



Luminescent-Based Detection Methods for Dissolved Oxygen Proposed by U.S. Environmental Protection Agency

On September 23, 2010, the U.S. EPA's approval of changes to ASTM* International D888-09 Standard Test Methods for Dissolved Oxygen in Water were published to the Federal Register under Clean Water Act 40 CFR part 136. The rules were open for comments until November 22, 2010.

The changes to ASTM D888-09 include the addition of Test Method C for the use of luminescent-based optical sensors for determining dissolved oxygen (DO) between 0.05-20 ppm in influent, effluent, and ambient water testing. The method may also be used for compliance measurements for Biological Oxygen Demand (BOD) and Carbonaceous Oxygen Demand (CBOD) testing.

YSI's optical dissolved oxygen sensors—the ProOBOD™, ProODO®, and ROX™—meet the ASTM D888-09 method requirements. If the method is promulgated by the EPA in 2011, then YSI sensors may be used for all EPA-regulated NPDES, BOD, and CBOD measurements without the need to contact a regional Alternative Test Procedure coordinator for interim approval.

The Federal Register promulgation can be viewed at <http://edocket.access.gpo.gov/2010/2010-20018.htm>. (See page 58031.)

It is important to note that the U.S. EPA and ASTM International approve methodologies, not specific equipment. When a method describes a specific technology (i.e., luminescent or optical dissolved oxygen sensors), then any product that meets those requirements is acceptable for use.

Similar test methods to ASTM Test Method C have also been proposed (Hach Company's Method 10360, and In-Situ Inc.'s Methods 1002-8-2009, 1003-8-2009, and 1004-8-2009). The optical DO sensors manufactured by these entities also meet the ASTM D888-09 method and their alternative test procedures provide no additional EPA approval or endorsement.

** ASTM International has the trust of end users in industry, municipalities, and the US EPA for the development of technical standards and practices for materials, products, systems, and services. The organization's consensus body is representative of manufacturers, users, consumers, government, and academia from more than 100 countries. Incorporation into the ASTM Standard D888 affirms, through technical consensus, the performance of the luminescent dissolved oxygen sensing method for measuring dissolved oxygen concentration in water.*



YSI ROX, OBOD, and ODO sensors utilize EPA-proposed lifetime-luminescence optical technology to eliminate stirring, interferences, and membrane changes and to reduce drift.

YSI offers the following optical dissolved oxygen sensors:

- **ProOBOD** - Optical DO sensor that fits in a BOD bottle and has a compact self-stirrer that requires no warm-up time.
- **ProODO** - Optical sensor for spot-sampling DO measurements in the lab or field, including fast response in cold waters.
- **ROX** - Optical DO sensor for long-term measurements in severe fouling and low-oxygen environments. Also ideal for sampling, flow cell, and ground-water measurements.

See the following page for details on the well-documented luminescent method used in YSI optical DO sensor technology and how YSI sensors meet the ASTM D888-09 method.

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How YSI Sensors Meet the ASTM D888-09 Method

The technological procedures for optical sensing of dissolved oxygen are described in the ASTM document D888-09 “Standard Test Methods for Dissolved Oxygen in Water,” specifically Test Method C Instrumental Probe Procedure–Luminescence-Based Sensor. The YSI optical dissolved oxygen sensors–ProOBOD, ProODO, and ROX–use the very same sensing technology as described in the ASTM standard method.

The sensing technology is described as follows:

1. A light source such as an LED is used to create a beam of excitation light. This light beam is modulated in order to gain the most accurate and precise information.
2. The excitation light travels to the end of the probe and strikes an oxygen-permeable, luminophore-embedded sensing layer (or substrate or foil). The interior side of the layer faces the oxygen probe and the exterior side faces the surrounding medium (water or air).
3. The excitation light is absorbed and excites the luminophore molecules. While the luminophores are in the excited state, the quality of the absorbed energy and its modulation are affected by the environment surrounding them.
4. The excited luminophore molecules release the excitation energy by emitting the energy back as light. The amount of time between the absorbing and emitting of light energy is the luminescence lifetime. The luminescence lifetime is a precisely known quantity and is predictably affected by several physical factors. One of these factors is the amount of oxygen present in the medium. Because the luminophore-embedded layer is in contact with the environment and because it is permeable to oxygen, the environmental oxygen concentration quantitatively causes an effect on the luminescence lifetime.
5. The changed light that is emitted back to the probe is sampled and accurately measured by an electronic light sensor such as a photodiode. The resulting electrical signal then travels into the probe circuits.
6. The electronics of the probe process the signal from the emitted light and calculate an accurate value for the quantity of dissolved oxygen. The signal processing includes information from a prior calibration and automatic temperature compensation.
7. Calibration can be performed in air-saturated water or water-saturated air. An optional second calibration point (zero oxygen) may be used.



An expanded illustration of YSI's ProOBOD dissolved oxygen probe. The excitation light (shown as a blue beam) is projected onto the sensing layer. Luminophores within the layer (shown as a red disk) begin to luminesce as a result of the excitation. The emitted light from the luminescing disk travels back into the probe (shown as a red beam). The amount of oxygen present at the layer affects the lifetime of the luminescence of the disk, which affects the red beam sent back to the sensors. The difference between the two beams is analyzed by the probe. The black disk represents an additional layer which protects the sensing layer and blocks external light from interfering with the sensor.

Many of the exact technical details of dissolved oxygen sensors are closely held and proprietary to each manufacturer. Such details include the actual molecules chosen as the luminophores, the polymer layers used to encapsulate it, the wavelengths of light utilized, the design of the electronics used to launch and collect the light energy, and the details of the signal processing algorithms. The choices made by YSI are selected to establish an accurate and robust method for determining dissolved oxygen, and this is packaged into user-friendly instrumentation.