Hydrogen sulphide (H₂S) is the number one hazardous substance in oil and gas production fields, when it comes to the risks posed by its presence. And that’s why prevention measures are so important — which can be successful with the right amount of know-how, training and good measurement strategies.
Why is H₂S so dangerous?

Hydrogen sulphide, even in concentrations as low as 0.03 ppm, is already perceptible to the human sense of smell. From about 20 ppm, the odour is unbearable. And not only can central nervous and cardiovascular systems be very quickly damaged, but olfactory nerves can even be paralysed. A fatal effect, as the natural warning system in the nose is thus rendered useless. From 500 ppm, a life-threatening effect begins to set in – from 700 ppm the body collapses from respiratory paralysis, seizures and loss of consciousness. From concentrations of around 1,000 ppm, even one single breath can lead to instantaneous death.

Because hydrogen sulphide is colourless and builds up at ground level, continuous and individual-based concentration monitoring is absolutely essential in the oil and gas industry. Additionally extremely high concentrations of H₂S in the presence of an ignition source may also lead to explosions.
**Typical sites and activities with possible H₂S hazards**

**Onshore: drilling fields**
With oil and gas production in drilling fields on land, and especially with crude oil production, H₂S can accumulate and vibrations can occur at the drill heads, in production and in processing areas. A particular risk is posed when the drill rods are pulled out of the boreholes too quickly, which can cause liquids containing H₂S to be released on the surface. Even when drills reach the bottom of the boreholes, drilling mud can be displaced and pulled up to the surface, creating safety-critical moments; and the same is true at sample points and during tests of the drilling holes.¹

Another unpredictable volatility: On the same drilling field, each drilling site can have a unique H₂S content, which can vary between a low single-digit ppm concentration and a higher double-digit ppm concentration.²

**H₂S is one of the most dangerous gases found in the oil & gas industry: Even today, there are regular occurrences of injuries and deaths due to H₂S exposure.**

Eric Dzuba, formerly Global Business Manager, Segments Oil & Gas and Chemical Industries, Dräger

**Onshore: sour gas fields**
The gas that is produced on sour gas fields naturally has an extremely high H₂S content, which is why such fields are called “sour”. Shuwaihat, a sour gas storage facility in the United Arab Emirates, has a 5,000-metre deep depot. The sour gas stored there has an H₂S content of 23%. Along with the potential lethal danger for workers on the site, the pipes and facility components on the plant must continually be checked for leaks due to the highly-corrosive nature of H₂S. In this situation, extreme safety measures are required.³

**Offshore: oil platforms**
Even with oil drilling on rigs, there is always a danger that the drilling mud suddenly has a high hydrogen sulphide content. Not only are the areas around the shaft tower and all pipe connections extremely dangerous in terms of H₂S emissions, but all employees’ quarters on the platform also face high risks. This is also true for oil tankers. Storage areas and processing areas are also considered high-risk locations.

On other sour gas fields, no work can take place in the so-called “red zones” – that’s to say areas with particularly high concentrations of H₂S – without self-contained breathing devices. Such respiratory equipment must have an extremely high protective factor against hydrogen sulphide. For reduced breathing resistance, the worker’s air supply can work through a closed circuit. With these types of drilling projects, it’s also very important to monitor workers during sleep and free-time activities to ensure against possible gas hazards.
Refineries:
In the refinery process, crude oil with a high H₂S content is desulphurised (Claus process). When this takes place, extremely high hazard risks are present at transfer points. However, it’s not just these points that need to be monitored. Because of the possibility of high H₂S concentrations being released in the event of damage or accidents, surrounding evacuation areas of up to several kilometres away also face H₂S dangers and must also be adequately monitored.

**Oil and gas areas with particularly high H₂S risks:**
- Drilling posts
- Drill hole valves
- Rock vibrations
- Drilling mud reservoirs
- Pipelines/pump stations for H₂S-contaminated waste water
- Raw material storage areas (refineries)
- Pipelines, tanks and valves (tank storage areas);
  - <200,000 ppm
- Confined spaces and vessels

**Economic arguments for H₂S monitoring**
Alongside the extreme cases of life-threatening effects for workers stemming from hydrogen sulphide emissions, there are also economic factors that speak for continuous on-site monitoring – because large-extent damage to people, plant facilities and the environment triggers downtimes and costs. What’s more: with precisely-defined, purposeful and coordinated measurement technology, efficiency can also be improved. For example, during test drilling, expenses for time-consuming installation of permanent gas-measuring systems can be omitted and flexible, mobile gas-monitoring solutions used instead.

**Prevention: averting H₂S incidents**
Important information can be pulled from on-site risk assessments to draw up risk management plans and appropriate prevention measures. First and foremost, this involves defining measurement strategies and deciding on suitable measuring technologies. In case of damage or accidents, a functioning emergency plan, including escape equipment, and corresponding training methods must also be developed.

The established occupational exposure limits implemented by official institutions serve as key indicators in the development of prevention and measurement strategies. They provide a yardstick for the maximum amounts of H₂S admissible during long- or short-term worker exposure. This varies worldwide, as this overview shows:
The official standards are commonly supplemented by a company’s own guidelines. In particular, this would include a definition for alarm threshold values (pre-alarm – A1, main alarm – A2) in the framework of individual safety concepts.

**Strategies for H₂S monitoring in relation to project phases**

Depending on which phase oil and gas mining projects are in, differing concentration-monitoring strategies and technologies are necessary – because when risks are present and how much of the hazardous substance could be released can vary a great deal.

**Test drillings**: proceed based on geological forecast; H₂S content unclear.

**Assessment phase**: No continuous monitoring, but personal monitoring possible when the field is being inspected.

**Development phase**: Mobile area monitoring, following the work advance

**Production**: Continuous monitoring necessary over a long period (ca. > 10 years); stationary gas equipment installation recommended

**EOR (Enhanced Oil Recovery)**: The drilling of oil through injection of compressed gases in deep-lying rock layers increases the risk of a sudden release of extremely high H₂S concentrations.
Programmes that simulate gas dispersion in specific uses and installations are also available for assistance. These can help to determine optimal positioning of monitoring sensors.

In order to monitor larger distances and plant areas the so-called open path gas detection is a good choice. This technology allows gas detection along an open measuring section and has been mainly used for flammable hydrocarbons like methane and propane, so far. Meanwhile also toxic gases can be detected.

Further factors to be taken into account when making selection decision:
- Potential occurrence of strong winds (particularly storms)
- Typical wind directions
- Sand and snow effects
- Extremes in ambient temperatures (heat/cold)
- Sudden, extreme changes in ambient temperature
- Possible positions of gas measuring heads
- Distance between gas measuring heads

For selection of the optimal measuring technologies and measuring system (electrochemical/optical), additional conditions apply:
- Fast response times (t90)
- Precise measurement, even under difficult conditions and at lower measuring ranges (< 1 ppm)
- Quick readings after overexposure
- Zero-point stability, no drift, no false alarms
- Minimal interference, particularly in terms of thiol, NO, SO₂, Cl₂, hydrazine
- Contamination resistance in regards to other gases (with electrochemical sensors)
- Compliance with regulations: Requirements relating to use of devices in Ex zones

=> Where appropriate, including audits to ensure device suitability for automated reactions to alarms from the gas measurement systems (SIL)
- Data interfaces and data-sharing possibilities with other system components (in particular in emergency situations and for remote decision-making)
- Durability of sensors – where applicable, simply maintenance and repair

Choosing measurement strategies and technologies

Firstly, it’s important to differentiate between temporary workplace monitoring, more permanent area monitoring and leak detection – especially with corroded pipelines. When new gas fields are being explored, it’s not worth it to install permanent gas measurement systems at that time.

Beginning from the phase of production, monitoring with a stationary gas detection system is advisable. Particularly in new extraction areas in countries such as Kazakhstan, there are purported sour gas fields with hydrogen sulphide content of up to 15 % in volume. In such cases, appropriate technology measures and organisational measures to protect the workers and the plant should be established. In addition to protective equipment and portable gas detection devices, stationary gas detection systems – for large-scale surveillance of the plant and for early detection of leaks – are necessary. A site-specific risk analysis can reveal where single-spot measurements or area measurements are advisable.

The key here is the selection of appropriate sensor measurement technologies and the proper placement of the measuring head in consideration of the material properties of the gas or vapour and the environmental conditions. Assistance with selection, installation, application and maintenance of devices for the measurement of flammable gases and oxygen is provided by the technical standard IEC/EN 60079-29-2.
Depending on individual application circumstances several measurement technologies are available for the monitoring of plant areas. Each of these technologies has its strengths and weaknesses in terms of measurement range, accuracy or even contamination resistance which have to be considered when making a selection.

**BOTTOM LINE:**

Awareness of the risk of suddenly-emerging, life-threatening hydrogen sulphide concentrations and an extensive understanding of prevention measures can contribute to a reduction in accident frequency. Continuous measurement and assessment of the measurement results is a task for safety experts. It is thereafter imperative that H₂S programmes and services are established for each specific facility.

Want greater insight into the subject? Take a look at the following:

**White paper: H₂S – a growing challenge in the Oil & Gas industry**

**Video: Safe breathing – even with extremely high H₂S concentrations**

**White paper: Safe breathing – even with extremely high H₂S concentrations**

**White paper: Choosing the best escape respirator for your emergency response plan**

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