NOTES ON OXYGEN PROBES

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How Oxygen Probes work

Although dissolved oxygen is usually displayed or expressed as mg/l or ppm (i.e. concentration of dissolved O2), oxygen probes do not measure the actual amount of dissolved oxygen in the water. They measure the pressure of oxygen in the water. The actual amount of oxygen (mg/l or ppm) is determined from the solubility of oxygen which is a function of temperature and salinity. This fact that oxygen probes measure pressure of oxygen and not the amount of oxygen dissolved in water is fundamental in understanding the principles of calibration and troubleshooting of oxygen probes.

Oxygen probes consist of two electrodes, a cathode and an anode. The electrodes are immersed in an electrolyte. A gas permeable membrane separates the probe internals from the outside. Oxygen diffuses through the membrane into the probe where it reacts chemically and produces an electrical current. The higher the oxygen pressure the more oxygen will be forced through the membrane and the higher will be the current produced. Hence, the magnitude of the electrical current produced by the probe is a measure of oxygen pressure. The actual output signal from the probe is the voltage produced when the electrical current flows through a built-in thermister within the probe. Thermisters are variable resistors whose resistance value changes with temperature - resistance decreases with increasing temperature and increases with decreasing temperature. As the resistance of the thermister changes so does the output voltage from the probe. This is how temperature compensation is accomplished within the probe or meter. For example, if temperature increases, the permeability of the membrane increases allowing more oxygen to enter the probe resulting in a higher electrical current being generated even though oxygen pressure has not increased. But as temperature increases, the resistance of the thermister decreases resulting in a corresponding reduction in output voltage, compensating for the increase in electro-chemical activity within the probe.

Temperature compensation is necessary for two reasons: one, to compensate for the permeability of the membrane which changes with temperature and two, to compensate for the solubility of oxygen in water which changes with temperature. The latter compensation is only necessary if dissolved oxygen is to be expressed as a concentration i.e. mg/l or ppm. Compensation for solubility is not necessary if dissolved oxygen is to be expressed as pressure (mmHg) or as %saturation (i.e. expressing the pressure of dissolved O2 as a percentage of the pressure of O2 in the air).

OxyGuard probes can be fitted with two types of membranes depending on how dissolved oxygen readings are to be expressed. The permeability characteristic of the two membranes are different, such that depending on which membrane is used, the output signal will vary with temperature proportional to the changing solubility of oxygen if readings are to be expressed in mg/l (mg/l membrane), or the output signal will remain constant with respect to temperature if dissolved oxygen is to be expressed as %saturation (%sat. membrane). Use "mg/l membranes" for readings in mg/l, use "%sat. membranes" for readings in %saturation. If a "mg/l membrane" is installed on a probe when %saturation readings are required, then readings will be erroneously low when temperature increases and erroneously high when temperature decreases.

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Note: OxyGuard Handy's use %sat. membranes. Handy's display readings in either %sat. or mg/l. - the "%sat." signal from the probe is converted to mg/l by electronics within the meter.

The Principal of Air Calibration

Water absorbs gases - oxygen, nitrogen, air etc. - the amount of gas that can be absorbed depends on the pressure of the gas in contact with the water as well as the solubility of the gas in the water. When the pressure of dissolved oxygen in the water equals the pressure of oxygen in the air we say the water is 100% saturated.

Since an oxygen probe measures oxygen pressure, it will put-out the same signal when placed in air as it would when placed in air saturated water at the same temperature as the air. When doing an air calibration we are using the oxygen in the air as a calibration standard. The user can designate any value he or she chooses to the air calibration signal. The signal can represent mg/l or it can represent %saturation. If the user chooses mg/l, then he or she must look up O2 solubility tables to determine the amount of O2 in air saturated water at the particular air calibration temperature and for the altitude and salinity of the water being measured. The unit is then set to the appropriate reading in mg/l. If the user chooses %sat., the unit should be set to 100%* irrespective of temperature, salinity or altitude. Subsequent measurements, of course, will be taken at different temperatures than the air calibration temperature, so mg/l values will have to be corrected for temperature. Because most, if not all, O2 meters on the market have automatic temperature compensation, mg/l values will be automatically corrected for temperature. Oxygen meters "convert" the pressure measurement from the probe into mg/l of dissolved oxygen. Oxygen meters usually do not have automatic salinity compensation (for this you would need a built-in salinity probe), so salinity compensation is done manually at time of calibration.

Even though oxygen meters have automatic temp. compensation, it is always best to try and do an air calibration as close as possible to the actual water temperature. This will limit calibration error. The closer the air cal. temp. to the water temp., the more accurate will be the calibration. Also, never attempt to calibrate a probe if it has just been moved to an area of different temperature. The probe must be at the same temperature as the air before doing an air calibration.

* Note: To account for water vapour pressure and because the membrane is a little less permeable when wet than when dry, the unit should be set to 101%. For OxyGuard Handy's Alpha and Beta, the 101% setting when doing an air calibration only applies to fresh water at sea level. A different %sat. setting has to be applied for elevations above sea level or for saline water if readings are to be taken in mg/l. This results in %sat. readings being incorrect. If readings are to be taken in %sat. then no adjustments are necessary for altitude or salinity - the unit is always set to 101% . But readings in mg/l will then be incorrect. This means that the user can choose readings in either %sat or mg/l - not both - only one of them can be correct. With the Handy Gamma, on the other hand, it is possible to set the unit up for actual altitude and/or salinity and then the meter will display both %sat. and mg/l readings correctly.

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