



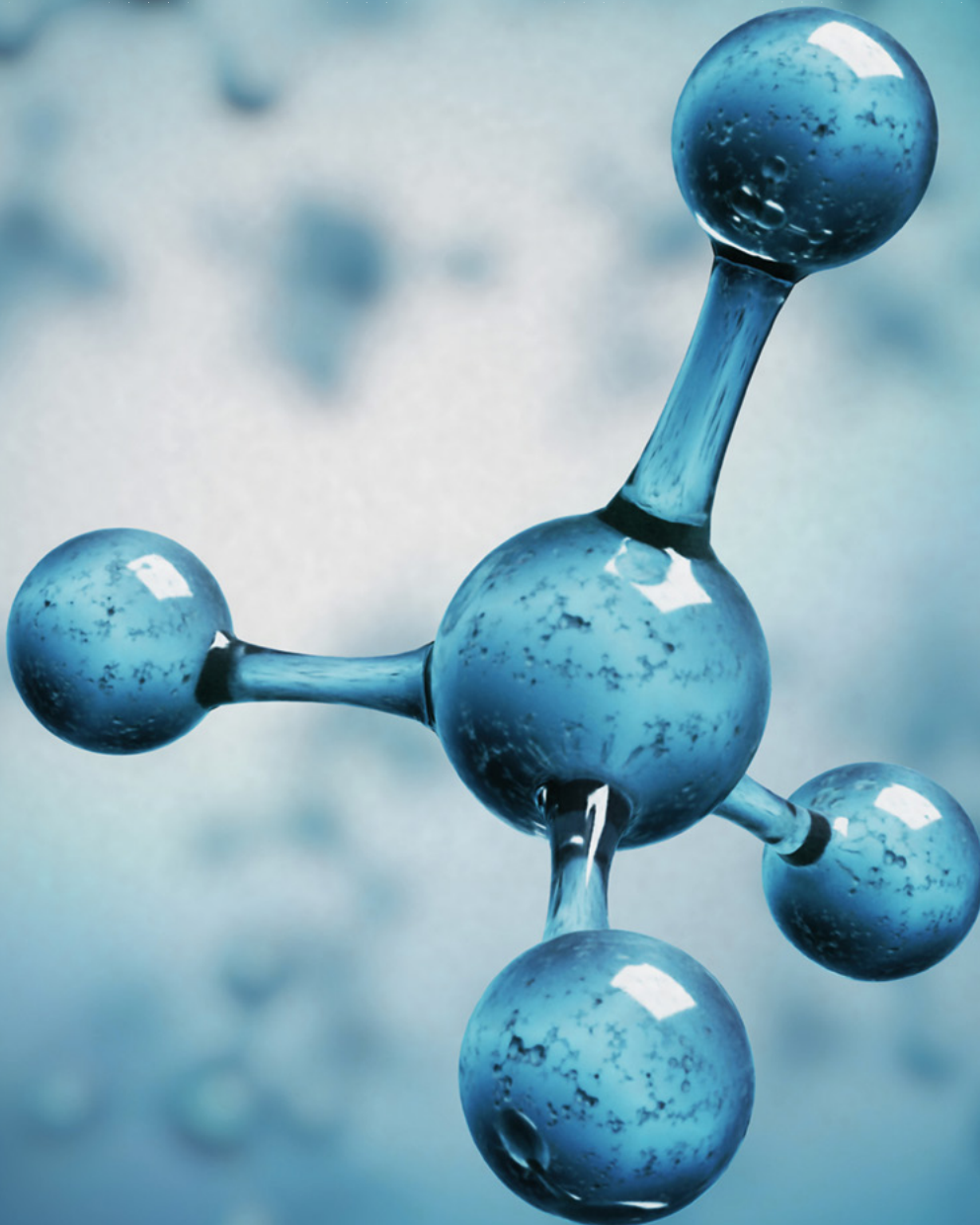
METHANE
GUIDING
PRINCIPLES

OCD Exhibit 30

Synopses

Reducing Methane Emissions: Best Practice Guide

September 2020



Disclaimer

This document has been developed by the Methane Guiding Principles partnership. Each Synopsis provides a summary of current known mitigations, costs, and available technologies as at the date of publication, but these may change or improve over time. The information included is accurate to the best of the authors' knowledge, but does not necessarily reflect the views or positions of all Signatories to or Supporting Organisations of the Methane Guiding Principles partnership, and readers will need to make their own evaluation of the information provided. No warranty is given to readers concerning the completeness or accuracy of the information included in each Synopsis by SLR International Corporation and its contractors, the Methane Guiding Principles partnership or its Signatories or Supporting Organisations.

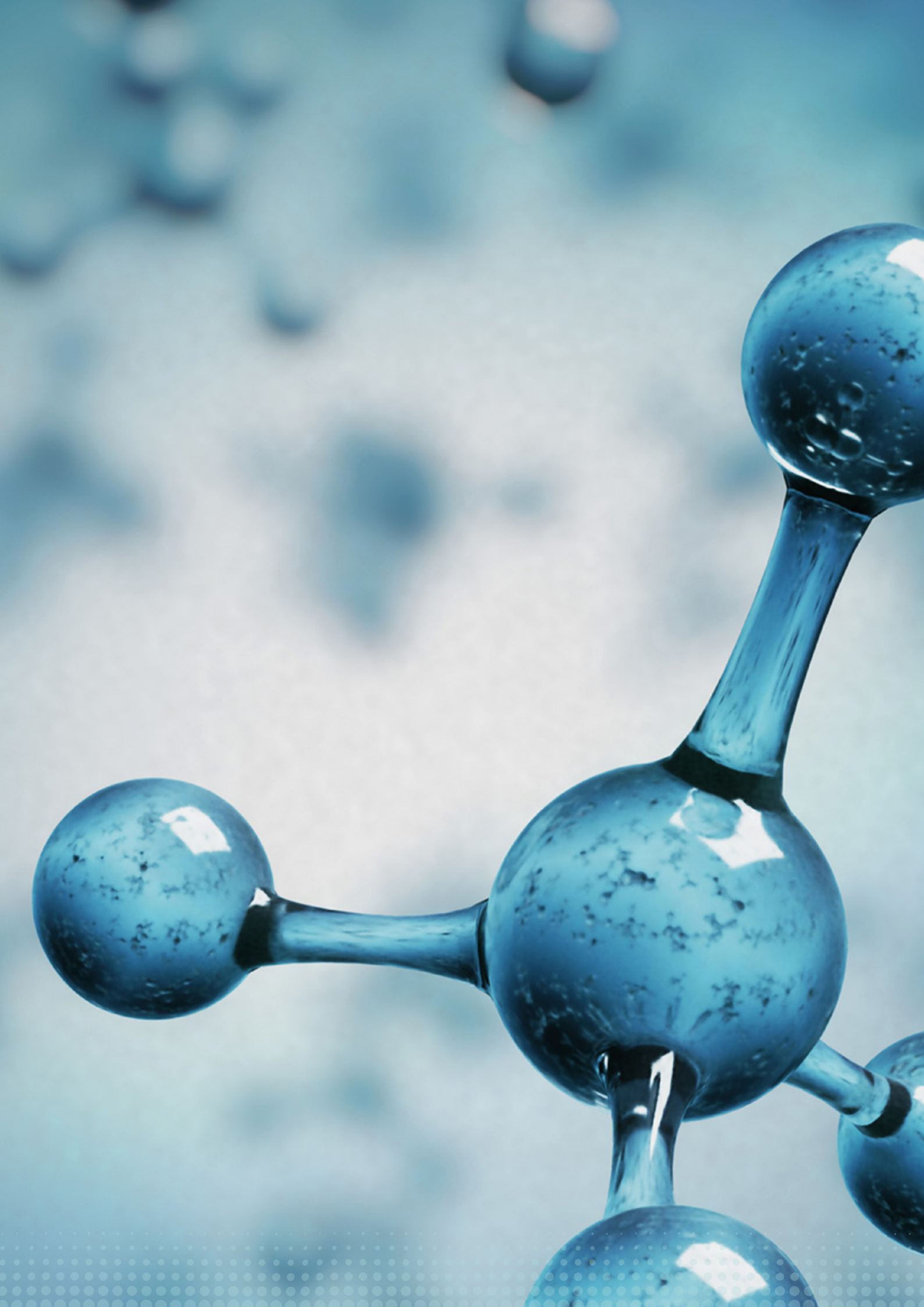
Each Synopsis describes actions that an organisation can take to help manage methane emissions.

Any actions or recommendations are not mandatory; they are simply one effective way to help manage methane emissions. Other approaches might be as effective, or more effective in a particular situation.

What readers choose to do will often depend on the circumstances, the specific risks under management and the applicable legal regime.

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Introduction

Providing access to energy, while addressing global climate change, is one of the greatest challenges of the 21st century. Natural gas plays a major role in meeting global energy demand today. Since natural gas consists mainly of methane, a potent greenhouse gas, its part in the transition to a low-carbon future will be influenced by the extent to which the oil and gas industry reduces its methane emissions.

A concerted industry response is needed to raise ambition and improve performance in methane emissions management along oil and gas supply chains, from production to the final customer. To support this effort, the Methane Guiding Principles (MGP) partnership, a coalition of industry, international institutions, non-governmental organisations and academics, has developed a series of Best Practices, which focus on the following:

1. Systematically minimise methane emissions through Engineering, Design and Construction
2. Reducing methane emissions from flaring
3. Reducing methane emissions that result from energy use
4. Reducing methane emissions from equipment leaks
5. Reducing methane emissions from venting
6. Reducing methane emissions from natural gas driven pneumatic equipment
7. Reducing methane emissions related to operational repairs
8. Systematically improving methane management through continual improvement
9. Reducing methane emissions through identification, detection, measurement and quantification
10. Reducing methane emissions in transmission, storage, LNG terminals and distribution

Each Best Practice is accompanied by a detailed guide and a summary overview, or synopsis, to support the uptake and implementation of the Best Practices.

This brochure contains the synopsis for each Best Practice. Full versions of the guides and other tools are available for download on www.methaneguidingprinciples.org

Reducing Methane Emissions: Best Practices

Strengthening the environmental credibility of gas



Engineering Design and Construction

Systematically minimise methane emissions

- Engineer and design equipment to reduce emissions including:
- Minimising potential fugitive and venting sources;
- Optimising combustion and operational efficiency; and
- Equipment selection and consideration of future upgrades.



Flaring

Reduce methane emissions from flaring

Eliminate or reduce flaring wherever feasible.

Where flaring is necessary, maximise its combustion efficiency.

Check your flare systems are operating according to design.



Energy Use

Reduce methane emissions that result from energy use

Use smart metering and controls to reduce end-user energy use and emissions (e.g. gas turbines and boilers).

Maintain gas fired equipment to operate according to design

When replacing equipment, update with the latest proven energy efficient models.

Consider upgrading to continuous or predictive emissions monitoring.



Equipment Leaks

Reduce methane emissions from fugitives and wells

Systematically perform fugitive inspections and prioritise repairs

Build your fugitive inspection and repair capability and skills, including operator discipline.

Consider new technology e.g. detection, quantification, condition monitoring and predictive maintenance.

Consider modern, high integrity materials and jointing technology when constructing downstream distribution networks.



Venting

Reduce methane emissions from process and cold venting

If methane needs to be released – prioritise recycling or flaring over venting.

Avoid or reduce venting from tanks, compressor seals and other potential emission sources (e.g. vapour recovery).

Conduct regular monitoring of vented emission sources (e.g. compressor seals and tanks).

Minimise emissions during well completion and maintenance activities (e.g. green completions).



Pneumatic Devices

Reduce methane emissions from natural gas driven pneumatic devices

Replace natural gas driven pneumatic devices with compressed air, electric or mechanical equipment where practical (e.g. power availability).

Confirm that your pneumatic device is operating per design and repair or replace malfunctioning equipment.

Phase out use of high-bleed pneumatic control devices where practical.

Conduct preventative maintenance on pneumatic devices.



Operational Repairs

Reduce methane emissions related to equipment repairs

Make reducing emissions a key aim of your repair planning.

Plan and make repairs promptly and safely.

Verify repairs are successful through follow-up leak monitoring surveys

When depressurising equipment minimise venting by recycling or flaring where feasible.



Continual Improvement

Systematically improve methane management

Optimise emissions monitoring frequency in operations and maintenance programs.

Incorporate emission reduction considerations into overall business and operating strategies.

Share learnings within your company and across the natural gas industry

Phase-in use of the latest proven lower emission technology and approaches where practical.

Regularly review the scope, quality and frequency of emissions reporting.



Identification, Detection, Measurement and Quantification

Reduce methane emissions through identification, detection, measurement and quantification

Identify known sources and potential sources of emissions in an inventory.

Survey known and potential sources to detect actual emissions.

Quantify methane emissions directly by measuring emission rates, or indirectly using a combination of measurements, calculations and modelling.

Use information from quantification to create or update inventories.

Periodically update and improve IDM&Q programs.



Transmission, Storage, LNG Terminals and Distribution

Reduce methane emissions in transmissions, storage, LNG terminals and distribution

Mitigation measures may be unique to transmission, storage, LNG terminals and distribution, or may have different technical or economic characteristics than measures in other parts of the natural gas supply chain.

Keep an accurate inventory of emissions from all sources.

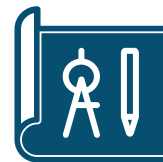
Prevent emissions whenever possible and reduce emissions that cannot be prevented.

Identify and repair equipment that is not working properly.

Track emissions and mitigation activities.

Synopsis

Reducing Methane Emissions: Engineering Design and Construction



Checklist

Methods of reducing methane emissions from engineering design and construction

- ✓ Use electric, mechanical, or instrument air powered equipment used where possible. Including pneumatic controllers, pumps and engines.
- ✓ Centralized and consolidated facilities where possible.
- ✓ Use pipelines for liquid and gas takeaway.
- ✓ Recover natural gas for beneficial use where possible.
- ✓ Flare or combust natural gas when recovery is not possible.
- ✓ Consider the use of alternative low emission alternative equipment/process.
- ✓ Consider the use of alternative low maintenance alternative equipment/process.

Engineering design can be used to reduce methane emissions prior to the start of operations for new facilities or modifications to existing facilities. The design phase is where there is the most opportunity to identify reduction opportunities. It is also typically less expensive to implement reduction strategies in the design phase than have to modify the facility after operations have begun. The engineer should consider the following hierarchy of strategies to reduce methane emissions:

1. Eliminate sources of methane,
2. Reduce the amount of methane emitted and fuel used if the source cannot be eliminated,
3. Control remaining sources of methane.

Most engineering solutions will be specific to a company's operations and each facility and will evolve as technology does. Any design must prioritize integrity, safety, fire protection, and regulatory requirement over methane reductions. Effective general design strategies to reduce methane emissions throughout the natural gas supply chain for both operations and maintenance activities are discussed in detail below.

1. Prioritize use of electric, mechanical and compressed air equipment
2. Centralize and consolidate facilities
3. Use pipelines for liquid and gas takeaway
4. Prioritize recovery of methane for beneficial use
5. Consider alternative low emission and low maintenance equipment

Design and Construction Strategies

Prioritize use of electric, mechanical and compressed air equipment

In some types of operations, pneumatic devices represent a significant source of emissions from the oil and industry. Using electric, mechanical or compressed devices can eliminate pneumatic device emissions completely. This also includes the use of electric compressors and pumps which reduces the amount of fuel used and for compressors can improve reliability.

Centralize and Consolidate Facilities

Centralization and consolidation of facilities allows for the use of more efficient equipment and processes. It also can make equipment more economically viable than at numerous smaller facilities. For example, an oil stabilizer can take production from surrounding facilities and eliminate venting from storage tanks but smaller stabilizers are not available or would not be economical at smaller facilities.

Use Pipelines for Oil and Natural Gas Transportation from Facilities

Use of pipelines ensures natural gas is sold and reduces or eliminates flaring or venting of natural gas. Liquid pipelines can eliminate atmospheric storage tanks, and truck loading sources.

Prioritize Recovery of Methane for Beneficial Use

Natural gas recovery should be prioritized over flaring or venting. The natural gas can be sold or used as fuel on site. Vapor recovery units can be installed to boost the pressure of low pressure gas to be sold. Gas can also be directed to a low pressure fuel system. The recovery of natural gas should be designed for where possible.

Consider Alternative Low Emission Equipment

Some processes or equipment can be eliminated or replaced with a low emission alternative system. These alternative low emission systems should be considered as long as they can meet the requirements of the project. For example methanol injection or desiccant dehydrators are some low emission alternatives to traditional glycol dehydrators.

Examples of actual design and engineering technologies and techniques that use these strategies include:

1. Locating facilities near current pipelines and power lines or brining pipeline and grid power to a facility
2. Using modular design on upstream facilities and removing equipment as production declines
3. Using welds instead of threaded connections and flanges
4. Locating fire gates and isolation valves as close to equipment as possible
5. Recovery of secondary and tertiary separator gas from condensate and crude oil
6. Elimination of storage tanks by using LACTs, pumping liquids around facility or storage in pressurized tanks
7. Proper design of storage tank control systems
8. Use of electrically driven compressors
9. Use of pig ramps and jumper lines to reduce the amount of methane released during pigging operations
10. Use of methanol for hydrate prevention instead of glycol dehydrators
11. Use of flash tanks on amine systems
12. Controlling amine acid gas streams with regenerative or recuperative thermal oxidizers

Synopsis

Reducing Methane Emissions: Flaring



Checklist

Methods of reducing methane emissions from flaring

- ✓ Keep an accurate inventory of flaring activity.
- ✓ Prevent flaring by designing systems that do not produce waste gases.
- ✓ Recover waste gases as products to be sold.
- ✓ Inject waste gases into oil or gas reservoirs.
- ✓ Find alternative uses for flared gases, such as generating electricity.
- ✓ Improve the efficiency of combustion when gases have to be flared.
- ✓ Track progress in reducing flaring and venting.

Flares burn flammable gases that would otherwise be released into the atmosphere. Flaring in upstream oil and gas operations may be needed for safety reasons, because of a lack of capacity to use produced gases, or as a part of routine emission controls. Approximately 145 billion cubic meters of gas per year are flared in oil and gas operations around the world, accounting for 2% of global methane emissions from oil and gas production.

Flaring can be reduced in three ways. Ideally, waste gas production is prevented. If this is not feasible then waste gas recovery for sale can generate revenue. Otherwise, storing (re-injecting) gases in oil and gas reservoirs is also an alternative. If the waste gas cannot be recovered to be sold as a natural gas or natural-gas liquid product, or cannot be stored, it may be able to be used for generating electricity. If flaring cannot feasibly be prevented, improving the efficiency of flares can reduce emissions of methane.

Methane emissions from flaring can be reduced in the following ways.

- Preventing flaring by designing systems that do not produce waste gases (for example, by introducing high- and low-pressure separators at well sites)
- Recovering waste gases from tanks and from well-testing and completion, and returning the gases to on-site product streams
- Recovering waste gases that are currently flared and transporting them to nearby gas-processing facilities, where they are recovered as natural gas and natural-gas liquid products
- Storing gases that might otherwise be flared by injecting them into oil and gas reservoirs (which may also increase oil and gas production)
- Finding alternative uses for the gas, often to generate electricity
- Improving the efficiency of flaring

Methods for reducing emissions from flaring have many elements in common with best practice for reducing emissions from venting of gases, and best practice for engineering design, which are summarized in other best-practice guides. Tracking your progress in reducing emissions from

flaring should be coordinated with the tracking of your progress in reducing venting, as some reductions in venting lead to increased flaring.

Methods of reducing methane emissions

Prevent flaring through the design of systems

Wells that produce condensate or crude oil send hydrocarbon liquid from a pressurized separator to a non-pressurized condensate tank. Methane will ‘flash’ from the liquid in the tank and may be flared. Flaring of this ‘flash gas’ can be significantly reduced by installing both high- and low-pressure separators on well sites.

Recover waste gases using vapor-recovery units

Vapor-recovery units can capture flash gas from tanks and compress it into the gas line so it can be sold rather than being released into the atmosphere or flared.

Recover waste gases from well-testing and completion

After a new well is drilled, it is brought into production through in a completion process that can result in venting or flaring of the completion flowback gas. Separators have been used during completion to capture the gas, and while some of the gas may be flared, some of the gas may be recoverable for sale.

Recover waste gases at well sites and transport by truck to gas processing facilities

Waste gas, which might otherwise be flared, can be treated to remove water, sulfur and carbon dioxide, then compressed on-site to produce compressed natural gas (CNG) and a natural gas

liquids (NGL) product. To meet pipeline and other product requirements, the CNG and LNG must typically be further treated. This can be done by transporting the products by truck to a gas processing facility.

Inject waste gases in oil and gas reservoirs

Gas that might otherwise be flared can, in some cases, be injected back into the reservoirs it was produced from, or other reservoirs. As well as storing the gas for future use, this also may help increase oil production.

Convert waste gas to electrical power

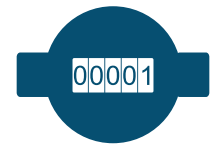
Gas turbines and ‘reciprocating engines’ can convert gases that would otherwise be flared into electricity. The electricity can be used on-site to power equipment (including controllers, pumps and compressors) or sold to the grid.

Improve the efficiency of flaring

If flaring cannot feasibly be avoided, methane emissions can be reduced by improving the efficiency of the combustion in the flare. Since the design of a flare depends on the volume of and variations in gas flow, methods for improving combustion differ between low-volume and high-volume flares. Some measures involve making changes to flaring equipment, while other measures involve changing practices.

Synopsis

Reducing Methane Emissions: Energy Use



Checklist

Methods of reducing methane emissions from energy use

- ✓ Keep an accurate inventory of where natural gas is used as fuel.
- ✓ Use electrical power or pneumatic power using compressed air or nitrogen.
- ✓ Improve the energy efficiency of gathering operations and other equipment.
- ✓ If natural gas needs to be used, improve the efficiency of fuel combustion.
- ✓ Track your progress in reducing fuel use.

Natural gas, which consists mainly of methane, is used as a fuel throughout oil and gas operations, for compression, generating electricity, heating, dehydration and removing acid gas. Equipment that uses natural gas as a fuel is generally designed to have at least 98% combustion efficiency (that is, at least 98% of the gas will be burned), so some methane is released as unburned gas. This is known as methane slip. Even though methane slip is generally a small percentage of the fuel used, in operations that use a significant amount of energy, methane slip can be a major source of emissions.

Using natural gas as a fuel also results in emissions associated with the engine burning the gas, such as emissions from cylinders or rod packing. Reducing the amount of natural gas used as fuel at oil and gas operations helps reduce methane emissions, and may cut energy costs.

Methane emissions from energy use (using natural gas as a fuel) can be reduced by doing the following.

- Using electricity or other types of power instead of natural gas
- Making processes more efficient, which reduces the amount of energy used
- When natural gas must be used as a fuel, improving the efficiency of the combustion engines

Reductions in fuel costs mean that the cost of options may be recovered in a few months to a year.

Methods of reducing methane emissions

Install electrical compressors

Compressors fired by natural gas, which are used in gas gathering and transmission, can be replaced with electrically driven compressors (if an electricity supply is available). This eliminates methane slip on the site. However, it may not reduce the total methane slip across the whole supply chain if the electricity is generated using natural gas as a fuel. Even if natural gas is used to generate the electricity used to power compressors, overall emissions for all operations may still be reduced. Using electrical compressors also eliminates emissions from engine components.

Replace natural gas used in compressor starter motors with electrical starters or pneumatic starters using air or nitrogen

In the natural-gas industry, combustion engines are often started using gas-expansion turbine motors. The starter motors use high-pressure natural gas, which is stored in a tank. To start the compressor, the gas is expanded through the starter turbine then vented.

Each start-up uses approximately 1.4 cubic meters of gas for every 100 horsepower of motor size. Methane emissions can be eliminated by using compressed air or nitrogen instead of natural gas. If electricity is available, the gas-expansion turbine motor can be replaced by an electrical motor.

Make more efficient use of energy in gathering lines

Gathering systems deliver gas from networks of wells to processing plants. The volume of gas processed and the capacity of the network changes because of changes in production, liquid and hydrate building up in the gathering lines, changes in the composition of the gas and changes in atmospheric and weather conditions. Extra compression and energy use may be needed at times for the network to function and to prevent flaring of gas. The capacity of a gathering system can be increased, and energy use reduced, through frequent clearing of lines (pigging) and minimizing the build-up of liquid and hydrate through line heating or chemical injection, although some of these operations may lead to venting. Increasing the capacity of a gathering system may also prevent flaring (see the best-practice guide on flaring).

Replace compressor-cylinder unloaders

A cylinder unloader is used to adjust the output of a reciprocating engine, by adjusting the volume of the cylinder. Cylinder unloaders release methane through leaking o-rings, covers and pressure packing. Unloaders that need frequent maintenance can also lead to emissions and shutdowns. Replacing unloaders can reduce methane emissions and may also reduce maintenance and unscheduled shutdowns.

Install automated air-to-fuel ratio controls

Engines in natural-gas supply chains are run under a variety of loads and air-to-fuel ratios. Low air-to-fuel mixtures (rich burn) are used when a greater horsepower is needed. High air-to-fuel mixtures (lean burn) are used when lower horsepower and greater fuel-efficiency are the goals. Rich burn results in more unburned fuel (mainly methane) and fewer emissions of nitrogen oxides (NO_x). Lean burn produces lower methane, but more emissions of NO_x. Installing automated air-to-fuel ratio control systems allows the performance of engines to be maximized by adjusting air manifold pressure and temperature, and improving the delivery of fuel to the combustion chambers. These controls might also allow captured hydrocarbon emissions to be used as fuel. Overall assessments of emissions should consider emissions of methane, carbon dioxide, unburned hydrocarbons and NO_x.



Synopsis

Reducing Methane Emissions: Equipment Leaks

Checklist

Methods of reducing methane emissions from leaks in equipment

- ✓ Keep an accurate inventory of emissions from equipment leaks.
- ✓ Conduct a periodic leak detection and repair program.
- ✓ Consider using alternative monitoring programs.
- ✓ Replace or eliminate components that persistently leak.

Unintentional leaks from pressurized equipment used in oil and gas operations can lead to gas being released to the atmosphere. Methane emissions from leaks in equipment are mostly caused by imperfections or ordinary wear in sealed joints such as flange gaskets, screwed connections, valve-stem packing, seats on pressure relief valves, or poorly seated open-ended valves. They sometimes (though rarely) come from the wall of a vessel or pipeline.

Methane emissions from leaks in equipment can be reduced by the following steps.

- Keep an accurate inventory of emissions from leaking equipment by using a screening or measurement approach.
- Conduct periodic leak detection and repair surveys (LDAR) on all facilities above ground, and on underground pipelines, to identify and then repair leaks.
- Use focused programs such as ‘predictive maintenance and condition monitoring’, ‘directed inspection and maintenance’ (DI&M), or an ‘alternative monitoring program’.
- Replace or eliminate components that are chronic leakers.

These leak-reduction methods involve detecting and repairing leaks or, in the case of focused programs, concentrating on certain equipment or components that can produce large leaks, or by repairing only leaks that can be corrected cost-effectively. Operational repairs of leaks are also covered in a separate guide on that subject.

To be fully effective, all methods for detecting and repairing leaks should be built into a company’s management systems.

Methods of reducing methane emissions

Leak detection and repair (LDAR) programs

Leak detection and repair surveys should be performed at intervals to identify and repair leaks. Leak detection and repair programs may be voluntary or, in some areas, required by regulation. The frequency of surveys varies (generally from once a month to once a year).

Subsets of detection and repair programs are ‘smart LDAR’ programs or directed inspection and maintenance (DI&M) programs, which survey only some equipment and components known to have the most leaks, or which survey all equipment and components but only repair leaks when it is cost-effective.

Alternative programs

Equipment leaks may be reduced by ‘alternative programs’ or ‘equivalent LDAR programs’ that are alternatives to the single method periodic surveys. Examples are varied, but include:

- more frequent remote screening combined with less frequent ground-based leak-detection surveys; or
- continuous monitoring programs.

These alternative programs are often based on newer technologies, and are still being developed and tested. Their equivalency to existing programs is not completely defined, but alternative programs may offer a more cost-effective solution than traditional LDAR.

Replacing or eliminating components that persistently leak

For components that regularly leak, instead of carrying out repeated repairs, you can replace the component with a superior one or completely eliminate the component.

Other methods of minimizing emissions during the repair of leaks are described in the operational repairs guide. Any method of leak detection and repair that you choose should be built into your management and record-keeping systems. The continual improvement guide deals with this integration.

Synopsis

Reducing Methane Emissions: Venting



Checklist

Methods of reducing methane emissions from venting

- ✓ Keep an accurate inventory of venting activity.
- ✓ Alter physical systems and operating practices to reduce venting.
- ✓ Recapture gas where possible.
- ✓ If methane needs to be released, flare it rather than venting it.
- ✓ Track your progress in reducing venting.

Venting simply means releasing gas arising from a process or activity straight into the atmosphere. There are a large number of sources of venting in the oil and gas industry, but this document deals with these main equipment sources – storage tanks, compressors (seals and starter motors), and glycol dehydrators. The main venting activities this synopsis deals with are removing liquids from gas wells, and well completions.

Methane emissions from the main sources of venting can be reduced by doing the following:

- Keeping an inventory of emissions from venting.
- Avoiding or reducing venting from the following.
 - Hydrocarbon liquid storage tanks
 - Compressor seals and starter motors
 - Glycol dehydrators
 - Removing liquids from gas wells
 - Well-completion operations
 - Oil well casinghead venting
- If methane needs to be released, using vapor recovery or flaring rather than venting.

The methods for reducing emissions from venting have a lot in common with best practice for reducing emissions from flaring, and through engineering design, which are summarized in separate documents.

Methods of reducing methane emissions

Reduce venting from storage tanks

Storage tanks, especially in production, can vent significant volumes of gas. Strategies to reduce emissions depend on the venting causes for your location. Strategies include:

- installing vapor-recovery systems;
- getting rid of tanks at production sites;
- adding automatic gauging and vapor-balance systems to tanks;
- adding tank-pressure monitors; and
- including tanks in a routine leak detection and repair program.

If venting cannot be reduced, flaring the gas released from tanks can reduce methane emissions.

Reduce venting from compressor seals

Emissions from reciprocating compressor rod packing can be reduced by including packing vents to a routing leak detection and repair program, or by replacing rod packing as part of a routine replacement program.

Venting from centrifugal compressors that have wet seals can be reduced by adding the vents in a leak detection and repair program, or converting the seals to dry systems, which release less gas.

Where venting cannot be reduced, flaring the released gas can reduce methane emissions.

Reduce venting from compressor starter motors

Compressor starter motors that are powered by natural gas can be converted to be powered by electricity or compressed air. If this is not possible, directing the released gases to a vapor-recovery system or flare can reduce methane emissions.

Reduce venting from glycol dehydrators

Glycol dehydrators can be replaced with alternative technologies (such as desiccant systems) that have lower emissions, or emissions can be reduced by electrifying the lean glycol pump, and by installing a flash tank so gas can be recovered and reused.

Reduce venting arising from well completions

Venting from the process of completing and flowback from wells can be reduced by using ‘green’ completion technologies, such as large temporary pressurized flowback equipment.

Reduce venting arising from removing liquid from gas wells

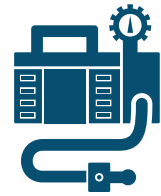
Venting from the process of removing liquid from gas wells (also called “gas well unloading”) can be reduced by altering the manual process to minimize the duration of venting, physically altering the well and downhole equipment to remove the need for processes that vent or, in some cases, adding automated liquid-removal systems.

Reduce venting arising from oil well casinghead venting

Venting at an oil wellhead from the annular casinghead space can be reduced by using vapor recovery systems or by flaring.

Synopsis

Reducing Methane Emissions: Pneumatic Devices



Checklist

Methods of reducing methane emissions from pneumatic devices:

- ✓ Keep an accurate inventory of pneumatic controllers and pumps powered by natural gas.
- ✓ Replace pneumatic devices with electrical or mechanical devices where practical.
- ✓ If pneumatic devices are used, eliminate emissions by using compressed air rather than natural gas to power them.
- ✓ If using devices powered by natural gas is the best option, replace high-bleed controllers with alternatives with lower emissions.
- ✓ Include pneumatic devices in an inspection and maintenance program and report emissions from these devices in an annual inventory.

Pneumatic devices are powered by gas pressure. They are mainly used where electrical power is not available. The two main types of pneumatic device used in the oil and gas industry are:

- pneumatic controllers, which control conditions such as levels, temperatures and pressure; and
- pneumatic pumps, which inject chemicals into wells and pipelines or circulate dehydrator fluids.

Millions of pneumatic devices, mostly pneumatic controllers, are used in the oil and gas industry. These devices, when powered using natural gas, can be one of the largest sources of methane emissions in petroleum and natural gas supply chains.

The methane released from pneumatic devices comes from the natural gas that is vented while powering the device, so preventing or reducing emissions can also often have economic benefits. The International Energy Agency (IEA) has estimated that methane emissions could be reduced by more than 11000 kilotons (kt) globally from pneumatic devices – more than 7000 kt from pneumatic controllers and more than 4000 kt from pneumatic pumps – by using best practices for reducing methane emissions. This represents about 15% of the total global emissions of methane from oil and gas operations.

Methods of reducing methane emissions from pneumatic devices range from preventing emissions, to reducing emissions, to repairing those devices with emissions that are higher than expected.

Methane emissions from pneumatic devices can be reduced by:

- replacing pneumatic devices with electrical pumps or controllers;
- replacing pneumatic devices with mechanical controllers;
- using compressed air rather than natural gas to power pneumatic devices;
- replacing 'high-bleed' pneumatic devices with intermittent or 'low-bleed' devices; and
- inspecting devices and repairing those that release emissions that are higher than expected.

Methods of reducing methane emissions

Replace pneumatic devices with electrical pumps or controllers

At remote locations where electricity is not readily available, circulation pumps in glycol dehydration units, and chemical injection pumps used to inject chemicals into wells and flow lines, are often powered by pressurized natural gas. Chemical injection pumps run at relatively low volumes (releasing roughly 10 cubic meters of natural gas a day for methanol injection pumps at well sites), while circulation pumps in glycol dehydration units may release hundreds of cubic meters of natural gas a day.

These pumps can be replaced by solar-powered electric pumps and standard electric pumps. Similarly, pneumatic controllers can be replaced by electrical devices where electricity is available.

Replace pneumatic devices with mechanical controllers

Pneumatic devices used to control pressure levels can be replaced with mechanical controllers. At low-pressure, low-volume wells, mechanical dump valves (rather than pneumatic dump valves) have been installed on vertical separators. Mechanical controllers have also been used at midstream dehydration facilities.

In separators operating at high pressure and high volumes, the dump valve needs to be continuously throttled, so fluids can constantly flow out of the vessel. As pressure and production decline, the need for pneumatic throttle control may be able to be replaced by separators with mechanical dumps.

Use compressed air rather than natural gas from the well to power pneumatic devices

Using compressed air rather than pressurized natural gas eliminates the methane in vented gas. Due to the cost of compressed-air systems, at present they are mainly used at locations, which use relatively high rates of gases to drive pneumatic devices.

Replace high-bleed (high-emitting) pneumatic devices with intermittent or low-bleed devices

High-bleed pneumatic controllers have vent rates that are typically more than 1 standard cubic meter per hour (scm/h). At these rates, natural gas with a value of more than US\$1000 a year is lost from each high-bleed device. If the operating conditions do not need high-bleed devices, low-bleed or intermittent controllers, with average vent rates of between 0.03 and 0.4scm/h, can significantly reduce methane emissions and the loss of natural gas.

Inspect devices and repair those that release emissions that are higher than expected

Several studies have found that a small fraction of pneumatic controllers tend to be responsible for the majority of methane emissions associated with pneumatic controllers. Although not all high emitting controllers are faulty, emission patterns indicate that some high emitting controllers are not operating as designed. Inspection and maintenance programs for pneumatic devices have been effective in reducing the number of high emitting pneumatic devices not operating as designed. New inspection and maintenance programs could be introduced specifically for these devices, or the devices could be added to an existing inspection and maintenance program, such as a program for detecting and repairing leaks.

Synopsis

Reducing Methane Emissions: Operational Repairs



Checklist

Methods of reducing methane emissions through operational repairs

For equipment leaks:

- ✓ Perform periodic leak-detection surveys.
- ✓ Repair leaks as soon as practical.
- ✓ Check that repairs have been successful.
- ✓ Keep track of repairs that have not been carried out.
- ✓ Keep and analyze records of leaks and repairs.

For routine maintenance and repairs:

- ✓ Use pumpdowns for pipelines and large vessels.
- ✓ Minimize the volume that has to be depressurized.
- ✓ Use vapor-recovery units when pigging.
- ✓ Avoid emissions by, for example, using hot taps to make connections to pipelines, carrying out non-intrusive inspections, and coordinating repairs and maintenance.
- ✓ If venting is necessary, flare the vented gases.

Operational repairs are vital for reducing methane emissions, by both repairing leaking equipment and minimizing emissions that arise during routine maintenance and repairs. This guide covers repairs to leaks discovered during inspections carried out as part of a leak detection and repair program, as well as releases that may occur because of other maintenance and repairs.

Methane emissions from equipment leaks can be reduced by the following measures:

- Keeping an accurate inventory of emissions from equipment leaks (including the duration of the leaks), and carrying out inspections as part of a leak detection and repair program (leak detection is also covered in the separate Equipment Leaks best practice guide).
- Emissions from leaks can be further reduced by:
 - making repairs as soon as reasonably practical and keeping track of any repairs that have to be delayed;
 - carrying out checks to make sure repairs have been successful;
 - keeping accurate records of leaks and repairs; and
 - routinely analyzing records of leaks and repairs.

Methane emissions from routine maintenance and repairs can be reduced by the following measures:

- Planning steps to reduce venting when large vessels and pipelines need to be depressurized;
- If venting cannot be avoided, flaring the released gases.

Methods of reducing methane emissions from equipment leaks

Carrying out a leak detection and repair program

With a leak detection and repair program in place, regular inspections are carried out to find leaks and carry out repairs.

Repairing leaks as soon as reasonably practical

Making repairs as soon as reasonably practical is important in order to minimize emissions.

Carrying out checks to make sure repairs have been successful

A leak is considered to have been repaired only after follow-up checks show that the equipment is no longer leaking.

Keeping track of outstanding repairs

Leaks not yet repaired should be placed on a 'delay of repair' list. This list should show the location of the leak, the date it was discovered, an estimated date for the repair, and an explanation of why the repair was delayed.

Keeping accurate records of leaks and repairs

Each facility should maintain a record of all leaks that are discovered, the date of each repair and an explanation of the repair method, and confirmation that the repair has been successful (when this has been confirmed). The record must be detailed enough to allow future analysis of whether the same component is leaking again.

Analyzing records of leaks and repairs and taking action where necessary

Regularly analyzing information, at approximately the same frequency as your inspections to detect leaks, can identify components or types of component

that persistently leak. These components should be targeted for correction or preventative maintenance.

Methods of reducing methane emissions from routine maintenance and repairs

Minimizing the volume that has to be depressurized

To reduce the internal volume of a pipeline or vessel that needs to be depressurized by releasing gas, use temporary line stops to isolate the section where repairs are needed.

Reducing emissions from pigging a pipeline by using a vapor-recovery unit to capture the released gases.

Gas is vented when a pig is launched and received. Gas is also released from storage tanks receiving the liquid and debris removed by pigging. These emissions can be reduced by using a vapor-recovery unit or flaring the gases that are released.

Avoiding emissions

In some cases, emissions can be avoided completely by:

- using hot taps to make new connections to pipelines;
- carrying out non-intrusive inspections (for example, by using pigs with sensors); and
- reducing the number of blowdowns by coordinating repairs and maintenance events into a single downtime.

Flaring vented gases, if venting cannot be avoided

If venting cannot be avoided, flaring the gas will reduce the emissions impact of a venting event.

Synopsis

Reducing Methane Emissions: Continual Improvement



Checklist

Achieving continual improvement in methane management

- ✓ Commit to a program of methane management.
- ✓ Improve methane reduction capabilities for preventing, identifying and repairing leaks, and using effective engineering and design.
- ✓ Set strong methane-reduction targets.
- ✓ Report methane-reduction efforts and results.
- ✓ Integrate methane management into the company culture.

Continual improvement of methane management efforts will eventually result in 'methane excellence', i.e., low methane emissions from oil and gas operations. Methane excellence can enable the oil and gas industry to become one of the main players in reducing methane emissions and providing low-carbon energy worldwide.

The most important factor in achieving methane excellence is commitment throughout the company, from senior management to front-line employees.

With that commitment, continual improvement of methane management is accomplished by doing the following;

- Systematically improving methane management by having a formal or informal management system such as the Plan Do Check Act cycle
- Improving methane-reduction by improving the processes of preventing, identifying and repairing leaks
- Learning from existing practices and maximizing methane reduction through project engineering and design
- Setting strong methane-reduction intensity targets for operated assets
- Reporting an overall group level methane number (Mte) and a methane intensity (%)
- Reporting methane as both carbon dioxide equivalents and methane
- Building methane-reduction efforts into company culture

Systematically improving methane management

Transforming a company from one that does the minimum required by law to one that achieves methane excellence is a complex journey that involves technical, organizational and leadership skills. Such an undertaking requires a systematic approach. Continual improvement in methane management requires a management system like the plan-do-check-act cycle to be applied to the elements of reducing methane emissions.

Improving methane monitoring and reduction capabilities

The starting point for improving methane management capabilities is an accurate inventory of the sources of methane and the amounts they emit. This helps to identify the sources that should be prioritized for reduction activities. From there, projects such as increasing leak detection practices and improving the process of repairing and preventing leaks can be launched. As methane reduction technologies develop and operations grow and change, a systematic continual improvement process will make sure that best practices continue to be applied.

Setting strong methane-reduction targets

Continual improvement in methane management is driven by methane reduction targets. Methane reduction targets should be ambitious but also achievable. Current best practice for setting strong methane reduction targets includes setting intensity targets for operated assets. Future recommended best practice includes setting targets for both natural-gas and oil production; addressing emissions from both operated and non-operated assets; including both an absolute and an intensity target for methane; performing rigorous emissions measurements and analysis to inform targets and validate reduction levels.

Transparent reporting

Transparent reporting of methane emissions and reduction targets, as well as the information these are based on, is critical to building internal and external stakeholders' confidence in a company's efforts to reduce methane emissions. Globally, investors are starting to ask more questions about a company's management of climate change issues. Current best practice demonstrating transparent reporting includes reporting an overall group level methane number (Mte) and a methane intensity

number (%) and reporting methane emissions in carbon dioxide equivalents (CO₂e) and methane (CH₄). Future recommended best practice includes reporting of asset level methane emissions, moving towards regional emission factors and the use of direct methane detection and measurement technologies and third party validation of methane performance reporting.

Building methane management into company culture

An oil and gas company can promote a culture that supports methane excellence by continually improving awareness of methane management strategies across the business until methane management is embedded in the company's culture. Specific best practices for integrating methane management into company culture include.

- Integrating methane reduction into existing business and operational procedures
- Establishing new learning opportunities relating to reducing emissions for both technical and non-technical staff
- Promoting methane excellence and innovation by encouraging team communications, setting team goals and boundaries, then tracking and rewarding positive results.

Synopsis

Reducing Methane Emissions: Identification, Detection, Measurement and Quantification



Checklist

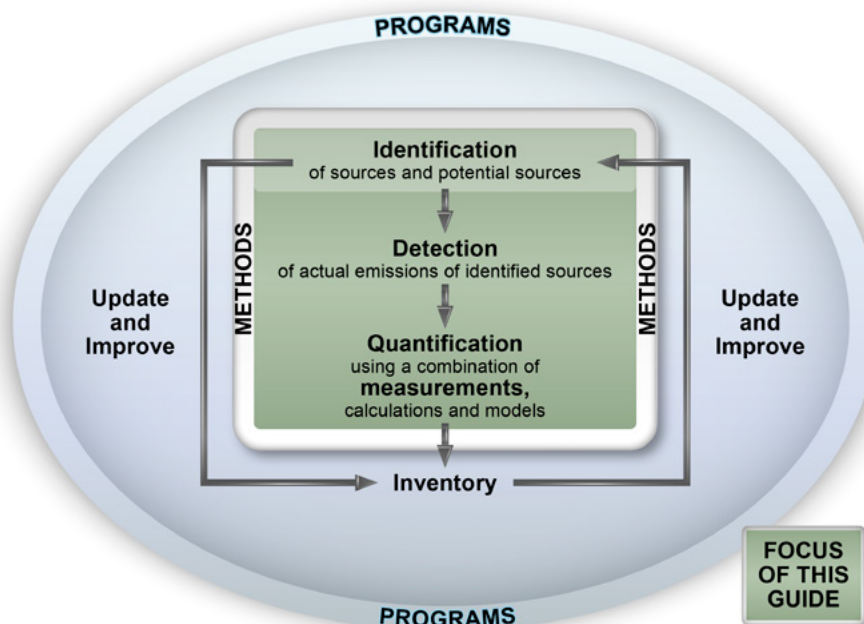
Methods of reducing methane emissions through identification, detection, measurement and quantification

- ✓ Identify known sources of emissions and survey for emissions
- ✓ Quantify sources of emissions directly by taking measurements or indirectly using a combination of measurements, calculations and models
- ✓ Create, update and periodically improve inventories of emissions

A key step in reducing methane emissions is to identify and detect sources of the emissions.

Emissions that have been identified and detected are measured, quantified and recorded in inventories. These inventories serve as a starting point for prioritizing mitigation activities (measures to reduce methane emissions). Because of the wide range of sources of methane emissions in natural gas value chains, methods for identifying, detecting, measuring and quantifying emissions are varied.

Methods include approaches that have been available for decades and approaches that are just emerging. The best practice to follow will depend on the characteristics of a facility and the cost-effectiveness of the methods. Best practice will also depend on the need for inventories, which may include introducing voluntary programs, developing detailed corporate inventories, or keeping to regulations that require particular methods to be used.



Identification and detection

Some sources of methane emissions are a known part of the design of natural gas systems. In these cases, analyses of a system's design are used to identify emission sources. Other methane emissions are unintentional. Detection surveys need to be carried out to identify unintended sources and to confirm known sources. Detection methods may use passive or active sampling. They may detect at a fixed point or over an open path, and may involve imaging. The methods use a range of sensing technologies. Some methods apply to all sectors of the natural gas value chain. Others have more specialized uses. Because of the wide range of methods and uses, best practice for identifying, detecting, measuring and quantifying emissions will depend on the characteristics of a facility and the cost-effectiveness of the methods.

Measurement and quantification

Once emissions are identified and detected, a wide variety of methods can be used to quantify them. Methods often involve measuring methane concentrations in flows of gases or ambient air, but could also include a wide variety of other measurements (ranging from gas pressures to wind speeds). Emission rates can be quantified directly by carrying out measurements or indirectly through a combination of measurements, calculations and models.

Methods applied at a variety of scales

Emissions are identified, detected, measured and quantified using devices that are handheld, fixed at a location or fitted on vehicles, drones or aircraft, or by satellite. Large-scale emission estimates

aggregated over many individual sources, are generally referred to as top-down assessments. Estimates of emissions from individual sources, which are then added together to produce estimates for a site or area, are generally referred to as bottom-up assessments. Bottom-up assessments provide detailed information about emissions from equipment and operations, but may miss some unexpected, unintended or uncharacteristic emission sources. Top-down assessments generally lack detail about individual sources but can provide comprehensive information about emissions at a site or in a region. Depending on the scale of the measurement, top-down measurements may include contributions from sources that are not a part of the natural gas value chain, and this needs to be accounted for when interpreting findings and reconciling top-down assessments with bottom-up estimates. Co-ordinated use of measurements at varying scales may provide more reliable quantification.

Programs to develop, update and improve inventories

Several methods are generally used in programs to identify, detect, measure and quantify emissions. The resulting information is recorded in emission inventories, which are regularly updated and improved. The continual improvement of inventories may include new methods of detecting and measuring emissions, new information on average emission rates from equipment, new emission models, or other innovations. Comparisons between top-down assessments and bottom-up assessments can guide continual improvement.

Synopsis

Reducing Methane Emissions: Transmission, Storage, LNG Terminals and Distribution



Checklist

Methods of reducing methane emissions in transmission, storage, LNG terminals and distribution

- ✓ Keep an accurate inventory of emissions from all sources
- ✓ Prevent emissions whenever possible
- ✓ Reduce emissions that cannot be prevented
- ✓ Identify and repair equipment that is not working properly
- ✓ Track emissions and mitigation activities

Methane emissions in the natural gas supply chain arise from venting, fugitive emissions and incomplete combustion (methane slip). Best practice for reducing or eliminating emissions from these sources has been described in guides developed by the signatories to the Methane Guiding Principles (MGP). However, the technical and economic characteristics of the best practice may vary depending on the characteristics of the part of the supply chain the best practice is applied in.

This synopsis describes 'mitigation measures' to reduce methane emissions in transmission, storage, LNG terminals and distribution. These measures may require different practices to other parts of the supply chain. For example, leaks from buried pipelines can be more difficult to identify and quantify than leaks from sources above the ground, and the cost of repairs will be higher.

Mitigation measures

Mitigation measures include approaches used across the full natural gas supply chain and methods that are specific to transmission, storage, LNG terminals and distribution. Sources which mitigation measures are applied to include the following.

- **Compressors** (convert wet seals to dry seals, address rod-packing seals, reduce emissions from gas starts)
- **Pneumatics** (convert to be powered by electricity or compressed air, replace high-bleed devices)
- **Dehydrators** (switch to low-emission or no-emission dehydration, optimize glycol dehydrators, and route flash gas to flare or use as fuel)
- **LNG truck loading** (dry connects, use nitrogen to purge lines, vapor balancing)
- **Pipeline maintenance** (pump down, recompress and reroute, use hot taps, flare residual gas, use in-line inspection technologies)
- **Pipeline commissioning** (vacuum instead of purge)
- **Third-party damage** (damage-prevention programs, install excess-flow valves in lines)
- **Storage systems** (monitoring, well-integrity monitoring and reviews)
- **Boil-off gas in LNG terminals**
- **Equipment leaks** (implement leak detection and repair programs, replace equipment prone to leaks)
- **Energy use** (reduce methane from incomplete combustion of fuel by having automated air/

fuel ratio controls, minimizing the number of start-ups and increasing combustion efficiency of equipment)

- **Flares** (minimize flaring, improve efficiency, avoid pilot failure)

Continual improvement in reducing emissions should be achieved across all parts of the supply chain.

Case studies with features unique to this sector

Pipeline draw-down and pump-down

Operators can lower gas pressure in sections of pipeline that need maintenance work by blocking it off and allowing customers to withdraw gas, before venting. Operators can also reduce venting using a mobile compressor that removes gas from the pipeline section to be vented and recompresses it into a nearby section.

Recovering blowdown gas with permanent compressors

Install electrically driven compressors in compressor stations to reroute and not vent blowdown gas, with temporary tank storage.

Flare residual blowdown gas

If gas cannot be moved into another pressurized system, or there is residual gas left after a recompression operation, flaring reduces the methane in the vented gas.

Hot tapping for pipeline connections

Hot tapping makes a new connection to a pipeline while the pipeline remains in service. This avoids

the need to depressurize and vent the pipeline to make the connection.

Monitoring underground storage

Implement well-integrity management systems.

Replace dehydrators in storage systems with lower-emission alternatives

Vapor-compression refrigeration and Joule-Thompson expansion can be used to condense water in gas streams, reducing emissions compared to glycol dehydrators.

Minimizing emissions through the design of LNG terminals and LNG truck-loading systems

A variety of mitigation practices reduce venting and fugitive emissions in LNG terminal operations.

Commissioning with vacuum pumps

Constructing and commissioning a new section of distribution network gives rise to methane emissions during the purging process and pressurization of the new section. Emissions can be avoided by using a vacuum pump to remove the air in the new section.

Avoid emissions caused by third-party damage

Civil work around gas networks can cause damage to service lines, resulting in emissions. Work with third parties to prevent damage events.

Install excess-flow valves in service lines

When damage arises in service lines or inside customer premises, gas is released into the atmosphere. The resulting flow of gas can be detected and stopped with an automated cut-off valve.

Further information

MGP Website:

www.methaneguidingprinciples.org

OGCI:

<https://oilandgasclimateinitiative.com>

CCAC OGMP:

<https://www.ccacoalition.org/en/activity/ccac-oil-gas-methane-partnership>

IEA Methane Tracker:

<https://www.iea.org/weo/methane>

Natural Gas STAR Program:

<https://www.epa.gov/natural-gas-star-program>



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