

H₂S - a growing challenge

in the Oil & Gas industry

SOLUTIONS FOR A SAFE 24/7 OPERATION
MODE AT SOUR GAS FIELDS



Introduction

The global exploration of oil and gas grows continuously. As a result, many mature fields containing high concentrations of Hydrogen Sulfide (H₂S) – so called sour fields, have to be developed. Since H₂S is at the occurring high levels a life-threatening, corrosive and flammable gas, the exploration and operation of such fields has to be undertaken under very strict safety precautions. This implicates a holistic approach concerning the safety, escape and rescue strategy of the facility – particularly because of the remote areas where such fields are located: Gas detection devices have to cover wide temperature variation and must be robust against harsh weather conditions such as sand storms. As incidents with high concentrations of H₂S can lead to death within seconds, every detection device

has to have a very fast response time, every protection device has to be appropriate (according to the required, exceedingly high protection factor and the personal fit), and every grip has to be trained – also all acts of escape and rescue. Because, if a severe incident occurs, the facility team will be on its own for a certain time until external aid arrives.

Driven by passion for safety Dräger provides equipment for detection, protection, escape and rescue as well as training programs to protect your personnel and your assets – and supports you with expertise in order to realize specific engineered solutions for your project. Learn more about this on the following pages:

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“Your safety is our passion”

Supporting your safety culture
since 1889.



Hazardous characteristics of H₂S





“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. That is why it is so important to have proper training on how to detect it, how to protect yourself, and what to do in case of a high concentration exposure.”

ERIC DZUBA, GLOBAL BUSINESS MANAGER, SEGMENTS OIL & GAS AND CHEMICAL INDUSTRIES, DRÄGER



What makes H₂S so dangerous?

Working in the oil & gas industry is associated with an often underestimated danger: Hydrogen sulfide, a toxic gas, which can unexpectedly occur during routine work. H₂S is colorless and invisible but can be perceived in very low concentrations by our sense of smell. Because of its distinct odor of rotten eggs, it is also known as sewer gas, digester gas, or marsh gas. However, hydrogen sulfide numbs olfactory nerves starting with a concentration of about 100 ppm¹. People are no longer able to smell this gas at these concentrations. Concentrations higher than 1,000 ppm can be immediately fatal. H₂S is heavier than air

and therefore often collects in low-lying areas and working sites near the ground.

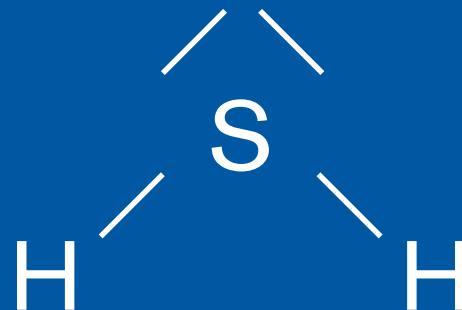
Hydrogen sulfide ignites on its own at a temperature of 518 °F. Due to its highly inflammatory property, an explosive atmosphere may occur when combined with air. Strong reactions are possible that can trigger spontaneous combustion, explosions and detonations in case of contact with peroxides, bromates, ammonia, or other chemical substances. H₂S combined with air and humidity or moisture also may corrode metals (such as in pipes, tanks, vessels, etc.) through the formation of sulfuric acid.

¹ source: IFA / GESTIS, [http://gestis.itrust.de/nxt/gateway.dll/gestis_de/000000.xml?f=templates\\$fn=default.htm\\$3.0,\[download date: November 4, 2013\]](http://gestis.itrust.de/nxt/gateway.dll/gestis_de/000000.xml?f=templates$fn=default.htm$3.0,[download date: November 4, 2013])

Specifications of H₂S

Identifiers

CAS No.:	7783-06-4
EINECS No.:	231-977-3
UN No.:	1053
Ignition temperature:	270 °C
Ionization energy:	10.46
Temperature class (EN):	T3
Explosion group (EN):	IIB
Vapor pressure:	18,100 hPa (at 20 °C)
Molecular weight:	34.08 g/mol
Density:	0.002 g/mL (at 20 °C)
Melting point:	-85,6 °C
Boiling point:	-60,2 °C



Explosive limits in air (typical for Germany):

UEL:	45.5 vol. %
LEL:	4.3 vol. %

Hazard symbols:



Water pollution class: 2

Kemler code: 263

Danger sign: 263/ 1053

Note: Details of toxic limit values on page 14.

Source: Dräger VOICE

Exposure levels and possible effects

0 – 20 ppm H₂S

0.00047 ppm:	Perception threshold, 50% of humans notice the odor
0.13 ppm:	Threshold of odor perception
0.77 ppm:	Readily perceptible odor
4.6 ppm	Easily noticeable odor Prolonged exposure may deaden the sense of smell
5 ppm	Metabolic changes in exercising individuals, not clinically significant
10 ppm	Eye irritation, soreness, redness, burning
10 – 20 ppm	Causes painful eye, nose and throat irritation, headaches, fatigue, irritability, insomnia, gastrointestinal disturbance, loss of appetite, dizziness. Prolonged exposure causes bronchitis and pneumonia.

21 – 99 ppm H₂S

- At these levels, OEL levels in all regions have been exceeded.
- Respiratory protection must be worn!
- Eye protection should also be worn.

27 ppm Strong, unpleasant, but not intolerable odor

30 ppm Up to this level, the rotten egg odor is recognizable

30 – 100 ppm Odor becomes sickly sweet

Prolonged exposure will cause serious eye damage, migraine headaches, nausea, dizziness, coughing, vomiting and difficulty breathing.

100 – 1,000 ppm H₂S

- IDLH* limits have been exceeded.
- An APR** should no longer be worn, use a supplied air system.
- Eye protection is indispensable.

100 ppm Immediate irritation of eyes and respiratory tract

150 ppm Sense of smell can be paralyzed quickly (in 2-15 min)

200 ppm Headaches, dizziness, nausea

500 ppm Unconsciousness leading to death within 30-60 minutes

Strong stimulation of nervous system, rapid breathing

1,000 ppm Immediate loss of consciousness and respiratory paralysis leading to death

* IDHL: Immediately Dangerous to Life and Health

**APR: air-purifying respirator

Source: H₂S (hydrogen sulfide) – Knowledge can save lives. Booklet; Dräger, 2013

Gas detection



Working on an oil field means anything but working under laboratory conditions:

Operators have to deal with harsh and remote areas, dusty environments and sand storms, in addition to hot days and cold nights. Even under these conditions, gas detection measurement has to be reliable all the time – not only for cases of emergency. Gas detection sensors with fast response times and a wide temperature range (-4 °F up to 131 °F) are needed. Facing the high potential of extreme and therefore deadly concentrations of H₂S the recovery time of the sensor technology has to be as short as possible: Because every second counts.

“What makes **gases** so
special is that they
cannot be seen”

Ulf Ostermann
Global Marketing Manager
Mobile Gas Detection Solutions



Why is detection so important?

The detection of gases before starting and during work is a question of general safety, as Ulf Ostermann, Dräger Global Marketing Manager for Mobile Gas Detection Solutions, explains in one of our 'Your safety is our passion' interviews: "Everybody working in the oil and gas industry knows that they have a dangerous workplace. And I don't mean severe accidents, explosions or something like that", Osterman says. "If I knew that I had to enter an area where I might encounter such a toxic substance I would protect myself with a properly working personal air monitor. What makes gases so special is that they cannot be seen and many times not even be smelled."

Why is the quality of detection devices so important?

As most of the global oil and gas recovery are realized in such harsh and remote areas and in accordance of the high

toxicity of H_2S the quality of the available gas detection devices is crucial. "Quality starts, first of all, with the basic functions. A gas detection instrument should, for example, indicate that it is operational. If it is not operational, it should report a fault. This is a simple but significant aspect of reliability", Christof Becker, Dräger Product Manager for Stationary Gas Detection, says in an interview. "The second point is the robustness of the measurement, in other words, to generate only true gas alarm conditions even when the ambient conditions are aggressive. The Dräger Polytrons, for example, are very robust under sand storm conditions. This, too, is quality. The third point is the measuring performance or the question of how accurate the measured values are during changing environmental conditions such as temperatures, humidity or over a long period of time without any maintenance, e.g. six or twelve months", Becker says.

Toxic limit values (selection)

It is important to know the current national or international limits of H₂S in occupational circumstances. H₂S can be identified in each language and country by the international Chemical Abstract Service Registry Number (CAS). It is called 7783-06-4.

Authority	Description	TWA	STEL	IDLH
NIOSH	REL	10 ppm TWA	15 ppm STEL	100 ppm
OSHA	PEL	20 ppm Ceiling	50 ppm for 10 min	
ACGIH	TLV	1 ppm TWA	5 ppm STEL	
UK	WEL	5 ppm TWA	10 ppm STEL	
Canada	OEL	10 ppm TWA	15 ppm Ceiling	
Australia	OEL	10 ppm TWA	15 ppm STEL	
Germany	AGW	5 ppm		
South Africa		10 ppm TWA	15 ppm STEL	
Brazil	OEL	8 ppm (max 48hrs/wk)		100 ppm (IPVS)
International	AGW	5 ppm		

NIOSH: The National Institute for Occupational Safety and Health (USA)

REL: Recommended Exposure Limit

IDLH: Immediately Dangerous to Life and Health

OEL: Occupational Exposure Limit

OSHA: Occupational Safety and Health Administration (USA)

STEL: Short-Term Exposure Limit

TLV: Threshold Limit Value

AGW: Arbeitsplatzgrenzwert

ACGIH: American Conference of Governmental Industrial Hygienists (USA)

TWA: Time-Weighted Average

WEL: Workplace Exposure Limit

PEL: Permissible Exposure Limit

Current monitoring practices

H_2S detection and monitoring practices vary by industry and the location of company operations (state, province, country, etc.). In one way or another, many types of gas monitoring equipment have the capability to continuously collect gas concentration data from a fixed location in a monitored area. In some cases data logging is a built-in function of a monitoring instrument. In other cases, the detector instrumentation can be connected to a PC or networked computer that runs software to collect and analyze the data.

Ambient H_2S concentrations in oilfields are frequently found at 3 to 5 ppm. Normal levels in sour gas facilities usually range between 1 to 3 ppm. Standard practice in upstream oil and gas has monitors set at 10 ppm with the emergency response plan to evacuate immediately to a safe muster point.



Adopting the latest detection technology

The prevailing methods of detection and monitoring in the workplace are colorimetric detector tubes and personal monitoring instrumentation that uses electrochemical sensors. It turns out there are commercially available products for both methods that have the sensitivity and accuracy needed to support even the new, lowered ACIGH H₂S guidelines (that are not legal requirements):

- Threshold Limit Value (TLV): 1 ppm;
- Time-Weighted Average (TWA): 1.4 mg/m³;
- Short-Term Exposure Level (STEL): 5 ppm, 7.0 mg/m³.

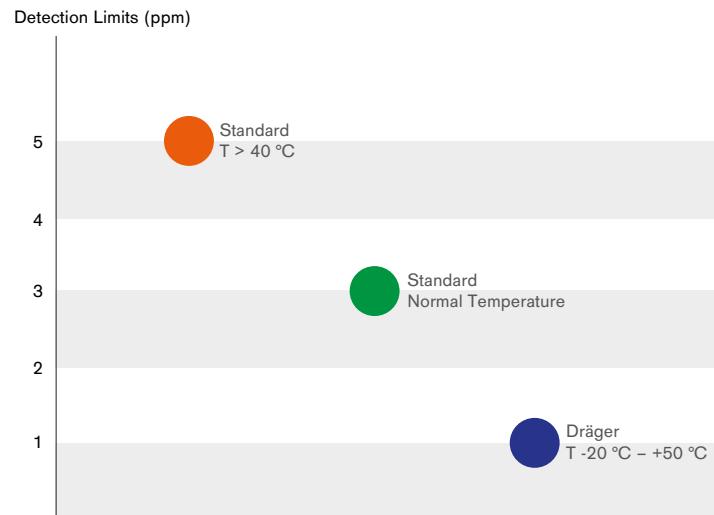
However, an electrochemical sensor in a personal monitoring instrument is the most practical one because it responds within seconds to a gas exposure. For example, the Dräger Model PAC 3500 Gas Detector equipped with an XXS H₂S LC sensor has a response time of 15 seconds or less. It also has a lower detection limit (sensitivity) of 0.4ppm,

with 0.1ppm resolution (smallest detectable change), and an accuracy of $\pm 5\%$ over its calibrated range of 0-100ppm. Other features include a built-in data logging function, and intrinsically safe design for use in hazardous duty areas where there may be a hazardous or explosive atmosphere.

There are various ways how such an instrument could be used in an industrial hygiene and safety program to monitor H₂S and meet even ACIGH guidelines. With an accuracy of ± 0.05 ppm at 1ppm ($\pm 5\%$) the X-am 5000 is more than adequate to meet the requirement of a reliable alarm and monitoring system. It has a low probability of false alarm results from the small temperature drift of the Dräger XXS H₂S LC sensor (less than 0.1ppm for the zero reading), and high selectivity for H₂S in the presence of interfering gases such as sulfur dioxide, nitrogen dioxide and hydrocarbons.

At a glance – key benefits of Dräger gas detection devices

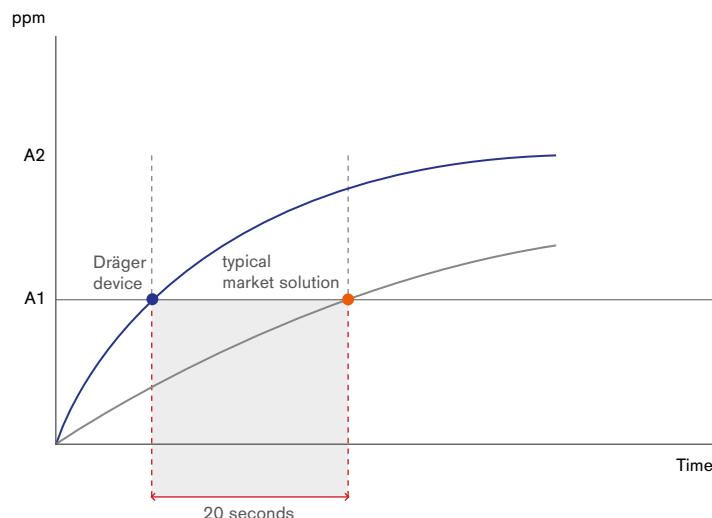
Detection limits for H₂S detection with portable devices



T= Temperature range

For exposure measurements Dräger recommends that the accuracy of the portable detection device is not higher than 1 ppm.

Response times of portable gas detection devices Dräger compared to typical market solutions



A= Alarmlevel

In case of a gas exposure the Dräger device warns up to 20 seconds earlier.

Issues of equipment selection

When monitoring equipment is selected for H₂S there are several issues that need to be considered. How do I monitor the 8 hour TWA and STEL exposure? In addition to periodic employee exposure monitoring, do I have employees wear gas detectors with alarms to warn of peak concentrations? If yes, what level do I set the alarm – 1 ppm, 5 ppm, 10 ppm? Do I also need area monitoring to detect the presence of H₂S to warn employees of its presence?

In order to provide maximum protection, it would be best to have an electronic instrument that could measure and store both the 1 ppm TWA and 5 ppm STEL H₂S levels and provides an alarm when concentrations reached 5 ppm. This instrument would have the following characteristics: it would measure both short term and time weighted average exposures; it would store the results for review after the monitoring was complete; it would have an alarm to warn of high H₂S levels; and it would be easy to operate.

The other consideration is for stationary measurement instruments associated with specific processes that would warn workers when concentrations exceeded the new STEL of 5 ppm. This would allow exposure avoidance – particularly in enclosed areas where H₂S may accumulate. For this application, an instrument with the following characteristics should be selected: it could be set to measure multiple gases; it would have an alarm to warn people of high concentrations; it would be rugged so it would stand up well in oil and gas environments and there would be adequate instructions/technical support for the monitoring equipment.

Excursus: Learn more about 'Mobile monitoring for all drilling rig operations' with the Dräger X-Zone (<http://www.draeger.com/sites/assets/Publishing/Images/Segments/ME/Generic/PDF/mobile-monitoring-for-all-drilling-rig-operations-cs-3839-en.pdf>)

Products for detection

Product	Product Type	Use Range	Comments
	Pac 500/5500/7000	Personal Air Monitor – single gas	0.4 to 100 ppm H ₂ S detection Long life sensor, quick response time
	X-am 2500/5000	Personal Air Monitor – multigas	0.4 to 100 ppm H ₂ S detection. Combination with further sensors Low false alarms; applicable for new NIOSH TLV levels, exposure monitoring
	X-zone 5500	Area Monitoring – multigas	0.4 to 100 ppm H ₂ S detection. Combination with further sensors Detects where exposure risk is expected; remote monitoring option
	Polytron 3000/7000	Intrinsically safe stationary transmitter	0.1 to 100 ppm H ₂ S detection Long life sensor, applicable for broad temperature range due to patented pressure compensation, quick recovery time, few false alarms
	Polytron 5100/8000	Explosion proof stationary transmitter	0.1 to 100 ppm H ₂ S detection Long life sensor, applicable for broad temperature range due to patented pressure compensation, quick recovery time, few false alarms

Personal protection



Dealing with high risks for personnel

Working in sour gas-containing oil fields, e.g. in Mexico, North- and South America as well as the Middle East (Saudi Arabia, Dubai Emirates etc.), holds as mentioned exceptionally high risks for the personnel, i. e. serious health damages or even death by asphyxiation. The oil of these wells contains very high concentrations of H₂S, which can cause a contamination of 250,000 ppm or more within the ambient air during incidents or accidents.

“You must have a lot of
confidence in your
safety equipment”

Hans Simon Cray
Global Marketing Manager
Protection Solutions



Special challenges for working at sour gas-containing oil fields

To provide devices that can protect people working under these conditions is one of the key competences of Dräger. Hans Simon Cray, Global Marketing Manager for Protection Solutions at Dräger, advises customers on this difficult task. Hans Cray is an expert for the creation of application-oriented safety concepts for the Oil & Gas Industry. He develops integrated solutions for breathing protection systems in H₂S environments – including customized escape, clarification and maintenance scenarios. In one of our 'Your safety is our passion' interviews he explains the need for devices with exceedingly high protection factors:

Mr. Cray, extremely high hydrogen sulfide concentrations are a topic you are currently researching intensively.

Hans Cray: Right, here again we are dealing with practical requirements that are not covered by the standards. Hydrogen sulfide is lethal starting at 1,000 ppm (parts per million). Exposed to this level of contamination or higher, you will be

unconscious within fractions of a second. The breathing reflex continues to function and one or two breaths lead to death. The current regulations for respiratory protection devices specify concentrations of up to 50,000 ppm H₂S. In the newly developed oil fields, however, we are not talking about 50,000 but more than 250,000 ppm, i.e., about 250 times the lethal concentration. As a user, you must have a lot of confidence in the performance of your safety equipment to work carefree in such environments!

As a rule, certificates should generate this type of trust.

Hans Cray: Right, and of course they do so in most cases. But when you talk about an oil field, in which up to 250,000 ppm can occur, it just is not enough when a device complies with the requirements of NIOSH / OSHA, or the EN.

How can higher performance then be demonstrated?

Hans Cray: Well, there are several options, such as to test

the tightness of a respirator. We are familiar with scenarios where subjects are exposed to an atmosphere with artificially generated particles and the particle concentration is measured in the room and in the protection system. The problem with such comparative testing, of course, is that the utilized dust particles or aerosols behave very differently than gas particles. Other tests work with gas, but the masks are not worn by people but placed only on the heads of dummies. These are rigid and immobile, however, which makes the scenario also not very realistic. But the user needs a protection system that has been tested under conditions as closely as possible to the requirements of the real-world application or task – both outlined test variants do not map this sufficiently. So we sat down and considered how a test should be conceptionalized that really helps the user.

What considerations have played a role?

Hans Cray: To test with real hydrogen sulfide is not possible due to ethical reasons, of course. We have therefore opted for a replacement gas, which behaves similarly as H₂S but is not harmful to humans. And it was important for us to test the masks in a setting that comes as close as possible to

the conditions in the field. Our volunteers simulated movements of a typical oil worker: carrying something, climbing up or down ladders, speaking through the mask, etc. During all of these activities, continuous measurements were taken of the concentration of the gas in the atmosphere and in the system. Testing was implemented and carried out by an independent technical monitoring organization to ensure a neutral analysis.

And what was the result?

Hans Cray: For us, after all the elaborate test preparations, the results were enormously gratifying: In fact, tests have shown a nominal protection factor of 33,000 for our respiratory protective devices. And that under conditions that are well comparable with those of an oil or gas production plant.

Excursus: Learn more about protection factors. Read our whitepaper 'Test results proved an exceedingly high protective factor of Dräger respiratory protection devices' (<http://www.draeger.com/sites/assets/Publishing/Images/Segments/ME/Generic/PDF/test-results-proved-an-exceedingly-high-protective-factor-of-draeger-respiratory-protection-devices-cs-9094589-en.pdf>)



Best practice:

Nine kilometers of breathing-air

The company Petroleum Development Oman (PDO) explores the oil and gas field Harweel II with a total area of approximately 556 acres situated in Oman. The main oil production technology applied in this case is the H₂S-EOR method². In this process, H₂S is being extracted, highly

compressed and pumped again into the oil well. This results in extremely high concentrations of H₂S, from which the employee must be protected. Dräger supports the safety concept with a plant-wide air supply system, rescue chambers and 600 gas sensor heads.

² EOR Enhanced Oil Recovery

The task

Due to the application of the H₂S-EOR process and the resulting necessary technology approximately 250 areas were classified as high-risk zones ('red zones') as part of the hazard assessment, during the development of the oil field. These are potentially hazardous locations where a particular risk, due to the high pressures and H₂S concentrations, might occur. During an incident, H₂S could spread very quickly and in very high concentrations – the minimum period of a few seconds necessary for escape or for fitting a respirator escape device would no longer exist. This means: When entering and during their entire stay in these 'red zones' must the staff work under permanent respi-

ratory protection. To ensure this the Harweel II-operator commissioned Dräger with the installation of a plant-wide breathing air system.

The solution

Over the eleven-month period of the project, Dräger planned and implemented the complete breathing air supply network from a single source. Beginning with the breathing air delivery, to distribution into the local extraction points within the 'red zones' for normal operation; for the case of an accident three rescue chambers including gas filtering and surveillance technology, which are connected to the air supply system; and for plant-wide area monitoring

600 Dräger Polytron H₂S sensors. The challenge to the design and engineering of the air supply system was to ensure uninterrupted availability of the system (24/7), with particular reference to the extreme climatic conditions in the desert. To achieve this a nine kilometer long system-wide low-pressure air supply was installed. It feeds from a high pressure breathing air system with correspondingly large capacity. Maintaining the breathing air supply in the high-pressure mode can save space, thus creating a large storage volume. The high pressure system – consisting of high-pressure compressors, filter units, breathing air monitors, memory banks, and pressure reduction stations – is located in a separate room. The supply of breathing air to the local extraction points ('red zones') occurs over 250 hosereels.

The added value

The breathing air system that was essential for the commissioning of the oil field, installed Dräger within very little time. A key advantage for the operator, as each day delay in exploration means a high loss of profit in the oil and gas industry.

All the more important that the system is ready for use, at any time (24/7). The air supply is ensured by the large-scale low-pressure supply system at all 250 extraction points in breathing air quality. Also for the case of an accident, provisions are made through the installation of the rescue chambers.

Products for protection against extreme concentrations of H₂S

Product	Product Type	Use Range	Comments
	X-plore 6300	Filter mask with type B filter	Depending on chosen filter Full face mask with RD40 filter connection
	PAS Colt	Self Contained Breathing Apparatus	330.000 ppm* H ₂ S Hip worn positive pressure SCBA with airline option
	PAS Lite	Self Contained Breathing Apparatus	330.000 ppm* H ₂ S Easy to clean, robust and lightweight SCBA with airline option

* STEL (short time exposure limit) 10ppm

Escape in an H₂S event



How to select an appropriate escape device

When confronted with an H₂S event, it is of the utmost importance workers have easy access to an appropriate escape respirator and follow recommended and required safety procedures and protocols.

To determine the most appropriate escape respirator for an H₂S event emergency response plan, the degrees of severity that the event will present and the potential exposure levels must be assessed. NIOSH's document 'Concept for CBRN Air-Purifying Escape Respirator Standard' e. g. classifies degrees of severity for emergencies as high, specific, and low:

- High: Any scenario involving a release or existence of unknown toxic substances in high or unknown concentrations, as well as oxygen-deficient atmospheres (less than 19.5 percent volume)

- Specific: Any scenario involving the release or existence of known toxic substances in any concentration. (Environments with 'specific' hazards always have sufficient oxygen.)
- Low: Any scenario involving the release or existence of known toxic substances in low concentrations. (Environments with 'low' hazards always have sufficient oxygen.)

The selection of the appropriate escape device in an H₂S event depends on the specific situation on-site. The assigned protection factor (APF) must be greater than the expected air contaminant concentration, divided by the exposure limit. NIOSH (USA) e.g. provides the following APF recommendations for H₂S:

Up to 100 ppm:

- APF = 25: Any powered, air-purifying respirator (PAPR) with cartridge(s) providing protection against the compound of concern.
- APF = 50: Any air-purifying, full facepiece respirator (APR) (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern.
- APF = 10: Any supplied-air respirator (SAR).
- APF = 50: Any self-contained breathing apparatus (SCBA) with a full facepiece.

Emergency or planned entry into unknown concentrations or Immediately Dangerous to Life and Health (IDLH) conditions:

APF = 10,000: Any SCBA that has a full facepiece and is operated in a pressure-demand or other positive pressure mode.

- APF = 10,000: Any SAR that has a full facepiece and is operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus.

Escape:

- APF = 50: Any APR with a chin-style, front- or back-mounted canister providing protection against the compound of concern.
- Any appropriate escape-type self-contained breathing apparatus.

Evaluating the degrees of severity

Through evaluating the degrees of severity of a potential H₂S event, as well as the possible exposure levels, companies can then determine which escape respirators will be most effective in their H₂S emergency response plan. First, two main options exist for hazardous areas where there is a threat of a major release. In airline applications with a nearby 'safe zone', SARs with an escape cylinder prove to be the best choice, whereas in airline applications with long distances to travel to a 'safe zone' wearing an SCBA with airline would keep the worker safest.

Next, in general working areas where potential hazards cannot be accurately quantified or in areas where there is a chance of oxygen deficiency, one should consider a 5-10 minute

Emergency Escape Breathing Apparatus (EEBA) with a cylinder and hood for short escape distances or a wall hanger SCBA for longer escape distances. Finally, in general working areas with predictable concentrations and risk, both EEBAs and SCBAs will work, however, each provides more protection than required. These respirators can also be expensive, require periodic maintenance, are heavy and difficult to carry, and offer no protection once air is spent. The alternatives are an APR or APR and escape hood. They can effectively filter high concentrations of toxic gases of oxygen levels (above 19.5 percent volume), are less expensive, require low maintenance, are small and lightweight, can be belt worn, and can assist in longer escape times, depending on concentration.

Train the safe use of escape devices

To keep workers a step ahead in their personal safety when confronted with a H₂S event, it is of the utmost importance that they have easy access to an escape respirator and follow recommended and required safety procedures and protocols. The right respirator will only maximize safety for those workers who know how to make use of it in an H₂S event. Panic often ensues in these situations, making it necessary to train on why an escape respirator may be needed and how it provides protection, in order to encourage second nature use by employees.



Escape devices for H₂S events

Product	Product Type	Use Range	Comments
	Parat 7500	Escape Filter Hood	2,500 ppm H ₂ S 15 minutes, 10,000ppm H ₂ S 5 minutes
	Parat 4920 (NIOSH)	Escape Filter Hood	1,000 ppm H ₂ S 30 minutes
	Saver CF (NIOSH)	constant flow Emergency Escape Breathing Apparatus	10,000 ppm* H ₂ S
	PAS Colt	positive pressure Emergency Escape Breathing Apparatus	330,000 ppm* H ₂ S
			Constant flow hood with pressurized breathing air cylinder for 10/15 minutes escape
			Hip worn positive pressure SCBA for 10/15/20 minutes escape with airline option

* STEL (short time exposure limit) 10 ppm

First aid: If something happens

- General: Develop an eye for the typical symptoms of H₂S poisoning. It is important to recognize the seriousness of an incident, to sound the alarm, and to take the right actions. Watch your colleagues: Does someone show typical symptoms of H₂S poisoning?
- When H₂S occurs, protect yourself first. Only then should you rescue victims from the contaminated area, leading them to fresh air and keeping them warm.
- Call the emergency doctor.
- If the victim stops breathing: Ventilate by machine (operated by you or someone else); do not inhale the breath of the injured yourself.
- In case of skin contact and subsequent irritation: immediately remove clothing, flush contaminated skin with clean water, and consult a physician; keep person warm, and use sterile dressings.
- After eye contact: Rinse the injured eye for at least ten minutes under running water while protecting the uninjured eye. Consult an ophthalmologist.
- The following applies to each contact with H₂S: Seek medical attention and inform rescue and medical personnel about the circumstances of the incident, what type of first-aid measures have already been carried out, provide information about the amount or extent of the inhaled dose – if known.

The above information may not be relevant for all locations. Please obtain information about current HSE guidelines and currently applicable limit values before starting work.

Rescue in an H₂S event



Rescue strategies for harsh environments

Incidents in harsh and remote areas are a special challenge. Between the first escape and the possibility to leave the contaminated area entirely is a big gap to be bridged. During this time personnel must have the chance to reach a safe haven or at least to be supplied with breathing air for a longer time.

“Oil and gas production is currently faced with challenges that no one was prepared for even a few years ago.”

Frank Pietrowski
Business Development
Manager



The expertise is in the detail

Just one breath can be deadly, if more than one thousand ppm of hydrogen sulfide is suddenly released into the air on a conveyor system. There is a risk of concentrations many times higher at the location of Frank Pietrowski's most recent project: "In the Gulf States there are fields that contain H₂S of up to 30 to 40 percent", explains the engineer. "Anyone looking to produce in these areas must include safety planning for incidents in which toxic gases can escape in fractions of a second and where even explosions are possible. If protective masks are not worn in these highly toxic environments or appropriate protective measures are not implemented, no one stands a chance in an emergency."

These are exactly the kind of incidents being investigated in this greenfield project where the task was to develop a corresponding rescue concept together with the customer and their HSE managers. "Not every platform operator has experience with these kinds of extreme H₂S concen-

trations", says Frank Pietrowski. "However, in this case, a safety engineer who had worked with us previously on another project in Kazakhstan was on site and was aware of our expertise on the topic of H₂S." He reports that specially manufactured terminal points with hose reels were delivered to a plant in Kazakhstan. "There, hazard zones exist in which work can only be performed with permanent ventilation. For example, when a fan is replaced during maintenance work, or a flange has to be sealed, all the workers connect their breathing apparatus to these terminal points. The hoses supply breathing air which allows them to work within a certain radius. However, the Caspian Sea also has extreme weather conditions: it can be very hot in summer, while the temperature can fall to minus 40 degrees Celsius in winter. As a result, it was necessary to develop a special housing for the hose reels. Due to the areas of application, the housing had to be resistant to sea water, and all electrical components such as the heating also had to be explosion protected. It was one thing after another until we were finally able to offer the customer a truly safe solution to their problem."

Needed: Innovative solutions for new problems

A shelter is also a central part of the safety concept. If an incident occurs, the plant must be able to be properly shut down from the control room. "That's where the monitoring screens are located, where all the decisions are made and, especially in critical situations, it is important that employees can continue to communicate and exchange information quickly and masks would only prove to be a hindrance", says Pietrowski. The control room is completely sealed and overpressure can be established for up to two hours. "It is completely safe even with high H₂S concentrations. In other words, the bridge of the Starship Enterprise has nothing on it" says Pietrowski with a wink. Once the plant has been shut down, breathing apparatus with connected external air supply provide additional protection for another two hours. The work performed by Engineered Solutions for this customer also included the development of a protection concept for the almost 500-person team. The employees are assigned to various points along the extensive premises covering several square kilometers. An area with a high military presence and a meter-high pro-

tective wall around the plant make escape impossible in an emergency.

As a result, the key question was how many protective chambers were required and where they were to be located in the surrounding area. Escape chambers were positioned at three locations on the premises, offering protection for 30, 90 and 250 people for four hours. A total of nine containers were connected to each other for the largest chamber; four locks ensure that escapees quickly reach the inner room. Two additional shelters in buildings that require special protection completed the concept.

In many cases advising also means drawing on our extensive experience to develop innovative solutions for new problems. "Oil and gas production is currently faced with challenges that no one was prepared for even a few years ago", says Pietrowski. "The aim now is to gain and share experience and work together to develop new solutions. Our task also includes thinking and planning ahead for the customer. Because these days society couldn't exist without oil and gas – and that's why we will continue to work on the sector's safety issues for a long time to come."



Ventilation of temporary refuges: Filtration protection or isolation protection?

Planning a temporary refuge in the oil and gas industry raises a number of questions for safety engineers: How do you ensure that sufficient breathing air is available –

even for extended periods and a large number of persons? Which system delivers the best and safest solution for the particular requirements?

A temporary refuge is defined as “a place or places where personnel will be adequately protected from relevant hazards while they remain on an installation following a major incident, and from where they will have access to the communications, monitoring and control equipment necessary to ensure their personal safety, and from where, if necessary, safe and complete evacuation can be effected.”

The question, which requirements such “adequate temporary refuge” should meet and where it should be located always has to be answered on the basis of a plant-specific risk analysis. But: “For the oil and gas industry, there is no standard that gives definite instructions on how to design a temporary refuge with regard to gas protection”, says Frank Pietrowski, Business Development Manager at Dräger Engineered Solutions. “Today, safety engineers do not even find specific guidelines for basic matters such as

construction and equipment.” It is therefore important to develop a basic understanding of the different technical approaches and their advantages and disadvantages.

Filtration protection: A classic with complex requirements

The protection principle is based on the fact that overpressure is generated in the temporary refuge due to a ventilation solution, which ensures that external contamination remains on the outside. During this procedure, outside air is drawn in from an uncontaminated area of the plant, is cleaned as thoroughly as possible via a filter line and is then “pressed” into the inside of the temporary refuge. In the case of H₂S contamination, uncontaminated air is attempted to be drawn in from higher areas, for example via vertical air intakes. For this procedure, a filter system adequate for the respective

hazardous materials as well as a gas measurement system before and after the filter are required, in order to check the concentration and detect any filter damages early enough. A filtration protection system requires constant power supply in order to build up overpressure against toxic gases from the outside.

Pros and cons

1. The hazardous materials must be known

Safety engineers have to know exactly, which hazardous materials are expected, and also in which maximum concentrations they can occur, in order to choose the right filter or absorbent and determine the dimensions of the filter bed.

2. Activated carbon filters do not offer 100 % protection

Filters are a defined 'leakage': The temporary refuge is not tight, as the contaminated atmosphere is drawn in on purpose, in order to be filtered. This means that even

with sufficient dimensioning of the filter bed or multiple filtration cycles, the hazardous materials cannot be filtered to 100 percent.

3. High maintenance effort in standby mode

For the filter to be ready for operation at any time, its protective packaging needs to be removed. Activated carbon filters, for example, require a certain level of humidity on the surface in order to be reactive – if it becomes to dry, the performance is affected. It is therefore essential to permanently check the condition of the filters.

4. Complexity of the system in the case of an alarm

In an emergency, the occupants of the temporary refuge need to permanently check the breathing air. The filter is saturated after a certain time, depending on the concentration of the absorbed hazardous materials and the duration of the exposure. It is therefore essential to install redundancies, for example a second filter system or breathing apparatuses.

5. Remaining risks that are difficult to control

One weak spot of the filter system is its dependency on the air conditioning system and the power supply: If it fails, not just cooling and ventilation but also the filtration system are disabled.

Another danger in the case of extremely high hydrogen sulphide concentrations, starting at approx. 10,000 ppm, is the risk of a self-ignition of the filters.

Isolation protection: An all-round solution even for the highest standards

The key advantage of this system is the protection of persons independent of the external atmosphere: The isolated temporary refuge is pressurised with stored breathing air and no exchange with the contaminated atmosphere takes place. In an emergency, the isolation solution does not require external power supply. An airlock in the entrance area ensures that the pressure in the inner chamber is maintained,

even when other employees enter the temporary refuge.

Pros and cons

1. Protection from all hazardous materials

While, in the case of filtration solutions, there is always the risk of an unknown or disregarded gas to come through the filter, the isolation protection is an all-round-er that prevents all hazardous materials from penetrating into the temporary refuge.

2. Stable conditions in the interior

The quality of the breathing air can be kept stable for the entire duration of the stay in the temporary refuge, as no supply from the outside takes place. The oxygen content of the air is constantly at 19 to 22 vol. %; the carbon dioxide content remains below 1 vol. %.

3. Low maintenance effort

The system requires virtually no consumables and there is hardly any waste (used filters, for example, need to be

disposed of as special waste). Only the compressed air cylinders need to be serviced and refilled, when required.

4. Redundancy in the system

The isolation protection disposes of a built-in redundancy, just because of the high tightness of the chamber: In an extreme case, the thermal effect of the persons in the chamber alone develops a pressure that prevents hazardous materials from entering.

The economic alternative: Regeneration of the breathing air

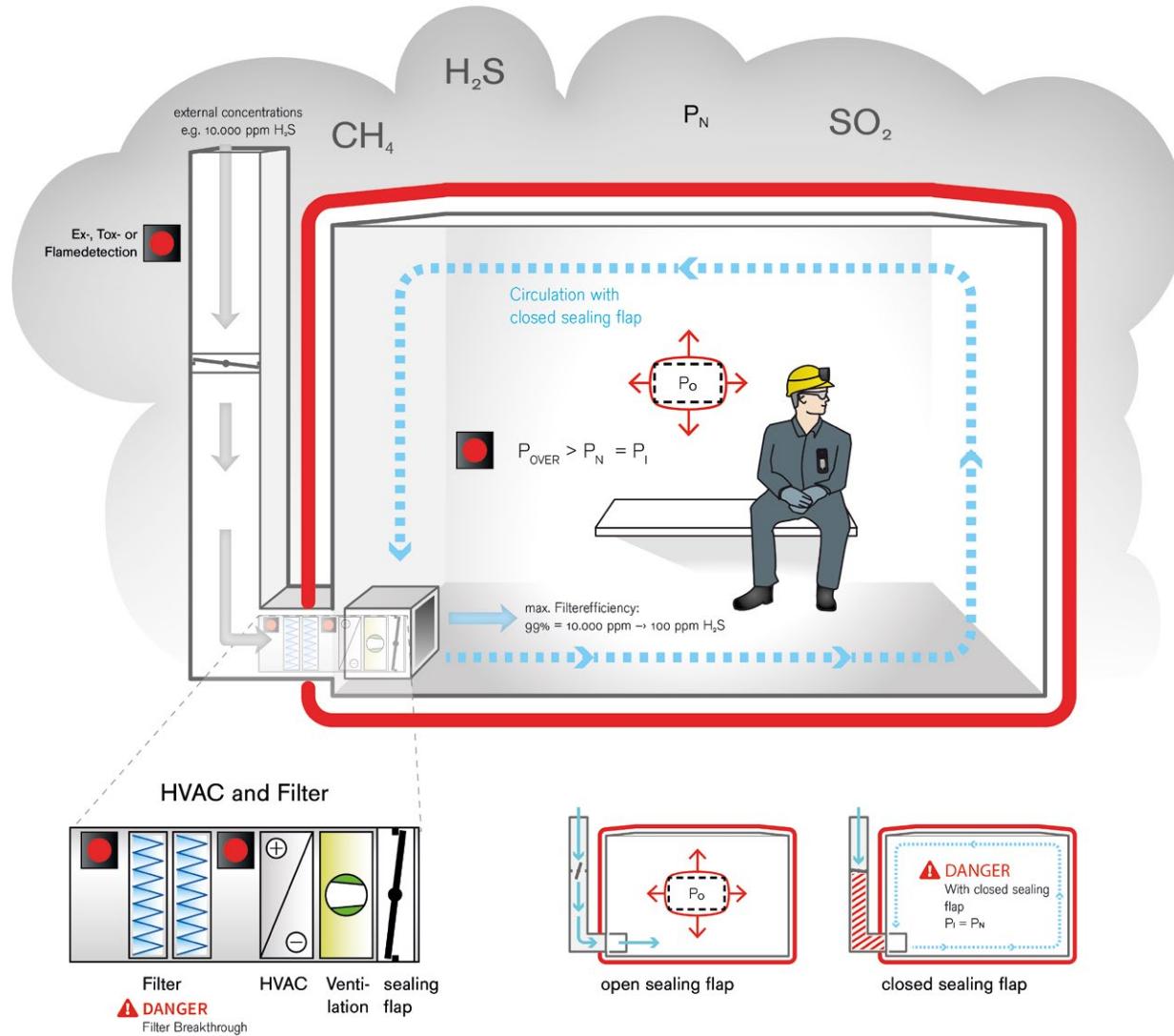
For the isolation solution, the supply with breathing air can either be realised by supply from compressed air cylinders or through the installation of a breathing air regeneration system, which uses soda lime to absorb the exhaled CO₂ in the temporary refuge and supplies new oxygen from a high-pressure cylinder. "This way, the isolation protection with regeneration system allows longer stays even for a larger

number of persons, when it comes to air supply", Frank Pietrowski states.

This alternative is not only an attractive solution when it comes to safety, but also regarding the costs: While the costs of the filter solution and the isolation protection with supplied air from compressed air cylinders rise exponentially, the more persons the temporary refuge has to accommodate and the longer the duration of the stay is, the costs only rise linearly for air-regeneration.

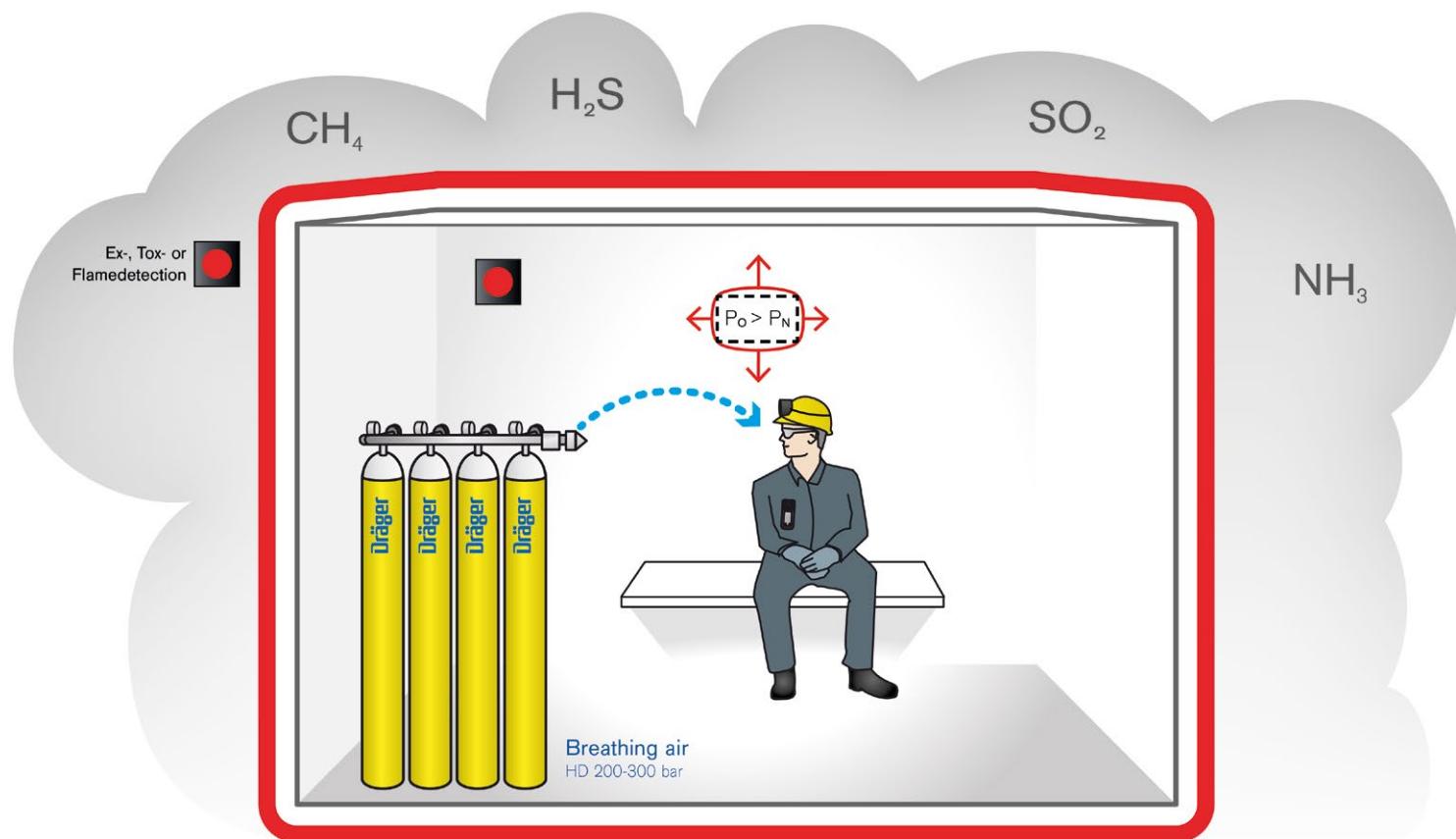
Conclusion: Choosing the right technique is anything but trivial – not least for this reason, there are no universal recommendations to use one system or the other. In view of the growing challenges that extremely high H₂S-concentrations pose for the safety concepts, many factors are in favour of an air-independent solution. Frank Pietrowski's conclusion: "In the end, it all depends on the safety philosophy of the operator."

Protection through filtration: Depending on ambient air

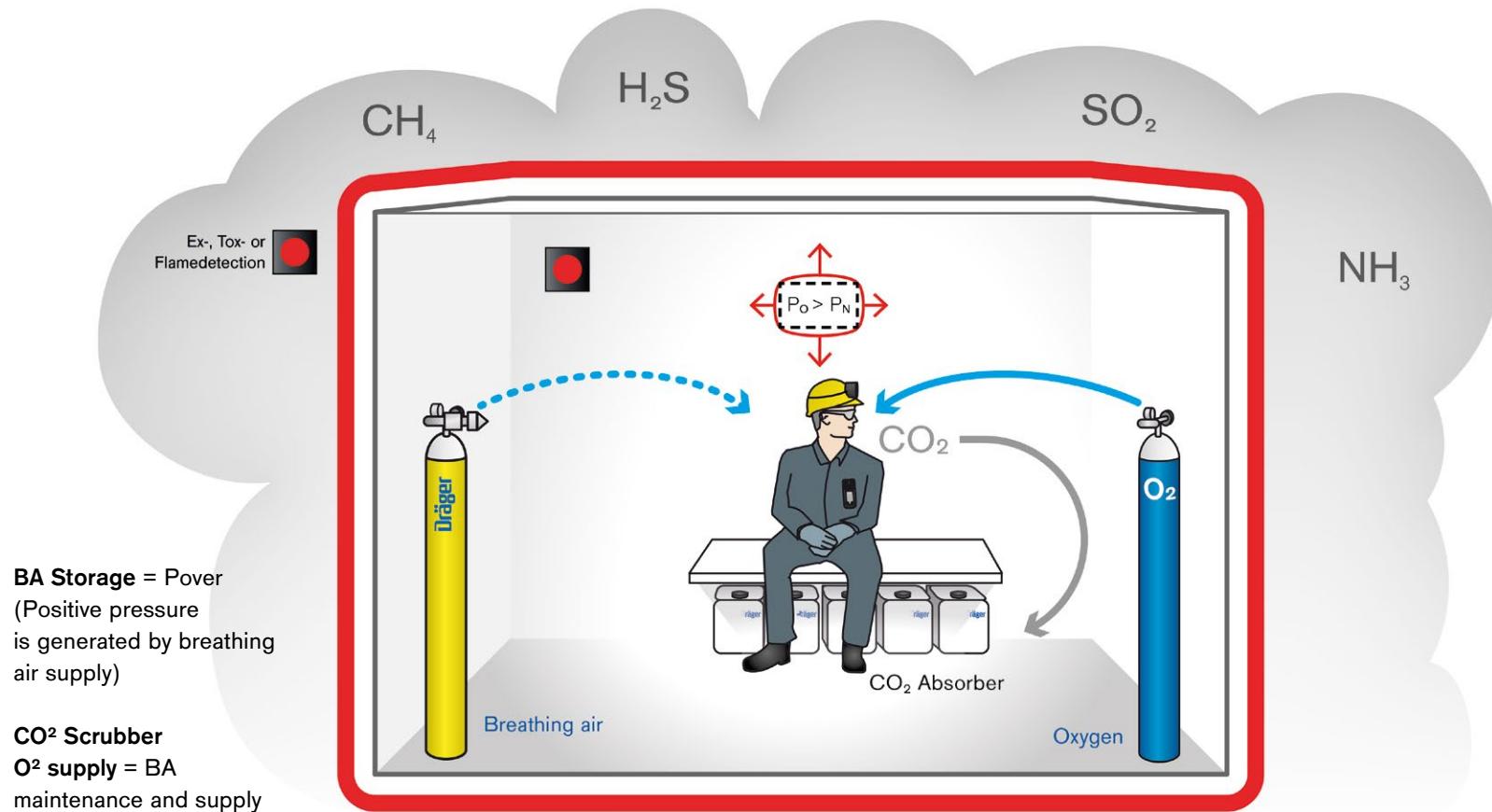


Protection through isolation: Independent of the ambient air

(Maintenance of positive pressure via flushing air technology)



Protection through isolation: Independent of the ambient air (Ensurance of positive pressure via breathing air maintenance and supply)



Solutions for rescue in H₂S contaminated areas

Product	Product Type	Use Range	Comments	
	Refuge shelters	Temporary refuge shelters for H ₂ S incidents	Unlimited due to isolation technology	Containerized modular designed shelter solutions

Individual rescue concepts are developed by Dräger Engineered Solutions (Dräger ES): The business unit realizes customized project solutions in the areas of respiratory gas supply, breathing protection as well as training and service systems. The custom implementation lies in the form of

integrated system concepts and -applications. Dräger ES assists its customers with interdisciplinary teams from the initial idea to concept development and on-site installation to after-sales service. Dräger ES operates from multiple locations worldwide.

SUMMARY

The exploration and 24/7 operating availability of sour gas recovery fields is highly depending on the ability to protect people from H₂S contamination. The expansion of this oil recovery standard is limited by safety and HSE precautions – if they cannot be ensured the whole project is balanced on a knife's edge. But our experience and our cases show: Together we can find the appropriate solutions for these challenges. For more information contact your local sales representative.

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IMPRINT / CONTACT

Draeger Safety Inc.

101 Technology Drive
Pittsburgh, PA 15275-1057

Tel +1 800 858 1737
Fax +1 412 787 2207
info@draeger.com