Role of In-situ Process Analyzers in Enhanced Safety in Hydrogen Production

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MODCON

About Modcon Systems

Modcon Systems is the multidisciplinary engineering company with own innovative technologies of process analysis, control and optimization for the process industries

Modcon's Unique Offering:

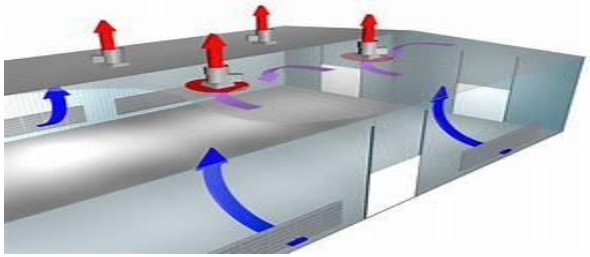
- New generation of online analyzers and optimization solutions
- Full turn-key project delivery including design, installation, support and training
- Standardized solutions for each industrial application

More than 50 years of experience in process analysis:

- Founded in 1972
- Operations in 30 countries of Middle East, Europe, Asia and America
- Over 2,000 customers worldwide
- Strategic partnership with more then 20 global companies
- ISO, ATEX, CE, IQNET, GOST.

Safety criteria for Hydrogen production

- To ensure the safety of personnel and equipment, it is crucial to keep hydrogen facilities and piping fully isolated. Complete isolation minimizes the risk of hydrogen escaping into the environment, where it can pose a significant hazard.
- Hydrogen production requires properly ventilation and hazardous zone classification.

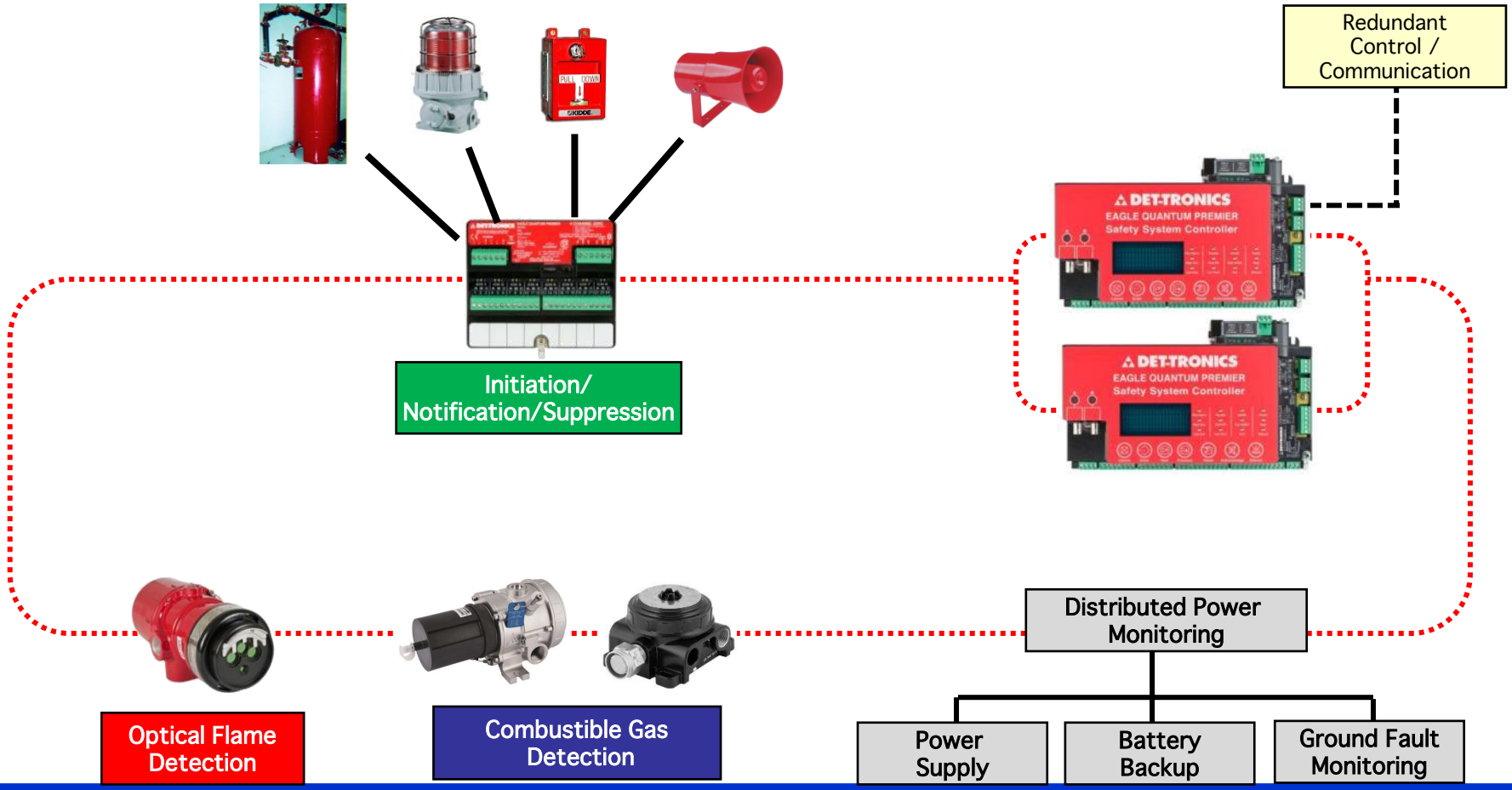


- The classification of an area as hazardous is an essential consideration in the design and operation of hydrogen plants.

This classification requires the implementation of stringent safety measures, including the use of certified equipment and controls designed for hazardous environments.

Facility and personal safety protection

System Block Diagram



Facility and personal safety combustible gas detectors

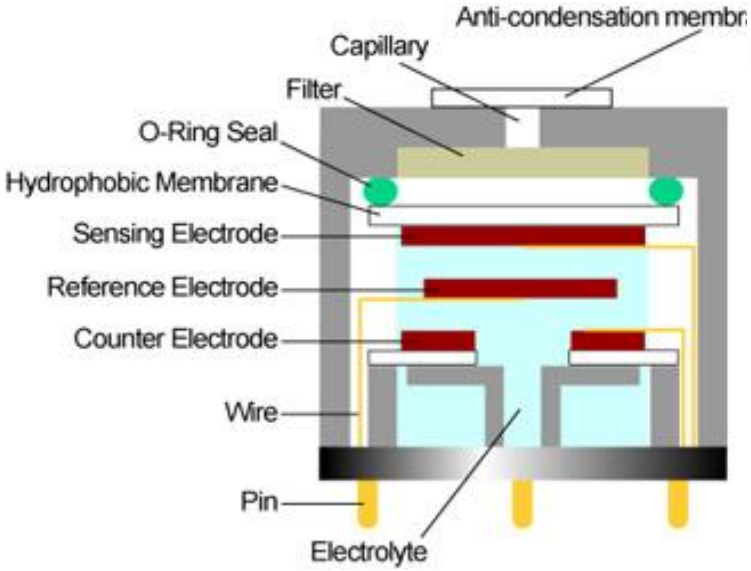
Fixed

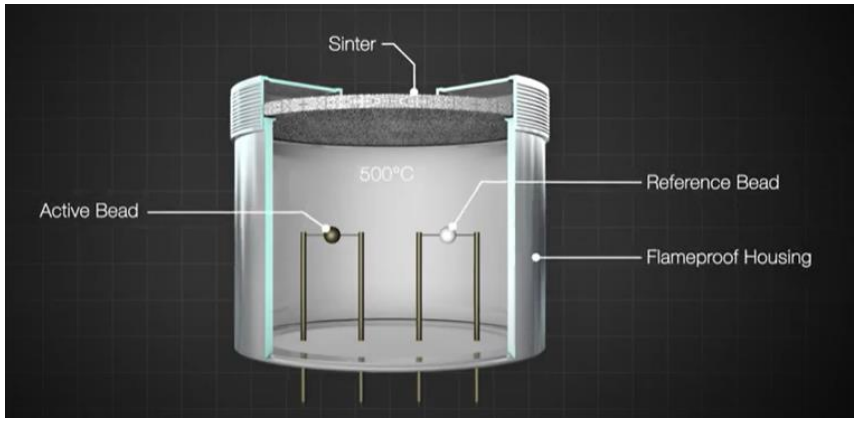
Portable

Hydrogen gas sensors

Electrochemical

Pellistor (LEL)





Chemical reaction creates an electric signal

Heating reaction changes the resistance between the beads (Wheatstone bridge)

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Hydrogen production quality requirements and complexities

- Maintaining high-quality hydrogen is essential for optimizing performance and reliability. Impurities, such as moisture, oxygen, and other contaminants, can have negative effects on the efficiency of various hydrogen-dependent processes, including fuel cells and industrial applications.
- Most of the process measuring technologies, especially for Oxygen require extraction and sampling of the sample because of the equipment's high-pressure limitations which create the potential leakage of the sample.
- All process equipment must be certified for safety SIL2 requirements and Hazardous zones if necessary.

Safety Integrity Level

- To establish risk reduction requirements.
- Probabilistic limits for hardware random failure.
- Architectural constrains.
- To establish systematic capability.

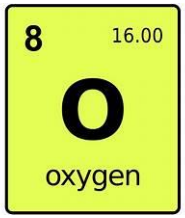
Safety Integrity Level	Safety	Probability of Failure on Demand	Risk Reduction Factor
SIL 4	> 99.99%	0.001% to 0.01%	100,000 to 10,000
SIL 3	99.9% to 99.99%	0.01% to 0.1%	10,000 to 1,000
SIL 2	99% to 99.9%	0.1% to 1%	1,000 to 100
SIL 1	90% to 99%	1% to 10%	100 to 10

Solutions to avoid the Hazardous conditions

- In-situ technologies of analyzers could operate directly within the process piping, eliminating the potential for gas leaks associated with sample extraction points. As a result, the area can be reclassified as general purpose, which significantly reduces the cost and complexity of the overall hydrogen plant facility.

- General purpose simplifies the design and construction of the hydrogen plant facility. It eliminates the need for complicated hazardous area wiring, instrumentation, and explosion-proof enclosures, streamlining the installation process and reducing associated costs.

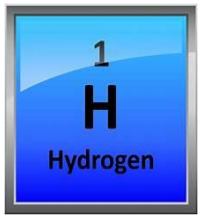
Importance of Oxygen and Hydrogen measurements



Oxygen

- **Safety reason-** explosion prevention.
- **Process optimization and quality control-**the concentration of oxygen can affect reaction kinetics and overall efficiency. Purity of hydrogen.
- **Equipment integrity-** corrosion prevention.
- **Energy efficiency-** optimizing of combustion efficiency.

Hydrogen



- **Safety reason-** explosion prevention.
- **Process optimization and quality control-** Hydrogen purity.
- **Equipment integrity-** Hydrogen Embrittlement.

The Technology of Oxygen analyzers

- Oxygen analysers are paramagnetic, laser, zirconium or electrolytic based analysers, which not applicable at high pressures.

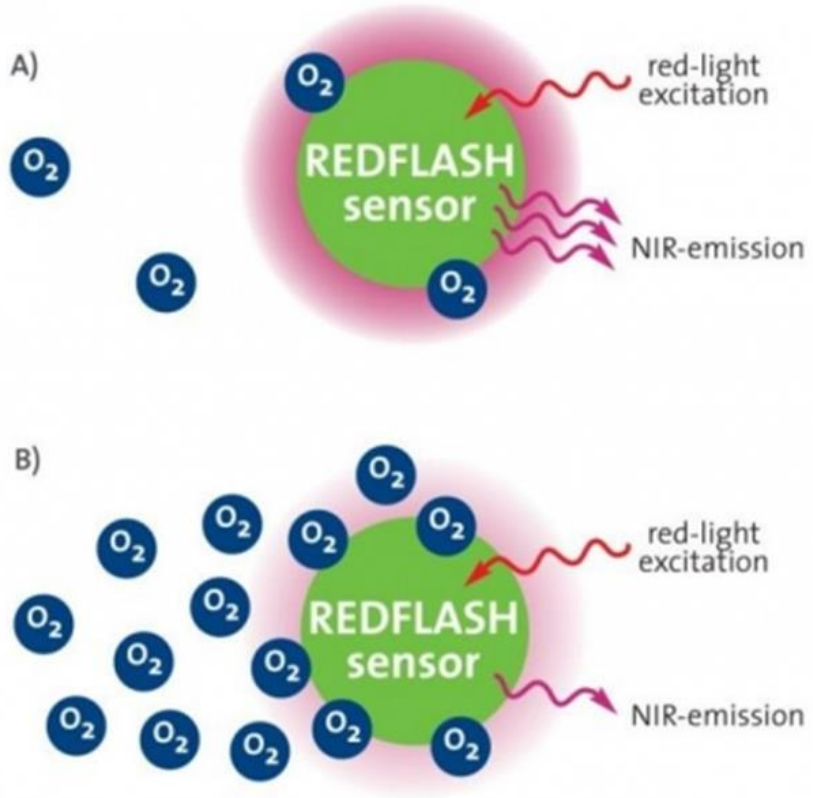
- ***<u>Solution:</u> Optical based oxygen analysers for high pressure***

- **Luminescence technology** is a non-contact optical measurement method that detects the emission from the oxygen molecules in a sample when excited by a specific wavelength of light.

- Optical oxygen analysers offer several advantages over traditional oxygen analytical methods, which also include their ability to measure high-pressure streams without pressure reduction, high accuracy and stability, and ease of installation and operation.

Luminescence Technology Description

- Optical Oxygen Analyzer is based on advanced photonics technology that relies on luminescence quenching of a specially-designed sensor spot, which is immobilized on a support foil.



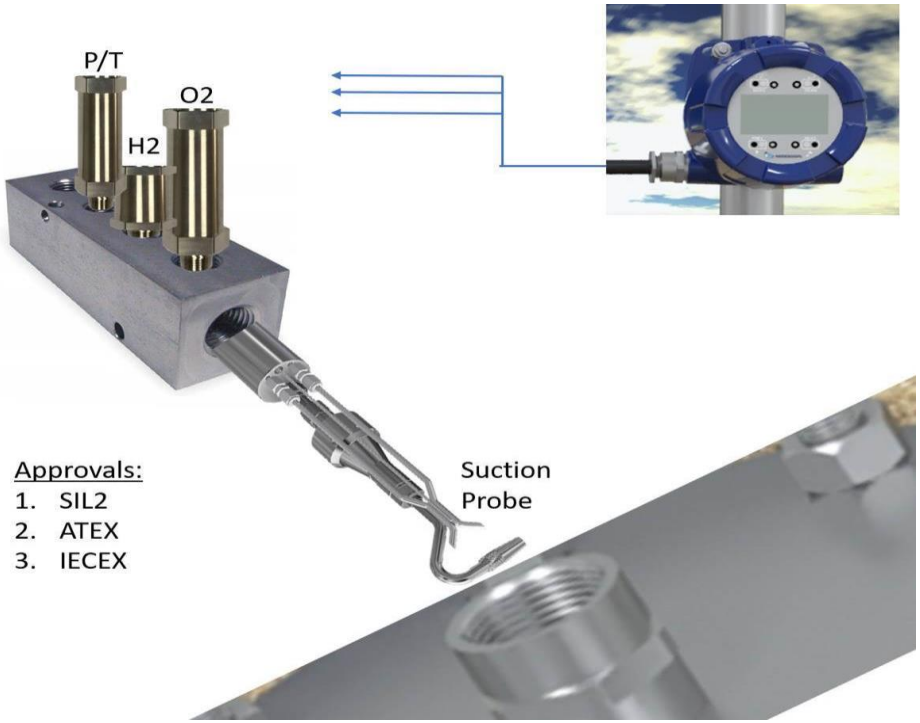
- When molecular oxygen is present, it causes the luminescence to be quenched, leading to a reversible change in both intensity and lifetime of the luminescence, which can be accurately measured and analyzed, allowing for precise detection and quantification of molecular oxygen
- This technology incorporates an innovative fully solid-state luminescence quenching technique that uses a sensor dye immobilized on a support foil, known as the "sensing layer".
- This spot is excited by red light, and the resulting luminescence is accurately measured in the near infrared region.

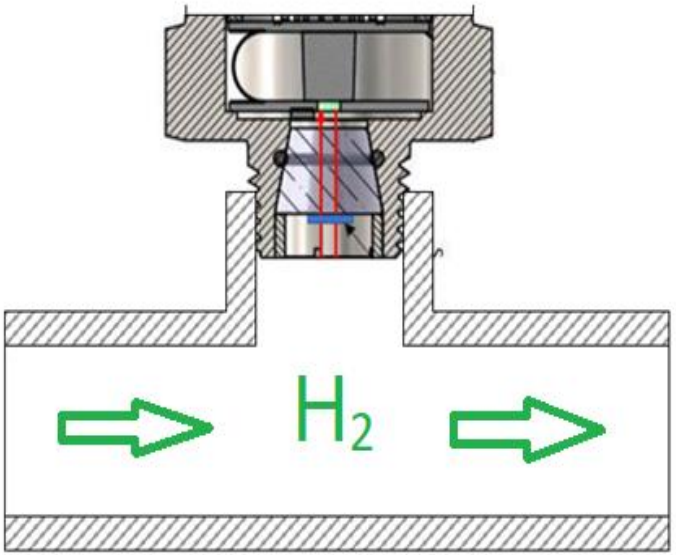
Advantages over other Technologies

Comparison Parameter	Paramagnetic Analysis	Zirconia Analysis	Electrochemical Analysis	Optical Analysis
Measurement Range	Narrower range	High range (above a few percent)	Limitations in very low or high concentrations	Wide range (low to high levels)
Response Time	Fast	Fast	Slower (due to chemical reactions)	Fast
Accuracy and Precision	High	High	Medium-high	High
Maintenance	Medium	Medium	Higher (replacement of electrolytes or membranes)	Low
Versatility	Medium (only gases)	Medium (only gases)	High (gases, liquids)	High (gases, liquids)
Interference	Prone to interference	Low	Very prone to interference	Prone to interference (Cl2, NO2, org.solvent)
Price	More expensive	More expensive	More affordable	More affordable

Features

The analysis method used is highly dependent on process conditions such as temperature and pressure. The Optical analyzer is equipped with built-in temperature and pressure sensors that measure the ambient environmental conditions. Analyzer kit consists of Oxygen and Hydrogen sensors with the option for the Hydrogen purity calculation by PLC.





MOD-1040 Product release 2024

The MOD-1040 oxygen analyzer is designed for operation in explosive atmospheres, specifically in Zone 1. It is manufactured in an Ex-d enclosure. Currently, it holds an explosion-proof certification for use in Zone 2. Additionally, certification is underway with INTERTEK to obtain a Zone 1 and SIL2 certification.

New H2 sensor will be added to the analyzer kit which offer numerous benefits, including enhanced safety, improved efficiency, cost savings, and accurate data.

Options for humidity sensor, CH4, CO2 and H2 purity calculation by PLC including Calorific value calculation for Natural gas and Hydrogen mix.

Thank you for your attention!

Questions?