Operational Controls

Operational Controls are the specific measures an oil and gas company uses to execute operations and implement its Fire and Explosion Hazard Management Plan. The **General Procedures and Guidelines**, **Rules of Thumb** and **Issues of Concern** you'll find below were gathered through interviews with Canadian oil and gas company representatives as part of research into how fires and explosions can be reduced across Canada's upstream industry.

General Procedures and Guidelines
Rules of Thumb
Issues of Concern

General Procedures and Guidelines

Purging
Confined Spaced Entry
Coiled Tubing Operating Procedures
Monitoring

Purging

Purging or inerting is done when a vessel containing hydrocarbons must be made safe. Alberta Workplace Health and Safety defines these terms as follows:

> *Purging* - Displacing or flushing out hydrocarbons by introducing substances such as an inert gas, steam, water or air [32:4].
>
> *Inerting* - Completely displacing or diluting the hydrocarbons in the vessel, tank or piping system with an inert (non-flammable and non-reactive) gas such as nitrogen or carbon dioxide, or a compatible inert liquid such as water [32:5].

Comparision: Procedures and Guidelines

A comparison of procedures and guidelines from a number of different Canadian upstream oil and gas companies revealed the following similarities:

- All companies considered began by isolating the system to be purged, and monitoring for hazardous areas.
- All suggested purging at a slow speed to avoid mixing the hydrocarbon and the purge gas. For purging with light mediums, a volume 2.5 times the containment vessel was to be used, injected from the top down. For purging with heavy mediums a volume of 1.5 times the containment volume was to be used, introduced from the bottom up.
- Although there were discrepancies between purging pressures, all indicated that the pressure should be kept low. The most common pressure applied was atmospheric pressure.

Safe Atmospheric Levels after Purging

The main difference between the guidelines reviewed was the atmospheric levels used to signal that it was safe to stop purging. Some companies based this decision on what medium was used, and whether it was heavier or lighter than the hydrocarbon being purged. Most companies based the decision on the oxygen, LEL, or H_2S levels in the vessel.

Unique Circumstances

Various companies also had written guidelines for unique circumstances, such as whether to purge up or downstream in a system; it's possible that other companies may make these types of recommendations in job specific procedures, which were not examined in the research. Other unique circumstances included:

- Purging at least three times when nitrogen was the purge medium; and
- Leaving the vessel open after purging to avoid a vacuum forming during cooling.

<u>Confined Space Entry</u>

The Alberta Occupational Health and Safety Act defines a confined space as:

> An enclosed or partially enclosed space having restricted access and egress and which, due to its design, construction, location, atmosphere, the materials or substances in it or other conditions, is or may become hazardous to a worker entering it or does not have an easy means of escape for or rescue of a worker entering it [23:106].

Comparison: Procedures and Guidelines

Most companies participating in the research had specific confined space entry procedures and guidelines for cleaning and maintenance. A comparison of this information revealed the following similarities and differences.

Similarities

All companies advised to prepare for confined space entry by:

- Isolating the area from the rest of the site, other equipment and ignition sources
- Flagging the area appropriately
- Purging the space with an inert medium, and ensuring proper ventilation

Before entering the confined space companies advised that:

- Atmospheric testing must show safe levels
- Equipment must be properly grounded and bonded
- Workers entering must be equipped with proper PPE
- A standby must be stationed at the entrance, remain in continuous communication with the worker inside, and be prepared to initiate emergency procedures

Differences

The main difference between the guidelines reviewed was the atmospheric levels used to signal that it was safe to enter the confined space. Each participating company had its own "safe" limits, ranging from 0 to 10 % LEL; for H_2S, levels ranged from 0 to 10 ppm. Specific levels based on the various purge mediums were also used. One consistency between the various guidelines was that oxygen levels were considered safe (breathable) between approximately 18 to 23 %.

Unique Circumstances

One company recommended wetting the confined space before introducing air to avoid the spontaneous combustion of pyrophoric iron sulphides. Several companies classified their confined space guidelines in two categories: one company classified them as either Low Hazard Entries or Moderate/High Hazard Entries, and another classified them with Hot Work or Cold Work Permits.

Coiled Tubing Operating Procedures

The coiled tubing operating procedures of two companies were examined. Similarities included:

- The use of air was only allowed on Alberta Energy and Utilities Board Class 1, shallow, sweet gas wells where no liquid hydrocarbons are present and gas production must not exceed 20,000 m^3 per day. This complies with ARP 4, the older version of IRP 4 – Well Testing and Fluid Handling.
- If air was to be used in the coiled tubing unit, the returns were to be flowed back to an open tank.

Unique Purging Guidelines

One company required that a spacer be used to prevent direct contact between the air and the hydrocarbons. The other provided a specific equation to calculate the minimum required purge time. These guidelines are both helpful in minimizing the potential for creating an explosive hydrocarbon-oxygen mixture.

Monitoring

Atmospheres that may contain flammable or explosive gases should be tested before any work begins. The atmosphere can be tested using a combustible gas meter. The meter should be accurate and fully functional. When monitoring for combustible gases, an incorrect reading can result if the detector is reading from an oxygen deficient atmosphere. [33]

Meter Reliability

Many different conditions can affect the reliability of a combustible gas meter. Some of these include:

- mechanical damage
- immersion in water
- moisture condensation on the sensor filaments

- exposure to catalytic sensor poisons
- exposure to high concentrations of combustible gases

Bump Test
A function test, known as a bump test, should be performed to ensure that a meter is working correctly. It should be done in the field before the meter is used, or at the beginning of each shift. The meter is exposed to a calibration gas where the concentration is known. If the monitor responds within certain predetermined limits, it is ready and safe to use. These limits are determined by the manufacturer. If a monitor fails the bump test, it must be removed from service immediately and sent for qualified inspection and recalibration. [33]

Types of Monitors
Two types of gas monitors can be used as portable monitoring devices or worn as PPE.

Single-head Monitors read LEL or H_2S levels and are generally used in buildings or facilities containing pressurized hydrocarbons.

Multi-head Monitors read LEL, H_2S, CO, and oxygen levels and are used during confined space entries and hot work operations. Low level H_2S monitors are standardly set at 10 ppm, and high level alarms are set to 15 ppm. Low level LEL monitors are standardly set to 20 % LEL, and high level monitors are set to 40 % LEL.

Rules of Thumb

In addition to written procedures and guidelines, the companies participating in this research also had rules of thumb for different operations. These rules varied between companies and are noted here.

Drilling
- Dry, sweet gas wells can be drilled safely with air. Air drilling cannot be completed safely if liquid hydrocarbons are present or encountered.
- If entering a known hydrocarbon-bearing zone while drilling, use an inert fluid such as nitrogen, stiff foam, or air with a water mist.

Snubbing
- To balance pressure during snubbing, you need to bleed off.
- For every 1500 ft of pipe snubbed, pressure increases by 1500 psi.
- After closing the annular BOP and equalizing pressure during snubbing, bleed off to a pressure tank.

Air Cleanouts
- It is safe to perform air cleanouts: in a shallow sweet gas environment (~95% methane), if no heavier-end hydrocarbons (condensate) are present, at pressures lower than 5000 kPa.
- Air cleanouts should be performed on Class 1 wells only (0 H_2S, < 5500 kPa).

- When performing coiled tubing air cleanouts, LEL and oxygen levels should be monitored, and pressure should be bled off.
- In coiled tubing air cleanouts, air should be constantly circulated, even while entering the well bore.
- After an air cleanout, the well should be purged of any air by allowing the well to flow to atmosphere for approximately half an hour.
- Under no circumstances should the well be flowed into a closed piping system or to a flare system with a pilot.
- After a coiled tubing cleanout, allow the well to flow 1.5 times the well bore volume.

General

- To avoid explosions inside vessels, it is generally better to maintain a positive pressure on the hydrocarbon side so that flow is always outward.
- It is recommended to purge with nitrogen before pressure testing equipment.
- Instead of bleeding off into tanks, bleed off to underground flow lines.
- Remove oxygen-hydrocarbon contact by using a buffer.
- If a vessel has been purged with air, it is preferable to bottom load the tank as opposed to splash loading to alleviate the risk of static electricity as an ignition source.

Issues of Concern

Based on interviews conducted with Canadian oil and gas company representatives and industry experts for research into upstream fires and explosions, several issues were repeatedly identified as areas of concern: purging, sources and properties of hydrocarbons, frac oil, training and awareness, pressure tanks and open tanks, oxygen, and improper use of equipment and technology. Explanations of these concerns follow.

Improper Purging

Improper purging and isolation on well sites was one of the most serious concerns expressed by research participants. They felt that:

- Purging procedures were often inadequate or improper, resulting in residual hydrocarbons remaining in the vessels.
- Air was frequently used as a purge medium because of its convenience and low cost. This posed a great hazard because hydrocarbons were most often the fluid being purged, and the addition of oxygen could form an explosive atmosphere. Participants commented that an inert gas could be used instead, but this was not seen as favoured due to cost.

- Steam was viewed as cheaper and safer than air, however, the time needed to purge properly with this medium was seen as a disadvantage.

Understanding the Sources and Properties of Hydrocarbons

Understanding the sources and properties of hydrocarbons and fluids used in different operations as well as the risks associated with them, numbered among the major issues of concern. Research participants provided examples of unusual hydrocarbon sources that may be unfamiliar to workers.

Leaching Hydrocarbons - It is possible for hydrocarbons to leach out of pores of metal surfaces such as the interior of tanks and vessels. This can happen when a tank containing stored hydrocarbons is heated. As a precautionary measure, tanks should be continuously monitored.

Residual Hydrocarbons in Produced Water - It is also possible for produced water to contain residual hydrocarbons and formation fluids. It is misleading if a vessel containing produced water is labelled water.

Formation Gas Forms Condensates - Another uncommon source of hydrocarbons brought to attention was when formation gas forms condensates.

Reuse of Frac Oil
Research participants said that frac oil was commonly misused in upstream oil and gas operations. They felt that the reuse of frac oil without proper testing was hazardous. The danger seen was that the Material Safety Data Sheet (MSDS) would not be adjusted to show how the frac oil's properties had changed as a result of its mixture with down hole fluids. For example, both the density and flashpoint of the frac oil can change as a result of its mixture with formation fluids. Participants recognized that the next user had no way of knowing the new properties of the used frac oil unless a sample was taken and tested for stability and the data sheet adjusted accordingly.

Training and Awareness
Research participants commented that worker complacency often causes incidents rather than equipment failure or inadequate procedures. Complacency can take many forms such as the misuse of equipment and deviations from procedures and guidelines.

Miscommunication between operations was sited as another potential cause of incidents. Participants said that well histories should be provided to contractors and rig reports made readily available. For workers to take hazards seriously, participants said that they need to be properly trained and competent in their respective operations.

Participants noted that many workers are inadequately trained in atmospheric monitoring with the result that monitors are frequently operated improperly. It was suggested that workers should be trained to use the site-specific monitors, because they often were unable to interpret readings from LEL monitors. Those interviewed commented on the need to calibrate monitors properly, and perform a bump test before each use to ensure accurate results. Participants believed that these steps were frequently overlooked.

Pressure Tanks and Open Tanks
While two common practices are used when flowing a well back to tanks, research participants were concerned that workers often don't know when to use each system. With the result that hazardous materials are inappropriately vented to the atmosphere.

The practices noted were:

For hazardous materials - flowing though a pressure tank and flare system to burn off hazardous gases before venting to atmosphere; or

For less hazardous materials - using an open top tank which vents directly to the atmosphere.

It was felt that the significant cost of flare systems could also be a factor in the inappropriate use of open top tanks.

Tank disposal was another concern. Those interviewed said that tanks are often disposed of at tank farms, which are generally temporary storage sites not subject to the same standards and regulations as permanent storage areas. The concern was the high risk associated with the storage of hydrocarbons.

Oxygen
Participants believed that most down hole explosions were due to poor control of oxygen in the well bore. They said that understanding oxygen and how it can be introduced in a well bore was of major importance to the industry. Participants commented that there are many ways air can be inadvertently introduced into a well bore.
One commonly overlooked way was when a well goes on vacuum and sucks air into the well bore. This can create an oxygen pocket large enough to be of risk. Another area of concern was workers lack of knowledge about oxidants and the great risk they pose. It was felt that many field workers do not know what oxidants are, what they do, or how they are formed.

Improper Use of Equipment and Technology
Participants commented that many operations that are safe in southeastern Alberta are not safe in other parts of the province. Most wells in the southeast are shallow, low pressure, sweet wells - characteristics which allow air operations to be performed safely. Some of those interviewed felt that air operations are now being applied to sour, deeper wells, although this may not be appropriate or safe. For example, bigger equipment such as coiled tubing units, is being made for use on deeper wells and was felt to cause problems.