

# Hydrogen safety sensors

the right sensor for the right job

## Collaborative activities

In collaboration with international and European partners, the facility is used in interlaboratory experimental programmes aimed at preparing guidelines for testing hydrogen sensors, assessing their performance and reliability and providing feedback on the results to interested stakeholders.



## Hydrogen, what is it?

Hydrogen is the simplest and lightest gas and the most plentiful element in the universe. However, on Earth hydrogen is normally not found as a gas but bound to other elements. Like electricity, hydrogen is an energy carrier and must be first extracted from another material e.g. natural gas, coal, biomass or water before it can be used. Commonly used as a chemical in the petrochemical industry or for production of ammonia, hydrogen can also be used as a fuel to power fuel cells or turbines. While not commonly used as a fuel at present, the energetic use of hydrogen could become more widespread as it can potentially be produced from renewable energy sources.

## Is it safe?

Hydrogen is not any more or less dangerous than other common fuels. It does, in fact, provide some safety benefits when compared to other fuels. For example hydrogen is non-toxic, non-carcinogenic, it is not radioactive and is non-polluting producing no hazardous combustion products. However like any fuel, hydrogen has associated hazards which must be properly addressed to ensure its safe use. Most of the hazards associated with hydrogen arise because hydrogen, like natural gas and petrol, is flammable and can be dangerous under certain conditions.

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When effective safety measures are taken, these hazards can be kept to a minimum. A thorough understanding of hydrogen's properties and behaviour is essential to provide the correct guidelines to ensure its safe and efficient use.

### Hydrogen properties

Hydrogen has a number of unusual properties which make it different from traditional fuels. It has the highest energy content of any common fuel by weight (about three times more than petrol), but the lowest energy content by volume (even at 700 bar about four times less than petrol). Hydrogen gas is 14 times lighter than air and rises rapidly if released. Hydrogen gas has a wide flammability range and low ignition energy. Nevertheless in order to burn, it needs to mix with air in the correct proportion and be ignited.

Hydrogen has no colour, odour or taste and so is not detectable by human senses. Since the use of odorants in hydrogen applications is not possible, special detection devices or sensors are therefore essential to warn of its presence even at low concentrations.

### Hydrogen sensors

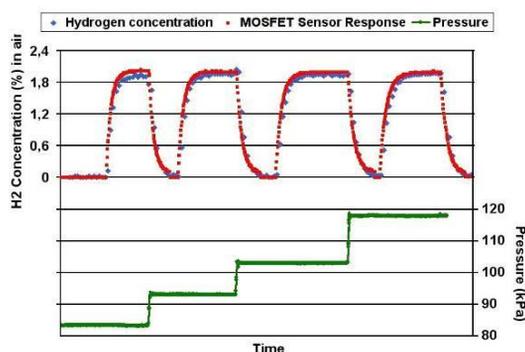
Hydrogen sensors will be used to detect hydrogen wherever it is produced, stored, distributed or used. There is a rapidly growing number of hydrogen sensors available on the commercial market. Different types of sensors exist and the most commonly available hydrogen sensors include catalytic, electrochemical, metal oxide, MOSFET and thermal conductivity sensors. Each type of hydrogen sensor has its own advantages and disadvantages in terms of performance. For example, some sensor types are extremely sensitive whereas others have a wide measuring range. A suitable sensor needs to be chosen for a specific application depending not only on the ambient working conditions but also on the detection requirements and sensor performance capabilities.

### Sensor performance testing at the JRC-IET

The JRC-IET has a state-of-the-art testing facility dedicated to independent characterisation of hydrogen sensor performance and reliability. Considering the future widespread use of hydrogen sensors by the public it is important to independently assess their performance to ensure their reliable and accurate operation.

The JRC-IET acts as a European scientific and technical reference centre and performs impartial and trusted research in support of Community policies related to energy. It serves the common interest of the Member States and the European citizen and is independent of commercial and national interests.

As part of our work, we liaise with sensor developers and manufacturers offering assistance in the development of hydrogen detection technologies. In addition we provide scientific support to international standardisation



Pressure test results from a MOSFET hydrogen sensor

authorities and sensor end users to facilitate the application of hydrogen detection devices towards the safe use of hydrogen.

### Sensor testing facility capabilities

Up to six sensors can be mounted in an environmental chamber in which temperature, pressure, humidity and gas composition can be varied to assess their influence on sensor output. Hydrogen in air mixtures can be routinely prepared for concentrations in the range of 100 ppm to 2vol% hydrogen.

Temperature can be controlled between  $-40\text{ }^{\circ}\text{C}$  and  $+130\text{ }^{\circ}\text{C}$  and held constant within  $\pm 2\text{ }^{\circ}\text{C}$ . The pressure range of the facility is about 50kPa up to 250 kPa. Relative humidity's of 10% at  $-10\text{ }^{\circ}\text{C}$  and 100% at  $60\text{ }^{\circ}\text{C}$  are possible. At lower or higher temperatures, the relative humidity's achievable increase and decrease respectively. A total of four gases may be mixed to produce the desired gas composition. A calibrated gas chromatograph independently confirms the gas composition which can be compared directly with the sensor output.

A new dedicated facility has been built to evaluate the cross-sensitivity of hydrogen sensors to other species such as carbon monoxide, hydrocarbons, ammonia and sulphur containing compounds. In addition a further facility allows measurement of sensor response and recovery times.

