/ Application Note

Hydrogen Impurity Measurements

Hydrogen as energy carrier has great potential for clean, zero-carbon industries and is considered to be one of the most promising candidates for replacing fossil fuel sources that contribute significantly to the anthropogenic climate change.

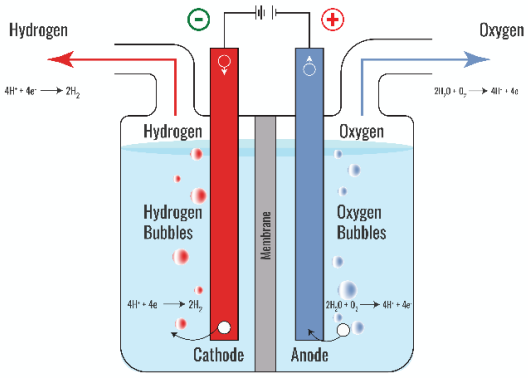
Hydrogen can be produced from a variety of resources, including natural gas, nuclear power, biomass, and renewable energy sources such as solar and wind. Hydrogen is now increasingly used as a fuel for transport (cars, trucks, trains, ships, airplanes …) and is also expected to be mixed with natural gas to improve the carbon balance of industrial combustion processes.

However, there is a problem with using hydrogen for these applications: potential impurities in the supply can damage fuel cells, shorten component life and increase pollution, undoing the very reason for its use.

/ Processes

Polymer Electrolyte Membrane (PEM) electrolyzers are using electricity to split water into hydrogen and oxygen. An electrolyzer consists of an anode (right) and a cathode (left); they are separated by an electrolyte (center). In a PEM electrolyzer, the electrolyte is a solid specialty plastic material.

- At the anode, the water reacts to form oxygen and positively charged hydrogen ions (protons).
- The electrons flow through an external circuit and the hydrogen ions selectively move through the PEM to the cathode.
- At the cathode, the hydrogen ions combine with electrons from the external circuit to form hydrogen gas.
  Anode Reaction: $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$
  Cathode Reaction: $4H^+ + 4e^- \rightarrow 2H_2$



Electrolysis of water

Alkaline electrolyzers function by transporting hydroxide ions (OH^-) through the electrolyte from the cathode to the anode, producing hydrogen on the cathode side.

Steam Methane Reformers (SMR) are commonly used for hydrogen production from methane. The process is divided into three steps:

1. Primary Reformer: $CH_4 + H_2O \rightarrow CO + 3H_2$
   [partial reaction only, remaining CH_4 is converted to H_2 and CO in the second stage]
2. Secondary Reformer: $2CH_4 + O_2 \rightarrow 2CO + 4H_2$
3. CO shift converter: $CO + H_2O \rightarrow CO_2 + H_2$
   [CO_2 is finally removed with an amine wet scrubber]

These are highly endothermic reactions that require addition of heat.
T = 800 °C – 900 °C; p = 20 bar – 30 bar

/ Typical process data

Trace amounts (typically sub-ppm levels) of contaminants in 100% Hydrogen.

H_2 from SMR process: CO & CH_4 impurities

H_2 from PEM: O_2 impurities

/ Motivation

Impurities in hydrogen can interfere with the proper functioning of equipment that stores, distributes, or uses hydrogen as fuel. When hydrogen is blended with natural gas and used in boilers, the tolerance for impurities is generally higher than when hydrogen is used in vehicles powered by polymer electrolyte membrane fuel cells. The presence of impurities in hydrogen depends on the production process used. Carbon monoxide and methane may be present in hydrogen from steam methane reforming, while oxygen is present in hydrogen from chlor-alkali or water electrolysis.

/ Solution

NEO Monitors' LaserGas™ II MP analyzer is using the unique properties of lasers that allow gas measurements in real time with high sensitivity and selectivity. With this extractive analyzer, impurities like CO & CH_4 (for H_2 from SMR) and O_2 (for H_2 from PEM or AE) can be measured at very low levels.

LaserGas™ II MP

- Sensitive
- Selective
- No zero-drift
- Internal heath check
- No consumables

		LDL (in H_2)	Range
Oxygen (O_2)		15 ppm	0-1000 pm
Carbon monoxide (CO)		0.05 ppm	0-5 ppm
Methane (CH_4)		0.05 ppm	0-5 ppm
Carbon dioxide (CO_2)		0.2 ppm	0-20 ppm
Combo	CO	0.05 ppm	0-5 ppm
	CH_4	0.2 ppm	0-20 ppm

(*) More gases on request.

/ Benefits

- The Multi Pass cell concept combines a long measurement path length with a compact analyzer design
- Well proven measurement technique
- Measures trace levels of gases, offline in a controlled environment
- Highly reliable real time analyzer
- Easy to install and operate
- Low maintenance cost