canadian energy pipeline association | association canadienne de pipelines d'énergie

Best Management Practice

Fugitive Emissions at Natural Gas Transmission and Storage Facilities

SEPTEMBER 23, 2016

PREPARED BY:
CEPA WORKING GROUP ON CLIMATE CHANGE
AND
CLEARSTONE ENGINEERING LTD.

DISCLAIMER OF LIABILITY

This Best Management Practice (BMP) was prepared by Clearstone Engineering Ltd. as an account of work managed by CGA-CEPEI and the Canadian Energy Pipeline Association (CEPA) on behalf of the sponsoring companies. Neither Clearstone Engineering Ltd., nor CGA-CEPEI, nor CEPA, nor the sponsors, nor any person on behalf of these parties:

- Makes any warranty or representation, express or implied with respect to the accuracy, completeness, or usefulness of the information contained in this document, or that the use of any information, apparatus, method, or process disclosed in this document may not infringe privately-owned rights; or
- Assumes any liability with respect to the use of, or for damages resulting from the use of, any information, apparatus, method or process disclosed in this document.

Executive Summary

Fugitive emissions are the unintended emissions from facilities or activities (e.g., construction) that could not reasonably pass through a stack, chimney, vent, or other functionally equivalent opening at a rate such that:

- When conducting audio/visual/olfactory leak monitoring, there is physical evidence that a leak is occurring.
- Where components are screened for leaks using organic vapour analyzers in accordance with U.S. EPA's Method 21, the hydrocarbon screening value is 500 ppm or more.
- Where components are screened using optical gas imaging, there is a visual indication of a leak.

This Best Management Practice document provides guidance for developing company, and site specific plans for the management of fugitive emissions at above-ground natural gas transmission and storage facilities. The members of the Canadian Energy Pipeline Association (CEPA) members have committed to a range of measures to limit fugitive emissions as shown in the table below:

Commitments	page
Companies should fully consider how they will ensure effective emissions control throughout the life of each facility.	10
The first step in managing fugitive emissions should be to minimize their potential by applying proper design and material-selection standards (for example, CSA Z662 – Oil and Gas Pipeline Systems).	11
Comprehensive leak surveys should examine all equipment components that have the potential to emit fugitive emissions of methane or VOC	12
Comprehensive leak surveys should, to the extent possible, be scheduled to eventually encounter each compressor unit in each applicable operating mode.	13
Comprehensive leak surveys should be conducted at a minimum of once annually.	13
Leaker tags should be hung on or near leaking equipment components and with appropriate information marked on it for others to be able to easily determine the location and source of the leak. The tags should be uniquely numbered, weather resistant, and designed for high visibility.	15

Commitments	page
All leaker tags should be left in place after the leak rate is measured to allow for follow-up action by maintenance personnel. The tags should only be removed once the component has been repaired and the leak is determined to be fixed.	16
AVO inspections should be conducted inside and outside each active process building, around all process units, and along aboveground piping.	16
Where operators become aware that a pressure safety valve (PSV) has lifted they should check the component to ensure that it has reseated properly and is not leaking.	17
After equipment has been re-pressurized following a blowdown event, the affected blowdown system and any affected bleed valve vents should be surveyed to confirm that these valves have seated properly and there is no leakage into the blowdown or bleed systems.	17
The effectiveness of repairs should be confirmed by the operator within 24 hours of the repair.	18

Contents

List of Figures

List of Tables

Definitions

Border Meter Station

A meter station where custody of the gas is transferred from one gas transmission system to another at a provincial or national boundary.

Compressor Station

A facility where gas pressure is increased to allow the gas to enter into a higher pressure pipeline system or for gas storage (i.e., feed rather than booster service). Both centrifugal and reciprocating compressor units may be used in these applications.

Connector

A connector is a mechanical component for connecting two sections of piping; for example: flanges, threaded connections, and hammer lock couplings. A properly installed connector can provide essentially leak free service for extended periods of time; however, there are many factors that can cause leakage problems to arise. Some of the common causes are misalignment, improper tightening procedures, damaged or fouled contact surfaces, and loosening of the connection due to vibrations or thermal cycling. Additionally, it is not uncommon for some connections to be inadvertently left un-tightened following a facility turnaround or specific inspection and maintenance activity (especially on fuel gas piping which is often the last piping to be reconnected). Good practice is to perform checks immediately following any changes or adjustments to a connection.

Equipment Component

A mechanical device that has the potential to leak and is used in hydrocarbon service in process units and piping systems at natural gas transmission and storage facilities.

Generic types of equipment components include, but are not limited to valves, connectors, pump seals, flanges, pressure relief devices, flow meters, pressure regulators, sampling connections, instrument fittings, sump and drain tank vents and covers, blowdown system vents, and open-ended valves and lines.

Farm Taps

Equipment to facilitate the direct gas sales from a transmission pipeline to an individual customer, usually in rural areas where access to an interconnected gas distribution system is not available.

Flow Indicator

A device that indicates whether gas flow is present in a line or whether the valve position would allow gas flow to be present in a line.

Fugitive Emissions

In the context of this document, fugitive emissions refer to unintended emissions from facilities or activities (e.g., construction) that could not reasonably pass through a stack, chimney, vent, or other functionally equivalent opening.

Fugitive emissions can occur due to normal wear and tear, improper or incomplete assembly, inadequate material specification, manufacturing defects, damage during installation or use, corrosion, fouling and environmental effects (e.g., vibrations and thermal cycling). The potential for such emissions depends on a variety of factors including the type, style and quality of equipment component, type of service (gas/vapour, light liquid or heavy liquid), age of component, frequency of use, maintenance history, process demands, whether the process fluid is odourized and operating practices.

Fugitive emissions, in this scope of this document, does not include:

- Emissions directly associated with combusted gas such as emissions from gas burned in burners, engines, flare stacks, combustors or incinerators.
- Area based sources such as ponds or pits.
- Below-grade and/or buried piping or components managed through existing pipeline integrity processes.
- Venting sources, including the following:
    - Pneumatic devices using hydrocarbon gas as the supply medium such as instrument control loops, compressor engine starter motors, automatic samplers, etc.).
    - Blowdown events.
    - Compressor seal vents.

Inaccessible Equipment Component

An equipment component may be deemed inaccessible for the purpose of inspection if it cannot be inspected without elevating the inspecting personnel more than 2 meters above a support surface. Components that are located in a confined space and components that are not accessible due to climatic conditions (e.g., snow cover) are also deemed inaccessible.

Leak

A fugitive emission will be classified specifically as a leak at surface facilities when there is the loss of process fluid past a seal, mechanical connection or a minor flaw at a rate such that:

- When conducting audio/visual/olfactory leak monitoring, there is physical evidence that a leak is occurring (defined in Section 8.1).
- Where components are screened for leaks using organic vapour analyzers in accordance with U.S. EPA's Method 21, the hydrocarbon screening value is 500 ppm or more.
- Where components are screened using optical gas imaging, there is a visual indication of a leak.

Mainline Block Valves

A block valve used to isolate a segment of the main transmission pipeline for tie-in or maintenance purposes.

Open-Ended Valves and Lines

Any valve that may release process fluids directly to the atmosphere in the event of leakage past the valve seat (i.e., a valve that is closed, has pressurized process fluid on one side and is open to the atmosphere on the other side). This leakage may result from improper seating due to an obstruction or sludge accumulation, or because of a damaged or worn seat. An open-ended line is any segment of pipe that may be attached to such a valve and that is open to the atmosphere at the other end.

Few open-ended valves and lines are designed into process systems; however, actual numbers can be quite significant at some sites due to poor operating practices and various process modifications that may occur over time. Some common examples of instances where this type of source may occur are listed below:

- scrubber, and compressor-unit blowdown valves,
- supply-gas valve for a gas-operated engine starter (i.e., where natural gas is the supply medium),
- instrument block valves where the instrument has been removed for repair or other reasons,
- purge or sampling points, and
- drain valves or chemical injection points where the valve is closed and the plug normally installed in the end of the valve has not been put back in place after use of the valve or is only loosely installed.

Pressure Regulator

Pressure regulators are used to reduce high-pressure supply gas to a safe and constant pressure for various applications. They are typically comprised of three functional elements; a pressure reducing or restrictive element (generally a poppet valve), a sensing element (generally a diaphragm or piston) and a reference force element (generally a spring). In operation, the spring produces a force which opens the valve. Pressure introduced into the inlet port then flows through the valve and then presses against the sensing device (diaphragm or piston). The regulated pressure acts on the sensing element to produce a force which opposes the spring force and closes the valve. Over time regulators may deteriorate and malfunction, leading to leakage and/or excessive venting. Fittings and drain valve (if equipped) are particularly prone to leakage. Some regulators are designed to vent occasionally if there is overpressure.

Pressure-Relief or Safety Valves

These are used to protect process piping and vessels from being accidentally over-pressured. They are spring loaded so that they are fully closed when the upstream pressure is below the set point, and only open when the set point is exceeded. Relief valves open in proportion to the amount of overpressure to provide modulated venting. Safety valves pop to full-open positions on activation.

When relief or safety valves reseat after having been activated, they often leak because the original tight seat is not regained either due to damage of the seating surface or a build-up of foreign material on the seat plug. As a result, they are often responsible for fugitive emissions. Another problem develops if the operating pressure is too close to the set pressure, causing the valve to "simmer" or "pop" at the set pressure.

Gas that leaks from a pressure-relief valve may be detected at the end of the vent pipe (or horn). Additionally, there normally is a monitoring port located on the bottom of the horn near the valve. If the pressure relief valve is connected to a flare system, then any leakage from the valve is deemed to be controlled.

Pump Seals

Positive displacement pumps are normally used for pumping hydrocarbon liquids at oil and natural gas facilities. Positive displacement pumps have a reciprocating piston, diaphragm or plunger, or else a rotary screw or gear.

Packing, with or without a sealant, is the simplest means of controlling leakage around the pump shaft. It may be used on both the rotating and reciprocating pumps. Specially designed packing materials are available for different types of service. The selected material is placed in a stuffing box and the packing gland is tightened to compress the packing around the shaft. All packings leak and generally require frequent gland tightening and periodic packing replacement.

Particulate contamination, overheating, seal wear, sliding seal leakage and vibration will contribute to increased leakage rates over time.

Receipt / Sales Meter Stations

A meter station for measuring the amount of gas being supplied from a given source or delivered to a downstream customer.

Storage Facility

A facility incorporating storage caverns or spheres and associated infrastructure to help balance daily and season variations in loads.

Valve

A device for controlling the flow of a fluid. There are three main locations on a typical valve where leakage may occur:

- From the valve body and around the valve stem (valve leaks),
- At the end connections (connector leaks), or
- Past the valve seat.

Leakage past the valve seat is only a potential source of emissions if the valve, or any connected downstream piping, is open to the atmosphere. This is referred to as an open-ended valve or line.

The potential leak points on each of the different types of valves are, as applicable, around the valve stem, body seals (e.g., where the bonnet bolts to the valve body, retainer connections), body fittings (e.g., grease nipples, bleed ports), packing guide, and any monitoring ports on the stem packing system. Typically, the valve-stem packing is the most likely of these parts to leak.

The different valve types include gate, globe, butterfly, ball and plug. The first two types are a rising-stem design, and the rest are quarter-turn valves. Rising-stem valves tend to leak more than quarter-turn valves. Valves may either be equipped with a hand-wheel or lever for manual operations, or an actuator or motor for automated operation.

1. Introduction

Canadian natural gas pipeline companies have been proactively managing and reducing greenhouse gas emissions, including fugitive emissions, since the mid-1990s. This Best Management Practice document provides guidance for use by natural gas companies in developing company, and site specific plans for the management of fugitive emissions, and specifically leaks, at above-ground natural gas transmission and storage facilities. The presented guidance incorporates current practice in asset management and the findings from industry and government-sponsored studies of fugitive emissions at Canadian natural gas facilities. The management of leaks in underground pipelines is not addressed and is beyond the scope of this document.

A fugitive emissions management plan should be designed to ensure effective and verifiable management of fugitive emissions at above-ground natural gas facilities while complying with all applicable regulations, and should comprise the following key elements:

- A written fugitive emissions management plan endorsed by management which documents initial baseline fugitive emissions or leak management performance, and that establishes the scope of the program, clear performance targets, ongoing performance monitoring requirements, critical areas and component categories on which to focus efforts, quality control and quality assurance measures, and the responsibilities of management, operations and maintenance personnel as well as any contractors.
- A system for managing all leak monitoring and repair records, relevant training records, and the calibration and maintenance records for all leak detection and quantification equipment used during each leak survey.
- Documentation of the basis for any ongoing noteworthy refinements to the company specific management plan such as performance-based changes to leak monitoring frequencies for specific component categories.

A reasonable phase-in period will be required to allow each natural gas company time to review these guidelines and, where appropriate, update or refine their fugitive emissions management plans accordingly. The phase-in period will be determined in consultation with appropriate regulatory bodies.

The amount of emissions from above-ground natural gas facility leaks depends on many factors including the number and type of equipment components in natural gas service, the quality and age of the components, activity levels, maintenance practices, leak monitoring and repair frequencies and various operating, environmental and other factors.

The natural gas industry considers the effective management of fugitive emissions an important element of an overall asset management system. The current practice in asset management is based on using a management system approach based on a "Plan, Do, Check, Act" methodology. This approach strives to make optimal asset management decisions by taking a total life cycle view of the asset and by approaching asset management decisions with the objective of achieving an appropriate balance of risk, cost and performance. This guidance for the management of fugitive emissions has been developed with these principles and objectives in mind.

The natural gas industry is characterized by many smaller facilities distributed over a large area rather than a few large, centrally located facilities; consequently, a practical approach is warranted which focuses on those facilities, components and service applications most likely to offer significant cost-effective emission control opportunities.

It is recognized that fugitive emissions management requires ongoing attention. Leaking components, even after successful repair, will eventually reoccur without proper inspection and maintenance. It is also recognized that different types of components and service applications have different leak potentials, and therefore, will require different management approaches. In this document, the typical key sources of fugitive emissions at natural gas facilities are identified, important considerations and constraints are noted, improved operating practices are suggested, and relevant technologies for the detection, measurement and control of fugitive emissions are identified.

1.1 APPLICABILITY

The potential for such emissions depends on a variety of factors including the type, style and quality of equipment component, type of service (gas/vapour, light liquid or heavy liquid), age of component, frequency of use, maintenance history, process demands, whether the process fluid is odourised and operating practices.

Components in odourized service tend to have much lower average fugitive emissions than those in non-odourized service. Components tend to have greater average emissions when subjected to frequent thermal cycling, vibrations or cryogenic service. Different types of components have different leak potentials and repair lives.

Only a small percentage of the equipment components have any measurable leakage, and of those, typically, only a small percentage contribute most of the emissions (e.g., 5 to 10 percent of the leakers may account for 80 to 90 percent of the emissions). Thus, the control of fugitive emissions may be most effectively achieved by focusing according to the type of facility and, at individual facilities, on system components with the greatest likelihood and consequence of leaks (i.e., those that tend to release larger quantities of gas when a leak occurs).

1.2 IMPLEMENTATION

The extent to which measures for the management of fugitive emissions are applied at individual facilities should be based on public and employee safety, environmental and health risks, the proximity of the facility to nearby residences, the effectiveness of existing measures for managing fugitive emissions, the cost-effectiveness of finding and controlling leaks and regulatory requirements. Some facilities may already have requirements for a fugitive emissions management plan as a condition of their operating approval.

Companies should fully consider how they will ensure effective emissions control throughout the life of each facility.

2. Basic Management Strategy

The key elements for effective management of fugitive emissions at above-ground natural gas facilities are the application of appropriate technology and standards, implementation of management systems and corporate commitment.

2.1 TECHNOLOGY AND STANDARDS

The first step in managing fugitive emissions should be to minimize their potential to occur by applying proper design and material-selection standards (for example, CSA Z662 – Oil and Gas Pipeline Systems). It is also important to select practicable control technologies (e.g., reduction, recovery and treatment systems) and to appropriately consider manufacturers' specifications for the installation, use and maintenance of components.

2.2 MANAGEMENT SYSTEMS

CSA Z662 requires operating companies to perform regular leak surveys or analyses for evidence of leaks, to promptly investigate leaks, and to periodically review leak detection programs to confirm their adequacy. These tasks provide a framework for implementation of a management system approach to fugitive emissions management (i.e., Plan-Do-Check-Act methodology).

As fugitive emissions occur from the time that a leak starts until it is repaired, environmental consequences can be mitigated through leak prevention (e.g., re-design or replacement with materials having a reduced leak likelihood or leak consequences), earlier leak detection, as well as earlier leak repair. The following are key elements of a leak management program for above-ground assets:

Plan - Companies should define and document the activities they undertake on their above-ground piping systems for leak detection, investigation, and repair. Planning should also include the setting of performance objectives. To ensure appropriate consideration of the environmental consequences of leaks, programs should define objectives and measure performance with respect to fugitive emissions.

Do - Companies should ensure that defined activities are implemented in accordance with company requirements (e.g., creation and management of required records and competency requirements).

Check - Companies should review their leak management program to ensure that objectives are met.

Act - Companies should take action to correct areas where objectives may not be met. In addition, companies should review their entire leak management program to identify opportunities for continuous improvement. This would include ensuring the ongoing appropriateness of objectives and performance measures.

2.3 CORPORATE COMMITMENT

Appropriate corporate commitment, including management authorization and review, should be provided to ensure that the objectives that have been established for the leak management program are met.

With respect to fugitive emissions management and environmental considerations within the overall leak management program, management should have appropriate involvement in setting objectives and in the evaluation of the program effectiveness.

3. Leak Management Programs

Although safety is a primary driver for leak management programs for operators of natural gas transmission and storage systems, it is recognized that environmental considerations require increasing focus. This document describes a cross-section of practices pertaining to above-ground natural gas facility leak management programs.

The key elements of a leak management program comprise the following activities below, each detailed in the sections that follow:

- Comprehensive Leak Surveys
- Supplemental Monitoring
- Repair
- Preventative Measures
- Reporting
- Recordkeeping
- Quality Assurance (QA)/Quality Control (QC)

The minimum program requirements are summarized by type of facility in Table 1 below, and the facilities are classified according to whether they are subject to target or non-target facility requirements.

Table 1: Leak management program requirements by type of facility

Facility type	Targeted?	Comprehensive leak surveys	Supplemental monitoring	Leak Repair	Preventative measures	Record keeping	Reporting
Compressor Station	Yes	Annual	✓	Set Repair Schedules	✓	✓	✓
Receipt/ Sales Meter Stations	No	Risk-based Monitoring Frequency	✓	Risk-based Repair Schedules	✓	✓	
Border Meter Stations	No	Risk-based Monitoring Frequency	✓	Risk-based Repair Schedules	✓	✓	
Storage Facilities	Yes	Annual	✓	Set Repair Schedules	✓	✓	✓
Mainline Block Valves	No	Risk-based Monitoring Frequency	✓	Risk-based Repair Schedules	✓	✓	
Farm Taps	No	Risk-based Monitoring Frequency	✓	Risk-based Repair Schedules	✓	✓	

3.1 COMPREHENSIVE LEAK SURVEYS

Comprehensive leak surveys should examine all equipment components that have the potential to emit fugitive emissions of methane or VOCs, including but not limited to valves, connectors, pressure relief devices, open-ended lines, flanges, and covers. Devices that vent as part of normal operations, such as natural gas-driven controllers or natural gas-driven pumps are equipment components that emit fugitive emissions and therefore are not targeted in this document.

3.1.1 Survey Frequency

Comprehensive leak surveys should be conducted at a minimum of once annually.

Facilities may be excluded if the operator can demonstrate that the facility is expected to be non-utilized (i.e. non-operational and depressurized) for 95% of the calendar year or more.

3.1.2 Detecting Leaks

The selected leak detection instrument must be designed to detect leaks in accordance with the definition of a leak indicated in the Definitions section of this document. Leak detection completed for comprehensive leak surveys should comply with the performance specifications of Method 21 and be maintained and operated in accordance with the manufacturer's specifications. Method 21 also allows bubble tests to be used for leak detection and the US EPA Alternative Work Practice allows for the use of hydrocarbon leak-imaging cameras.

Standard practice for screening equipment components for leaks should follow a logical easy-to-repeat path through the process to avoid missing any components. Optical gas imaging cameras must be designed to observe hydrocarbon gases and be capable of detecting a methane leak rate of approximately 1.0 gram per hour based on the manufacturer's specifications.

Leak detection methods that do not meet these performance requirements (e.g., by AVO means) can be used as a supplementary approach, but are not, in themselves, sufficient for conducting either a comprehensive or risk-based targeted leak survey.

When optical gas imaging cameras are used, the following are recommended to be incorporated into a survey procedure to ensure effective leak identification:

- Be within 30 metres of tanks and 6 metres of small fittings.
- Inspect components perpendicular to wind direction.
- Use an appropriate lens to see tank top components (it is recommended that a fixed lens of 70 mm or more be used on tank tops when viewing from distances approaching 30 metres).
- Multiple viewing angles.
- Attention to background conditions.
- Interfering effects (e.g. sunlight, precipitation, wind speed, temperature).

Operating modes

Comprehensive leak surveys should, to the extent possible, be scheduled to eventually encounter each compressor unit in each applicable operating mode. Notwithstanding this, operating modes that are expected to contribute most to total leakage at a site (i.e., based on typical emission factors and the fraction of time they occur), should be given the greatest priority.

There are three potential operating modes that occur for process equipment and piping at a facility: (1) operating, (2) standby and pressurized, and (3) depressurized. The emissions potential may be different in each of these modes. In Modes 1 and 2, all equipment in pressurized natural gas service will have a potential to leak. This includes a potential for leakage past the seat of closed blowdown valves into the blowdown vent system.

In Mode 3, there is a potential, in the absence of any isolation blinds being installed, for leakage to occur past the seat of the upstream and downstream isolation valves into the cavity of the depressurized equipment and piping. Such leakage subsequently vents to the atmosphere via either the open blowdown system or, where double block and bleed isolation techniques are applied, the bleed vents.

The operating practices of individual companies may vary, and Mode 2 may not necessarily apply to all companies. As well, where Mode 2 does occur, some operators may partially depressurize the equipment while in this state.

At sites having backup compressors, it may be possible to survey Modes 1 and 2 (if applicable) during a single leak survey. Operators should not be obligated to depressurize a compressor unit strictly for the purpose of conducting a Mode 3 leak survey on the basis that this unnecessarily creates significant blowdown emissions that negate the benefit of a Mode 3 leak check.

Risk Based Leak Surveys

Risk-based survey could be conducted by operators in addition to comprehensive surveys. The types of components that may be targeted within a risk-based leak survey include flanged and threaded connections (i.e., connectors), valves, pressure-relief devices, open-ended lines, blowdown vents (i.e., during passive periods), instrument fittings, regulators and actuator diaphragms, sump and drain tank vents and covers. The amount of emissions from a leaking component is generally independent of the size of the component.

Leakage into vent systems, pressure relief valves and open-ended lines tend to be the most common sources of big leaks. Still, components such as connectors and valves can, on occasion, also be major leak sources. Examples of situations where this or other unexpected significant leak contributions may occur include the following:

- Connections left untightened after a scheduled turnaround or maintenance which go unnoticed due to high background noise levels or because the component is in a difficult to access or infrequently visited location (e.g., at high elevation location or on a pipe rack).
- Holes that have developed in equipment or piping due to corrosion, abrasion or damage.
- Components that have been improperly installed or that were neglected to be installed (e.g., a pressure gauge removed during maintenance work is not put back into its port and the valve on the port is in an open or partially open position).
- Major failures of valve stem packing systems (e.g., blowout of the packing material).

Accordingly, consideration should be given to all possible emissions sources when selecting components for targeted leak surveys.

Table 2 is included to help illustrate the implications of a leak survey program targeted on those components with the greatest leak likelihood (indicated by leak frequency) and the greatest leak consequences (a function of the number of sources and the average emissions per source). This information has been combined into a calculated value called “relative leak potential”, which provides a company-specific view of where the greatest benefit with respect to fugitive emissions may be gained through improvements to the overall leak management program.

If the leak potential (i.e., average emission rate per component) for a connector is set to 1 (see the final right-hand column in Table 2), then the leak potential for block valves is 9 times greater, the value for control valves is 37, open-ended lines is 205, and so on. Based on these statistics, their percentage contribution to total fugitive emissions and their leak frequencies, leak control efforts should be focused on the top 3 categories shown in Table 2, namely: blowdown systems, pressure relief valves and open-ended lines. Collectively, these three categories account for only 1.1 percent of the total component population but contribute more than 85 percent of the total emissions from leaks. Considering the top 6 categories would comprise 2.1 percent of the component population and account for 87.6 percent of the estimated emissions due to leaks.

Table 2: Sample leak statistics for gas transmission facilities

Source	Number of Sources[1]	Leak Frequency	Average Emissions (kg/h/source)[2]	Percent of Component Population (%)	Contribution to Total Emissions (%)	Relative Leak Potential
Station or Unit Blowdown System	219	59.8	3.41E+00	0.131	68.163	7616
Pressure Relief Valve	612	31.2	1.62E-01	0.367	9.063	362
Open-ended Line	928	58.1	9.18E-02	0.556	7.790	205
Orifice Meter	185	22.7	4.86E-02	0.111	0.823	109
Control Valve	782	9	1.65E-02	0.469	1.179	37
Pressure Regulator	816	7	7.95E-03	0.489	0.593	18
Block Valve	17029	2.8	4.13E-03	10.207	6.431	9
Connector	145829	0.9	4.47E-04	87.406	5.960	1
Other Flow Meter	443	1.8	9.94E-06	0.265	0.000	0.02

1. Sample population of equipment components in natural gas service for a typical natural gas transmission company.
2. Data determined from industry surveys (CEPEI, 2007 and prior surveys)

3.1.3 Tagging

To assist with subsequent identification during planned follow-up activities (e.g., re-survey or repair), it is recommended that leaking components be tagged.

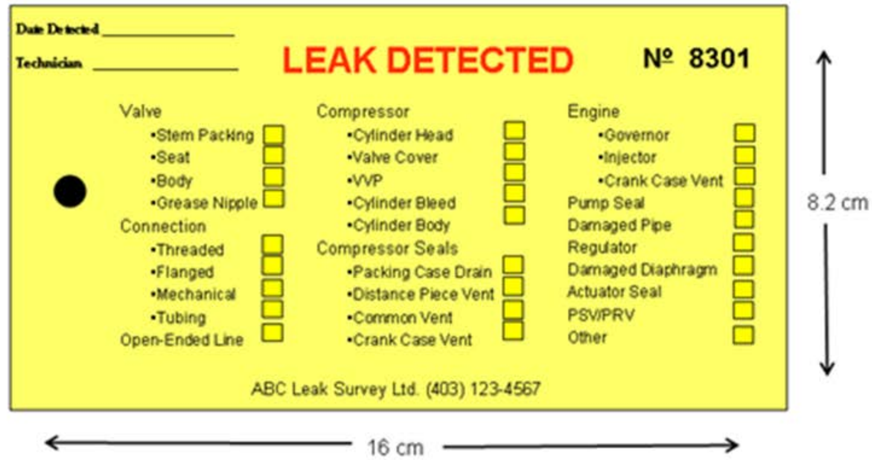
Leaker tags should be hung on or near leaking equipment components and with appropriate information marked on it for others to be able to easily determine the location and source of the leak. The tags should be uniquely numbered, weather resistant, and designed for high visibility.

Care should be taken to avoid placing the tag where it might melt, wear away, affect the operation of any equipment or instrumentation or pose a danger to the person hanging the tag. Useful information to include on the tags includes, but is not limited to: the date, the type of component, the part of the component that is leaking, and the rate of leak, if applicable. Information marked on the tag in the field should be done using indelible markers to resist fading of the ink over time from exposure to the elements.

When screening equipment components and installing tags, it is useful to follow a logical route through the process and place tags in sequential order to make them easier to find. The number of tags installed at the site should be carefully tracked. Additionally, recording the following information on a separate form is suggested to assist in future management of the leak: leaker tag identification number, process area or unit, process stream, type of component, size of component and process tag number.

All leaker tags should be left in place after the leak rate is measured to allow for follow-up action by maintenance personnel. The tags should only be removed once the component has been repaired and the leak is determined to be fixed.

Figure 1: Sample Leaker Tag



3.2 SUPPLEMENTAL MONITORING

Supplemental leak monitoring is the monitoring that is done in addition to leak surveys (Section 3.1).

3.2.1 Audio/Visual/Olfactory (AVO) Inspections

Operators should conduct periodic walkabout AVO inspections of all accessible piping and equipment in hydrocarbon service. The frequency of the inspection should be at least monthly at target facilities, and at a frequency appropriate on a risk-basis at non-target facilities.

The AVO inspections should be conducted inside and outside each active process building, around all process units, and along aboveground piping. AVO inspections should include checks for signs of:

- Frosting or sweating of valves and pressure relief devices connected to vent lines.
- Visible vapour or steam plumes, or dripping from equipment components.
- Normally-closed valves connected to vents or open-ended lines that are not fully closed during normal operations.
- Components (e.g., covers, plugs, pressure gauges, etc.) that have been temporarily removed for inspection, maintenance or other purposes and not put back in place afterwards.
- Unlit pilots on fired equipment (e.g., line heaters) and unlit flares.
- Odours inside buildings and downwind of piping and process equipment.
- Sounds indicative of a leak.

Recording of AVO inspections may be incorporated into existing checklists/forms or take the form of an addition to existing operator check sheets or preventative-maintenance forms that shows when an AVO inspection was done.

3.2.2 Event-Driven Inspections

Pressure Relief Events

Where operators become aware that a pressure safety valve (PSV) has lifted they should check the component to ensure that it has reseated properly and is not leaking. Where these situations are not apparent, operators should consider putting in place measures to detect when a PSV has lifted.

Blowdown Events

After equipment has been re-pressurized following a blowdown event, the affected blowdown system and any affected bleed valve vents should be surveyed to confirm that these valves have seated properly and there is no leakage into the blowdown or bleed systems.

Inspection and Maintenance Events

Individual equipment components that have been subjected to repairs, servicing or replacement, or have been disassembled should be checked for leaks after being put back into pressurized service.

3.3 REPAIR

Risk-based monitoring frequencies and leak repair schedules provide operators a means to optimize leak management programs in order to achieve the greatest impact for the available resources. As an example, a risk-based approach may lead an operator to target older (e.g., if leak likelihood is believed to or is evidenced to increase with asset age) and larger facilities (e.g., while not always the case, larger facilities may present a greater opportunity for leak management).

3.3.1 Target Facilities

At target facilities, all detected leaks should be fixed (i.e., repaired or replaced) as soon as reasonably possible. For the majority of leaks, the repairs can be completed immediately. Where immediate repairs are not possible, leaks should be repaired in accordance with the following in order to mitigate unintended negative consequences of completing leak repair:

- Operators should take no longer than 30 days to initiate internal processes for completing leak repairs (e.g. reviewing leak survey results and identifying component details).
- Operators should repair leaks within 6 months where reasonably practicable. Some situations may not warrant the repair of leaking components within 6 months. Examples of these situations include:
    - Repair of leaking components would result in an otherwise unplanned customer outage.
    - The facility or the leaking component utilization is sufficiently low that repair is impractical.
    - Repair within a 6-month window would result in health and safety concerns.
    - The emissions from isolating equipment necessary to complete the repair would be greater than the emissions generated from the leak itself over the life of the equipment.

When an operator cannot reasonably repair a leak within 6 months, the operator should have a process for tracking extended leaks and documenting the reason why the repair was impractical. The operator should aim to resolve extended leaks within 2 years.

Use of repair techniques that will avoid the need for a facility shutdown or customer outage should be considered to help reduce delays in repairing leaks.

3.3.2 Other Facilities

At non-target facilities, the determination of whether or not to repair a leak should be based primarily on the current and foreseeable health and safety risk. Other factors that should also be considered include the following:

- Impact to the business (e.g., repair costs, including both direct and indirect costs).
- Impact to the environment.

A listing of all tagged leakers from each survey should be maintained and used to track when the leaks were detected and when they were repaired. Where it is decided not to repair a leaker, appropriate justification should be provided in the survey records and the component should remain tagged and be regularly monitored to determine if and when the amount of leakage increases to the point where repair of the component is justified.

3.3.3 Re-Screening of Tagged Components

Repaired Components

The effectiveness of repairs should be confirmed by the operator within 24 hours of the repair. Repaired components should subsequently be inspected as part of the existing AVO inspections completed at stations.

Components Having Delayed Repairs

Where the repair of a leaking equipment component has been delayed, for whatever reason, the component should be monitored at a frequency as may be needed to ensure that the situation does not, at any time, pose an occupational health or safety concern.

The monitoring should comprise, at a minimum, determining that the leak does not cause any high percent-LEL alarm conditions in unclassified areas (for example, as determined using a personal monitor or other combustible gas detector).

3.4 PREVENTATIVE MEASURES

Predictive maintenance techniques may improve fugitive emissions management as opposed to reactive measures, and may be considered for applications involving components that leak frequently (e.g., leakage into vent or blowdown systems).

3.4.1 Predictive Maintenance Techniques

Predictive maintenance involves the implementation of continuous or frequent leak detection systems to provide advance notice of developing leaks. Devices such as flow switches, flow meters, vapour sensors or transducers and other devices that provide an indication of leakage should be considered.

3.4.2 Permanent Leak Detection Systems

The use of permanent leak detection systems could be considered for appropriate applications (i.e., chronic leaking and key difficult-to-access components and vent and blowdown lines) to facilitate regular leak detection. Permanent leak detection systems may include the installation of screening ports and sample lines, end-of-pipe flow indicators or in-line flow indicators (such as flow switches or vapour sensors), or other systems appropriate for the selected application.

Screening ports can be provided on emergency vent and flare lines, as well as blowdown systems, to allow convenient periodic detection and quantification of residual flows in these systems where continuous flow meters are not provided or where such meters are only sized to quantify large flow rates (e.g., during relief or blowdown episodes).

For pressure relief valves that discharge directly to the atmosphere through their own dedicated vent stack, it can be beneficial from a leak management perspective to either install end-of-pipe caps that pop off when appreciable leaks start to occur, or easy-to-access leak detection ports on the discharge piping.

One approach to this could involve the implementation of continuous or frequent leak detection systems to provide advance notice of developing leaks and to facilitate proactive response activities. Devices such as flow switches, flow meters, vapour sensors or transducers for other parameters that provide a good indication of leakage may be installed at component vent ports (e.g., seal vents) and open-ended lines. Building or area hydrocarbon gas detection systems, although an accepted means of detecting workplace health and safety hazards, are not generally considered to be an effective leak detection technology due to the dilution that may occur between the individual leakage points and the fixed sensors given the typically large building ventilation rates.

3.5 REPORTING

The Canadian natural gas transmission and storage sector is willing to publicly report, through CEPA, the aggregate results of its leak management program.

3.6 RECORD-KEEPING

Operators should have appropriate records management in place to support their leak management program. Proper records assist in ensuring that leaking components are identified, and that appropriate follow-up actions are taken. This information will also assist in justifying modified screening frequencies for targeted leak surveys.

Records of leak surveys, including quality assurance/quality control (QA/QC) measures, should be maintained for a minimum period equal to the greater of 5 years or the requirements of any applicable regulations. These records should include the leak survey results, training and calibration records, and any analysis performed as part of the leak management program. In accordance with CSA Z662, records of all completed leak repairs should be maintained for the life of the pipeline system (pipeline system, as defined in Z662 includes above-grade facilities).

3.7 QUALITY ASSURANCE (QA) / QUALITY CONTROL (QC)

Review and continuous improvement of leak management programs relies on the development of effective objectives and measures, as well as the ongoing tracking of program performance. Key performance indicators may include leak frequencies, repair success rates, percent of leakers repaired within a defined timeframe, as well as the percent of components scheduled for repair at the time of major facility turnarounds. As indicators provide an opportunity to trend program performance over time, they should be recorded and reviewed at appropriate periodic intervals (which may vary depending on the measure).

Fugitive emission programs that do not apply proper care, attention and resources may not identify significant leaks, may result in incomplete emission capture during measurements, and therefore may understate the amount and extent of fugitive emissions. QA/QC measures should be considered within the leak management program.

Operators of natural gas transmission and storage systems should have a QA/QC document that includes the following subsections.

3.7.1 Training Requirements

Personnel performing leak detection surveys, whether in-house staff or third-party contractors, should possess the appropriate competencies. At a minimum, a training program is required to familiarize personnel with equipment and procedures relevant to completing a comprehensive leak survey. Training should ensure that personnel have achieved an adequate level of competence through, but not limited to, a training course and on-the-job training. Training should include a refresher course or review of survey work at a reasonable pre-determined frequency to assure competence.

Examples of topics that should be considered for training and competency programs include:

- Leak detection and measurement techniques.
- Component identification.
- Quality control and quality assurance requirements (e.g., calibration, daily functional checks and maintenance of the employed instruments).
- Safety requirements.

Operating companies should consider periodic reviews or audits of work as a method of evaluating the effectiveness of training programs, and to ensure the completeness and accuracy of completed work.

3.7.2 Calibration and Servicing Requirements

All leak detection and quantification instruments should be serviced and calibrated regularly in accordance with procedures and tolerances specified by the manufacturer, and whenever problems may arise.

All equipment should be subjected to a functional and zero check each time it is turned on and more often where required to ensure reliable instrument performance. Where applicable, span checks should be performed at least as frequently as specified by the manufacturer. Zero checks should give values consistent with expected background levels. Span checks should give a result within the accuracy specified by the manufacturer.

In the absence of any specific accuracy limits from the manufacturer, span checks on gas detectors should be in error by no more than 5 percent of value, and the flow measurement devices should be in error by no more than 15 percent.

These errors may be calculated using the following relation:

$$Error = \left[1 - \frac{reading}{reference\,value}\right] \times 100\%$$

Records of all calibration and servicing activities should be prepared and managed in accordance with the requirements of Section 3.6.

4. References

The Canadian Council of Ministers of the Environment. 1993. Environmental Code of Practice for the Measurement and Control of Fugitive VOC Emissions from Equipment Leaks. Prepared by the National Task Force on The Measurement and Control of Fugitive VOC Emissions from Equipment Leaks. Ottawa, ON. pp. 35.

Canadian Standards Association. 2016. CAN/CSA Z662 Oil and Gas Pipelines Systems. CSA Group, Toronto, ON.

U.S. Environmental Protection Agency. 2016. Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources. Federal Register, Vol. 81, No. 107.

U.S. Environmental Protection Agency. 2008. Alternative Work Practice to Detect Leaks from Equipment. 40 CFR Parts 60, 63, and 65. https://www3.epa.gov/ttn/caaa/t3/fr_notices/ldar_fin_121508.pdf

U.S. Environmental Protection Agency. 1993. Test Method 21 – Determination of volatile organic compound leaks. 40 CFR Part 60 Appendix A.

U.S. Environmental Protection Agency. 1988. Protocols for Generating Unit-specific Emission Estimates for Equipment Leaks of VOC and VHAP. Research Triangle Park, NC. Report No. EPA-450/3-88-010.

U.S. Environmental Protection Agency. 1980. VOC Fugitive Emissions in Synthetic Organic Chemicals Manufacturing Industry - Background Information for Proposed Standards. Report No. EPA-450/3-80-033a. Table 4-7. Page 4-24.