White Paper

Why and how to use portable optical oxygen analysers in power plants?

Introduction

Oxygen analysis is one of the key parameters measured in the power plant. Tracking and reducing it ensures a lower corrosion rate, higher plant availability and protection of plant assets. This is done either by tracking low values on all-volatile treatment (AVT) chemistry or higher oxygen concentration with the oxygenated treatment chemistry (OT).

On the other hand, trends in the Power Industry have generated pressure and challenges on the instrumentation technology in the plant. The recent availability of new luminescent technology for dissolved oxygen (DO2) measurement provides answers to these requirements. For a few years now, the use of luminescent technology for on-line oxygen measurement has provided significant improvements against the classic electrochemical (EC) technology: reduction of maintenance frequency and complexity, long term stability and reduced cost of ownership. The optimisation of this technology allows having low ppb detection limit oxygen sensors with low maintenance needs.

A last step reached a few years ago opened new opportunities when combining LDO and portability. This paper describes the different scenarios of use and the associated benefits when the optical LDO technology and portability are put together. The result is a versatile yet accurate device for better corrosion control with data confidence and a positive impact on plant efficiency and availability.

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Trends and challenges in the power industry

Before talking about the oxygen analysis it make sense to identify all trends and challenges driving instrumentation in the power industry.
The last decade has seen increased pressure on cost reduction together with other challenges leading to several consequences:

- Maintenance and service personnel reduction leading to optimisation of the different tasks and to decrease service and calibration time on all analysers in the plant.
- Less formal chemical training and knowledge applied in task supervision and instrument operation.
- Outsourcing of instrumentation services requiring the need for devices with less complexity and easier service operations.
- Extension of the operating lifetime of the plant equipment, challenging the entire steam and water analytic system in terms of performance and reliability.
- Peak power plants, running only during high demand periods with a large oxygen level variability between them, leading to more frequent calibration and service operations for the oxygen measuring devices.

Fig. 1: Power plant trends also impact instrumentation

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LDO, how does it work?

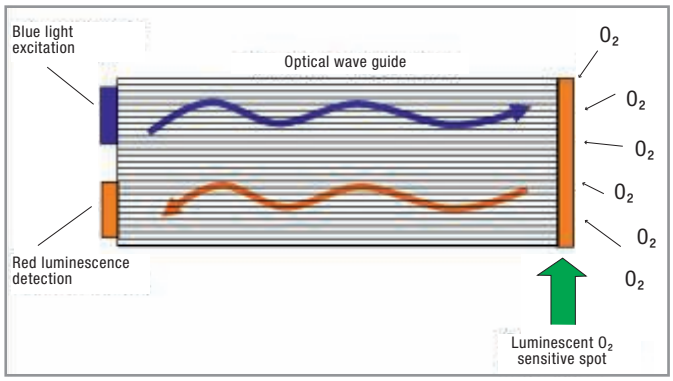
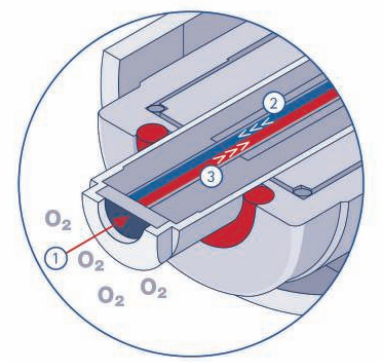


Fig. 2: Principle of an LDO sensor

LDO stands for Luminescent Dissolved Oxygen. The optical sensing of oxygen is based on the measurement of the red fluorescence of a dye/indicator illuminated with a modulated blue light as shown in Fig.2
The presence of oxygen results in a phase shift of the red fluorescence light when compared to the modulated blue light source. By measuring this phase shift, it is possible to make a direct measurement of the oxygen concentration in the sample.



Oxygen interacts with active luminescent sensor
1. Active luminescent spot 2. Blue light (excitation) 3. Red light (detection)

Fig. 3: Mechnical setup of an LDO sensor

The sensing surface is encapsulated into a cartridge for easy replacement (see Fig.3). This technology provides several benefits:

- Solid state technology. The sensor has no electrolyte and no membrane. This makes any service operation very easy as only the sensor cap needs to be replaced without any cleaning operation or special tools. Risk of incorrect service operation is also reduced.
- Long term stability. The LDO sensor has a very low drift over time. It can last up to three years without replacement whereas for EC sensors a service is required every few months. Calibration checks may be required every 6 to 12 months.
- No interference from typical compounds found in the water loop of the plant. Traditional EC technology suffers from hydrogen interference. Hydrogen is used only in nuclear plants on the primary loop but then analyzers require correction or compensation with a second hydrogen sensor.

How to use a portable oxygen analyser in the plant?

There are various scenarios for the use of a portable oxygen analyser in the plant. Combining the flexibility of a portable monitor with the strengths of the LDO provide new opportunities.

As a validation tool
Validation is a single comparison between the reading of an analyser and a reference. When using typical EC technologies and procedures, the reference is taken either in air or with a reference that also requires removing the sensor from its process location.

The portable unit is calibrated in the lab with recommended standards and is kept for validation purposes for several months. The benefit of this procedure is an important time savings, removing any manipulation of the installed sensor and also a more reliable reference with less operator influence. Measuring close to the online measurement provides a comparison which also takes account of any sampling phenomenon. This is not possible when removing the on-line sensor from its location.

On-line calibration
Calibration means first a comparison with a reference, as described above, and then an adjustment of the device being calibrated. For EC standard sensors, air has been used as the calibration medium. For LDO sensors the reference is nitrogen with high purity. These operations generate some drawbacks when having to calibrate on-line sensors: additional material required, sensor manipulations, and a long recovery time after the sensor is exposed to air (especially for the EC technology).

As on-line analysers have direct calibration functions, it will take just a few seconds to calibrate the on-line analyser with the portable unit used as a reference and connected on the same sampling point. With a portable device used as a reference and “linked” to external official standards, the reference traceability is covered. This operation takes no longer than 3 minutes. The final consequence is important time savings. If we consider 10 on-line measurements to be calibrated, the savings goes from minutes to hours.

Troubleshooting the process

High dissolved oxygen concentration may require performing a root cause analysis to identify the point of air leakage into the plant water loop.
Several basic points should be identified, such as time and maximal concentration of DO2, location of the event, frequency of the DO2 excursion, pattern identification, etc.
The methodology is to move up the process water flow, starting at the first measurement where the high DO2 has been or is measured. At a specific location the value will be within spec. This means that the air entry is located in the line portion defined by the two last measurements. Defective pump seals or valves are the most common sources of air leakage.

Troubleshooting on-line analyzers

In this scenario the item to check is the on-line measurement, either the controller or the oxygen sensor. The goal is to verify first the on-line oxygen measurement loop performance and remove any doubts about the values shown. This action is mainly a validation of the analyser. Secondly, and if necessary, a troubleshooting process can be initiated. Keeping the portable analyser with the same sample location provides a very straightforward way to validate the on-line device.

As a backup unit

In case of an on-line analyser being out of operation for any reason, then a portable oxygen analyzer can be installed as a backup unit and provide a continuous oxygen measurement when the device has a data storage function.

Features of the portable ORBISPHERE 3100

The HACH ORBISPHERE 3100 is a highly rugged, reliable and long-lasting portable optical oxygen analyser designed to withstand the harshest environments and operating conditions. It has a stainless steel enclosure surrounding a bright touch screen for easy operation anywhere in the plant. It provides fast and reliable results, with longer calibration intervals and easy on-site maintenance making it the most stable portable oxygen device with the longest calibration interval in the power industry.

Fig. 4: The ORBISPHERE 3100 oxygen analyser

4 modes of use with the ORBISPHERE 3100

After having previously described in this paper the different scenarios of use for an oxygen portable device, different modes and functions of the analyser are described below.

Direct reading

This is the most common way to use the analyser for spot checks. Connect it to a sample location and get the real oxygen concentration in no more than 3 minutes. The sample point identification can also be stored together with the measurement data, to ensure data traceability.

Data logger function

This function may be used for troubleshooting the process or an on-line analyser. The memory capacity allows recording up to 5700 measurements. This means a capacity of 8 hours at a storage frequency of 5 sec, or 4 days at a frequency of 1 minute. Oxygen concentration, time and temperature are recorded at the same time.
A USB connection allows downloading all data for further analysis.

Graphical view and screenshots

A graph gives a better view of the oxygen behavior at one sampling point and makes oxygen transient analysis much easier. This can be done with the ORBISPHERE 3100 without any additional computer or screen. The large display generates colored graphs (red or green) that are easily readable thanks to the bright display.
In addition, the graph on the screen can be stored and published as a bmp image file.

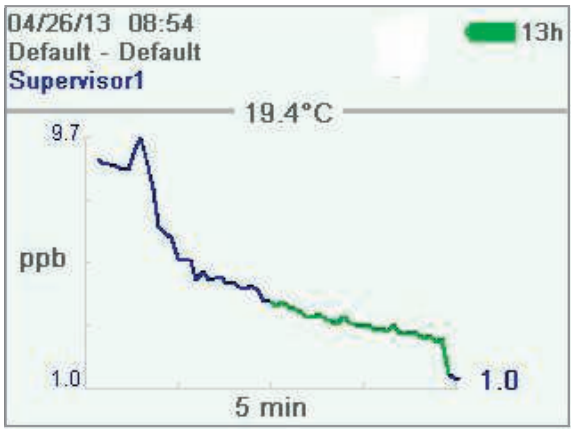


Fig. 5: Graphical view of the measurement

Live connection with a PC

In this configuration the analyser saves all oxygen measurements directly to the PC. The storage capacity is then almost unlimited and all data are automatically stored. The operator can then perform process analysis with any data analysis software.

How does the ORBISPHERE 3100 meet the challenges of the Power Industry?

The combination of the LDO technology integrated in a portable device provides the right answers to instrumentation challenges in the Power Industry:

- **Pressure on costs** is covered by two main features. The device can be used for a wide range of applications such as validation, calibration, troubleshooting and as a backup unit. The solid state sensor requires no maintenance for up to 3 years and the device requires no “babysitting” time when waiting for quick measurement results.
- **Complexity is reduced** by the high level of ergonomics of the unit with a bright touch screen and different tools and modes of use from spot measurements to a graphic view. The operator can concentrate his attention on data analysis.
- **Extension of the plant operation lifetime** requirement is supported by a better continuous monitoring of the corrosion source, by keeping the on-line oxygen loops at peak performance. This is the direct consequence of the LDO sensor short response time. With an EC sensor, going straight from a stand-by state to accurate reading may take more than 15 minutes. With the LDO it takes no more than 3 minutes to get the result, even if the analyser has not been used for many weeks. Validating or calibrating 10 on-line oxygen loops with a portable device has never been so quick and accurate.
- High level of **data confidence** over a long period of time. This allows for real tracking of the main corrosion source and better protection of the plant assets.

Conclusion

The use of a portable optical oxygen monitor is justified because of the good performances shown in terms of ppb level accuracy, long-term stability and data confidence provided. This is obtained with the solid state optical technology which removes old drawbacks of the electrochemical sensor technology.
The ORBISPHERE 3100 can be used for a wide range of applications such as validation and calibration reference, for process or on-line troubleshooting purposes, as well as a backup unit. Benefits gathered improve the operator/instrumentation efficiency, lifetime of the plant, reduce costs and finally improves the asset management of the plant and enables operation under optimum conditions.

About the author

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