Dissolved Oxygen Meter

DO 4000

Code 1903

LaMotte

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SPECIFICATIONS

MEASUREMENTS

1. Oxygen concentration expressed in parts per million (ppm) of O_2
2. Oxygen concentration expressed as percent (%) of oxygen saturation
3. Temperature expressed as °C

RANGE (for Specified Accuracy)

1. 0 to 19.99 ppm O_2
2. 0 to 199% saturation
3. 0 to 40°C

PRECISION

1. 0.01 ppm for O_2 concentration
2. 1% for water saturation
3. 0.01°C for temperature

ACCURACY

1. For Oxygen Concentration 5% of reading or 0.10 ppm (whichever is greater) when taken within 5°C of the calibration point temperature
2. For Temperature ±0.5°C

RESPONSE TIME

90% of final readings within 45 seconds, except at extreme temperatures

SIZE AND WEIGHT

Case: 150 x 80 x 45 mm (5 **t** x 3 **c** x 1 **n** in.)
0.33 kg (**n** lb)

Probe: 15.5 mm diameter x 120 mm (**a"** dia x **6 g")**
0.10 kg (**c** lb)

POWER REQUIREMENTS

Maximum requirement of 100 mW

Source: **Internal** - Battery, Type 1604A (9 volt)- replaceable or Nickel/Cadmium rechargeable with built in charge regulator

External - Wall type AC adapter rated at 9VDC/50mA (minimum) with 3.5 mm jack, "tip positive" polarity (LaMotte Code #1708)

DISSOLVED OXYGEN BASICS

Oxygen, in the form of a gas, is a major component of air. Humans, plants, and animals use this oxygen to respire, or breathe. Gaseous oxygen also occurs in the water, where aquatic life uses it to respire. Oxygen in water is often called dissolved oxygen.

Dissolved oxygen is vital to the survival of aquatic organisms. Naturally present, dissolved oxygen enters water when plants photosynthesize or through dispersion. When plants, particularly algae, photosynthesize, sunlight is converted into needed chemical energy, releasing oxygen into the water. Dispersion, the exchange of oxygen between the atmosphere and water, can be aided by wind and wave action. Oxygen can also be mechanically introduced into the water by use of an aerator.

Once in the water, oxygen is consumed in several ways, including the respiration of plants and animals and the oxidation, or chemical breakdown, of dead and decaying plants and animals. In extreme cases all available oxygen may be used in the decomposition process, so no oxygen is left for respiration, and the plants and animals eventually suffocate.

Dissolved oxygen can be measured as the concentration of oxygen present in the water (mg/L or ppm oxygen), or as the percent of oxygen actually in the water as compared to the maximum amount the water can hold. This is referred to as percent (%) saturation. The level at which water is saturated is dependent upon several factors, but two of the most important are temperature and salinity. As the temperature of the water decreases, its ability to hold oxygen increases. Likewise, as salinity levels decrease the saturation level increases.

Dissolved oxygen levels are vital in many areas, but they are of particular concern to aquaculturists, environmental analysts and wastewater treaters, who must constantly monitor levels in the water. For aquaculturists, dissolved oxygen can be the difference between a healthy, profitable crop of fish, and disaster. If sufficient levels of dissolved oxygen are not maintained fish growth can be hindered, the fish may be more susceptible to infectious diseases, or they may even suffocate. Many aquaculture systems use aerators, especially at night when DO levels are lower, to ensure sufficient oxygen for a healthy crop.

Environmental analysts are also concerned with dissolved oxygen levels. This test is one of the most important for determining the ability of a pond, lake, or other body of water to support life. It is also used as part of the biochemical oxygen demand (BOD) test to determine the pollution level of the water.

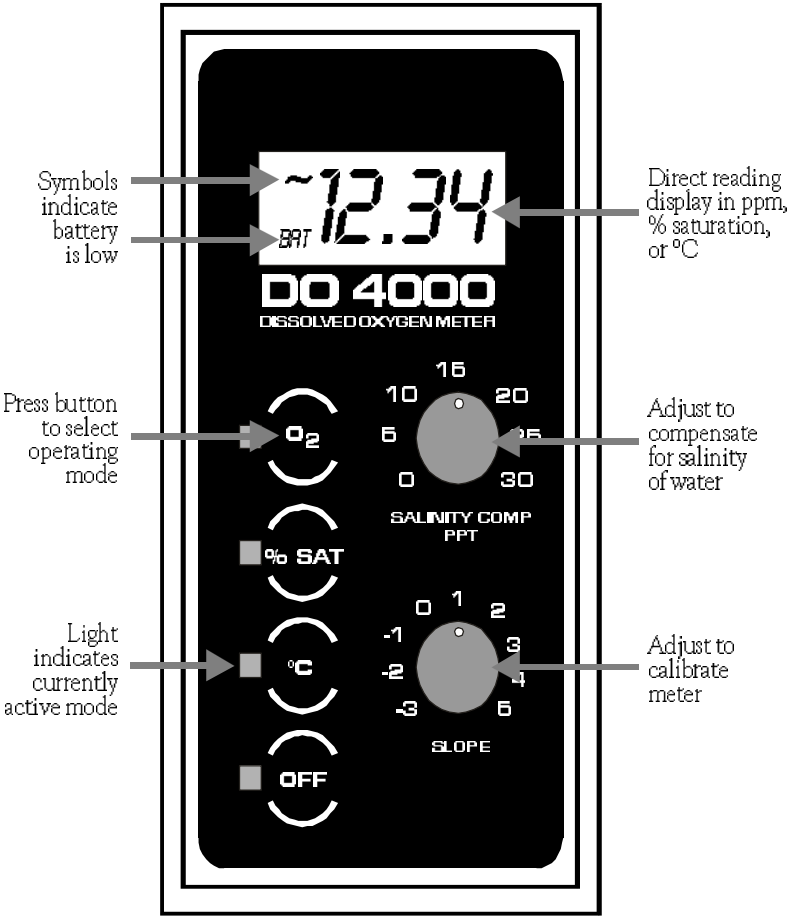
The dissolved oxygen test is also important to operators of waste water facilities, both at the operation site and in the lab. Dissolved oxygen levels are monitored at the wiers, and before the water leaves the plant after being dechlorinated. In the laboratory the dissolved oxygen test is used to analyze the BOD of the water.

DO METER BASICS

A voltage is applied across the electrodes of the Dissolved Oxygen probe. Silver ions are oxidized at the anode producing silver chloride and electrons. Oxygen is reduced at the cathode accepting electrons and producing hydroxide ions. The current generated by the chemical reactions is conducted through the filling solution. This current is proportional to the oxygen concentration and is converted by the meter to a dissolved oxygen reading.

The DO 4000 provides a digital readout of oxygen concentration in mg/L or ppm, or percent (%) saturation. The meter compensates for temperature and salinity which can effect the dissolved oxygen reading. Built-in thermistors automatically provide a readout in degrees centigrade (°C). Salinity levels from 0 to 30 parts per thousand (ppt) are set with the “Salinity Comp” knob. An altitude correction can be determined by consulting the Altitude Chart on page 13.

FUNCTIONS OF THE DO 4000 METER



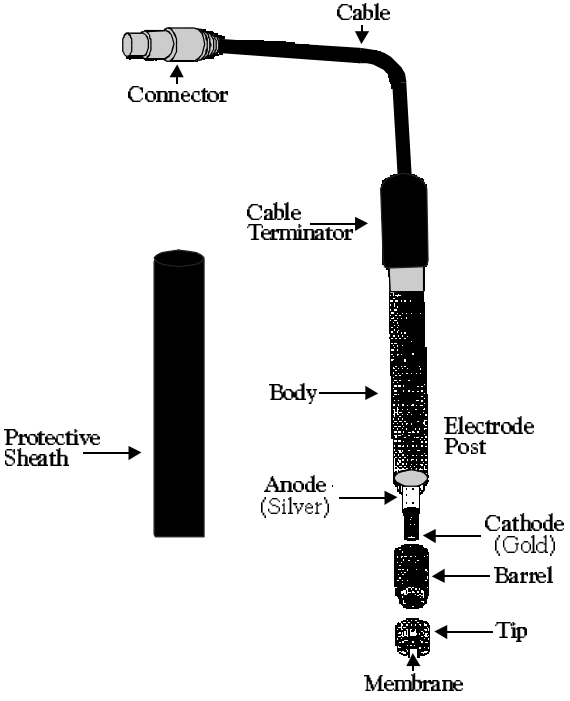
ASSEMBLING THE PROBE

GOOD PRACTICE GUIDELINES

Keep the membrane wet at all times. Between readings the probe can be stored with the tip in a beaker of deionized water. For longer periods, the probe should be stored in the protective sheath. The sponge insert in the tip of the sheath should be dampened with distilled water.

MEMBRANE REPLACEMENT

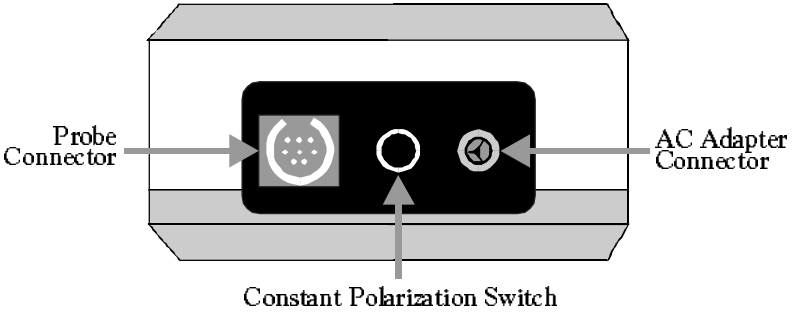
1. Hold the probe in a vertical position. Carefully unscrew the membrane module.
2. Holding the new membrane module in a vertical position with the threaded end up, fill with DO Filling Solution (2787).
3. Keeping the module in a vertical position, carefully screw the module onto the probe, allowing excess filling solution to escape through the screw thread. After assembly inspect the membrane. Make sure no air bubbles are present and the membrane is not creased.



POLARIZATION

Polarization is the term used to describe when the probe has reached equilibrium, and is able to produce stable, reliable measurements. For the probe to be polarized, voltage must continually be applied to the probe, allowing the oxygen reaction to proceed. When voltage stops, the reaction no longer continues and the probe is no longer considered polarized. When either ppm or %SAT is selected on the meter, a voltage is automatically applied across the electrodes, but the reading is not accurate until the 15 minute "warm up" time has elapsed. The DO4000 has a constant polarization feature, which allows a small voltage to be continuously applied to the probe, even when the meter is turned off, eliminating the 15 minute warm up time. To select the constant polarization option, set the small button between the connectors to the **OUT** position. Since it does use power to keep the probe constantly polarized, it is recommended this feature not be used if there will be a span of several hours between measurements.

Do not leave probe polarized for prolonged periods of time (overnight). Prolonged use will cause membrane fouling and require more frequent anode cleaning.



INITIAL/REPLACEMENT PROBE CALIBRATION

A precalibration procedure must be performed on a new meter and probe or each time a new probe is attached to the meter. After the precalibration procedure has been performed, the meter should be calibrated following one of the calibration procedures on pages 11-14.

1. Assemble probe.

2. Attach the probe to the meter with the arrow on the connector facing upward.

3. Set the salinity and slope knob to zero. Set the constant polarization button to the out position. Wait 30 minutes.

4. Place the probe several inches above a container of water. The probe must be calibrated in humid, not dry, air.

5. Press the "% SAT" button. Adjust the slope knob until the display reads 100%. If the slope knob is between -1 to 1, the meter is ready to use. Proceed to the section in the manual on testing.

6. If the slope knob is not within -1 to 1 range, set the slope knob back to zero and continue with Steps 7-10.

7. For meters with serial numbers 375 or higher (meter case has two holes on the side to access potentiometers), remove hole plug from the Slope Adjustment Pot.

For meters with serial numbers 0-374 (meter case has one hole on the side), remove the 4 screws and remove the case.

8. Turn the meter so that is aligned like the diagram on page 15. The potentiometer, on the circuit board, closest to the probe jack at the bottom of the meter, is the Slope Adjustment Potentiometer. Be sure to identify the correct potentiometer before making any adjustments.

9. Adjust the Slope Adjustment Potentiometer with a slotted screw driver (1/8” or smaller) until the meter reads approximately 100%.

10. Replace the hole plug or case. Use the slope knob to set the meter display to exactly 100%. The meter is now ready to use. Proceed to the CALIBRATION section.

CALIBRATION

The DO 4000 should be recalibrated daily using one of the following methods to account for changing environmental conditions. For most accurate results, calibrate as close to the temperature of the sample to be tested as possible. **DO NOT CALIBRATE WITH THE SHEATH ON.**

The saturated air calibration is easiest and generally considered to be a very accurate and reliable procedure. Alternative methods are listed on pages 12-16.

NOTE: If the DO 4000 has not been set on the constant polarization mode, set constant polarization button to **out** position on top of meter and wait 15 minutes before calibrating.

SATURATED AIR (RECOMMENDED PROCEDURE)

NOTE: It is very important that the membrane be completely dry before starting air calibration. Vigorously shake the probe several times to remove water droplets from the membrane. However, calibration must be done in humid not dry air!

1. Hold the probe several inches above water surface.
2. Set "SALINITY COMP" knob to 0. Press "%SAT" button to turn the meter on. Wait for display to stabilize.
3. Adjust the "SLOPE" control until display reads 100. The meter is now calibrated for use. Turn off constant polarization unless meter is to be used again shortly.

   NOTE: If readings are erratic, or the meter can not be calibrated see Troubleshooting on page 18.

SATURATED WATER USING A CALIBRATION CHART

The saturated water calibration using a chart requires more careful aeration and assumes the water is saturated after 15 minutes of aeration. An aquarium pump or other bubbling equipment can be used to aerate the sample. It is important the sample be saturated. If bubbling equipment is not available, the sample can be vigorously stirred with a magnetic stirrer for 2 hours.

1. Fill a 1 liter beaker with distilled or deionized water.
2. Aerate sample for approximately 15 minutes. Press the °C button to turn the meter on. Record the temperature.
3. Use the Solubility In Water chart to determine the solubility of oxygen at the sample temperature.
4. Use the Altitude correction chart to determine the altitude correction factor.
5. Multiply the oxygen concentration (Step 3) by the altitude correction factor (Step 4) to obtain the oxygen concentration of the sample.

   EXAMPLE: Sample temperature is 25°C; pressure is 642 mm Hg.

   8.263 x 0.84 = 6.94 ppm O_2

6. Set "SALINITY COMP" and "SLOPE" knobs on meter to zero.
7. Keeping probe at an angle, slowly immerse the probe at least 3.5" into the aerated sample. Tap the probe gently against the side of the beaker to remove air bubbles.
8. Press "O_2" button. Wait for reading to stabilize. Adjust the "slope" knob until display reads concentration of the sample as determined in Step 5.

   NOTE: If readings are unstable, stir more rapidly to avoid oxygen starvation at the membrane.
9. The meter is now calibrated and ready for use. See Testing on page 16 for instructions.

SOLUBILITY OF OXYGEN IN WATER

°C	O_2	°C	O_2	°C	O_2	°C	O_2
0.0	14.621	13.0	10.537	26.0	8.113	39.0	6.515
1.0	14.216	14.0	10.306	27.0	7.968	40.0	6.412
2.0	13.829	15.0	10.084	28.0	7.827		
3.0	13.460	16.0	9.870	29.0	7.691		
4.0	13.107	17.0	9.665	30.0	7.559		
5.0	12.770	18.0	9.467	31.0	7.430		
6.0	12.447	19.0	9.276	32.0	7.305		
7.0	12.139	20.0	9.092	33.0	7.183		
8.0	11.843	21.0	8.915	34.0	7.065		
9.0	11.559	22.0	8.743	35.0	6.950		
10.0	11.288	23.0	8.578	36.0	6.837		
11.0	11.027	24.0	8.418	37.0	6.727		
12.0	10.777	25.0	8.263	38.0	6.620		

ALTITUDE CORRECTION

Altitude feet	Pressure mm Hg	Correction Factor	Altitude feet	Pressure mm Hg	Correction Factor
-500	773	1.02	5000	642	0.84
0	760	1.00	6000	619	0.81
500	747	0.98	7000	596	0.78
1000	734	0.96	8000	572	0.75
2000	708	0.93	9000	548	0.72
3000	682	0.90	10,000	525	0.69
4000	666	0.88			

Tables derived from *Standards Methods For The Examination of Water And Wastewater*, 17th Ed.

SATURATED WATER USING A WINKLER TITRATION

The saturated water method using a Winkler titration to check the oxygen level is limited by the accuracy the titration.

1. Fill a 1 liter beaker with distilled or deionized water. Adjust temperature of the sample to approximately 25°C. Press the °C button to turn the meter on. Record the temperature.
2. Aerate sample for 15 minutes.

   NOTE: An aquarium pump or other bubbling equipment can be used to aerate the sample.
3. Remove aerator from beaker. Determine dissolved oxygen level using a Winkler Titration. Record reading. Repeat titration for a total of three results. Use the average of the results as the dissolved oxygen reading of the sample.

   NOTE: LaMotte Company offers a dissolved oxygen kit using an azide modification of the Winkler Titration. Order as code #7414 or code #5860 (all liquid reagents).
4. Set "SALINITY COMP" and "SLOPE" knobs on meter to zero.
5. Keeping probe at an angle, slowly lower at least 3.5" into the aerated sample. Tap the probe gently against the side of the beaker to remove air bubbles. Press "°C" button. Stir sample continuously.

   NOTE: If reading is unstable, stir more rapidly with probe.
6. Press "O_2" button. Wait for reading to stabilize. Adjust the "slope" knob until display reads concentration of the sample as determined in Step 3.

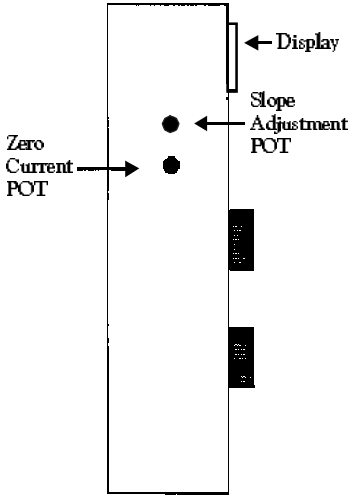
ZERO CALIBRATION

Dissolved Oxygen meters often include a zero point calibration procedure. Generally the most common source of zero point drift is filling solution contamination. There are two methods to correct this problem. **The recommended method is to change the filling solution** (see Membrane Replacement page 8). The second method is to calibrate out the error caused by the contamination. Calibrating out the error not only overlooks the source of the problem but leads to errors especially significant when testing very low oxygen solutions.

Use this zero calibration only when contamination of the filling solution is suspected.

ZERO CHECK

1. Add 0.1 g spoon (0699) of Sodium Sulfite (3970) and several crystals of Cobalt Chloride (3971) to about 100 mL of tapwater. Mix thoroughly. Wait one minute.
2. Select "ppm" on meter to turn the meter on. Immerse probe in solution and allow reading to stabilize. A reading of 0.1 ppm or more could indicate significant contamination and require a filling solution change.
3. With probe still in the Zero Oxygen solution prepared in Step 1, remove hole plug on side of meter and adjust the "Zero Current POT" with a slotted screw driver (1/8" or smaller) until meter reads 0.00 ppm.



TESTING

The DO 4000 has a constant polarization feature, which eliminates the 15 minute warm-up time between periodic use. If the meter has not been set on this function, set constant polarization button to **OUT** position on top of meter and wait 15 minutes before testing. For more information on the constant polarization feature, see page 9. This feature allows readings to be taken after the meter has been turned off without waiting for the 15 minute warm-up time.

TEMPERATURE

1. Press "°C" button to turn the meter on.
2. Lower probe vertically at least 3.5" into sample. Swirl until display stabilizes.

   NOTE: It may take a minute or so for the display to stabilize (if temperature is very low or very high).
3. Record reading as degrees Centigrade (°C).
4. Press "OFF" button.

DISSOLVED OXYGEN READING

1. Press "O_2" button to turn the meter on.
2. Set the "SALINITY COMP" knob to the salinity of the sample water.
3. Keeping probe at an angle, slowly lower at least 3.5" into sample. Tap probe against side of beaker to remove air bubbles. Stir solution gently with probe until display stabilizes. If testing deeper water, gently raise and lower probe several times to remove air bubbles. Continue to raise and lower to avoid oxygen starvation at the membrane.

   NOTE: It may take a minute or so for the display to stabilize. If readings are erratic, see Troubleshooting on page 18.
4. Record reading as ppm Dissolved Oxygen.
5. Press "OFF" button and **turn off constant polarization unless meter is to be used again shortly**.

PERCENT SATURATION READING

1. Press "%SAT" button to turn meter on.
2. Set the Salinity Compensation knob to the salinity of the sample water.
3. Keeping probe at an angle, slowly lower at least 3.5" into sample. Tap probe against the side of the beaker to remove air bubbles. Stir solution gently with probe until display stabilizes. If testing deeper water, gently raise and lower probe several times to remove air bubbles. Continue to raise and lower to avoid oxygen starvation at the membrane.

   If readings are erratic see Troubleshooting on page 18.
4. Record reading as percent (%) Saturation.
5. Press "OFF" button and **turn off constant polarization unless meter is to be used again shortly**.

TROUBLESHOOTING

If dissolved oxygen readings appear erratic or unusual, there are several things which can be checked.

1. Check that the BAT Low indicator is not on. The temperature function will be the first function to be affected by a low battery. Replace the battery as soon as possible.
2. There may not be enough sample flowing over the membrane. Try stirring the sample faster or steadier. Do not stir fast enough to cause bubbles or splashing.
3. Check the connection between the probe and the meter.
4. The probe may be fouled. Look closely at the membrane; if it looks dirty or wrinkled it should be replaced. See Cleaning the Probe on page 20.
5. If calibration is not successful after following Step 4, adjust the "Slope adjustment pot" according to instructions on page 15.

METER CARE

CONNECTING THE PROBE

If it is necessary to remove probe from the meter, reconnect the probe with the arrow on the probe connector facing up. See diagram below for the proper connection to the meter.

REPLACING THE BATTERY

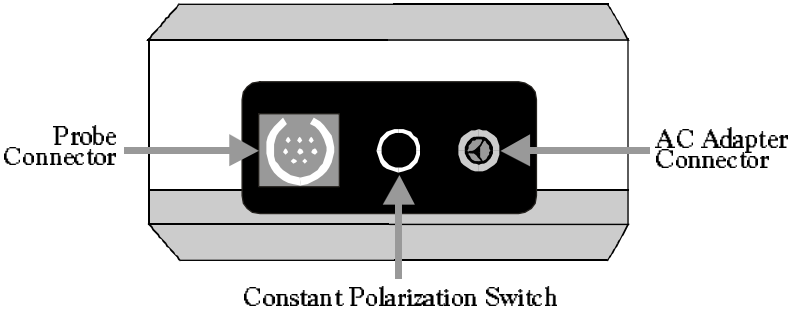
When "BAT" appears on the display, the battery should be changed. The DO 4000 uses a type 1604A (9 volt) replaceable or rechargeable Nickel/Cadmium battery.

1. Use a #1 Phillips head screwdriver to remove the four screws on back of the meter case.
2. Gently lift back panel from meter.
3. Lift battery from bottom of meter. Remove battery from connector.
4. Snap new battery onto connector.
5. Lower the new battery back into the meter.
6. Replace back panel. Replace screws. Wait 15 minutes for the DO 4000 to repolarize after replacing the battery.

AC ADAPTER

An AC adapter is available for use with the DO 4000 (order LaMotte Code 1708). See diagram below for the proper connection to meter.

NOTE: The use of an AC Adapter other than the one supplied by LaMotte Company may damage the meter and will void the meter warranty.



CLEANING THE PROBE

THE CATHODE

1. Remove membrane cartridge, wipe probe dry.
2. Lay crocus paper on a table or other flat surface.
3. Holding the electrode vertically, gently move the tip over the crocus paper in a circular motion.

THE ANODE

1. Remove membrane cartridge.
2. Dip a toothbrush in a dilute ammonia solution.
3. Gently rub toothbrush over the silver anode. Continue until the deposits have been removed.
4. Rinse with deionized water before reassembly.
5. Reassemble the probe. Wait 15 minutes for probe to polarize before use.

WARRANTY INFORMATION

PACKAGING AND DELIVERY

Experienced packaging personnel at LaMotte Company assure adequate protection against normal hazards encountered during shipping. After the product leaves the manufacturer, all responsibility for its safe delivery is assured by the transporter. Damage claims must be filed immediately with the transporter to receive compensation for damaged goods.

REPAIRS

If it is necessary to return the instrument for repair, contact LaMotte Company at 1-800-344-3100 for a return authorization number.

INSTRUMENT GUARANTEE

The meter and probe are guaranteed to be free of defects in material and workmanship for twelve months from original purchase. If in that time it is found to be defective, it will be repaired without charge, except for transportation expenses. This guarantee does not cover the batteries.

This guarantee is void under the following circumstances:

- operator's negligence
- improper application
- unauthorized servicing

NOTE: The use of an AC Adapter other than the one supplied by LaMotte Company may damage the meter and will void the meter warranty.

LIMITS OF LIABILITY

Under no circumstances shall LaMotte Company be liable for loss of life, property, profits or other damages incurred through the use or misuse of their products.

REPLACEMENT PARTS & ACCESSORIES

DESCRIPTION	CODE
DO probe & cable	1913
Membrane replacement package (includes 2787-G & 3 membrane cartridges)	1914
DO Filling Solution, 30 mL	2787-G
Spoon, 0.1g	0699
Double Magnetic Stirrer	1776
AC Adapter, 9 volt	1708
Dissolved Oxygen Kit, Winkler Titration	7414
Dissolved Oxygen Kit, Winkler Titration, Liquid Acid Version	5860
Deionized Water (*-G, 30 mL; -L, 500 mL; -N, 3800 mL)	5115-*
Beaker, 1 liter, glass	2-2027
Sodium Sulfite, 5g	3970-C
Cobalt Chloride, 5g	3971-C

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