UNDERSTANDING DISSOLVED OXYGEN

Dissolved oxygen (DO) is one of the most important water quality parameters across environmental monitoring, aquaculture, wastewater treatment, laboratories, and industrial processes. Understanding what dissolved oxygen is, what affects it, and how to measure it correctly is essential for obtaining reliable results.

WHAT IS DISSOLVED OXYGEN?

Dissolved oxygen (DO) is the amount of molecular oxygen (O_2) dissolved in water. It is one of the most important indicators of water quality because oxygen is essential for aquatic life and many biological and chemical processes.

Dissolved oxygen meters measure the concentration of oxygen dissolved in a liquid and typically display results using one of two measurement scales:

mg/L (ppm)

Milligrams of dissolved oxygen per liter of water. This value represents the actual concentration of dissolved oxygen present in the sample.

% Saturation

The percentage of dissolved oxygen relative to the maximum amount the water can hold under the current environmental conditions. Unlike mg/L, % saturation automatically takes into account factors such as temperature, atmospheric pressure, and salinity.

GOOD TO KNOW

mg/L tells you how much oxygen is present.

% saturation tells you how close the water is to its oxygen-holding capacity under the current conditions.

WHY IS DISSOLVED OXYGEN IMPORTANT?

Dissolved oxygen is a critical parameter wherever water quality affects biological activity, industrial processes, or environmental health. Whether supporting aquatic life, optimizing treatment efficiency, or protecting equipment from corrosion, accurate DO measurement helps ensure safe, stable, and efficient operation across a wide range of applications.

Natural Waters

The dissolved oxygen level is a key indicator of water quality and ecosystem health. Low DO concentrations may indicate pollution, excessive organic matter, or poor water circulation.

Aquaculture & Fish Farming

Maintaining adequate dissolved oxygen levels is essential for fish health, growth, reproduction, and survival. Continuous monitoring helps prevent stress, disease, and mortality caused by oxygen depletion.

Wastewater Treatment

Biological treatment processes rely on sufficient dissolved oxygen for microorganisms to efficiently break down organic matter. Accurate DO monitoring helps optimize aeration, improve treatment efficiency, and reduce energy consumption.

Industrial Water Systems

In closed-loop systems, boilers, and cooling circuits, dissolved oxygen can accelerate corrosion, particularly at elevated temperatures. Monitoring DO helps protect equipment and extend system life. Beyond these primary applications, dissolved oxygen monitoring is also widely used in laboratories, brewing and beverage production, winemaking, paper manufacturing, bioreactors, environmental research, and many other water quality applications:

- Aquaculture
- Environmental Monitoring
- Wastewater Treatment
- Industrial Water Systems
- Laboratories
- Wine production
- Brewing & Beverage

WHAT AFFECTS DISSOLVED OXYGEN?

The amount of Dissolved Oxygen in water depends on 3 factors:

Temperature

The amount of DO increases with the decreasing of temperature – Colder water holds more oxygen. Temperature compensation is necessary for standardized D.O. measurements.

Salinity

The presence of dissolved solid limits the amount of oxygen that can dissolve in water. Amount of DO increases with the decreasing of salinity – Freshwater holds more oxygen than saltwater does.

Atmospheric pressure

The amount of DO decrease with decreasing of atmospheric pressure – amount of DO absorbed in water decreased as altitude increases

Water movement

Standing water generally contains less oxygen than flowing or aerated water.

HOW DISSOLVED OXYGEN IS MEASURED

Dissolved oxygen meters commonly use electrochemical sensors to measure the oxygen present in water. These sensors are separated from the sample by an oxygen-permeable membrane. Oxygen diffuses through the membrane and takes part in an electrochemical reaction inside the probe. The resulting electrical current is proportional to the amount of dissolved oxygen in the sample.
There are two commonly used electrochemical DO sensor types: polarographic and galvanic.

Polarographic DO sensors

Polarographic sensors require an applied voltage before measurement. This means the probe must be polarized before use. During this warm-up period, the sensor stabilizes so that accurate dissolved oxygen readings can be taken.

Polarographic probes are used in instruments such as the Milwaukee MW600 PRO and MW190 MAX bench meter.

Galvanic DO sensors

Galvanic sensors generate their own voltage through the internal chemistry of the probe. Because of this, they do not require conditioning time before measurement.

The Milwaukee MW605 MAX uses a galvanic DO probe, which allows fast operation without probe conditioning time.

Feature	Polarographic sensor	Galvanic sensor
Power principle	Requires applied voltage	Self-generating electrochemical cell
Warm-up / conditioning	Required	Not required
Milwaukee examples	MW600 PRO, MW190 MAX	MW605 MAX
Best suited for	Ideal for routine occasional DO measurements, lab/bench use, education, wastewater	Ideal for daily, fast field measurements, aquaculture, environmental monitoring
Maintenance	Membrane and electrolyte care required	Membrane and electrolyte care required

GOOD TO KNOW

Galvanic sensors continuously generate current through their internal electrochemical reaction. When left unused for long periods, this ongoing reaction gradually consumes the probe components. For occasional measurements, a polarographic sensor may therefore be the better choice.

PRINCIPLE OF OPERATION

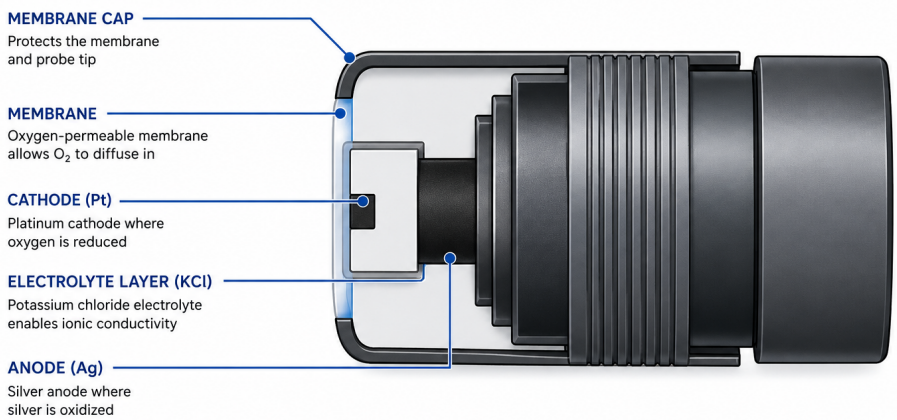
Electrochemical dissolved oxygen sensors measure oxygen by allowing dissolved oxygen molecules to diffuse through an oxygen-permeable membrane into the probe. Inside the sensor, oxygen participates in an electrochemical reaction that generates an electrical current. The magnitude of this current is directly proportional to the amount of dissolved oxygen in the sample, allowing the instrument to display the result in mg/L (ppm) or % saturation.

Polarographic sensor operation

In a polarographic sensor, an external polarization voltage (approximately 790 mV) is applied between the electrodes before measurement. Oxygen entering the probe is reduced to hydroxide ions (OH^-) at the cathode, while silver is oxidized to silver chloride (AgCl) at the anode. Because the electrical current produced by this reaction is proportional to the amount of oxygen diffusing through the membrane, the meter can accurately calculate the dissolved oxygen concentration.

DO PROBE – CROSS-SECTION

Polarographic (Clark-type) Dissolved Oxygen Sensor

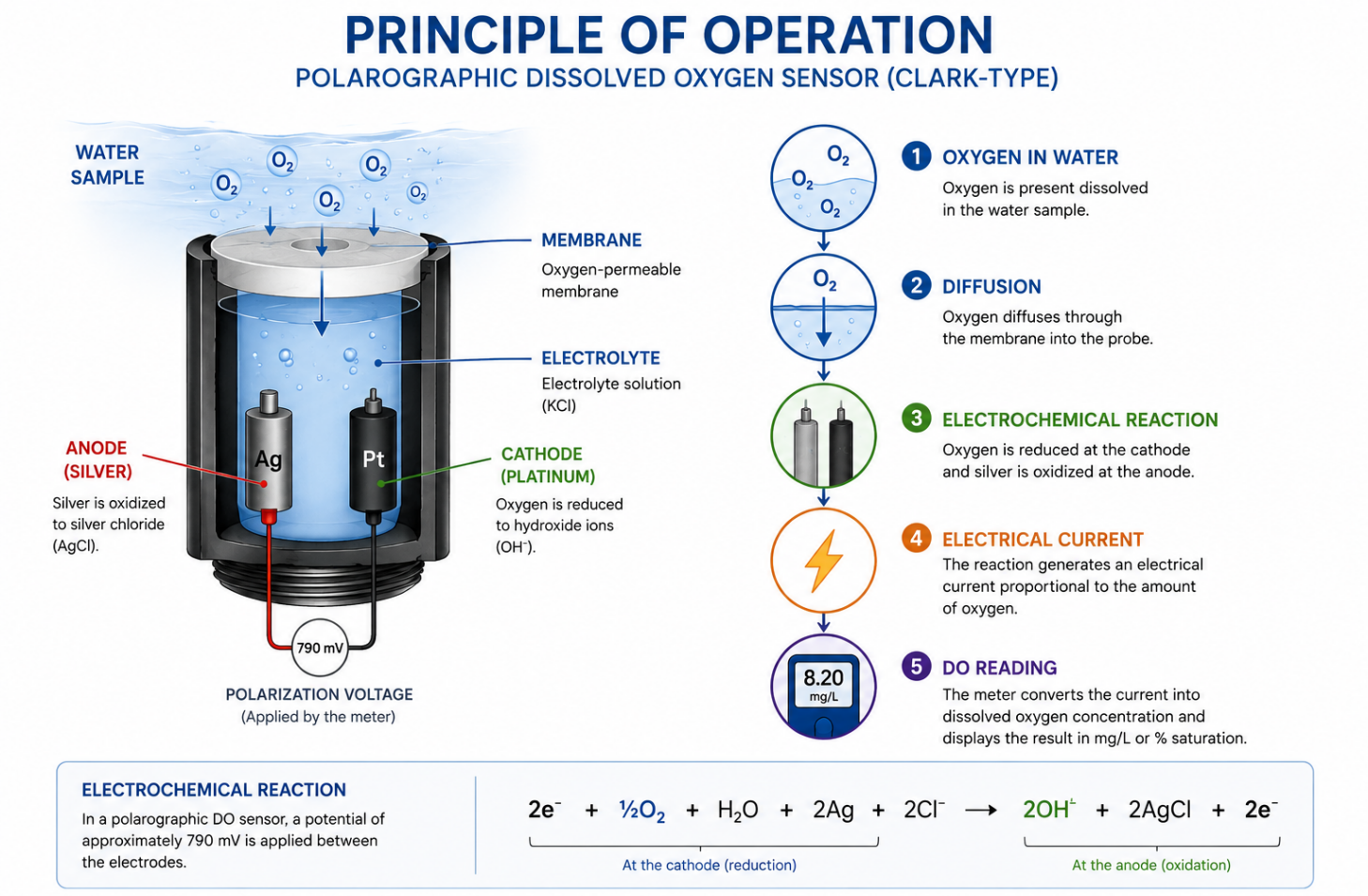


Oxygen diffuses through the membrane into the electrolyte, where an electrochemical reaction occurs between the cathode (Pt) and anode (Ag). The resulting current is proportional to the dissolved oxygen concentration.

Reaction:

$$2e^- + \tfrac{1}{2}O_2 + H_2O + 2Ag + 2Cl^- \rightarrow 2OH^- + 2AgCl + 2e^-$$

NOTE: This reaction describes the operating principle of a Clark-type polarographic dissolved oxygen sensor. Galvanic sensors operate on the same electrochemical measurement principle, but generate the required voltage internally through their electrode materials, eliminating the need for a polarization (conditioning) period before use.



Why is a membrane used?

The membrane allows oxygen molecules to pass into the probe while preventing water and contaminants from entering. This protects the electrodes and ensures that only dissolved oxygen contributes to the measurement.

MEMBRANE VS. WATER

Although water cannot pass through the membrane, oxygen molecules can. This selective permeability is what makes electrochemical DO measurement possible. The membrane creates a controlled environment inside the sensor, allowing only dissolved oxygen to participate in the electrochemical reaction while protecting the electrodes from contamination.

PRO TIP: Some experienced users let a new membrane sit overnight with deionized water before filling the cap with fresh electrolyte. This can help the membrane settle, making it easier to achieve a bubble-free assembly.

FACTORS THAT INFLUENCE MEASUREMENT ACCURACY

Obtaining reliable dissolved oxygen measurements requires more than simply placing the probe into the sample. Both environmental conditions and proper probe maintenance influence the accuracy of the results.

Temperature

Water temperature has a major influence on dissolved oxygen. Cold water can hold significantly more oxygen than warm water, while increasing temperature reduces oxygen solubility. Because dissolved oxygen saturation changes with temperature, temperature compensation is essential for accurate measurements. Most modern DO meters automatically compensate using a built-in temperature sensor.

Salinity

Dissolved salts reduce the amount of oxygen that water can hold. Freshwater therefore has a higher dissolved oxygen capacity than seawater at the same temperature. When measuring saltwater or brackish water, salinity compensation should be applied to ensure accurate results.

Atmospheric Pressure

Atmospheric pressure directly affects oxygen solubility. At higher altitudes, where atmospheric pressure is lower, water reaches 100% oxygen saturation at a lower dissolved oxygen concentration. For this reason, professional DO meters often allow atmospheric pressure or altitude compensation.

Membrane Condition

The membrane is a critical part of the sensor. It must remain clean, intact, and free from wrinkles or damage. A damaged, contaminated, or aging membrane can slow oxygen diffusion and cause inaccurate or unstable readings.

Electrolyte Condition

The electrolyte solution enables the electrochemical reaction inside the probe.
Over time, the electrolyte becomes depleted or contaminated and should be replaced according to the manufacturer's recommendations. Fresh electrolyte helps maintain sensor stability and accuracy.

Air Bubbles

When replacing the membrane cap, trapped air bubbles inside the electrolyte chamber should be avoided. Air bubbles reduce the effective sensing area and may lead to unstable or inaccurate measurements.

Probe Cleanliness

Deposits, biofilm, algae, or other contaminants on the membrane can interfere with oxygen diffusion. The probe should be inspected regularly and cleaned using the procedures recommended by the manufacturer.

Calibration

Regular calibration is essential for obtaining reliable dissolved oxygen measurements.
Most routine applications require calibration in water-saturated air (100% calibration). A zero-oxygen calibration using sodium sulfite solution may also be performed when higher measurement accuracy is required or as part of routine verification.

DID YOU KNOW?

At 0°C, freshwater can hold almost twice as much dissolved oxygen as warm water at 35°C.

Common Measurement Mistakes

Even with a properly functioning dissolved oxygen meter, incorrect measurement techniques can lead to inaccurate results. The following are some of the most common mistakes encountered during routine DO measurements.

Measuring Before Temperature Stabilizes

Dissolved oxygen is highly temperature-dependent. Allow sufficient time for the probe and sample to reach thermal equilibrium before recording the measurement.

Using a Damaged Membrane

A torn, wrinkled, or contaminated membrane affects oxygen diffusion into the probe and can result in unstable or inaccurate readings. Inspect the membrane regularly and replace it whenever damage is observed.

Trapped Air Bubbles Inside the Membrane Cap

Air bubbles introduced during electrolyte replacement reduce the effective sensing area and interfere with the electrochemical reaction. Always ensure the membrane cap is filled correctly and free of trapped air.

Incorrect Salinity Compensation

When measuring seawater or brackish water, failing to enter the correct salinity value will lead to incorrect dissolved oxygen results.

Dirty Probe

Biofilm, algae, mineral deposits, or other contaminants on the membrane can slow oxygen diffusion and reduce measurement accuracy. Clean the probe according to the manufacturer's recommendations.

Infrequent Calibration

Calibration should be performed regularly, especially after membrane or electrolyte replacement, extended storage, or when high measurement accuracy is required. An improperly calibrated sensor can produce systematic measurement errors.

Best Practices for Accurate DO Measurements

- Allow the probe to reach temperature equilibrium.
- Enter the correct salinity and altitude settings when applicable.
- Keep the membrane clean and undamaged.
- Replace the electrolyte and membrane when necessary.
- Remove any trapped air bubbles after refilling the probe.
- Calibrate the instrument regularly.
- After filling the membrane cap with electrolyte, gently tap or flick the cap before installing it. This helps release small trapped air bubbles that may otherwise affect the measurement.
- Keep the probe or sample moving during measurement. Oxygen must continuously diffuse across the membrane surface. In completely stagnant water, oxygen near the membrane becomes depleted, resulting in artificially low readings.

TIP: Polarographic probes require a polarization (conditioning) period before measurement, while galvanic probes are ready for use immediately after power-up. Always follow the operating procedure recommended for your specific sensor type.

PRACTICAL CONSIDERATIONS FOR POLAROGRAPHIC DO SENSORS

Like any electrochemical sensor, polarographic dissolved oxygen probes require periodic maintenance to ensure long-term accuracy and reliable performance. The following characteristics are inherent to the operating principle of Clark-type sensors.

Silver Chloride Build-up

During normal operation, silver chloride (AgCl) gradually forms on the silver anode as part of the electrochemical reaction. Over time, excessive AgCl deposits can reduce sensor performance and eventually prevent the reaction from occurring. Periodic cleaning or maintenance of the anode is therefore required.

Electrolyte Aging (Zero Drift)

As the electrochemical reaction continues, hydroxide ions (OH^-) accumulate within the electrolyte solution, gradually changing its chemical composition. This can lead to measurement drift over time, making periodic electrolyte replacement necessary to maintain measurement accuracy.

Electrolyte Depletion

The electrochemical reaction also consumes chloride ions (Cl^-) from the electrolyte.
As the electrolyte becomes depleted, the sensor response deteriorates. Replacing the electrolyte restores proper sensor operation.

Polarization Time

Unlike galvanic sensors, polarographic probes require an external polarization voltage before measurements can begin. After the probe is connected or after electrolyte replacement, a conditioning period is required for the electrochemical system to stabilize. Measurements taken before full polarization may produce inaccurate results.

GOOD TO KNOW

These characteristics are specific to polarographic dissolved oxygen sensors. Galvanic sensors eliminate the need for polarization time but still require regular membrane inspection and electrolyte maintenance.

CALIBRATION AND MAINTENANCE

Calibration

- 0 oxygen solution (sodium sulfite saturated solution - Milwaukee MA9070)
- 100% in air. Air-saturated water represents a stable reference point with a known oxygen saturation value. For this reason, routine calibration is normally performed at 100% saturation rather than at a specific mg/L value.

Maintenance

- The electrolyte solution must be maintained at a set level and it has to be replaced periodically.
- When replacing the electrolyte solution, the probe must be polarized to eliminate any residual oxygen that may still be present in the cell
- The duration of the polarization process can vary from a few minutes to several hours. Milwaukee instruments' oxygen meters complete the polarization process in approximately 6 minutes
- Avoid trapping air bubble. After filling the membrane cap with electrolyte, gently tap or flick the cap before installing it. This helps release small trapped air bubbles that may otherwise affect the measurement.
- Membrane integrity & cleaning

WHICH DO METER FITS YOUR APPLICATION?

MW605 MAX Waterproof Galvanic DO Meter

Best for fast, portable DO measurements in the field. Its galvanic probe requires no conditioning time and supports automatic temperature compensation, altitude compensation, salinity compensation, data logging, and USB export.

SPECIFICATIONS

O_2 Range*:	0.0 to 45.00 mg/L (ppm)
O_2 Range:	0.0 to 300.0 % Saturation
Range Temperature:**	-20.0 to 120.0 °C (-4.0 to 248.0 °F)
O_2 Resolution:	0.01 mg/L (ppm) / 0.1 % Saturation
Temperature Resolution:	0.1 °C (0.1 °F)
O_2 Accuracy:	±1.5% of reading ± 1 digit
Temperature Accuracy:	± 0.4°C (±0.8°F)
Calibration:	One or Two % saturation calibration points 0 % (MA9070) and 100 % (water saturated air)
Temperature Compensation:	Automatic, from 0.0 to 50.0°C (32.0 to 122.0 °F)
Altitude compensation:	-500 to 4,000 m (-1,640' to 3,123') with 100 m (328') resolution
Salinity Compensation:	Manual, from 0 to 40 g/L (with 1 g/L resolution)
Logging/Memory:	Max. 1,000 log records (stored in up to 100 lots) / On Demand, 200 logs / On Stability, 200 logs / Interval logging, 1,000 logs
PC Connectivity:	1 micro USB port
Battery Type:	3 x 1.5V alkaline AA (included)
Battery Life:	Approx. 200 hours of use
Environment:	0 to 50°C / 32 to 122°F; max RH 95%
Dimensions Meter:	8 x 3.3 x 2.0 inches (200 x 85 x 50 mm)
Dimensions Packaging:	14 x 12 x 6.0 inches (355.6 x 304.8 x 152.4 mm)
Weight Meter:	0.57 lbs (260 g)
Weight Packaged:	5.0 lbs (2.27 kg)
Probe:	MA860 Galvanic Probe included
Temperature Range:	0.0 to 50.0°C / 32.0 to 122.0°F
Temperature Sensor:	Built in Thermistor
Cathode:	Silver
Anode:	Zinc
Membranes:	Oxygen permeable PTFE (2) included
Connector Socket:	DIN 7pins
Body:	PP, ABS, IP67 rating
Cable:	Jacket material: PP

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** Do measurement is performed within automatic temperature compensation interval.*
*** Limits will be reduced to actual sensor limits.*

MW600 PRO Dissolved Oxygen Meter

A practical portable DO meter with a refillable polarographic probe. Suitable for wastewater, education, aquaculture, and routine dissolved oxygen testing. Allow approximately 10 minutes for probe polarization before measurement.

SPECIFICATIONS

O2 Range:	0.0 to 19.9 mg/L
O2 resolution:	0.1 mg/L
O2 Accuracy:	±1.5% Full Scale
Calibration:	Manual on 2 points (zero and slope)
Temperature Compensation:	Automatic, from 0 to 30°C
Probe:	MA840 refillable polarographic probe included
Membranes:	5 included
Environment:	0 to 50°C / 32 to 122°F; max RH 95%
Battery Type:	1 x 9V alkaline (included)
Battery Life:	Approx. 70 hours of continuous use
Dimensions:	5.7 x 3.1 x 1.6 inches
Weight:	7.5 ounces with battery

CHOOSING THE MW600 PRO

The MW600 PRO is an excellent choice for users who need reliable dissolved oxygen measurements without the complexity of laboratory instrumentation. Its portable design and refillable polarographic probe make it well suited for routine field measurements, educational use, aquaculture, and wastewater applications.

Compared to galvanic DO meters, the MW600 requires a short polarization period before measurement. In return, it provides stable, repeatable results using a proven Clark-type polarographic sensor, making it a trusted solution for routine dissolved oxygen monitoring.

LEARN MORE

DID YOU KNOW?

The amount of dissolved oxygen that water can hold changes continuously with environmental conditions. Cold freshwater can contain significantly more dissolved oxygen than warm or saline water, even when both samples are at 100% oxygen saturation. This is why professional DO meters compensate for temperature, salinity, and atmospheric pressure to ensure accurate measurements.

MW190 MAX Dissolved Oxygen Bench Meter

A bench DO meter for laboratory and professional use. It uses a polarographic probe, supports automatic calibration, automatic temperature compensation, altitude and salinity compensation, and USB connectivity.

SPECIFICATIONS

O_2 Range:	0.00 to 45.00 mg/L O_2 (ppm)
% Saturation O_2:	0.0 to 300.0% O_2
Temperature Range:	-5.0 to 55.0°C (23.0 to 131.0°F)
O_2 resolution:	0.01 (ppm) mg/L
% Saturation O_2 Resolution:	0.1%
Temperature Resolution:	0.1°C / 0.1°F
O_2 Accuracy:	±1.5% Full Scale
% Saturation O_2 Accuracy:	± 1.5% Full Scale (@20°C / 68°F)
Temperature Accuracy:	± 0.4°C (±0.8°F)
Calibration DO:	Automatic single (offset MA9070) or dual point with slope in 100% saturated air
Calibration Temperature:	2 point at 0 and 50°C (32.0 and 122.0°F)
Temperature Compensation:	Automatic, from 0 to 50°C (32.0 to 122.0°F)
Altitude compensation:	0 to 4000 m (13,120')
Altitude Resolution:	100 m (320')
Salinity Compensation:	0 to 40g/L
Salinity Resolution:	1 g/L
Probe:	MA840/2 polarographic probe (included)
Membranes:	5 included with O-Rings (included)
Computer Interface:	USB
Power Supply:	12 VDC (included)
Dimensions Meter:	230 x 160 x 95 mm (9.0 x 6.3 x 3.7 inches)
Weight:	0.9 kg (2.0 lbs.)
Environment:	0 to 50°C / 32 to 122°F; max RH 95%
Warranty:	3 years (meter)

DESIGNED FOR DEMANDING LABORATORY WORK

The MW190 MAX combines laboratory-grade accuracy with advanced features such as automatic calibration, salinity and altitude compensation, data logging, and USB connectivity. It is an ideal solution for professionals who require reliable dissolved oxygen measurements and complete trace-ability.

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