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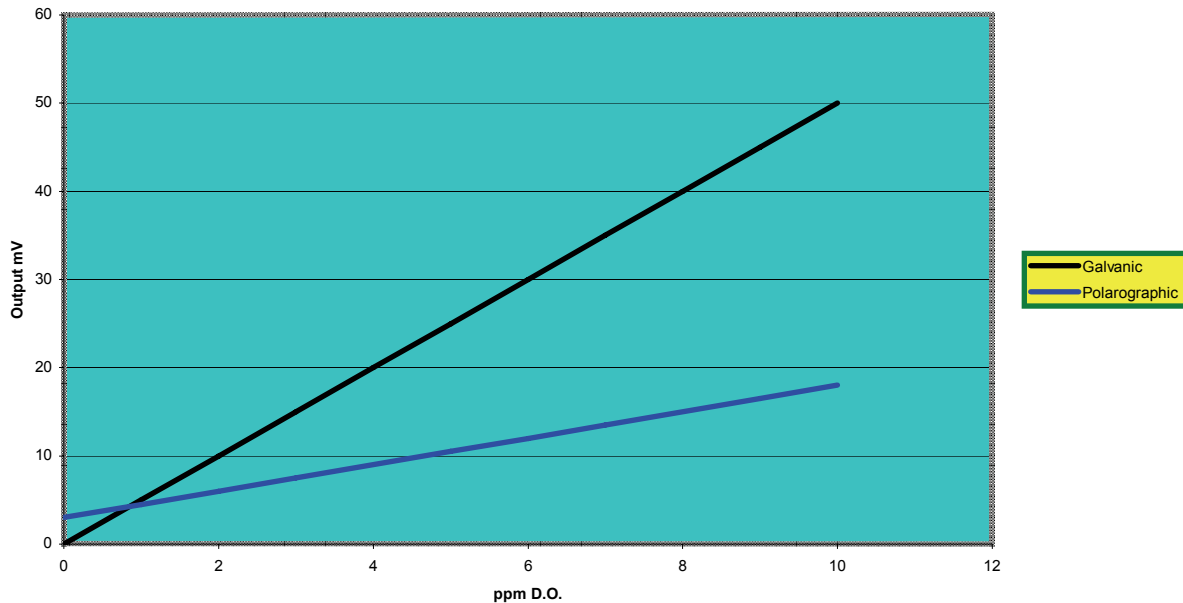
Measuring Dissolved Oxygen Below 2 PPM in Biological Reactors

Almost all dissolved oxygen analysers are calibrated using air as the reference. At 25°C, the saturation value of oxygen in water is 8.4ppm. However, oxygen concentrations in a biological reactor (aerobic and anaerobic zones) normally range from 2.0 ppm down to zero. Very few manufacturers recommend checking the zero point, even though the measurement range is much closer to zero than the air calibration point.

There are 4 basic sensor technologies available today, and their low range measurement capabilities are as follows:

- 1. Galvanic (membrane).** The anode and cathode are immersed in an electrolyte, into which oxygen permeates through a membrane. The galvanic sensor converts oxygen into a voltage (via a sacrificial anode) that is proportional to the amount of dissolved oxygen. Therefore, the sensor has an absolute zero. Zero D.O. = Zero output.
- 2. Galvanic (no membrane).** The electrodes of this sensor are exposed to the wastewater, which is used as the electrolyte. The sensor is calibrated in oxygen saturated water. As water has different pH and conductivity values to that of wastewater, there can be no certainty that the measurement, especially below 2ppm, is accurate.
- 3. Polarographic (membrane).** Sometimes called amperometric. The anode and cathode are immersed in an electrolyte, into which oxygen permeates through a membrane. It differs dramatically from a galvanic sensor in that the anode has to be polarized, after which a current flows in the sensor. So at 0 ppm D.O., the sensor has an output which is offset by the parent analyser. As the sensor ages, it's zero offset changes.
- 4. Optical (Fluorescent).** Sometimes called Luminescent. A certain wavelength light is focused onto a fluorescing material, which produces light at a different wavelength. The presence of oxygen slows or reduces the amount of fluorescent light produced. As light is constantly produced in a bandwidth rather than an absolute wavelength, there is no absolute zero. However, as the measurement is frequency (rate of change) based, there is no drift as long as the signal strength is reasonable. However, the detector sees any light (sunlight, area lighting etc) as a change in oxygen concentration, so it must be calibrated and operated in an almost black box environment. It must be submersed into a reactor, sometimes cannot normally be used in effluent channels, and in some cases the sensor is irreparably damaged by sunlight.

D.O. Sensor Curves



Development History

The Clark Cell principal for the measurement of dissolved oxygen, both galvanic and polarographic was developed in the 1960's. Over the years major advancements were made, such as the use of pure electrodes rather than plated ones, and electrochemically cleaned membranes.

The optical measurement technique has also been available for several decades. But there is a major problem in that the fluorophore is soluble in water. So the material needs to be bonded to another material, which impedes or stops the degradation of the fluorescing material. Only the Ruthenium (fluorophore) / Silicon (bond) matrix does this, and this sensor is patented and licensed to one manufacturer.

Third Party Verification

While there have been numerous tests and evaluations carried out in the wastewater industry since the 1980's, the only independent, scientific evaluation of all sensor technologies was performed in 2002/2003.

The Instrument Testing Authority carried out testing of 10 D.O. analysers in Decatur, Illinois over a 3-month period. The comprehensively documented report makes no recommendations or draws conclusions, it simply reports on the performance of the technologies.

The report can be found at www.instrument.org

Operation in Biological Reactors

Fundamentally, the galvanic membrane sensor is the superior technology at the moment. In time the optical technology may prove to be equal, but only where the fluorescing material can be made impervious to water, as is the case with one sensor that is patented.

There are many myths associated with accurate, reliable on line D.O. measurement. So much so that there are some who flatly refuse to use anything but timers for control. Others have tried ORP to control D.O., and some have used nutrient monitors. Some have simply given up and set blowers to fixed settings.

A primary requirement in these reactors is biological nutrient removal. A common methodology is to control D.O. at below 0.5ppm so that nitrification and denitrification occur simultaneously. This requires D.O. analysers to reliably and accurately measure under 0.5ppm, and history has shown only galvanic membrane D.O. sensors are reliable and accurate at this concentration.

Modern reactors are commonly designed with two zones, aerobic and anaerobic. This somewhat reduces the reliance on D.O. analysis, as nitrification and denitrification are bound to occur. However, without D.O. control, the process is inefficient, and the delay in using nutrient results for control is similarly inefficient. Using timers or fixing airflows is even less efficient, and results in increased sludge removal and/or chemical costs.

Conclusion

A reliable dissolved oxygen analysis system costs approximately 0.1% of a biological reactor project cost, so there is no valid reason for not purchasing D.O. instrumentation for the reactor, and certainly not the cheapest available instrumentation. It is well publicized that approximately 60% of a plant's operational cost is due to blower electricity consumption, so a reliable D.O. monitoring/control system is quickly paid for in electrical savings alone.

The selection of such a D.O. system needs to be made based on accuracy, long-term reliability and maintainability. There are systems available that are proven to operate accurately and reliably for 12 months or more with no maintenance whatsoever. Selecting the right dissolved oxygen analyzer is paramount in improving treatment and lowering costs.



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