MSA
The Safety Company

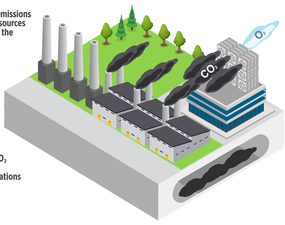
GAS & FLAME DETECTION GUIDE FOR CCS/CCUS

WHAT IS CCUS?

CC Carbon Capture — Capturing CO_2 emissions from industrial sources or directly from the atmosphere

U Utilization — Converting captured CO_2 into useful products like fuels, chemicals, or building materials

S Storage — Safely storing CO_2 underground in geological formations



MAIN SAFETY CHALLENGES

CCS/CCUS presents several safety challenges that should be addressed to support a safe operations.

Capture Challenges

Different carbon capture processes introduce various gases that can create safety concerns:

- Pre-combustion: CH_4, CO, H_2, CO
- Oxy-fuel combustion: CH_4, CO_2 , N_2, O_2
- Post-combustion: CO_2, N_2, CH_4 , SO_2

Impurities in the captured CO_2 stream result from a combination of different feedstocks, carbon capture technologies, and solvents used across various sources. Common impurities include H_2O, N_2, O_2, H_2S, H_2, and SO_2, which can lead to corrosion or pose health and safety risks.

Transportation Challenges

CO_2 is transported in a supercritical state through pipelines and as liquefied carbon dioxide (LCO_2) via ships or specialized carriers. Impurities such as H_2O, O_2, H_2S, and SO_2 can accelerate corrosion, increasing the risk of gas leakage. Additionally, sudden decompression in LCO_2 carriers can result in dry ice formation, posing further safety and operational challenges.

Storage Challenges

Impurities can compromise CO_2 storage facilities by accelerating corrosion, increasing the risk of leaks, and other safety hazards. Additionally, CO_2 leakage may result from geological faults or poorly sealed wells, which can have significant environmental impacts.

UNDERSTANDING GAS-RELATED RISKS IN CCS/CCUS

CO_2

Colorless — Odorless

- Heavier than air. Density: 1.98kg/m³ (approx. 1.5 times denser than air).
- High concentration: Displaces oxygen and can lead to asphyxiation.
- Non-flammable but a potent greenhouse gas that its leakage can contribute to environmental concerns.

O_2

Colorless — Odorless

- Slightly heavier than air. Density: 1.429kg/m³ (slightly denser than air).
- Non-toxic but deficiency below certain level in the atmosphere is lethal.
- Non-flammable but supports and accelerates combustion of other flammable materials.

SO_2

Colorless — Pungent, strong odor, similar to a burning match

- Heavier than air. Density: 2.619kg/m³ (approx. 2.3 times denser than air).
- Highly toxic. Can cause respiratory problems and irritation to eyes and mucous membranes.
- Non-flammable.

CH_4

Colorless — Pure form: Odorless; Common form: Mixed with an odorant (e.g., mercaptan) to detect by sense of smell.

Highly Flammable

- Lighter than air. Density: 0.717kg/m³ (approx. 0.55 times the density of air).
- Non-toxic but a potent greenhouse gas that its leakage can contribute to environmental concerns.
- Explosive range:
  - 4.4-17.0vol% (IEC 80079-20-1:2019)

H_2S

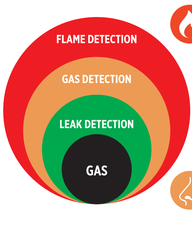
Colorless — Low concentration: Rotten egg smell; High concentration: Desensitize the sense of smell

Highly Flammable

- Heavier than air. Density: 1.536kg/m³ (approx. 1.19 times the density of air).
- Highly toxic and potentially fatal. Can cause severe respiratory distress and fatal in high concentrations.
- Explosive range:
  - 4.0-45.5vol% (IEC 80079-20-1:2019)

MITIGATING THE HAZARDS: THE SAFETY APPROACH

A layered fire and gas detection approach for CCS/CCUS facilities involves integrating leak, gas, and fire detection systems to help achieve comprehensive safety by identifying potential hazards at every stage of operations.



LAYER 1: LEAK DETECTION LAYER

Ultrasonic gas leak detection provides the earliest possible response to pressurized gas leaks. This technology is vital as the gas captured in CCS/CCUS is compressed to high pressures to ease transportation, utilization, and storage. This safety layer helps prevent potential escalation to hazardous levels, as CO_2 and other hazardous gases in CCS/CCUS can pose significant safety and environmental risks if left undetected.

LAYER 3: FLAME DETECTION LAYER

Flame detectors provide a fast response to the presence of flame, minimizing the risk of fires from various CCS/CCUS processes, such as the pre-combustion, post-combustion, and oxy-combustion capture processes. Fire hazards arise from a combination of flammable gas leaks, high pressure, and high temperatures that can ignite. This approach helps prevent fires from spreading and causing further damage, protecting equipment and personnel.

LAYER 2: GAS DETECTION LAYER

Point-type and open-path gas detection technologies can help mitigate risks of oxygen deficiency, toxic gases such as CO_2, H_2S, and SO_2 and flammable gases such as CH_4. Point detectors provide quantitative measures in %LEL or ppm at specific locations, while open-path detectors cover larger areas with detection in ppm.m and LEL.m to detect gas clouds at greater distances.

GAS LEAK DETECTION

Observer® i Ultrasonic Gas Leak Detector

Pressurized leaks

Ultrasonic gas leak detection quickly detects pressurized gas leaks at the speed of sound. The ANN (Artificial Neural Network) technology distinguishes gas leaks from other background noises.

GAS CLOUD DETECTION

ULTIMA® X5000 Gas Monitor

Senscient ELDS™ Laser-Based Open Path Gas Detector

IR5500 Infrared Open Path Gas Detector

Localized Gas Clouds

Point-type detection monitors oxygen deficiency, toxic gases, and combustible gases. The dual sensor feature offers a combination of two sensor technologies, such as infrared (IR), electrochemical, and catalytic technologies. CO_2, CH_4, and other hydrocarbons are detected using an infrared (IR) sensor. O_2 deficiency and toxic gases such as H_2S and SO_2 are detected using an electrochemical sensor. Flammable gases are detected using catalytic bead sensor.

Expanding Gas Clouds

Open-path gas detection (OPGD) provides fast response to large gas clouds outdoors or in large open spaces. NDIR OPGD technology can be used for hydrocarbon gas cloud detection while laser-based OPGD technology can be used for specific target-gas leaks such as CO_2, CH_4, H_2S, and sour gas clouds.

FLAME DETECTION

General Monitors® FL5000 MSIR Flame Detector

General Monitors® FL500-H2 UV/IR Flame Detector

Flame

Optical flame detectors provide early hydrocarbon and hydrogen flame detection before the fire spreads across various capturing processes or pipelines for transportation.

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