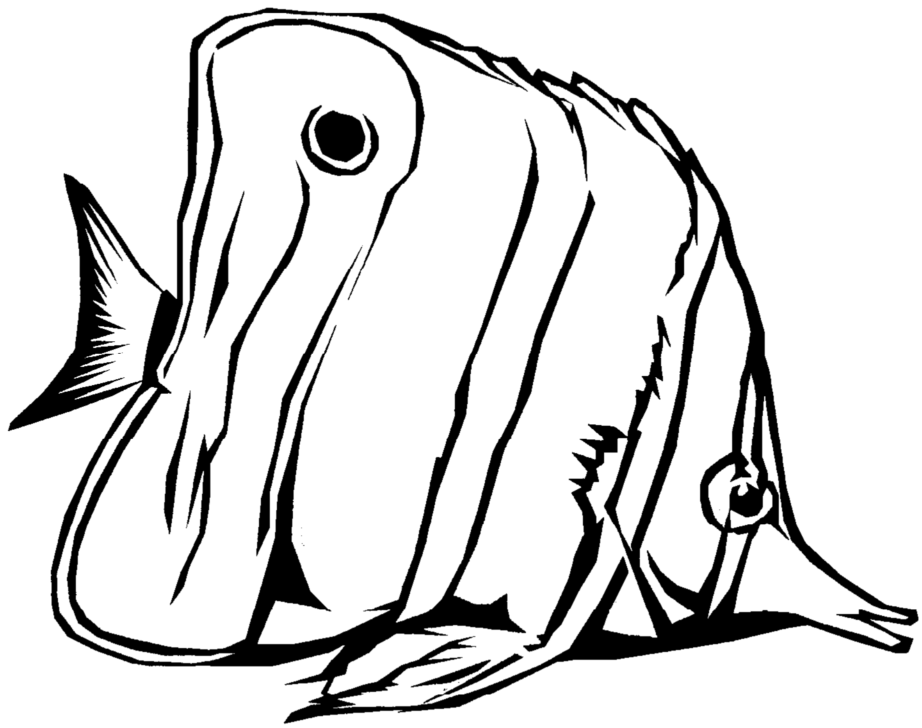
ORP

Sounds Fishy Doesn't it!



A Layman's Guide to Simplified Water Quality Utilizing ORP Sensing Technology

Author: Marc R. Cartier
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What is ORP (Redox) ?

ORP or Redox is a measurement of a solution's ability to oxidize or reduce. Presence of oxidizers in a water system will cause organics in the system to be oxidized, or destroyed (often called disinfection). Although this is a necessary process for our drinking water, excess oxidizer discharged into a lake, stream, or aquarium will literally kill the ecostructure of that system.

Why should we oxidize (disinfect) the water.... the fish might not like it ?

Nature does a fine job of disinfection with tidal activity, wave action, ultraviolet radiation, evaporation, and an immense buffering and filtering capacity all contributing to the maintenance of a healthy water system required for life support. Humankind has yet to duplicate natural systems on a scale small enough to be practical without the need for daily attention to those systems, and just when the water obtains a healthy balance, we add fish to the process. Fishes' main purpose is to alter the nice balance created. As with all organic species, fish will produce waste products that must be disinfected, or the ecosystem will be destroyed by a surge in the growth of bacteria and or algae capable of consuming massive amounts of oxygen and spreading disease. Oxidation of the water as it is re-circulated and filtered is needed to control oxidizer levels and maintain a healthy system.

What sort of oxidizers are used ?

Chlorine, Bromine, and Ozone are the three primary oxidizing agents used within fresh and saltwater pools and aquariums. Chlorine has been used almost exclusively for many years within the United States with Ozone being the oxidizer of choice in Europe. There are pro's and con's for each, chlorine for instance has a long term residual effect necessary for water distribution, but can form harmful compounds (chloramines) as it reacts with organic compounds. Ozone is gaining in popularity however it cannot retain a residual level as long, it also offers the ability to react with Bromine in such a way as to re-activate the free Bromine ion. Ozone/Bromine systems are rapidly replacing Chlorine in commercial pools and spas. Ozone gas, like Chlorine gas is highly toxic and handling is a major concern. A few systems are available today that are designed to liberate Ozone from the atmosphere, or Chlorine from saltwater electrically allowing for generation of the needed oxidizer without a need to transport and handle gas filled bottles.

If a little is needed, is a lot of oxidizer better.....or can fish be too clean ?

There is no one single oxidizer level which is ideal for all species; that would be simple. Some species can withstand relatively high oxidizer levels, marine mammals for example, whereas species with gills are very sensitive to the level of oxidizer within the water system. If dissolved oxidizer levels are excessive, gas can form on the gills reducing their ability to respire. The typical ORP ranges encountered in aquariums are from 200 to 400 mV's, as measured using ORP sensors.

Do ORP sensors indicate precise oxidizer levels (ppm) ?

ORP sensors work by measuring the electrical activity of ions in solution. In natural waters ions are constantly associating and dissociating. Additionally, solutions that are not stable in air can be difficult to measure repeatedly with the same result. ORP can only be used as a general purpose indication, and not used to determine a precise level.

If ORP is not precise why is it used ?

ORP is not capable of being used to obtain an absolute or ppm (part per million) value, however (AND THIS IS IMPORTANT) it is used to observe and track trend changes within a system. If the oxidizer levels rise or fall, the ORP level will also rise and fall. This is known and ORP guidelines have been established based on average values. In fresh water titration can provide fairly precise ppm values allowing a calibration to an established value. Saltwater cannot be tested using typical titration chemistries due to interference by ions such as ammonia and iodine and so another reference must be used. ORP systems allow for trending and since the sensing technology is cheap, can be affordably installed to record and alarm if conditions become unacceptable.

If it is not precise in process (saltwater) how is it calibrated ?

ORP systems are calibrated by immersing the sensor in solutions known to produce a stable mV value. pH buffers 4 and 7 saturated with quinhydrone yield 64 mV and 285 mV respectively. Additional non-quinhydrone based solutions are available with a range of from 200 to 500 mV's. Care must be taken in handling these references since most are toxic.

If calibrated in mV, with a precise reference solution, I must obtain a precise process value, right ?

Not exactly. The ORP calibration performed with reference solutions verifies the accuracy and repeatability of the **electrical** system. Differences in readings can occur from probe to probe from a single manufacturer and can very even more between manufacturers, even though they agree in reference testing. This is primarily due to two reasons. The first is due to construction differences. Platinum surface area and reference construction can cause differences particularly in solutions which see interference from atmospheric oxygen. A second cause for discrepancies is the difference in immersion location and duration. Since most commercial or research aquariums comprise several hundred thousand gallons, you can be sure that there will be different ORP levels found within the water system. It is easy to visualize this concept if you imagine that at any point in time, a fish (or large marine mammal) may have defecated near the sample drawn and not near a permanently installed sensor. The time a sensor is immersed is another important factor. All ORP probes will drift from their initial reading when immersed for a length of time. This drift that occurs initially is known as equilibration and may take from 15 minutes to 48 hours (this differs manufacturer to manufacturer). Equilibration may occur after calibration due to the change in platinum surface condition. Chemically, pH, temperature, depth, sunlight exposure, algae, respiratory processes of plant and animals all can cause fluctuations in ORP levels detected. Location should allow for a representative sample of the process.

How do I know where to best locate the sensor ?

Testing and obtaining profiles of various ORP readings within the system can yield data on the best location for trend development or safeguarding prior to the introduction of species. Sensor placement is unfortunately normally dictated by manufacturer preference or determined by the contractor for mechanical reasons of service access and may not be optimally placed for the best trend development. It is the life support system operators who must make the installed ORP systems work, ...accurately! The intended use is important and so is service access but they cannot override the need for a representative sample. If it is to detect a failure in the de-gassing system before returning water to the pool; it should be far enough from the oxidizer addition system to last an optimal period; and yet, not too near the pool that the system can't be protected from ORP level excesses. If it is to gauge optimal oxidizer levels, it should be placed where the value is least variable and best represents the system as a whole.

General tips on installation:

1. Choose sensors with the best materials of construction for the application. CPVC bodies and HDPE junctions offer good corrosion resistance. Flat sensing surfaces enable simple and effective cleaning, minimize breakage and reduce the rate of fouling in in-line systems.
2. Mount the sensor suitably for the process of interest. Submersion within a tank may prove to be advantageous with respect to probe access and system integrity. ORP probes, like pH probes require routine removal and re-calibration.
3. Flow rates on in-line sensors should be only moderate, not exceeding four feet/second.
4. Mount the sensor within 0 to 45 degrees from TDC to prevent an internal open circuit within the gel or liquid filled sensor.
5. Sensor cables should be placed in conduit, away from AC wiring, and shoud allow length for service
6. Sensor and monitor/transmitters should be co-located to enable simple single-handed calibration.

The instrumentation is installed, now how do I obtain an accurate trend if a baseline doesn't exist?

The better you are at tracking the variables mentioned above, the better your results will be in establishing a baseline. This includes knowledge of oxidizer addition or generation, filtration system performance, and most important fish species and health. A properly balanced system will be reflected in great water quality and healthy ecosystems. Follow established guidelines for baseline development and don't adhere to hard and fast ORP (mV) numbers obtained after calibration. A newly commissioned system using a single ORP probe may indicate mV values fifty mV's greater or lower than expected. This perceived difference is that particular probes mV reaction to the process in question and the fifty mV difference can be calibrated out to agree with the expected result. Linearity of the probe is not affected by this "offset" term (Remember that in saltwater systems in particular, and in ammonia or urea laden solutions the probe will require time for equilibration).

What is a recommended maintenance interval ?

The sensors will change over time due to coating or biofouling of the sensor surfaces, due to contamination of the reference, and just aging in general. The general recommendation is to start with a weekly interval (remembering equilibration), and to slowly back off of that aggressive schedule to determine an optimal interval for cleaning and calibration. It may be necessary to clean without the need for re-calibrating or vice versa.

What does it mean to maintain........the sensor, the sensor ?

ORP sensor construction is fairly simple (if you're not the one building it) to understand and even simpler to maintain. They consist of a platinum wire forming the center conductor of a BNC connection with an internal reference electrode connected to the BNC outer conductor. The platinum detects a voltage from the ions in solution acting as a transport mechanism through the probe. The sensors are normally directly connected to a preamplifier which converts the electrical (mV) potential from the sensor from a very high impedance (low current) output to a low impedance (high current) output. This provides for better signal detection. The first step to maintenance is the removal from the process and a visual inspection of the platinum surface and junction area. The sensor/preamplifier assembly should be dried carefully, and left probe down (non inverted) to prevent moisture seepage into the preamplifier connector area. Deposits on the surface can usually be cleaned rather effectively with a mild bleach and water solution. Hard growths will require a mild acid soak. The platinum surface can be renewed to new condition with light polishing using fine-grained emery cloth or powdered alumina. A smooth surface will reach equilibration faster than a rough one. Rinse thoroughly and re-calibrate. In strong oxidizing solutions such as reference solutions, the response time and mV stability should be noted. 3 to 5 seconds is typical while stirring the probe in solution. Stability is normally within 2 to 5 mV's. **Remember: Equilibration may be needed upon return to the process.**

A few last things to remember. . .

- Avoid prolonged drying it may cause an open circuit within the internal gel reference and increase aging.
- Avoid scratching the platinum surface.
- Do not touch or contaminate the sensor/preamp BNC connection.
- Do not drop, freeze, or mechanically abuse.

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Signet Scientific Company, 3401 Aerojet Avenue, El Monte, CA 91731-2882 U.S.A. • Tel: (626) 571-2770 • Fax (626) 573-2057
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