CANADIAN ASSOCIATION
OF PETROLEUM PRODUCERS

Canada's Oil and Natural Gas Producers

SAFETY GUIDE

Small, Portable Oil & Gas Production Facilities: Recommended Solutions for Design and Operation

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Overview

This guide describes design and operation practices that support safe working conditions at small, portable oil and gas production facilities, often classified as high hazard industrial occupancies. The objective of the guide is to limit the probability that a person in or adjacent to a facility may be exposed to an unacceptable level of risk of injury or illness.

This guide is an update of the 1993 CAPP Safety Guidelines and reflects subsequent national and provincial amendments. The new guide is intended to supplement other applicable standards and regulatory codes. It recommends solutions for safe design, operation and maintenance practices for field facilities including worker training and competency. The guide addresses common safety issues and establishes minimum safety standards. There are three main areas of focus: process safety, public safety and occupational health and safety. Owners should assess their own requirements to establish design, operating, maintenance, and worker competency standards to create a safe work environment.

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1 Introduction

This document was developed to outline some design, operating procedures and training recommendations to help mitigate facility accidents at small, portable oil and gas facilities. The goal of these recommendations is to communicate the design and work practices that facilitate safe working conditions. Much of the content is based on CAPP's Safety Guidelines published in 1993.

Twenty years later, the original intent of this guideline continues to be relevant. That said, over the past 20 years there have been significant regulatory changes in Alberta. This new Safety Guide reflects amendments to the Alberta Occupational Health and Safety (OHS) Act, Regulations and Code, Alberta Safety Codes Act and Regulations, Energy Regulations, and the National Building and Fire Codes.

The recommended solutions outlined in this guide were developed with the help of experienced facility operators. It is strongly recommended that this guide be used to supplement other applicable standards and regulatory codes. These recommendations address some of the most common issues, but are not all-inclusive. Owners should assess their own requirements to establish:

- design specifications and standards to meet their specific needs,
- operating and maintenance procedures, and
- worker competency programs.

This document is focused on Alberta Safety Code requirements. It is important to keep in mind that each provincial jurisdiction may have its own unique requirements that operators must be aware of and address.

1.1 Background

Accidents at oil and gas facilities can be prevented by a combination of the following:

- employer commitment to safety in every phase of facility development and operation;
- use of qualified personnel in every aspect of facility design, installation or operation;
- appropriate work plans and procedures during engineering, construction or operation of the facility;
- adequate training for operating personnel to ensure competency; and
- safety awareness with an emphasis on hazard identification during engineering, installation and operation.

To create a safe work environment, many oil and gas companies, in cooperation with various government agencies, have researched and developed equipment standards, work procedures and training to produce safety "packages" more specific and more comprehensive than the Alberta Building Code or the Alberta Fire Code.

- **1993 CAPP Safety Guidelines**
  In 1992, the Production Facility Safety Committee (PFSC) was established to develop the original guideline document. The committee was made up of representatives from government including OH&S and the AER (formerly ERCB), key industry associations including CAPP, EPAC (formerly SEPAC), the Alberta Pressure Vessel Manufacturers Association (APVMA), and insurance industry representatives. The resulting guideline was released in August 1993.
- **2007 STANDATA Building Code Variance**
  Effective September 2007, the Alberta Municipal Affairs Building Code Variance STANDATA 06-BCV-001 Oil and Gas Processing Facilities references the CAPP publication. This variance outlines the provisions which exempt oil and gas processing facilities from the requirements of Group F, Division 1, high hazard industrial occupancies of the 2006 Alberta Building Code. Without this guideline, the variance will be removed.

1.2 Mission, Purpose and Scope

The original mission, purpose and scope for the 1993 guideline were

Mission

To promote safety in small, portable oil and gas production facilities

Purpose

To identify unsafe work practices and develop guidelines for design standards and safe work procedures

Scope

- To make recommendations for the safe design, operation and maintenance of small, portable oil and gas production facilities with the aim of preventing injury and loss of property
- To address common safety issues identified by regulators, operators and insurers for small, portable oil and gas production facilities
- To establish the minimum safety standards and recommendations for design, operation and maintenance of production facilities
- To be a resource for industry and government agencies in matters pertaining to safety in small, portable oil and gas production facilities, and to foster exchange of information

1.3 How to Use This Guide

There are five key components to the working content of the new Safety Guide. They are as follows

- Section 2 outlines the Objectives of this Safety Guide. These are based on and consistent with the objectives of the 2010 National Building and Fire Codes of Canada.

- Section 3 outlines the Recommended Solutions for Process Safety Management Systems. This section also provides related risk assessment recommendations for addressing the STANDATA Variance.
- Section 4 summarizes the Recommended Solutions for Facility and Building Design.
- Section 5 summarizes the Recommended Solutions for Operating and Maintenance Practices.
- Section 6 summarizes Recommended Solutions for Worker Orientations and Training.

2 Objectives

Portable oil and gas processing buildings and facilities are often classified as Group F, Division 1, high hazard industrial occupancies because of the nature of the processes being housed. Consistent with both the Building and National Fire Codes of Canada, the objective of this guide is to limit the probability that a person in or adjacent to the oil and gas processing buildings or facility will be exposed to an unacceptable risk of injury or illness as a result of

- activities related to the construction, use or demolition of the building or facility
- the condition of specific elements of the building or facility
- the design or construction of the specific elements of the building or facility
- inadequate built-in protection measures for the current or intended use of the building or facility

More specifically, this guide focuses on three areas of safety:

- process safety
- public safety
- occupational health and safety

2.1 Process Safety

An objective of this guide is to limit the probability that a person in or adjacent to a portable facility will be exposed to an unacceptable risk of injury or illness due to the loss of primary containment (LOPC) from that facility. Hazardous materials include toxic, explosive or flammable substances including the potential ignition of such a release and similar process safety incidents (PSI).

2.2 Public Safety

An objective of this guide is to limit the probability that, as a result of the design, construction or operation of the oil and gas processing buildings or facility, the public will be exposed to an unacceptable risk of injury or illness due to the uncontrolled release of a hazardous substance or energy.

2.3 Occupational Health and Safety

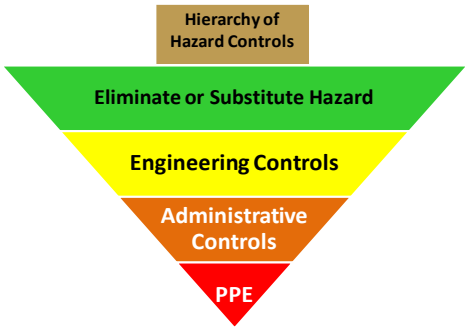
An objective of this guide is to limit the probability that, as a result of the design, construction or operation of the oil and gas processing buildings or facility, a worker in or adjacent to the facility will be exposed to an unacceptable risk of

injury or illness due to hazards. The risks of injury due to hazards addressed in this guide are those caused by the following:

- tripping, slipping, falling, contact, or collision,
- contact with hot surfaces,
- contact with energized equipment,
- exposure to hazardous substances,
- exposure to high levels of sound,
- persons being trapped in confined spaces, and
- persons being delayed in or impeded from moving to a safe place during an emergency.

3 Recommended Solutions for an Integrated Safety Management System

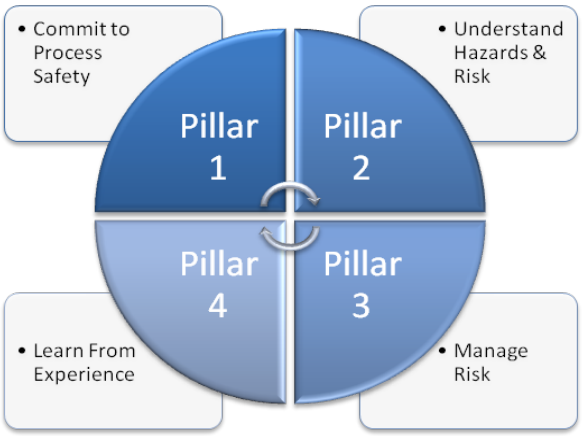
Organizations are required to establish and maintain processes that implement preventive and protective measures for the management of hazards and risks identified. More specifically, preventive and control measures are normally implemented according to the priorities shown in the diagram and list below.



1. elimination of the hazard
2. substitution with other materials, processes, or equipment
3. use of engineering controls
4. use of safer work systems that increase awareness of potential hazards (lights, signage, etc.)
5. implementation of administrative controls, such as training and procedures
6. provision of personal protective equipment, including measures to ensure its appropriate use and maintenance

3.1 Introduction to Process Safety Management (PSM)

Recent process safety incidents have resulted in regulators and the oil and gas industry becoming increasingly aware of the importance of process safety management and its application to all phases of operations. It is recommended that facility owners incorporate process safety concepts into their Health Safety and Environment (HSE) management systems. Effective risk-based process safety systems include the four main accident prevention pillars[1] as highlighted in the adjacent figure.



To address the principle of process safety, the following concepts must also be considered:

- quality assurance/quality control,
- supply chain management,
- operational readiness, and
- management of change.

3.2 Integrated Management System Recommendations

It is important to develop an effective management system that integrates operations and technical systems with the management of occupational health, safety and environmental protection, and process safety to ensure compliance with OHS Acts and Regulations.

The management system should correspond to the size, nature and complexity of the operations and activities, hazards and risks associated with the operations. System documentation should be controlled and set out in a logical and systematic fashion to allow for ease of understanding and efficient implementation.

The management system should address the following basic safety considerations.

- **Management involvement and commitment**: the policies on which the system is based and personnel accountable for the establishment and maintenance of the management system and the personnel responsible for implementing it
- **Goals, objectives and continued improvement**: the processes for setting goals for the improvement of occupational health, safety and environmental protection and process safety
- **Roles, responsibilities and accountability**: the processes for making personnel aware of their roles, responsibilities and accountability with respect to them

1 American Institute of Chemical Engineers, 2007. *Guidelines for Risk Based Process Safety*. pp liii.

- **Compliance with standards**: the processes for identifying the applicable company standards, industry codes and regulations that apply to the design, construction, operation, and maintenance activities
- **Hazard identification and risk assessment**: the processes for identifying hazards and for evaluating and managing the associated risks including design and operational readiness reviews
- **Training and competence**: the processes for ensuring that personnel are trained and competent to perform their duties
- **Emergency response planning**: the processes for developing and implementing emergency response procedures
- **Incident reporting and investigation**: the processes for the internal reporting and analysis of hazards, minor injuries, incidents, and near-misses and for taking corrective actions to prevent their recurrence
- **Performance measurement and corrective action**: the processes for conducting periodic reviews or audits of the system and for taking corrective actions if reviews or audits identify areas of non-conformance with the system and opportunities for improvement

Where applicable, the management system may need to incorporate process safety management considerations.

- **Information management**: the processes for ensuring that all documentation associated with the system are current, valid and have been approved by the appropriate level of authority
- **Asset and equipment integrity**: the processes for inspecting and maintaining the quality and integrity of all facilities, structures, installations, support craft, and equipment necessary to ensure occupational health and safety, environmental protection and process safety
- **Workforce interaction**: the processes for coordinating the management of operations of the proposed work or activity among the owner, the prime contractor, the contractors, the suppliers, the operator, and workers, as applicable
- **Human factors**: the processes for reducing the risk and the potential for human error though engineering and design
- **Change management**: the processes for ensuring that changes are reviewed for hazards before implementation of the change

An effective management system, together with operational discipline, is important to maintaining safe and reliable operations and regulatory compliance.

3.3 Hazard Assessment and Risk Management

In the past 20 years, there has been a significant shift towards risk and objective based regulation. The regulatory agencies responsible for oil and gas operations have each established requirements to identify hazards related to the operations being conducted and complete risk assessments.

3.3.1 Regulatory Requirements

The Alberta Occupational Health and Safety Code requires hazard assessments of all worksites including a documented report of the methods used to control or eliminate the hazards identified. Other acts and regulations also include a requirement for hazard assessment and risk management. Employers must identify all applicable requirements and ensure that management systems address them.

3.3.2 When Hazard Assessments are Required

Workplace hazard identification, assessment and control are on-going processes. They should be undertaken at various times, including:

- if they have not been done before,
- when a hazard has been identified,
- when a change to the workplace occurs,
- after an incident or workplace illness,
- at regularly scheduled times appropriate to the workplace, and
- when a change in personnel occurs.

3.4 Applicable Regulations, Codes, Standards, and Industry Practices

There are a number of regulations and industry standards important to the design of oil and gas processing buildings and facilities which, when adequately implemented, greatly contribute to the safe design and operation of oilfield facilities.

3.4.1 Manufacturers Specifications and Engineering Certifications

Part 3 of the Alberta OHS Code identifies the engineering certification requirements that dictate oilfield equipment requirements.

Those responsible for the planning and supervision of work should be familiar with those circumstances that require the use of certified equipment.

3.4.2 Energy Regulator Directives

The AER has established regulations and directives specific to oil and gas equipment design standards.

3.4.3 Industry Recommended Practices

In addition, the upstream petroleum industry has established a number of industry recommended practices (IRPs) that drives equipment standards for wells. When identified by the key petroleum industry associations, additional industry recommended practices are developed. The Enform website should be checked regularly to confirm the availability of new or revised IRPs.

Other regulatory considerations related to equipment standards include:

- Equipment must be registered, certified or licensed in accordance with federal, provincial and local requirements, even when equipment is used on private property.

- All licences and certifications required to operate equipment must be available to the worker responsible for operating the equipment. If not, the equipment must not be operated.
- When purchasing manufactured equipment, the required engineering specifications and certifications will normally have been addressed. As highlighted in Part 3 of the Alberta OHS Code on specifications and certifications, there are two situations where added care and attention is required, specifically:
  - whenever equipment is being specially constructed for circumstances identified on that equipment that require certification by an engineer; and
  - whenever certified equipment is being repaired or modified in a manner that may affect the structural integrity or stability, the repairs or modifications must be certified by an engineer.
- International Standard NACE MR0175/ISO15156—Petroleum and Natural Gas Industries—Materials for use in H_2S-containing Environments in Oil and Gas Production must be consulted when designing sour service facilities and equipment. Refer to CAPP Guide on the use of the NACE MR0175 Standard.

3.5 Integrity Management Programs

Current regulations governing the design and operation of oil and gas processing buildings and facilities require companies to establish integrity management programs. The focus of the programs is to improve both process and occupational safety by reducing the number and severity of process-related incidents, especially loss of primary containment events.

Key plans and programs integral to meeting the objectives of this guide include:

- **Well Equipment Standards**
  The critical issue is ensuring the equipment provided by each contractor is aligned with objectives of the owner's well program and the technical requirements needed to achieve the drilling objectives. Well equipment standards are based on a combination of AER well-related directives and industry recommended practices developed by the Drilling and Completions Committee (DACC).
- B**oilers and Pressure Equipment Safety Code Compliance**
  Owners and contractors are responsible for the safe operation of their boilers and pressure equipment. They are required to establish an inspection program to ensure that these responsibilities are met, ensuring that the inspection of all boilers, fired heaters, pressure vessels, and piping systems that contain an expansible fluid above 103 kPa (15 psi) are completed under an approved pressure equipment integrity management plan, as required under the provincial pressure vessel regulations (ABSA AB 512: Pressure Equipment Integrity Management Requirements in Alberta). Important: ABSA AB-512 requires that key components of a process safety management system be addressed including: management of change (MOC), hazard assessments, design documentation, and purchasing controls.

- **Management Plan Requirements for Storage Equipment**
  The owner, and in some cases contractors, are responsible for implementing an integrity management plan for storage equipment to ensure that operation of all storage facilities is in compliance with AER Directive 055: Storage Requirements in the Upstream Petroleum Industry. Similar requirements have been established by both the British Columbia and Saskatchewan energy regulators.
- **Pipeline Integrity Management Plans**
  Once a pipeline is successfully constructed and tested for operation, it is the responsibility of the owner/licensee to ensure that it is operated and maintained in a manner consistent with the regulations. To address this requirement, owners are required to develop a Pipeline Integrity Management Plan Manual (formerly referred to as Pipeline Operating and Maintenance Manual) to provide guidelines for the operation and maintenance of their production pipeline systems.
- **Electrical Safety Code Compliance**
  It is important to utilize licensed contractors to ensure that the design, construction, maintenance, and operation of electrical equipment are in compliance with provincial electrical regulations and standards. Both the owner and service contractors are responsible for ensuring electrical inspections and maintenance are completed in accordance with CSA C22.1-06 Canadian Electrical Code Part 1, the Code for Electrical Installations at Oil and Gas Facilities (2006) and provincial regulations established by the responsible authority.
- **Gas Safety Code Compliance**
  To comply with provincial gas safety requirements, all fuel gas installations for gas fired equipment are to be installed in accordance with CSA B149.1-05, Natural Gas and Propane Installation Code and provincial gas regulations. This includes the installation of propane tanks at wellheads and installations where raw gas is being used as fuel.
- **Measurement Equipment QA/QC**
  The owner is responsible for ensuring measurement activities at each facility are completed in accordance with regulations AER Directive 017: Measurement Requirements for Oil and Gas Operations or BC OGC 07-21.

4 Recommended Solutions for Facility and Building Design

This section provides design recommendations for small, portable oil and gas production facilities. Key areas of concern include the following

- layout and spacing of equipment, particularly with respect to ignition sources such as fired equipment and flare stacks
- potential for entrapment of hydrocarbon liquids and vapours beneath the skid floor
- electrical area classifications needs to be determined for portable facilities to ensure that the correct electrical equipment is purchased and installed
- building design and layout to ensure adequate ventilation and heating including confirmation of building air changes to maintain electrical

classifications is an important consideration for winter operation for skid packages (Note: The Division 2 electrical classification may be voided if the proper air changes are not provided in winter and may require an upgrade to Division 1.)

- equipment spacing and separation distances as required to comply with AER, OHS and Canadian Electrical Code requirements
- safe worker egress in an emergency, safe location of equipment air intake, and gas exhaust
- flare and closed-drain systems design
- fire, gas and H_2S detection and shutdown systems
- protection from freeze-up of lines, vents and equipment
- dehydration unit design, particularly with respect to freeze-up, pressure relief on reboilers and separators for wet gas
- fired heater design, particularly with respect to location of the heaters, design of flame arrestors and use of ignition systems
- product loading facilities, including design of safety systems and location away from hazardous areas

There are other design concerns that have not been covered here. Owners should do their own hazard assessments to identify specific design requirements.

Design of oil and gas facilities should be carried out by a professional engineer registered with the Association of Professional Engineers and Geoscientists of Alberta (APEGA) or a qualified technologist. The design should be in accordance with all codes and regulations referenced in this document and other relevant sources. This guide is intended as a supplement to, not a replacement for, existing guidelines and regulations.

Owners should remember that not all safety-related concerns can be designed out. In these cases, written operating procedures will need to be put in place and operating personnel must be trained to identify hazards and implement site-specific operating procedures.

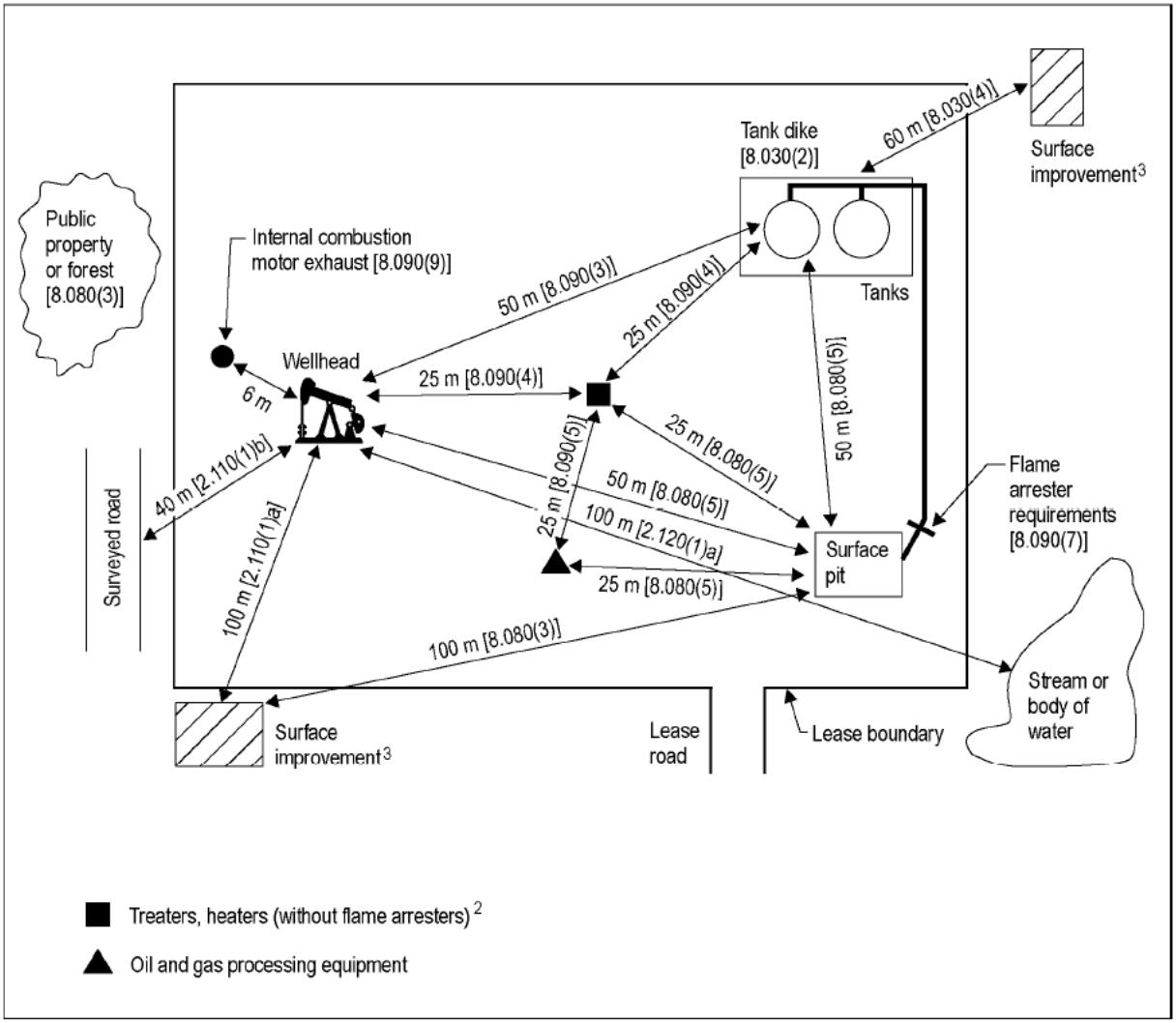
Construction and installation of small portable oil and gas production facilities should be performed by competent personnel under the direction of a prime contractor with control over the work being performed.

4.1 Equipment Layout and Spacing

All storage areas, facilities and rigs must comply with the equipment spacing requirements identified and detailed in the Alberta Oil and Gas Conservation Rules and summarized in AER Directives 036, 055 and 056. IRP Volume #20—Wellsite Design Spacing Recommendations provides guidelines on wellsite size and spacing. Specifically, this IRP provides a set of best practices to ensure consistent and legal lease size information for typical drilling, completions, and production facilities in Western Canada and the North West Territories. Diagrams illustrating Alberta Energy Regulator spacing requirements are included on the following pages.

Figure 4.1 Surface Equipment Spacing

(source: AER Directive 056: Energy Development Applications and Schedules, Appendix 6)



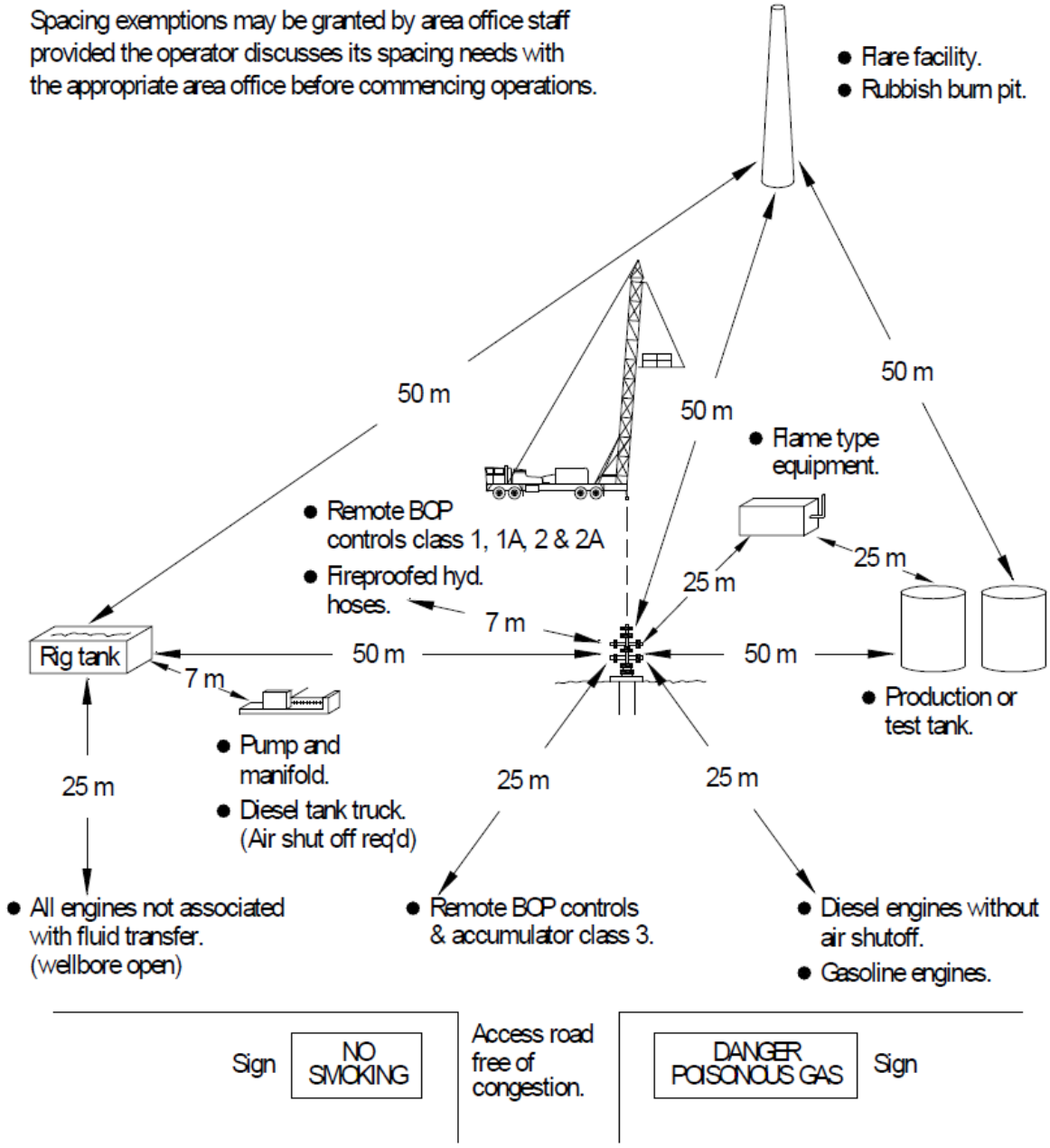
1 The spacing requirements illustrated here are as specified in the *Oil and Gas Conservation Regulations* sections indicated within square brackets alongside or underneath each measurement.
No person shall smoke within 25 m of a well, separator, oil storage tank or other unprotected source of ignitable vapour or on a rig or derrick at a well site Section 8.120(1)].

2 No flame type equipment shall be placed or operated within 25 metres of any process vessels unless, where such is applicable, the flame type equipment is fitted with an adequate flame arrester [8.090(5)]. No flame type equipment shall be located in the same building as any process vessel or other source of ignitable vapour, unless a) the air intakes and flues of all burners are located outside the building, b) relief valves, safety heads, and other sources of ignitable vapours are vented outside the building and discharged above roof level, and c) the building is adequately cross ventilated [8.090(6)a,b,c].

3 "Surface improvement" means a railway, pipeline or other right-of-way, road allowance, surveyed roadway, dwelling, industrial plant, aircraft runway or taxiway, building used for military purposes, permanent farm building, school or church [1.020(1)28].

Compressors (electrically or engine driven) that are permanent and housed in a building must be located 25 m from wells, oil storage tanks, or unprotected sources of ignitable vapours. Compressors that are nonpermanent (on wheels or skid mounted) must be placed such that the air intakes and exhaust must be no closer than 6 m from a well. Nonpermanent electrically driven compressors must comply with the current edition of *Code for Electrical Installations at Oil and Gas Facilities*, Safety Codes Council (Alberta).

Figure 4.2 Equipment Spacing for Well Servicing
(source: AER Directive 037: Service Rig Inspection Manual, Schedule 11)



Note: The doghouse and light plant shall be positioned in accordance with smoking and open flame regulations under the Electrical Protection Act.

All distances shown are minimum distances.

4.2 Skid Mounted Equipment

Skid-mounted equipment must be installed with an understanding of the hazards involved. This section provides recommendations for the following:

- packaged skid-mounted equipment,
- piping design on skid-mounted equipment, and
- minimizing hazards in and around skid-mounted buildings.

4.2.1 Packaged Skid-Mounted Equipment

The oil and gas industry usually "packages" or "modularizes" process equipment. A skid package may include all the equipment completely piped with instrumentation installed and electrical work completed. It may also include a building. The packages are usually set on steel driven piles or a concrete slab.

There are unique potential hazards associated with skid space and transport of this type of equipment.

4.2.1.1 Skid-Space Hazards

Possible hazards include inadequate under-floor (skid-space) ventilation and combustibility of materials. The following safeguards are recommended:

- When pile-mounting skids, eliminate depressions where liquids or heavier-than-air vapours can accumulate.
- If checker-plate flooring is used, provide ventilation on all sides of the area beneath the floor or fill the space between the beams completely with a solid non-combustible material that will not settle.
- Weld all checker-plate seams, ensuring no holes remain in the floor.
- Use non-combustible, non-hydrocarbon absorbent materials to insulate under floor areas that are freely ventilated. Closed-cell plastic material must be fire retardant.
- Have a drain opening for each 6.5 m^2 (70 ft^2) of floor area. The drain should be piped to the skid edge and from there to on-skid containment with suitable vent, dip stick and tank truck-out connections. (Note: Environmental regulations require all liquids be contained. Also note that underground storage is not recommended due to longer-term integrity concerns.)
- Seal weld sleeves with a 50 mm (2 in) rise for electrical cables coming through the floor.
- Use drip pans under pumps to contain possible seal leakage.

4.2.1.2 Transport Hazards

When moving skid-mounted equipment:

- do not bend skids during loading and transport (over-stress of piping or equipment nozzles may result),
- use at least a four-point lift or the jack-and-roll method, and
- leak-test all connections after transport.

4.2.2 Piping Design on Skid-Mounted Equipment

Piping design recommendations include issues encountered during installation, applicable specifications, connections, valves, and instrumentation.

4.2.2.1 Facility Piping Installation

The following specifications apply to carrying out piping installations:

- Check that the vendor has supplied all materials and equipment as specified.
- Use only professional engineers or qualified technologists to design piping additions or modifications to existing facilities. Update drawings in accordance with Alberta Boilers Safety Association (ABSA) requirements.
- Use only qualified personnel to perform and direct field construction and facility installation.
- Do not install pressure piping under floors. If required, under-floor piping should be butt or socket welded.
- If packaged equipment includes flare piping, set elevations to prevent the flare header from being trapped at the skid boundary. Flare piping should slope towards the flare knockout drum.

4.2.2.2 Piping Specifications

Make sure piping meets all necessary specifications.

- Use insulation or protective guards in accordance with OHS regulations to protect workers against contact with high temperature piping.
- Consider the weldability of the materials (e.g., low carbon content as per NACE MR-01-75) and the need for post-weld heat treating (e.g., stress relieving of the welds as per ASME B31.3) in specifying sour process piping when required by the welding procedure or in circumstances where it is required to mitigate hardness or residual stress.
- Do not use copper or brass in sour service.
- Comply with the applicable American National Standards Institute (ANSI) ratings for relief valve protection and piping both upstream and downstream of packaged units.

4.2.2.3 Valves

The following recommendations apply to valves:

- Provide over-pressure protection for all specification breaks (changes in pipe pressure rating), taking temperature effects into consideration.
- Do not use check valves for isolation. Use spectacle blinds or double block and bleed if pressure piping is frequently opened.
- Use indicating-type isolation valves below relief valves in accordance with ABSA requirements. (Valves must be car-sealed or chained and locked open.)
- Install double-block valves at sampling points. Do not use process connections for routine sampling.

4.2.2.4 Connections

The following recommendations apply to piping connections:

- Use a minimum of Schedule 80 material for threaded connections. Note: This is the recommended minimum up to 60.3 mm (2 in) for mechanical strength, but not above 60.3 mm (2 in).
- Avoid using threaded connections if H_2S partial pressure is more than 0.30 kPa for the main process connections.
- For small diameter side branch connections in vibrating service, consider the use of gusseting and ensure that the design and installation of piping supports will be adequate for the design loads. Consider the use of armoured flex connections to minimize the use of threaded connections in vibrating service.

4.2.2.5 Instrumentation

The following recommendations apply to piping instrumentation:

- Use dry air for instruments if possible. If a flammable or inert gas is used, ensure instruments are safely vented outside and instrument housing seals are periodically checked for leaks.
- Never use sour gas for instruments (i.e., gas with detectable concentration of H_2S).
- Never interconnect air and gas instrumentation systems without purging. System purging is necessary if gas is to be used as a backup to eliminate the potential for explosive mixtures. (Note: A nitrogen cylinder is preferred.)
- Externally mount level switches if possible. If internal switches are used, they must be tested while in service.
- Match level gauges to the design pressure of the equipment and blow down into the drain system. Leave valves turned off, or use appropriate automatic shut off valves when not taking a reading. Use level gauge valves with ball-check shut-off valves.
- Install compression-type tube fittings in strict accordance with the manufacturer's recommendations. Check fittings with a gap gauge.

4.2.3 Minimizing Hazards In and Around Skid-Mounted Buildings

Minimize potential hazards in buildings by doing the following:

- Ensure adequate gravity ventilation or exhaust fan activation if hydrocarbon-containing equipment is inside a building. In buildings where sour gas may be present there should be a minimum of 12 air changes per hour; in sweet gas packages there should be at least six changes per hour.
- Have a minimum of two doors with panic hardware in buildings larger than 7.4 m^2.
- Incorporate alternate escape routes (including windows) in the building layout.
- Leave a clearance of at least one meter between major equipment for easy evacuation.

- Install canopies and/or ice rakes above doors located under the down slope of the roof.
- Locate hydrocarbon accumulators outside buildings and making sure building heaters, for structures where hydrocarbons are present in piping or vessels, are approved for use in hazardous locations.
- Vent and install catalytic heaters with start-ups, shut-offs and guards in compliance with electrical protection branch regulations. Fuel gas scrubbers supplying catalytic heaters should have a high-level shut-off device.
  - **Note:** Propane is acceptable as an alternate fuel in catalytic heaters. Sour gas should never be used in catalytic heaters.
  - Prevent liquid hydrocarbons (which have a lower ignition temperature than natural gas) from coming into contact with catalytic heaters.

4.3 Oil and Gas Processing Packages[2]

Additional recommendations are provided for the following types of packages:

- compressor
- heater
- pump
- separator
- treater

4.3.1 Compressor Packages

To help ensure compressor packages operate safely:

- Minimize flow through rotating equipment (especially centrifugal compressors) during depressurizing or purging as this will also help prevent damage to the equipment.
- Use engine ignition systems approved for use in hazardous locations.
- Use gussets for Pressure Safety Valve (PSV) in vibrating service.
- Install industry standard shutdown devices in all packages in accordance with risk assessment results.

4.3.1.1 Compressor Intake and Start Gas Systems

The following steps help ensure compressor intake and start gas systems function safely:

- Direct start gas exhaust piping to the building exterior above the building eave following the precautions outlined in CAPP's Flammable Environments Guideline.

[2] Section 4.3 References

American Petroleum Institute. *RP7C-11F, Recommended Practice for Installation, Maintenance, and Operation of Internal Combustion Engines*.

Occupational Health and Safety Act (OSHA) Fact Sheet, "Internal Combustion Engines as Ignition Sources."

CAPP. *Flammable Environments Guideline.*

- Avoid the intake of hydrocarbon vapours by making sure the combustion air intake draws from outside air for gas-engine-driven compressors at hazardous locations. Make sure that air intakes are at a safe distance from gas headers.

4.3.1.2 Compressor Piping, Connections, and Valves

The following steps help ensure compressor piping, connections and valves function safely:

- Insulate or guard engine exhaust piping inside the building.
- Minimize the use of threaded piping in vibrating service.
- Threaded piping is acceptable for:
  - low-pressure service such as fuel and start gas,
  - connections for pressure and temperature indicators,
  - small pipe sizes (e.g., Nominal Pipe Size [NPS] less than 48.3 mm [1.5 in]).
- Use vibration analysis to pinpoint sources of vibration and correct problems before piping fails.
- Provide adequate support to process piping. Vibration effects must be considered.
- Separate drain-line headers for glycol and oil waste storage tanks.
- Install fire-safe valves on makeup controls and day tanks.
- Use flanged connections, not threaded control and drain connections, in sour service.
- Locate pressure taps on adjacent upstream/downstream piping.
- Minimize the number of flanged connections on compressor cylinder pulsation bottles to reduce the risk of failure from equipment vibration.
- Use external level cages with flanged isolating valves for mounting instrumentation on sour service scrubbers. Ensure that adequate drains and/or vents are installed on external level legs and gauge glasses.
- Provide flanged spool pieces to allow adequate maintenance access or access as required by process considerations. Mount breaking flanges on supports.
- Locate unit block valves outside the package building if possible. If the valves are located inside, they must be installed as close to the building wall as is allowable.
- Install relief valves on each compression stage of the unit with set points appropriate for the maximum working pressure of the compressor.
- Provide over-pressure protection from shut-in pressures occurring upstream. Connect relief valves to the flare system or above the building eave line and secure them against reaction forces.
- Use socket or butt welding on sour gas piping for packing vents and drains.
- Connect compressor distance piece vents and drains to an independent vent-and-drain system to prevent back pressure on the system. Also provide integral packing vent- and drain-tanks with drain-out and atmospheric-vent connections.
- Keep oil drains independent of all other drain systems. Provide waste oil tanks with drain-out and atmospheric-vent connections.

- Locate glycol/water header tanks so leakage will not drain onto exhaust piping or insulation.
- Provide gauge glasses, protected against mechanical damage, for glycol/water and lubricating oil header tanks. (Lube oil header tank auto shut-off valves may be used.)
- Install crankcase explosion-relief valves on compressor engines.

4.3.1.3 Compressor Instrumentation

The following recommendations apply to compressor instrumentation:

- Use intrinsically safe instrumentation systems or systems approved for use in hazardous areas.
- Use gas detection and fire detection equipment as specified in Section 4.10 of this guide.

4.3.2 Heater Packages

The following steps help ensure heater packages operate safely:

- Install adequate expansion tanks on bath heaters.
- Protect heater shells with a tank hatch outside the building or a pressure-relieving device that discharges outside the building.
- Use heater coils designed to withstand full field shut-in pressure or that are protected by PSVs.
- Provide a stack-inspection/clean-out port at the bottom of the stack.
- Use stainless steel flame arrestors on combustion air intake of salt bath heaters or arrange arrestor to prevent contact with nitrate/nitrite salts in the event of fire-tube failure.
- Size the fuel gas scrubber PSV to handle full upstream flow and pressure. (Design must consider possible fuel gas regulator failure.)
- Install liquid knockout facilities with a high-level shutdown on the fuel gas supply.

Also consider the recommendations in Section 4.5, Fired Equipment.

4.3.3 Pump Packages

The following steps help ensure pump packages operate safely:

- Use belt drives of the approved static conductive type.
- Use pulsation dampeners on plunger-type positive displacement pumps as required by the manufacturer.
- Use vibration analysis to pinpoint sources of vibration and correct problems. (Concrete mass for foundations should be sufficient to minimize vibration.)
- Install vibration shutdowns on pumps where appropriate.
- Install PSVs between the pump and pump discharge block valve that are of adequate size rating for use with positive displacement reciprocating pumps.
- Install a filter separator upstream of the pump if there is a possibility that the fluid contains abrasives.

4.3.4 Separator Packages

The following steps help ensure separator packages operate safely:

- Use inlet separators that have high-level and high-pressure alarm and shutdown switches and can handle the predicted quantities of liquids, including slugging.
- Use dump valves that are fail-close and provide shut-off at the maximum vessel operating pressure differential.
- Consider the addition of abrasives (e.g., sand) filter upstream if abrasives are anticipated (e.g., frac sand or reservoir sands).
- Provide man ways that are a minimum of 500 mm (20 in) internal diameter (I.D.) on vessels with an I.D. greater than or equal to 900 mm.

4.3.5 Treater Packages

The following steps help ensure treater packages operate safely:

- Use packages that contain the following shutdowns: high and low level, high temperature, high pressure, and flame failure.
- Use electrostatic treaters that have circuit breakers and an indicator light that shows if the grid is energized.
- Install vent hoods and drains on sample boxes.
- Use coalescing media (other than wood excelsior) to minimize the hazards associated with confined space entry to treater for cleanout.
- Use purge-gas connections on treaters designed to eliminate potential air trap points so a complete purge can be made.
- Use corrosion coupons and internal coatings for the treater if in corrosive service.
- Use external caged level controls to provide a safe means of isolation and removal.
- Use high-pressure transparent or reflex-type level gauges instead of tubular glass columns.

Also consider the recommendations in Section 4.5, Fired Equipment.

4.4 Dehydrator Units[3]

The following steps help ensure dehydrator units operate safely:

- Install heat tracing to prevent freezing on the top of the still column and on any extension of the piping on the vapour outlet connection of glycol regenerator still columns. Insulate with foam glass or a non-permeable material. Alternatively, reroute the still column vent down through the packing section.
- Slope the vent line continuously to drain.

[3] Section 4.4 References

CAPP. *Control of Benzene Emissions from Glycol Dehydrators.*

CAPP. *Guideline for the Prevention and Safe Handling of Hydrates.*

- Route the vent line off the still column to a storage tank with a heat-traced vent to make sure the vapour steaming off is visible.
- Install the storage tank as far as possible from the reboiler flame arrestor, and provide for level gauging and pump out.
- Prevent overpressure of the reboiler by installing a U-tube, a witch's hat cone-type check, a liquid relief regulator, or other pressure relief device on the reboiler.
- Use pressure regulators and PSVs on gas-powered glycol pump installations.
- Vent gas lines to the eave line away from openings and provide protection against water surges.
- Use hydrocarbon flash tanks complete with skimmer connections on dehydrators treating rich gas.
- Install a 0-to-70 kPa pressure gauge on the reboiler that is big enough to be easily visible to the operator.

Also consider the recommendations in Section 4.5, Fired Equipment.

4.5 Fired Equipment[4]

The following recommendations for fired equipment apply to the design, installation, operation and maintenance and shall be in accordance with CSA B149 Code and Provincial Regulations.

4.5.1 Design of Fired Equipment

The following recommendations apply to the design of fired equipment:

- Use burner pilots that will shut down in an ESD situation.
- Install ignition systems that eliminate the need for torch lighting.
- Add safety floats to ensure dry fuel.
- Use appropriate sight glass and burner-access ports. Where possible use screwed-on access ports instead of bolted types.
- Use only fired equipment that has high-temperature, flame failure and low-level shutdown devices.
- Mount the high temperature shutdown thermostat below the temperature control thermostat and above the fire tube to ensure liquid coverage.
- Provide a clean-out port at the bottom of the stack.
- On the pilot piping, do not use a burner that has a trap where liquids can accumulate.
- Use five-piece mitred firebox returns and a removable fire tube.
- Bolt flame arrestor housing to an external flange.

[4] Section 4.5 References

American Petroleum Institute. RP 12N Operations, Maintenance and Testing of Firebox Flame Arrestors.

Occupational Health and Safety. Safe Operation of Fired Equipment in Hazardous Locations Bulletin, SH014.

4.5.2 Installation of Fired Equipment

The following recommendations apply to the installation of fired equipment:

- Locate fired equipment outside of areas classified as hazardous locations. It is better to use remote/indirect heating of process equipment than direct fire-tube heating.
- For existing facilities where it is not possible to locate fired equipment outside hazardous locations:
  - never locate firebox ends of fired equipment in enclosed hazardous areas,
  - equip firebox air intakes with adequate flame arrestors,
  - do not locate points of hydrocarbon venting near firebox air intakes, and
  - use a firebox that is air tight except for the air intake flame arrestor's element.

4.5.3 Operation and Maintenance of Fired Equipment

The following recommendations apply to the operation and maintenance of fired systems:

- Maintain clean flame arrestor cells.
- Never increase fuel pressure to burners above maximum pressure suggested by the manufacturer.

4.6 Liquid Petroleum Gas (LPG) Handling Facilities

The following recommendations will help ensure the safe operation of LPG-handling facilities:

- Provide for the safe venting of any LPG trapped between the truck and loading line valves after loading or unloading.
- Locate loading and unloading facilities in well-ventilated areas that are well separated from site facilities and equipment.
- Install back check valves in process rundown lines and unloading lines close to storage tanks.
- Install excess flow valves in truck loading lines from pressure storage tanks.
- Install emergency shut-off valves on truck loading lines to ensure valves close when trucks pull away or start up.
- Install bulkheads and shear points downstream of valves to ensure there is a reliable failure point downstream of valves.
- Ensure grounding cables and clamps are in place and are used.

4.7 Refrigeration Process Units

The following recommendations will help ensure the safe operation of refrigeration units:

- Locate propane accumulators outside buildings because propane can be a significant hazard if it remains in the plant. (Propane refrigerant is not normally depressurized to flare, but it can be blown down to flare if fire is detected in the plant.)
- Double-valve all propane drain and vent lines.

- Use indirect-fired reboilers if possible. If it is necessary to use direct-fired reboilers, locate them away from hazardous areas. Also see this guide, Section 4.5, Fired Equipment, for more information.
- Use antistatic belts on belt-driven engines.
- Sleeve and air cool the engine exhaust. The crankcase vent should be short and vented to the atmosphere. Mount the engine air intake on a natural-gas-driven engine outside hazardous areas.
- Provide engine oil-change facilities for motors and compressors to avoid and/or contain spills.
- Use a glycol flash tank to prevent hydrocarbon carryover into the glycol reboiler.

4.7.1 Piping, Connections and Valves

The following recommendations will help ensure the safe operation of refrigeration piping, connections and valves:

- Match low-temperature cast steel valves to the pressure rating of standard flange materials. Both A352 LCB and A352 LCC valves are suitable for service at -45^{o}C (-50^{o}F). (The A352 LCB has a lower pressure and temperature rating than Standard A-105 or A350-LF2 flanges.)
- Use flexible connections as little as possible. If vibration is a problem, use high-pressure rated steel wire reinforced flex connections.
- Install adequate ESD stations with shutdown logic to ensure the safe and timely shutdown of the facility.
- Install isolation valves on sensing points.

4.8 Oil and Water Production Tanks

The following recommendations will help ensure the safe operation of production tanks and oil batteries:

- Use emergency venting of tanks for storage of production liquids that complies with API 2000.
- The design of tank vents and pressure relief devices shall consider potential overpressure from high pressure gas discharged through the liquid side of the upstream pressure vessel if the liquid dump valve fails to open or the manual bypass is left open.
- Make provision for upsets or flows in over-pressure/vacuum protection, including the failure of blanket gas regulators and emergency relief systems.
- Use remote level gauges on tanks to eliminate the need to climb a tank to gauge the fluid level.
- Locate all truck loading/unloading stations outside designated hazardous areas.
- Use grounding cables and clamps.

4.9 Flare Systems and Vent Stacks[5]

The following recommendations will help ensure the safe operation of flare systems and vent stacks:

- Lock off in the field all valves identified by "CSO" (car-seal open) or "CSC" (car-seal closed). This includes block valves under relief valves and bypasses around emergency shutdown valves.
- Install and record the locks in compliance with ABSA requirements.
- Provide for venting and blowing down instruments and instrument manifolds during design.
- Provide flare knockout drums that are large enough and have the required instrumentation to prevent the liquids blowing out the flare stack.
- Protect fuel gas purge/high-pressure piping connections from backflow to the fuel system. If sweet gas is used to purge sour gas piping, the connection must incorporate a double block with bleed between to a safe location. If sweet gas is not used, the connection should be removed.
- Do not direct dump valves from hot oil heaters to the flare system in an ESD condition as a major fire may result.
- Do not restrict relief vent lines by swages or any obstructions. Ensure the relief system is carefully designed if field-gathering lines have a design pressure higher than that of the plant.
- If fuel gas is used as the instrument medium, use a flare header that will not backpressure the system (ESD valve “open”) and over-pressure the actuators.
- Design gas plants and production facilities to minimize escape of low-pressure vapours and comply with AER regulations and CAPP flaring guideline.
- Design relief systems for facilities with multiple compressors to provide protection for all possible combinations of suction pressure and number of operating units.
- Size flare headers to handle the total volume of gas that the facility could receive during an ESD.
- Slope flare headers to allow liquid drainage into the flare knockout drum. Use rain covers and weep holes to protect relief valve vent stacks against water accumulation.

4.9.1 Flashback Protection

The following considerations help ensure adequate flashback protection:

- For permanently lit flares, maintain a minimum purge pressure of sweet natural gas flow to protect against air inflow and to keep flowing vapours above the upper explosive limit (UEL).

[5] Section 4.9 References

CAPP. *Best Management Practice for Fugitive Emissions Management.*

CAPP. *Best Management Practices for Facility Flare Reduction,*

CAPP. *Best Management Practices for the Efficient Use of Fuel Gas in Flaring Operations*.

- Install an adequate means of protection when venting off of a tank system. Alternatives include installing a positive purge gas system or a flame arresting device at the bottom of the flare stack as a secondary means of protection.
- Do not use in-line flame arrestors marketed as UL-listed because they are not capable of stopping flashback under most conditions that may occur in the flare system. Use detonation or second-generation flame arrestors that have been tested according to API RP 12N.
- Be aware of the hazard of flame stabilization at the flame arrestor.

4.10 Detection and Emergency Shutdown Systems

Safety systems and personal safety are integral to effective facility design. Process designers use a variety of safeguards or layers of protection to provide a defence system against serious incidents. Potential safeguards include

- inherently safe design features
- safety instrumented systems
- physical protection such as relief devices
- post-release protection systems
- facility and community emergency responses

4.10.1 Safety Systems

A risk assessment of each facility should be performed and the following equipment installed as required:

- Install emergency shutdown device (ESD) stations with remote activators and locate ESD valves outside of skid limits. ESD valves should be of a fireproof and fail-safe design and must be accessible and unobstructed.
- If reliable power supplies are available, install combustible gas and fire detection equipment. This gas detection equipment should activate alarm/call-out devices and auxiliary ventilation at gas readings of 20 per cent of the lower explosive limit (LEL). The facility should be shut down at 40 per cent LEL.
- If reliable power is not available, use temperature-rated plastic tubing or alloy plugs in steel tubing as a simple fire detection shutdown system.
- Install a reliable pilot in the flare stack to ignite the sour gas in case the facility depressurizes as a result of high H_2S.
- Install H_2S detection (if power is available) to
  - activate alarm/call out devices
  - start auxiliary ventilation at 10 ppm H_2S
  - start shut in and depressurize at 20 ppm H_2S
- Install fire detection equipment to automatically shut down and depressurize the facility.
- In sour gas facilities, mount alarm-activated warning beacons inside and outside buildings.
- If H_2S exceeds, or may exceed 10 ppm, use wind direction indicating devices.

4.10.2 Personal Safety

The following steps help ensure the safety of workers:

- Ventilate the building as required to maintain a safe work environment.
- Insulate engine exhaust piping to protect workers from burns.
- Include escape routes and access to escape windows in the layout design.
- Install adequate guards for fans, belts and all moving equipment.
- Install combustible gas and fire detection equipment.
- Install appropriate signage to alert operators and maintenance personnel to specific hazards.
- Provide enough clearance around equipment for safe access.
- Carefully evaluate the use of quarter-turn valves that open to the atmosphere. They can be accidently knocked open and result in equipment damage or injury to workers.
- Vent sample lines to the outside.
- Provide adequate clearance for drain valves that terminate close to the floor or ground level.

5 Recommended Solutions for Operating and Maintenance Practices

Ensure workers follow these recommendations for facility operations and maintenance or equivalent as determined through risk assessment. Review the guidelines during employee orientations, post them in appropriate locations at the site and discuss them at regular safety meetings. The guidelines address the following unsafe practices:

- failure to take precautions around ignition sources near vents or blow downs
- using poorly maintained or incorrectly calibrated gas/explosive meters
- installing non-specification piping components
- failure to develop and follow equipment start-up, shutdown, operating and maintenance procedures
- failure to take account of the ramifications of process changes

5.1 Site Safety Management

5.1.1 Safe Work Permits

Before an operation begins, it is important to establish a plan for controlling and coordinating the work including the “what, who, where, how, and when” of completing the operation. This information should be included on safe work permits issued to permanent, temporary and contract personnel involved in critical or hazardous equipment maintenance tasks.

Ensure workers obtain a hot work permit before proceeding with any work involving pressurized or live equipment, or using equipment that could ignite a flammable source. When there are unanticipated upsets, ensure workers follow company procedures or prepare special work permits before responding. Do not allow workers to improvise.

Alberta Workplace Health and Safety Bulletin SH013–General Safety provides additional guidance on safe work permits.

5.1.2 Concurrent Operations

In those situations where multiple activities are taking place on the same worksite, the development of a site-specific, concurrent operations plan is recommended. The purpose of the plan is to address the operational safety risks and should consider the following:

- chain of command and supervisor/worker responsibilities for the site
- regulatory requirements related to minimum equipment and operational spacing, fire control requirements and risk assessments
- the identification and communication of unique hazards related to the planned drilling, well servicing, construction, and operating activities and the confirmation of any required safe work procedures
- communication and coordination with other operators if well(s) owned by different companies
- physical and fire safety protection of in-place wellheads, facilities, etc. when working on adjacent well(s) and confirmation of emergency response procedures

5.2 Hazardous Substance Exposure and Control

WHMIS is an information system about hazardous and potentially hazardous materials which are found in the work place and which, when handled, may cause injury, illness or death to the worker.

Key WHMIS requirements include the following:

- All controlled products, including all hazardous waste, on a worksite or used by workers of the owner and all contractors are required to have the appropriate WHMIS labels affixed.
- Material safety data sheets (MSDS) are required for all production streams and for all controlled products being used at each worksite. Copies must be kept on site in such a manner that they are easily accessible to all workers using controlled products.
- All workers, including contractor workers, on worksites where controlled products may be handled, shall be fully trained in understanding and using the WHMIS system and the safe handling of controlled products and hazardous waste.
- Clients and contractors are required to review their WHMIS program at least annually, or more frequently if required by a change in work conditions or available hazard information, with instruction and training provided to workers concerning controlled products.
- Owners and contractors are required to update all MSDS every three years.

The Canadian Environmental Protection Act (CEPA) also includes important requirements such as the following:

- Companies who own or manage specified toxic and hazardous substances at or above the specified thresholds must provide required information on the substance(s), including quantities and must prepare and implement environmental emergency plans.

Hazardous substances commonly associated with portable oil and gas processing buildings and facilities include hydrogen sulphide (H_2S), benzene and other chemicals.

5.2.1 Hydrogen Sulphide (H_2S)

Hydrogen sulphide is a common petroleum contaminant. It may be present as a gas or may be dissolved in produced water, crude oil or natural gas condensate. Hydrocarbons contaminated with H_2S are called "sour."

For health and safety purposes, all facilities processing hydrocarbons contaminated with any concentration of H_2S should be evaluated for the potential of worker overexposure. If the potential exists, then a code of practice should be implemented.

CAPP has developed a Hydrogen Sulphide (H_2S) Guideline to assist member companies in the development of their codes of practice.

5.2.2 Benzene

Benzene and the associated compounds of toluene, ethylbenzene and xylene (commonly referred to as BTEX) have an anesthetic effect and primarily attack the central nervous system. Prolonged exposure to benzene concentrations of 100 ppm (IRP 14) will have adverse consequences.

BTEX compounds are normally found as liquids in gas condensates and crude oil streams. If liquid hydrocarbon streams at a gas plant have concentrations of benzene that exceed the 0.1 per cent level and are in the range of 0.5 to 1.5 per cent, extra caution must be taken. Normally, condensate is stored and transported in a closed system of vessels, lines and pumps but workers can be exposed when those systems are opened for maintenance.

CAPP has developed a Best Management Practice for the Control of Benzene Emissions from Glycol Dehydrators.

5.2.3 Chemicals

Owners and employers are required to identify the potential for worker exposure to harmful chemicals as part of the hazard identification and assessment process. It is important to ensure that a worker's exposure to any substance does not exceed occupational exposure limits specified in Part 4 of the Alberta OHS Code. Employers are required to assess the need for atmospheric testing before workers are exposed.

Regulations and recommended industry practices may require an exposure control plan (ECP) to be prepared to protect workers and building occupants from potential risks identified in a risk assessment.

5.2.4 Other Potential Occupational Exposures

Other potential occupation exposures include

- asbestos
- hantavirus
- normally occurring radioactive materials (NORM)
- silica

Under normal circumstances, the development of a code of practice will be the responsibility of either the prime contractor or the employer completing the work.

5.3 Critical Safe Operating Procedures

As previously stated, any critical task to be undertaken by workers must be preceded by a hazard assessment of that task. Codes of practice may be required for the following critical tasks. In addition, a hazard assessment may be completed prior to commencing the task:

IMPORTANT: Company representatives are responsible for ensuring that a code of practice is available and being applied for key critical tasks. When critical tasks are undertaken by a contractor, the contractor will be responsible for development of a code of practice pertinent to the equipment and personnel required for completing the work safely. In most circumstances, the contractor completing the work should have an acceptable code of practice. If not, the owner's code of practice must be referenced and applied as required.

5.3.1 Confined and Restricted Space Entry

A written code of practice is required that outlines the procedures to be followed whenever a worker enters a confined space. This practice must identify existing and potential confined space work locations at a worksite, training, hot work, and confined space entry permit requirements.

5.3.2 Critical Lifts and Safe Lifting Certifications

Prior to performing a lift, the operator shall determine the weight of the object to be lifted and ensure that cables, lifting devices, slings, wire ropes, chains, etc., are of sufficient strength, in safe condition and positioned to support the weight of the load. Lift/load calculations MUST be conducted for lifts exceeding 75 per cent of lifting device capacity. Only competent/qualified, authorized workers shall operate lifting devices. Critical lifts are further defined in provincial OHS regulation and can include heavy lifts, lifts over process equipment, lifts involving two cranes, lifts where the operator cannot see the load, lifts using personnel-baskets, etc.

When critical lifts are being made, a critical lift plan must be developed and communicated to all personnel involved in the critical lift at a documented pre-job meeting. A critical lift plan identifies the minimum requirements that must be evaluated before completing a critical lift.

5.3.3 Electrical Safety (Including Working near Overhead Power Lines)

Contractors are required to take precautions when working near overhead power lines.

5.3.4 Energy Isolation (Including Lock-Out/Tag-Out)

A written Code of Practice is required that outlines the minimum requirements for locking out and tagging equipment.

- This practice is to be applied when a worker removes or bypasses a safeguard on equipment that is not under the worker's direct control. In these cases, the worker must control hazardous energy (e.g., lockout), as required by Part 15 of the Alberta OHS Code and Part 10 of the BC OHS Regulation. This ensures that the equipment cannot be activated by another worker.
- This is an important consideration any time a worker is required to work on or near active production equipment (e.g., pumps jack, pressurized piping and vessels, etc.). In these cases, lockout protocols must be reviewed to determine who is required to place a lock on the equipment in question.

5.3.5 Flammable Atmospheres (Including Hot Work and Fire and Explosion Prevention)

The OHS regulations highlight the need for having a process for managing "hot work." In addition, AER 033 requires licensees to have a documented fire and explosion prevention plan available at the wellsite for the safe management of the potential for explosive mixtures and ignition in wells and associated surface equipment.

5.3.6 Ground Disturbance (Including Damage Prevention)

The Alberta OHS Code and the AER under the Pipeline Act identify the specific procedures required for ground disturbances. This includes digging sumps, placing anchors and other similar ground disturbances associated with drilling and completion operations. Also refer to IRP 17 Ground Disturbance Checklist and AER Backfill Inspection Report.

5.3.7 Hydrate Handling

Hydrates in wells, gas piping and pipelines are very hazardous. The uncontrolled removal of hydrates has caused pipes to be knocked off supports, equipment damaged due to ruptures, and injuries and even death to occur. Therefore, it is extremely important for workers to know about the prevention and safe removal of hydrates in gas lines.

The purpose of the CAPP Guideline for Hydrate Prevention and Handling is

- to provide an understanding of the conditions under which hydrates are formed so that, when possible, they can be prevented
- to ensure that hydrates are removed safely

5.3.8 Purging

Purging operations may require a code of practice to provide pertinent information, minimum requirements and a consistent approach to safely remove air, combustible, chemical, toxic, or other reactive gases or liquids from vessels, equipment and piping.

5.3.9 Vehicle Operations—Journey Management

Vehicle operation and driving practices are a significant hazard for Canadian oilfield workers. Companies should consider developing minimum vehicle operating practices and journey management guidelines.

5.3.10 Working Alone

Employers are not required to have a written code of practice for workers working alone. Notwithstanding this, companies are required to develop a code of practice outlining the working-alone risk assessment strategy adopted by the company. It is important for company representatives and contractors to establish working-alone procedures when applicable.

5.3.11 Working at Heights

An employer must develop procedures in a fall protection plan for a worksite if a worker at the worksite may fall three metres (3 m) or more and workers are not protected by guardrails. This plan must specify the fall hazards, the fall protection system to be used at the worksite, and the procedures for maintenance, inspection and rescue.

5.4 Site-Specific Procedures

In some cases it may be necessary to develop site-specific procedures to better address unique equipment and operating hazards not addressed by standard operating and maintenance procedures.

5.4.1 Knowledge of Equipment

Ensure workers understand the process, equipment and materials they use. For the safety of themselves and fellow workers, it is important that workers

- Follow site-specific procedures to lock out mobile equipment.
- Know the locations and operations of all safety equipment and portable fire extinguishers.
- Exercise caution when draining a vessel (flashing liquid becomes cold and metal failures can occur).
- Isolate, depressurize and purge before working on equipment vessels and piping.
- Install blind flanges on all nozzles before working on a vessel, section of piping or other equipment.
- Lock out and tag all valves, switches and brakes used to isolate systems and equipment.
- Use appropriate test equipment such as "sniffers” to detect gases, and voltmeters to detect live circuits before proceeding with maintenance.

- Ensure all electrical equipment is adequately grounded.
- Use the correct fuses and breakers on all electrical equipment installed.
- Ensure that all relief valves required to protect pressurized equipment are correctly installed and maintained.
- Steam out or chemically wash vessels in sour service to remove all traces of hydrogen sulphide and iron sulphides before anyone enters the vessel.
- Cold cut the checker plate and check for explosive vapours before working on or under skid floors.

5.4.2 Commissioning and Start-up

The start-up of operations can be especially hazardous. Develop start-up procedures and communicate them to all persons involved in start-up operations. See Sections 5.4.2.1 to 5.4.2.8 for methods to reduce key safety risks during start-up.

5.4.2.1 Air Blowing (Depressurizing Lines of Air)

Make sure workers

- Notify all personnel in blow-off areas and keep them away from blow-off points.
- Wear ear protection (if noise levels are high) and safety goggles.
- Check the entire system before blowing.

5.4.2.2 Water Flushing

Make sure workers

- Check lines to be flushed before starting.
- Notify all personnel in the area and limit access if necessary.
- Discharge flushing fluids into areas where they will not create a hazard.
- Drain all dead legs (low points in the piping) during winter to prevent damage from freezing.

5.4.2.3 Leak Checking with Air

Make sure workers

- Thoroughly check equipment for loose connections before starting (an overlooked leak at this stage may later develop into a serious hazard).
- Isolate equipment that is not designed for pressure.

5.4.2.4 Purging

Use an inert medium for purging. If an inert medium like nitrogen (N_2) cannot be used, take the following precautions:

- Tightly control or prohibit all sources of ignition in the area (including smoking).
- Allow only essential personnel in areas where purging is done.
- Purge at atmospheric pressure.
- Purge very slowly to keep gas velocities low.

- Use hoses to direct vented gas outside buildings and confined areas. Make sure hose ends are secured.
- Purge each line separately and track using colour coding on a mechanical flow diagram.

5.4.2.5 Pre-start-up Check

Operations personnel need to be satisfied that the facility is safe to start.

Operational readiness considerations include

- procedures in place
- maintenance plans in place
- documentation necessary to manage risks in the facility are available
- action items from risk assessments that are necessary to be completed prior to start-up have been completed
- commissioning activities completed, etc.

After purging and before start-up, make sure workers complete the following:

- Test oxygen levels in lines or vessels. Oxygen levels must be below 5 per cent.
- Visually check the facility for any tools or purging equipment left behind that could create hazards during start-up.
- Complete a full electrical and controls system check.
- Refer to manufacturer's start-up manuals (or contact manufacturer) for safe procedures.
- Evaluate hazardous conditions before start-up (Refer to HAZOP API RP750).

5.4.2.6 Production Chemistry

The potential effect of downhole chemistry on the operation of surface equipment needs to be reviewed. Consideration may have to be given to corrosion protection, hydrate management, scale, etc. A production chemistry consultant may need to be engaged to develop an appropriate chemical program.

5.4.2.7 Building Entry

There are many hazards involved when entering buildings on various locations, personnel must be aware of all the risks and challenges of completing this task. An obvious increase in risk is encountered when dealing with buildings in sour applications and should be dealt with accordingly. Employers must ensure all reasonable precautions are taken to ensure the safety of personnel and property when entering onto a lease and into buildings that may contain toxic gas vapours, combustible atmosphere or lack of sufficient oxygen.

5.4.2.8 Working with Steam

Ensure workers take the following precautions when using steam hoses:

- Use only approved steam hoses that have a sufficiently high pressure rating.
- Always shut off the steam supply to the hose before closing the valve at the discharge end.

- Wear leather gloves and appropriate hearing protection when noise levels warrant.
- Do not blow off steam where workers may be endangered.
- Secure open ends of the blow-off hose (if used) and fence off the blow-off and drain areas.
- When steaming lines, watch line expansion, check pipe supports, sliders and hangers. Stop steaming if undue stress occurs.

5.4.2.9 Housekeeping

Make sure the following basic "good housekeeping" rules are part of every worker's daily routine:

- Keep floors, stairs and platforms clean and free of tools and other loose materials.
- Keep oily rags and paint rags in tightly sealed metal containers.
- Clean up oil spills immediately using only approved solvents, never gasoline.
- Have a place for everything and keep everything in its place.

6 Recommended Solutions for Worker Competency

This section describes the safety and technical training workers and contract operators at oil and gas facilities need to understand in order to respond to the hazards they may encounter in their daily work.

It is important that training prepare workers to both recognize the hazards in a task and to take appropriate safety measures. Basic safety training must be supplemented with technical training and site-specific safety training.

Employers are responsible for ensuring workers complete this training and work in a manner that safeguards everyone on or near the worksite.

6.1 Worker Orientations

As shown in the adjacent diagram, the industry has identified four phases of the safety orientation process:

1. employer onboarding
2. oil and gas industry General Safety Orientation (eGSO)
3. prime contractor messaging (optional)
4. site specific orientation

The responsibility of company representatives is to ensure that all on-site workers (workers and contractors) receive a site-specific safety orientation. The orientation process is an introduction to critical aspects of an HSE Management Program and provides immediate information that workers need to know, including a review of any relevant company policies and practices, responsibilities and expectations, as well as relevant administrative issues.

6.2 Basic Training & Competency Requirements

Section 1(g) of the Alberta OHS Regulation defines a "competent worker" as one who is adequately qualified, suitably trained and with sufficient experience to perform work safely. Specific to worker training, the above regulation requires the following:

- Section 13–General Protection of Workers
  - the employer shall ensure that work is done only by a competent worker
  - workers must be familiar with any procedures developed by employer
  - workers must be competent in care and use of safety equipment
  - employers must ensure workers perform duties
- Section 15–Safety Training
  - workers must be trained in safe operation of equipment
  - worker training must include: use of equipment, limitation of the equipment, inspections and basic maintenance, and associated hazards specific to the operation of the equipment
  - workers must participate in training provided by employer
  - workers must apply training

In consideration of this, the following components should be considered by employers when establishing worker competency standards:

- core safety training
- technical training

6.2.1 Core Safety Training (Pre-Hire Confirmation and Documentation)

Core safety training requirements should be determined and scheduled as soon as possible. It is recommended that companies maintain a detailed file for their worksite supervisors to ensure that the training certifications are maintained for all required courses, with an expiry date. In addition to training certifications, copies of a current résumé, orientation completion, and other documents relevant to the competency and safety performance of personnel should be obtained.

Table 6.1 Required Certification and Training

Certification Required	Training Requirements	Supervisor	On-Site Worker
General Safety Orientation	Best Practice (ENFORM)	Recommended	Required
Safety Management and Regulatory Awareness for Wellsite Supervision (3 Yr)	Industry Recommended Practice 7 Alberta OHS Act Section 3	Recommended	Recommended
Standard First Aid (3 Yr)	Alberta OHS Code Part 11	Required	Required
H_2S Alive (3 Yr)	Alberta OHS Code Part 04	Required	Required
WHMIS	Alberta OHS Code Part 04	Required	Required
TDG (3 Yr)	Federal TDG Requirements	Required	Required
Ground Disturbance	Alberta OHS Code Part 32 + AER	Required	Recommended
Detection and Control of Flammable Substances	Alberta OHS Code Part 10	Recommended	Recommended
Confined Space Pre-Entry	Alberta OHS Code Part 05	Recommended	Recommended
Emergency Response	AER Directive 071	Required	Required
Spill Response	Industry Practice (Enform – WCSS)	Recommended	Recommended
ATV Training	Best Practice (Canada Safety Council)	Recommended	Recommended

Note: The majority of safety courses are valid for a three-year period. Employers are responsible for ensuring training is kept current and training records are maintained. Where a project or regulation requires certificates of competency to perform designated tasks, a record of the certificates will be taken at time of employment or orientation prior to workers being able to perform those tasks. The certificates of competency must be readily available for management review.

6.2.2 Technical Training: Core and Operations-Specific

In addition to core safety training, all oil and gas facility operators should receive both general and specific technical training applicable to facility operations. Recommended technical training is summarized in Table 6.2.

Contractors are responsible for providing trained and competent workers.

Table 6.2 Technical Training: Core and Operations-Specific

Type of Training	Training Elements
General Technical	Introduction to oil and gas operations and equipment: Flow measurement: orifice plates Level measurement Pressure measurement Pumps (including pd and centrifugal pumps) Static electricity Temperature measurement Valves Gas and fire detection equipment Handling of hydrocarbon fluids Hydrates and ice plugs Hydrocarbon fluid storage and loading Internal combustion engines Isolation of mechanical and electrical equipment Oil and gas composition and sales specifications Pressure safety devices Purging Produced water handling and disposal Worksite inspection and hazardous area classification
Oil Well Operations	Oilfield operations overview Pumpjacks Sucker rod strings Bottomhole pumps Pipeline pigging Production testing
Battery Operations	Battery operations overview Oil and emulsion treating Operation of fired vessels Oil and water storage and custody transfer
Gas Well Operations	Gas production overview including problem prevention Field operations Design and normal operation Gas dehydration Gas-line heating Separation procedures and equipment Properties and characteristics of natural gas
Compressor Station Operations	Classification and types of gas compressors Basic controls

	Compressor components Drivers and operational controls Lubrications Valve and rod packing
Gas Plant Operations	Condensate stabilization systems Dehydration chemicals, liquid desiccants dehydration, testing Development and types of gas plant processes Glycol equipment and operation Inlet equipment and operation Inlet separation process description Process flow refrigeration Stabilization equipment Sweetening processes, equipment and chemicals

6.3 Competency Management and Development

A training program needs to address the following due diligence factors related to worker competence and training initiatives:

- level of worker competence based on prior training and experience
- level and amount of worker training required to competently operate the assigned facilities
- operating and maintenance requirements for the equipment in use
- safe work practices and industry guidelines appropriate for the operations
- work conditions, including any specific personal protective equipment
- consultation and use of experts when appropriate

In developing a worker capability management system, employers should consider the following:

- **Capability management and development system (CMD)**
  A capability management and development system is a supportive administrative system and process, the purpose of which is to ensure the status for each worker is maintained and monitored. Regular reports are prepared and issued to field management summarizing the status of each worker.
- **Safety critical task analysis and skill profile development**
  Development of an area skills profile is based on the nature of job requirements and a safety critical task analysis. The skills profile is reviewed regularly to ensure the tasks specific to the job are included. Regular review is required to identify and maintain appropriate skills profiles. This includes the addition of any skills required to address site-specific procedures required by the company.
- **Prior learning assessments and validations**
  Validation of competency includes two recommended steps:
  - All workers should complete a self-assessment of prior learning to confirm their knowledge level.

- An on-the-job validation should be completed by a qualified person to confirm each worker's knowledge level and verify competency.

- **Competency development and support**
  Upon completion of the on-the–job validation, appropriate measures are taken to address any knowledge and skill gaps. A worker-specific training plan may be developed in those circumstances where a more structured learning plan is required. Once skill gaps are addressed, the worker validation is updated. A wide range of capability development tools are available to support the program, including standard operating practices which are supplemented as company activities evolve.