back-up) Direct In-Situ Sampling Procedure

1. Turn meter on by pressing the  button. Allow 10-15 min for the meter to warm-up.
2. Insert the probe into the sample water. Move the probe in the water to release any air bubbles and to provide a fresh sample to the sensor cap. The continuously stir the sensor. Allow the temperature to stabilize and wait for DO readings to stabilize, while continuing stirring.
3. Record the readings in mg/L (same as ppm) in the field data log.
4. Clean the sensor using distilled water.
5. At the end of data collection, verify the instrument's calibration, place the sensor in its calibration environment and check to see that the DO% is reading its calibration value based on the current barometric pressure. Refer to Appendix A for a list of DO% calibration values and corresponding barometric pressure readings.

6. To clean the probe, use the YSI Probe Reconditioning kit. For chemical cleaning refer to the user manual. Store the sensor in the storage chamber with sponge moistened for storage <30 days.
7. For storage >30 days, remove the batteries from the instrument. Moisten the sponge in the chamber. Inspect the sponge every 30 days to make sure it is still moist. Alternately, you can place the sensor, with the cap on, directly in a beaker of water, making sure that the water does not evaporate over time.

YSI Model 55 Calibration and DO Membrane Installation

Calibration Frequency: The YSI Model 55 should be calibrated prior to each usage. New membranes should be installed every 3 weeks or prior to each usage, whichever occurs most frequently. Erratic readings are a result of fouled membranes.

Membrane Installation:

1. Secure a membrane between your thumb and the probe body. Add the provided KCl electrolyte to the probe until a large meniscus completely covers the gold cathode. Remove any air bubbles which may form on the meniscus.
NOTE: Handle the membrane material with care, touching it at the ends only.
2. With the thumb and forefinger of your other hand, grasp the free end of the membrane.
3. With a continuous motion, stretch the membrane up, over, and down the other side of the sensor. Stretching forms the membrane to the contour of the sensor tip.
4. Secure the end of the membrane under your forefinger while continuing to hold the probe.
5. Roll the O-ring over the end of the probe, being careful not to touch the membrane surface. There should be no wrinkles in the membrane or trapped air bubbles under the membrane. Some wrinkles may be removed by lightly tugging on the edges of the membrane beyond the O-ring.
6. Trim off excess membrane with scissors or a sharp knife. Check that the stainless steel temperature sensor is not covered by excess membrane.
7. Shake off excess KCl. Rinse the stainless steel thoroughly with distilled water to prevent corrosion. Reinstall the sensor guard. The sensor should be kept in a humid environment (such as the calibration chamber) between measurements and when not in use.

Meter and Sensor Calibration:

1. To accurately calibrate the YSI Model 55, you will need to know the approximate altitude of the region in which you are located and the approximate salinity of the water you will be analyzing. Also, calibrate at a temperature within $\pm 10^{\circ}\text{C}$ of the sample temperature.
2. Ensure that the sponge inside the instrument's calibration chamber is wet to provide a 100% relative humidity environment. Insert the probe into the calibration chamber.
3. Turn the instrument on by pressing the **ON/OFF** button on the front of the instrument. Wait for the dissolved oxygen and temperature readings to stabilize (usually 15 minutes is required after turning the instrument on).
4. To enter the calibration menu, use two fingers to press and release both the **UP ARROW** and **DOWN ARROW** keys at the same time.
5. The LCD will prompt you to enter the local altitude in hundreds of feet. Use the arrow keys to increase or decrease the altitude. Example: Entering the number 12 here indicates 1200 feet.
6. When the proper altitude appears on the LCD, press the **ENTER** key. The Model 55 should now display **CAL** in the lower left of the display, the calibration value should be displayed in the lower right of the display and the current DO reading (before calibration) should be on the main display.

7. Make sure that the DO reading (large display) is stable, then press the **ENTER** button. The LCD will prompt you to enter the approximate salinity of the water you are about to analyze. Use the arrow keys to increase or decrease the salinity setting. When the correct salinity appears on the LCD (zero for fresh water), press the **ENTER** key. The instrument will return to normal operation.
8. Record the results in the calibration data log.

YSI Model 55 Direct In-Situ Sampling Procedure

1. Turn the instrument on by pressing the **ON/OFF** button on the front of the instrument. Wait for the dissolved oxygen and temperature readings to stabilize (usually 15 minutes is required after turning the instrument on).
2. Insert the probe into the sample water. Move the probe in the water to release any air bubbles and to provide a fresh sample to the sensor cap. The continuously stir the sensor. The sensor consumes dissolved oxygen so it is important to stir (but not agitate) the sample. Allow the temperature to stabilize and wait for DO readings to stabilize, while continuing stirring.
3. Record the readings in mg/L in the field data log.
4. Clean the sensor using distilled water.
5. At the end of data collection, verify the instrument's calibration. Place the sensor in its calibration environment (storage chamber with wet sponge) and check to see that the DO% is reading its calibration value based on the current barometric pressure. Refer to Appendix A for a list of DO% calibration values and corresponding barometric pressure readings.
6. To clean the probe, rinse with DI water. For chemical cleaning refer to the user manual. Store the sensor in the storage chamber with sponge moistened for storage <30 days.
7. For storage >30 days, remove the batteries from the instrument. Moisten the sponge in the chamber. Inspect the sponge every 30 days to make sure it is still moist. Alternately, you can place the sensor, with the cap on, directly in a beaker of water, making sure that the water does not evaporate over time.