

## Hydrogen Sulfide (H<sub>2</sub>S) Code of Practice

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**Table of Contents**

**1.0 Purpose .....3**

**2.0 Scope .....3**

**3.0 H<sub>2</sub>S Management .....3**

    3.1 What is H<sub>2</sub>S? .....3

    3.2 H<sub>2</sub>S Safety .....3

    3.3 H<sub>2</sub>S Management Program .....4

**4.0 Roles and Responsibilities .....9**

**5.0 Training .....12**

    5.1 Training .....12

    5.2 H<sub>2</sub>S Alive Certification .....12

**6.0 Quality Assurance .....13**

    6.1 Performance Measurement.....13

    6.2 Management of Change .....13

    6.3 Practice Verification .....13

**7.0 Glossary .....14**

**8.0 References .....15**

    8.1 External Documents.....15

    8.2 Internal Documents .....15

**List of Tables**

Table 1: H<sub>2</sub>S Exposure Symptoms/Effects .....4

Table 2: Occupational Exposure Limits for H<sub>2</sub>S .....5

Table 3: Roles and Responsibilities .....9

Table 4: Terms and Definitions .....14

Table 5: Acronyms, Initialisms and Abbreviations .....14

Table 6: External Document References.....15

Table 7: Internal Document References .....15

## **1.0 Purpose**

The purpose of the Hydrogen Sulfide (H<sub>2</sub>S) Code of Practice (COP) is to set a minimum standard and provide operational guidance for controlling worker exposure to H<sub>2</sub>S.

## **2.0 Scope**

This H<sub>2</sub>S COP applies to all Cenovus worksites and encompasses all Cenovus work activities. Contractors working at Cenovus sites where H<sub>2</sub>S may be encountered are expected to have their own H<sub>2</sub>S COP in place that offers an equivalent level of awareness and safety.

## **3.0 H<sub>2</sub>S Management**

### **3.1 What is H<sub>2</sub>S?**

H<sub>2</sub>S is a naturally occurring colourless gas commonly encountered in the oil and gas industry. It may be trapped in solid sediment, or dissolved in produced water, crude oil or natural gas condensate. Commodities that contain sulfur compounds including H<sub>2</sub>S are colloquially termed "sour" and facilities that process sour commodities are termed sour facilities. Facilities that do not have H<sub>2</sub>S may turn sour over time. Agitation or circulation of sour material or depressurization of a sour system may cause H<sub>2</sub>S gas to release. At low concentrations, H<sub>2</sub>S has a characteristic rotten egg smell, which is not detectable at higher concentrations.

### **3.2 H<sub>2</sub>S Safety**

H<sub>2</sub>S is acutely toxic; inhaling elevated concentrations of H<sub>2</sub>S gas in the hundreds to thousands of ppm range can render a person unconscious and can cause death. The adverse health effects associated with exposure to H<sub>2</sub>S gas vary depending on the concentration and duration of exposure (Table 1).

Although H<sub>2</sub>S smells like rotten eggs at lower concentrations, above 100 ppm the gas impairs the olfactory nerve and we can no longer smell it. The lack of odour at elevated concentrations may give workers a false sense of security or safety when they in fact are in grave danger.

H<sub>2</sub>S is highly flammable with a flammable range of 4 – 44% by volume. H<sub>2</sub>S in its pure state is heavier than air. When the concentration of H<sub>2</sub>S in a gas mixture is high, it tends to collect and settle in low lying and poorly ventilated areas. When H<sub>2</sub>S is present in lower concentrations (i.e. found in trace amounts, or is considered a contaminant), it tends to travel with the gas mixture. Additionally, when H<sub>2</sub>S is heated or warmer than ambient air it will rise.

**Table 1: H<sub>2</sub>S Exposure Symptoms/Effects**

Concentration (ppm)	Symptoms/Effects
0.01-1.5	Odor threshold (when rotten egg smell is first noticeable to some).
2-5	Prolonged exposure may cause nausea, tearing of the eyes, headaches or loss of sleep. Airway problems (bronchial constriction) in some asthma patients.
20	Possible fatigue, loss of appetite, headache, irritability, poor memory or dizziness.
50-100	Slight conjunctivitis ("gas eye") and respiratory tract irritation after 1 hour. May cause digestive upset and loss of appetite.
100	Coughing, eye irritation, loss of smell after 2-15 minutes (olfactory fatigue). Altered breathing, drowsiness after 15-30 minutes. Throat irritation after 1 hour. Gradual increase in severity of symptoms over several hours. Death may occur after 48 hours.
100-150	Loss of smell (olfactory fatigue or paralysis).
200-300	Marked conjunctivitis and respiratory tract irritation after 1 hour. Pulmonary edema may occur from prolonged exposure.
500-700	Staggering, collapse in 5 minutes. Serious damage to the eyes in 30 minutes. Death after 30-60 minutes.
700-1,000	Rapid unconsciousness, "knockdown" or immediate collapse within 1 to 2 breaths, breathing stops, death within minutes.
1,000-2,000	Nearly instant death.

Source: U.S. Occupational Safety and Health Administration (OSHA)

### 3.3 H<sub>2</sub>S Management Program

As a result of the safety risks associated with H<sub>2</sub>S exposure, all Cenovus worksites where H<sub>2</sub>S is present requires a H<sub>2</sub>S management program. The H<sub>2</sub>S management program must be implemented by the respective asset team and shall consist of the following items:

- recognition of H<sub>2</sub>S on site
- pre-job hazard assessment
- air monitoring and evaluation
- H<sub>2</sub>S hazard controls
- storage, use, handling and disposal procedures
- training
- review of the program every three years

### 3.3.1 Recognition of H<sub>2</sub>S on Site

When working in a sour facility or performing tasks or activities that involve sour commodities, assume H<sub>2</sub>S is present and put in place controls to protect the health and safety of workers.

### 3.3.2 Pre-Job Hazard Assessment

For any task or activity where H<sub>2</sub>S may be present, a pre-job hazard assessment must be conducted and a work plan developed prior to the commencement of work. All affected workers (i.e. the work crew and other workers in the surrounding area) must be accounted for in the pre-job hazard assessment.

The following must be considered during the hazard assessment and reviewed with on-site personnel during the pre-job safety meeting:

- job-specific procedures
- H<sub>2</sub>S hazards and where they may be found
- monitoring requirements (continuous or specified intervals)
- tending worker or safety watch, and rescue personnel requirements
- muster point location(s)
- alarms and emergency response and rescue procedures
- Personal Protective Equipment (PPE), including respiratory protection

### 3.3.3 Exposure Evaluation and Air Monitoring

Exposure to H<sub>2</sub>S is regulated in Alberta and Saskatchewan. The Occupational Exposure Limits (OELs) are as follows:

**Table 2: Occupational Exposure Limits for H<sub>2</sub>S**

Jurisdiction	H <sub>2</sub> S (ppm)		
	15-minute	8-hour	Ceiling
Alberta	-	10	15
Saskatchewan	15	10	-

**Despite the legislated OELs, due to the acute toxicity and the unpredictability of H<sub>2</sub>S, gas monitors are set to alarm at 10 ppm, at which point any workers in the immediate vicinity will evacuate to a safe area to avoid further exposure.**

H<sub>2</sub>S air monitoring is achieved by a combination of means to protect workers' health and safety. These include fixed monitor, personal monitor, remote area monitor and handheld area monitor.

#### Fixed Monitor

Permanent, fixed H<sub>2</sub>S detectors shall be provided in facilities where there could be a release or accumulation of more than 10 ppm H<sub>2</sub>S. Single well facilities with more than 1% H<sub>2</sub>S concentration in the fluid stream require fixed H<sub>2</sub>S detectors.

Fixed H<sub>2</sub>S detectors, alarm and shutdown settings, exhaust fans, warning lights and horns and other design features shall be in accordance with specification CVE-GEN-S-04, Practice for the Development of Emergency Shutdown Systems.

**Personal Monitor**

Workers working in an environment where H<sub>2</sub>S is or may be present will don a personal H<sub>2</sub>S monitor. The monitor will be donned with the sensor exposed to atmosphere in the worker's breathing zone, e.g. on the lapel or the front breast pocket of the outermost garment, for life safety protection.

Workers monitoring H<sub>2</sub>S must be aware of the potential limitations and interference associated with the use of gas detection equipment. All equipment must be properly calibrated, bump-tested and maintained in accordance with the manufacturer's specifications.

Drilling and completions rig personnel may work without personal monitors provided continuous monitoring is used on the rig floor, substructure and mud tanks.

**Remote Area Monitor**

A remote area monitor shall be installed as a temporary solution if the installation of a fixed H<sub>2</sub>S monitor in a building or area, wherein H<sub>2</sub>S release is possible, is not possible, feasible or is pending, or if it has been determined that additional H<sub>2</sub>S monitoring is required in a given location.

Examples of portable gas detection equipment include BW Rig Rat, Otis Instrument Gen II Gas Detection, and RAE Systems MeshGuard.

**Handheld Area Monitor**

A handheld area monitor, which typically draws air in with an active internal pump via an extended wand, may be used to screen hard to reach areas prior to work to determine the presence of H<sub>2</sub>S during specific tasks and confined space entry.

Examples of handheld area monitors include Industrial Scientific MX6, RAE Systems VRAE and BW Honeywell GasAlertMax XT.

**3.3.4 H<sub>2</sub>S Hazard Controls**

Cenovus will reduce workers' exposures to H<sub>2</sub>S at Cenovus worksites by ensuring control strategies are implemented in the following order, or in combination where necessary:

1. Elimination/substitution
2. Engineering controls
3. Administrative controls
4. Personal protective equipment (PPE)

#### **3.3.4.1 Elimination/Substitution**

If practical and feasible, a H<sub>2</sub>S-free product should be chosen over a product containing H<sub>2</sub>S, provided the substitute material has no greater health, safety and/or environmental impacts.

#### **3.3.4.2 Engineering Controls**

Wherever possible, engineering controls will be employed to reduce H<sub>2</sub>S release and worker exposure. Recommended engineering controls include the following:

- Keep H<sub>2</sub>S-containing materials enclosed as much as possible.
- Neutralize H<sub>2</sub>S via a chemical process (e.g. H<sub>2</sub>S scavenging).
- Provide local exhaust ventilation where handling material containing H<sub>2</sub>S.
- Design facilities with materials and components appropriate for the level for the level of H<sub>2</sub>S in the fluid streams to prevent corrosion of piping or equipment and the subsequent release of H<sub>2</sub>S.
- Install closed drain systems and connecting drain, vent and relief devices to a flare system where H<sub>2</sub>S can be safely combusted.
- Equip facilities with purge connections to provide for safe purging of residual sour fluid from piping or equipment to flare prior to opening equipment for maintenance.

#### **3.3.4.3 Administrative Controls**

Where contact with H<sub>2</sub>S is anticipated, work practices shall be implemented to reduce potential exposure. These include but are not limited to the following:

- Conduct a process hazard analysis such as a HazOp to study scenarios for leaks and loss of containment of sour fluids.
- Educate workers of the hazard associated with H<sub>2</sub>S exposure. Workers must participate in training and monitoring programs.
- Conduct pre-job hazard assessments.
- Erect conspicuous signage to inform workers of the hazard, and limit access to authorized persons only.
- Use available engineering controls to minimize H<sub>2</sub>S release.
- Have consideration for H<sub>2</sub>S exposure in work tasks or activities where H<sub>2</sub>S or H<sub>2</sub>S-containing material is present.
- Have an inspection and maintenance schedule for engineering controls used to reduce exposure.
- Record H<sub>2</sub>S alarm events in IMS.

### 3.3.4.5 Personal Protective Equipment (PPE)

#### Acceptable Respiratory Protective Equipment (RPE)

Due to the risk associated with H<sub>2</sub>S exposure, in the event respiratory protection is required, only atmosphere-supplying respirators (ASR) described below are acceptable:

- a full-face, positive-pressure self-contained breathing apparatus (SCBA)
- a full-face, positive-pressure SABA equipped with a minimum of a 5-minute escape air bottle

Air-purifying respirators (APR) are **not** acceptable for the purpose of protecting against H<sub>2</sub>S exposure.

For detailed information on respiratory protective equipment, see CEN-EHS010, Respiratory Protection Equipment Code of Practice.

#### Tasks/Activities Requiring RPE

Tasks or activities that require respiratory protection against H<sub>2</sub>S exposure include but are not limited to the following:

- breaking integrity of sour equipment
- initial entry into a confined space containing sour liquids or gas
- responding to an H<sub>2</sub>S alarm
- responding to an emergency involving H<sub>2</sub>S
- entering or working in a building or area wherein a sour equipment failure or a sour leak has occurred or is suspected to occur
- entering or working in a building or area wherein ambient H<sub>2</sub>S concentrations fluctuate beyond 10 ppm
- entering or working in a building or area wherein ambient H<sub>2</sub>S concentrations are equal to, or greater than 10 ppm
- entering or working in a building or area wherein ambient H<sub>2</sub>S concentrations are unknown or unpredictable

#### RPE Availability

RPE must be made available at worksites where exposure to concentrations of H<sub>2</sub>S requiring RPE is possible (see Tasks/Activities Requiring RPE above) and:

- supplied in sufficient quantities to accommodate concurrent tasks or prepare for a high level emergency
- located at the work site and accessible for immediate use; and
- maintained in serviceable condition

Contractors must provide their own respiratory protective equipment and be able to demonstrate that the equipment is in serviceable condition and have it approved where necessary by the Cenovus worksite supervisor before any work is started.



### 3.3.5 Storage, Use, Handling and Disposal

Where practicable, all materials containing H<sub>2</sub>S should be enclosed to limit the potential release of gas to atmosphere, and to prevent worker exposure. Open containers of H<sub>2</sub>S-containing material are not acceptable.

Procedures shall be developed to ensure that H<sub>2</sub>S releases and worker exposures are kept to a minimum using control methods deemed appropriate by the business unit.

The toxic and flammable nature of H<sub>2</sub>S must be taken into consideration when labelling or transporting materials or waste containing H<sub>2</sub>S as per WHMIS or TDG requirements, where applicable.

## 4.0 Roles and Responsibilities

The following responsibilities apply to this practice:

**Table 3: Roles and Responsibilities**

Role	Description
Cenovus Leadership	Commission, develop, review and approve a written H <sub>2</sub> S COP as defined by provincial regulations. This practice will be reviewed and updated approximately every three years or when conditions or regulations change.
Asset Team and Site Leadership	<ul style="list-style-type: none"> <li>• Provide resources for facility design, construction and maintenance that minimize the potential for release of H<sub>2</sub>S to the atmosphere.</li> <li>• Ensure relevant training has been provided to all workers who may handle or work in proximity to sour fluids, sludge or solids at Cenovus worksites (including the transportation of sour product).</li> <li>• Ensure equipment necessary to monitor and control potential worker H<sub>2</sub>S exposure is available at the work site prior to entering or working in a H<sub>2</sub>S environment.</li> </ul>

<p>Cenovus Supervisors</p>	<ul style="list-style-type: none"> <li>• Be competent and knowledgeable in the following:             <ul style="list-style-type: none"> <li>○ this COP and safe operating procedures in a potentially sour environment</li> <li>○ site-specific procedures</li> <li>○ applicable industry codes of practice</li> </ul> </li> <li>• Ensure compliance with all provincial regulatory requirements.</li> <li>• Identify the hazards and potential hazards that may be encountered during the assigned work or task in an H<sub>2</sub>S environment.</li> <li>• Ensure a Safe Work Permit is issued.</li> <li>• Identify young and/or new workers and offer coaching necessary.</li> <li>• Ensure all workers, including the Tending Worker:             <ul style="list-style-type: none"> <li>• hold a valid certificate in H<sub>2</sub>S Alive</li> <li>• are trained in procedures used to complete work in a potentially sour environment</li> <li>• are properly trained, fit-tested and competent in the use of supplied air respiratory equipment</li> </ul> </li> <li>• Ensure those who use vehicles to service sour facilities, where there is the potential to be exposed to more than 10 ppm H<sub>2</sub>S, have H<sub>2</sub>S detection equipment available and access to self-contained breathing apparatus when needed.</li> <li>• Ensure sour processing facilities, where workers may be exposed to more than 10 ppm H<sub>2</sub>S, are equipped with the necessary H<sub>2</sub>S monitoring equipment and respiratory equipment (SCBA) with spare cylinders.</li> <li>• Ensure all H<sub>2</sub>S detection equipment and respiratory equipment (SCBA) are maintained as per Cenovus's practice and/or the manufacturer's specifications.</li> <li>• Report all uncontrolled H<sub>2</sub>S releases to the applicable regulatory agencies according to Cenovus's reporting guidelines.</li> <li>• Take immediate and appropriate action when an H<sub>2</sub>S release is suspected or detected.</li> <li>• Ensure, when specified on the Safe Work Permit, a qualified person is assigned to test and monitor the air monitoring devices and/or ventilation systems.</li> <li>• Review (M)SDS and ensure WHMIS labelling is correct.</li> <li>• Ensure appropriate rescue and first aid procedures are in place.</li> <li>• Conduct training drills in the use and maintenance of respiratory equipment.</li> </ul>
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	<ul style="list-style-type: none"> <li>• Ensure employees are clean-shaven as per Cenovus Respiratory Protection Equipment (RPE) COP and wearing personal monitors and PPE when required.</li> </ul>
Workers	<ul style="list-style-type: none"> <li>• Comply with all Cenovus’s safe work procedures, operating practices and rules.</li> <li>• Complete required training and hold valid tickets, where appropriate, as per <a href="#">5.0 Training</a></li> <li>• Be aware of all potential H<sub>2</sub>S release points where they perform work.</li> <li>• Wear and correctly use the required PPE and RPE.</li> <li>• Immediately evacuate a worksite should their personal monitor or the facility’s H<sub>2</sub>S alarm sound.</li> <li>• Report all uncontrolled H<sub>2</sub>S releases and odour complaints to their Supervisor</li> <li>• Report to the Work Site Supervisor any alarm events, sour spills, incidents and/or unusual conditions that may occur during the work and stop the work if necessary.</li> </ul>
Health & Safety	<ul style="list-style-type: none"> <li>• Assist the asset team in complying with this COP and all associated procedures.</li> <li>• Respond to questions or concerns relating to the interpretation of this COP and all associated procedures.</li> <li>• Provide assistance to the business unit regarding appropriate H<sub>2</sub>S measurements.</li> </ul>
Occupational Health	<ul style="list-style-type: none"> <li>• Assist in the development of a H<sub>2</sub>S COP and provide technical feedback on the health and safety aspect of H<sub>2</sub>S.</li> <li>• Provide expertise on H<sub>2</sub>S monitoring and detection.</li> <li>• Review and provide continuous improvement on the COP.</li> </ul>
Visitors	<ul style="list-style-type: none"> <li>• Are persons who are not normally assigned to the work site, or do not have the training and experience to carry out unsupervised activities at the work site.</li> <li>• Must receive a worksite orientation and wear required PPE.</li> <li>• Are not permitted on a sour location unless approved by a worksite supervisor.</li> <li>• Must be escorted at all times by a Cenovus Representative who is certified in H<sub>2</sub>S Alive.</li> </ul>

## 5.0 Training

The purpose of Hydrogen Sulfide (H<sub>2</sub>S) training and certification is to maintain an industry recognized baseline competency that includes an understanding of H<sub>2</sub>S hazards and the ability to wear appropriate respiratory protective equipment.

### 5.1 Training

All personnel whose work duties include handling or work in proximity to sour fluids, sludge or solids at Cenovus worksites, including the transportation of sour product, are required to have done the following:

1. Completed a H<sub>2</sub>S Alive training course and received a valid **H<sub>2</sub>S Alive** certificate
2. Completed the **Cenovus H<sub>2</sub>S Code of Practice eLearning module**
3. Received an **orientation** on the worksite's rules and procedures along with the relevant emergency response and rescue/evacuation procedures

Personnel exclusively assigned duties removed from a live facility, who will not enter a live facility, and whose exposure to H<sub>2</sub>S is improbable, will be required to complete the **Cenovus H<sub>2</sub>S Code of Practice eLearning module** only; H<sub>2</sub>S Alive training is not required.

#### 5.1.1 Training Agencies

Contact your local LMS administrator, a Health & Safety Advisor or a qualified Enform-accredited training agency for schedule dates and locations.

### 5.2 H<sub>2</sub>S Alive Certification

For a worker to receive a valid H<sub>2</sub>S Alive certificate, he/she must complete an Enform-approved H<sub>2</sub>S Alive training course. Enform is the only industry recognized certification body in Canada for H<sub>2</sub>S Alive training.

H<sub>2</sub>S Alive is valid for three years from date of certificate issuance.

Employees are responsible for maintaining valid H<sub>2</sub>S certification and blacken folder in the Learning Management System (LMS).

#### 5.2.1 Re-certification

Enform offers an H<sub>2</sub>S Alive Challenge course for individuals who have taken the full H<sub>2</sub>S Alive course immediately prior to re-certification. Once an individual has successfully completed the challenge course, he/she will have to complete a full H<sub>2</sub>S certification course the next time his/her certificate expires.

#### 5.2.2 Semi-Annual Refresher Training (Saskatchewan Only)

In Saskatchewan, semi-annual refresher training on the safe use of the breathing apparatus must be provided for workers who are required to use breathing apparatus for emergency purposes only.

## **6.0 Quality Assurance**

### **6.1 Performance Measurement**

Compliance with this practice and program effectiveness shall be assessed through program assessments and internal audits, or other measurement criteria as specified in the COMS Assurance Standard. Measurement can also be accomplished through the tracking of appropriate Key Performance Indicators (KPI).

Business functions or departments impacted by this practice must include compliance and program effectiveness verifications in their business assurance program. Performance will be monitored and reported within the responsible departments at least every three years.

Health and Safety Solutions will review Cenovus-wide program KPIs at a minimum every three years in conjunction with program review and update activities.

### **6.2 Management of Change**

Proposed changes to this practice can be directed to H&S Programs and Projects.

### **6.3 Practice Verification**

The document owner will complete and document reviews of this practice, as follows:

- at minimum once every three years
- if there is a significant regulation or industry best practice change that indicates the need for review
- if an incident investigation indicates the causes were related to unclear or inadequate written instructions described within this practice

If frequent and multiple variances are required due to operational needs, the reason(s) will be investigated and the document owner will determine if there is a business need to update the practice.

If submitted MOC requests indicate gaps or significant improvement opportunities, the document owner will determine if there is a business need to update the practice.

**7.0 Glossary**

Definitions and acronyms for safety documents are described in CEN-EHS243, H&S Definition and Acronym Standard. The following definitions and acronyms are specific to this document:

**Table 4: Terms and Definitions**

Term	Definition
Breathing Zone	A hemisphere forward of the shoulders within a radius of approximately 6-9 inches (US OSHA).
Flammable Range	The range between the LEL and UEL is known as the flammable range for that gas or vapour. The minimum concentration of a gas or vapour that will burn in air is defined as the lower explosive limit (LEL). Below this level, the gas or vapour is too lean to burn. The maximum concentration of a gas or vapour that will burn in air is defined as the upper explosive limit (UEL). Above this level, the mixture is too rich to burn.
Safety Watch	A worker stationed at a confined space entrance who conducts continuous atmospheric monitoring of a confined space for the wellbeing of the work crew inside the space.
Tending Worker	A worker who maintains a constant means of communication with a work crew inside a restricted space and limits the entry and exit of that space.

**Table 5: Acronyms, Initialisms and Abbreviations**

Term	In Full
ASR	Atmosphere-supplying respirators
COMS	Cenovus Operations Management System
COP	Code of practice
H <sub>2</sub> S	Hydrogen sulfide
OELs	Occupational exposure limits
KPI	Key performance indicators
PPE	Personal protective equipment
PPM	Parts per million
RPE	Respiratory protective equipment
SABA	Supplied air breathing apparatus
SCBA	Self-contained breathing apparatus
SDS	Safety data sheet
WHIMS	Workplace hazardous materials information system

## 8.0 References

### 8.1 External Documents

The following external documents support this practice:

**Table 6: External Document References**

Document Type or Number	Document Title
N/A	Enform – H <sub>2</sub> S Training, 6 <sup>th</sup> Edition

### 8.2 Internal Documents

The following Cenovus documents support this practice:

**Table 7: Internal Document References**

Document Type or Number	Document Title
Policy	<a href="#">Corporate Responsibility Policy</a>
CEN-EHSReg787	<a href="#">Regulatory Definitions and Acronyms</a>
CEN-EHS019	<a href="#">Hazard Assessment and Control Practice</a>
CEN-EHS022	<a href="#">EHS/Operations Risk Management Practice</a>
CEN-EHS039	<a href="#">Fire Explosion Hazard Management Practice</a>
CEN-EHS085	<a href="#">Flammable Liquid Loading/Off Loading Practice</a>
CEN-EHS010	<a href="#">Respiratory Protection Equipment Code of Practice</a>
CEN-EHS131	<a href="#">Well Site and Facility (Process Building) Entry Practice</a>
CVE-GEN-S-04	<a href="#">Practice for the Development of Emergency Shutdown Systems</a>