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Reducing Methane Emissions: Best Practice Guide Pneumatic Devices

November 2019



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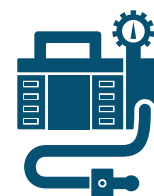
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This Guide describes actions that an organisation can take to help manage methane emissions. Any actions or recommendations are not mandatory; they are simply one effective way to help manage methane emissions. Other approaches might be as effective, 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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Summary



In the oil and gas industry, one of the largest sources of methane emissions is pneumatic devices.

This document sets out ways of, and best practice in, reducing or eliminating methane emissions from those devices.

Methane emissions from pneumatic devices can be reduced or eliminated 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 have emissions that are higher than expected.

Best practice for reducing methane emissions from pneumatic devices is summarized in the table below.

Best practice for reducing methane emissions through operational repairs

- ✓ Keep an accurate inventory of pneumatic devices that are driven by the natural gas produced from wells.
- ✓ Replace pneumatic devices with electrical or mechanical devices where practical.
- ✓ If pneumatic devices have to be used, choose ones that use compressed air rather than natural gas.
- ✓ When using devices driven by natural gas is the most feasible option, replace high-emission devices with lower-emission alternatives.
- ✓ Include any pneumatic devices driven by natural gas in a formal inspection and maintenance program and record the emissions in an annual inventory.

Introduction

Pneumatic devices are powered by gas pressure. They are mainly used where electrical power is not available.

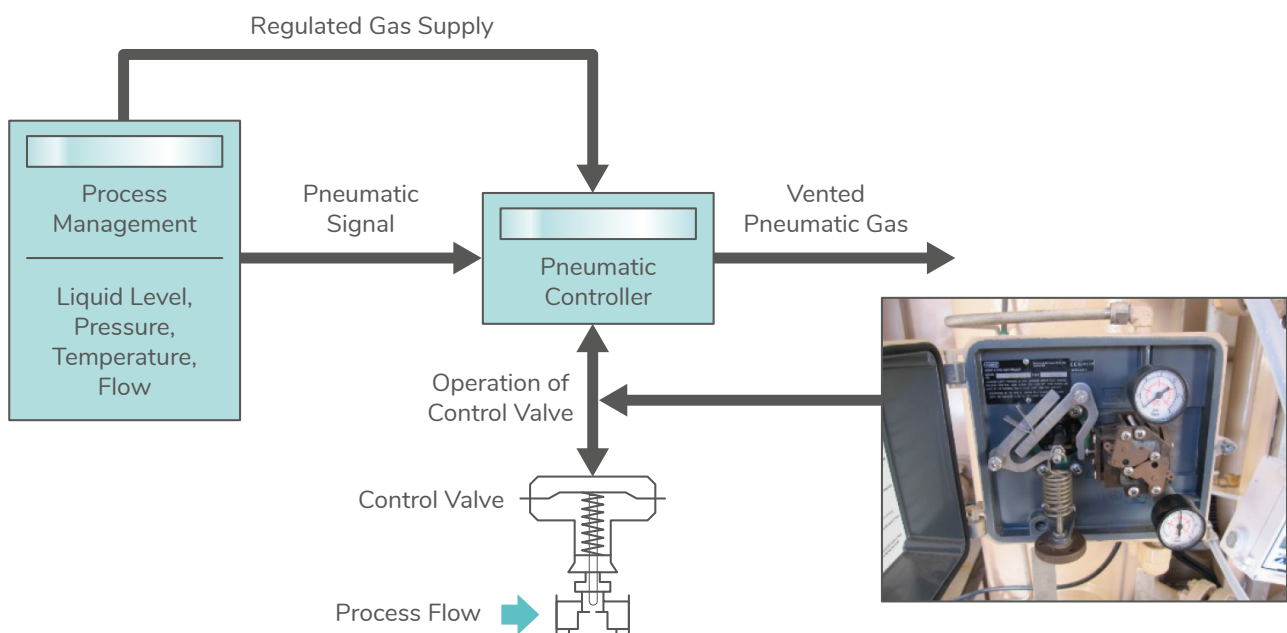
The two main types of pneumatic devices used in the oil and gas industry are pneumatic controllers and pneumatic pumps.

- Pneumatic controllers are mechanisms that control conditions such as levels, temperatures and pressures. When a pneumatic controller detects the need to change liquid level, pressure, temperature or flow, it opens or closes a control valve. As shown in the diagram below, the pneumatic controller can open or close the valve by directing pressurized gas to the control valve. The natural gas used to drive the controller is continuously vented or vented intermittently, depending on the design of the device.

- Pneumatic pumps are used to inject chemicals into wells and pipelines and for circulation in glycol dehydration units where water is removed from natural gas. The natural gas used to drive the pump may be vented as the pump operates.

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. For example, in the United States, pneumatic devices are the main source of methane emissions arising from the oil and gas industry, and approximately 97% of those emissions are due to pneumatic controllers.¹

Figure 1: Pneumatic controller



Source: XXXXXXX

Quantifying Emissions

- Emissions from pneumatic devices can be quantified by multiplying the total number of devices by the average emissions from a device. Emissions vary depending on the design of a device, so pneumatic equipment is often broken down into categories. Common categories of pneumatic controllers are high-bleed, low-bleed and intermittent-vent.
- Even for devices that are identical in design, emissions can vary widely, depending on how they are used and whether they are working properly.

The total emissions from pneumatic pumps is generally quantified by multiplying the number of pumps by the estimated or measured emissions from a single pump, as explained above. The emissions from pneumatic controllers can be quantified in the same way. However, because of the large number of pneumatic controllers used, and the differences in emissions associated with different designs, different approaches are

generally used to quantify pneumatic controller emissions, as shown in the table below.

In the table below, the number of devices is referred to as the activity factor, and the level of emissions from a device is referred to as the emission factor. The table summarizes the types of activity factors and related emission factors used to quantify emissions.

Pneumatic pumps	Activity factor	Emission factors
Pneumatic controllers	The number of pumps used.	The emissions from a pump.
	The number of controllers used.	The emissions from a controller.
	The number of a particular type of controller (high-bleed, low-bleed, intermittent).	The emissions from a controller of that particular type.
	The number of controllers producing emissions that are higher than expected.	The emissions from a controller producing emissions that are higher than expected.

The United States Environmental Protection Agency (US EPA) classifies the different designs of pneumatic controller as:

- intermittent-vent devices;
- continuous-vent low-bleed devices;
- continuous-vent high-bleed devices; and
- zero-bleed devices.

Intermittent-vent controllers are ‘snap-action’ devices that vent only when a specific condition is met. Intermittent controllers are the most common type of controller used in the oil and gas industry.

Continuous-vent controllers use gas pressure to sense the conditions of an operating process. The gas flows to the valve controller continuously and then vents (bleeds) to the atmosphere (that is, is released into the atmosphere).

- If the designed bleed rate is less than 0.17 standard cubic meters per hour (scm/h) – equivalent to six standard cubic feet per hour (scf/h) – the device is low-bleed.

- If the designed bleed rate is 0.17scm/h or more, the device is high-bleed.

Zero-bleed controllers divert vented gas to the gas being produced from the well, rather than into the atmosphere.

The prevalence of each type of device used in the oil and gas industry in the United States, and the average emission per device used by the US EPA when quantifying emissions from pneumatic devices, are shown in the table below.

	Fraction of all pneumatic devices used in the US oil and gas industry (according to the 2017 US EPA Greenhouse Gas Inventory) ¹	Average whole gas emission per device ^{*2}
Oil and gas production		
Pneumatic pumps	8%	0.526scm/h (diaphragm mechanism) 0.0575scm/h (piston mechanism)
Intermittent-vent controllers	69%	0.382scm/h
Continuous-vent low-bleed controllers	21%	0.0394scm/h
Continuous-vent high-bleed controllers	2%	1.06scm/h
Gas transporting and storage		
Intermittent-vent controllers	86%	0.0666scm/h
Continuous-vent low-bleed controllers	7.5%	0.0388scm/h
Continuous-vent high-bleed controllers	6.5%	0.516scm/h

^{*}Methane emissions are calculated by multiplying the gas emission rate by the volume fraction of methane in the gas

Quantifying Emissions

Because pneumatic controllers are a large source of methane emissions from the oil and gas industry¹ a relatively large number of studies on emissions from controllers have been published. Details of recent studies are given in appendix 1^{3,4,5,6,7,8,9}. Major conclusions from those studies include the following.

- A relatively small percentage of controllers were responsible for the emissions identified. For example, at production sites surveyed in the United States, about 95% of the emissions measured from pneumatic controllers arose from less than 20% of the pneumatic controllers⁶.
- Some controllers that are producing higher-than-expected emissions may be not working properly, and these might be replaced or repaired to reduce the emission rate.
- Emission rates from intermittent-vent controllers depend on how often the mechanism is triggered to release gas.
- Controllers can switch between relatively low emission rates and relatively high emission rates, but what causes this is not well understood.⁹

These recent findings have important implications for both quantifying emissions and designing mitigation strategies (ways to reduce emissions). For example, a study⁶ found that around 16% of low-bleed controllers had emission rates of more than 0.567 scm/h (20scf/h), which is higher than the EPA emission limit for low-bleed controllers. If those low-bleed controllers with high emission rates could be identified and then repaired or replaced, the total emissions from those low-bleed controllers could be reduced by more than half. Similarly, studies⁶ have found that 83% of intermittent-vent controllers had emission rates of less than 0.0567scm/h (2scf/h), 7% had emission rates of more than 0.567scm/h,

and the remaining 10% had emission rates of between 0.0567scm/h and 0.567scm/h. Again, identifying and repairing or replacing devices with high emission rates may reduce emissions.

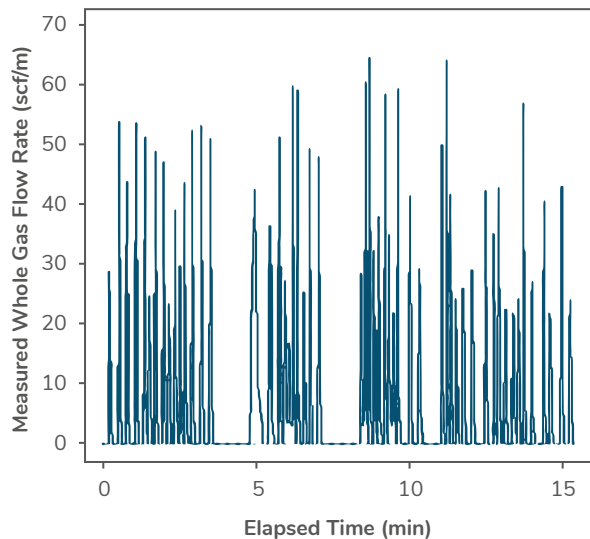
Because pneumatic controllers, even of the same design type, can have lower emission rates (less than 0.17scm/h) or higher emission rates (0.17scm/h or more), when emission rates are quantified it may be more accurate to determine average emission rates for high and low emission controllers (this only applies to intermittent-vent and low-bleed controllers, as high-bleed controllers all have high emission rates) and then determine, through measurements, the fraction of controllers that have higher emission rates and the fraction that have lower emission rates.

However, differentiating between:

- controllers that have high emission rates and are not working properly; and
- controllers that are working properly but have emission rates that are higher than expected; can be difficult.

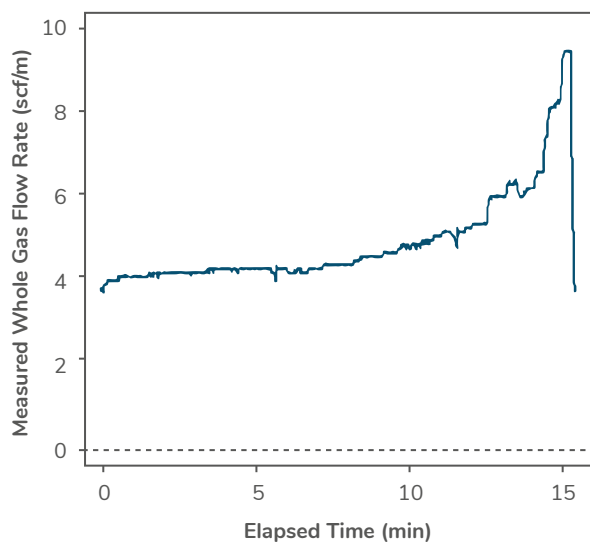
The graphs below are for two intermittent-vent controllers that have very similar emission rates. Figure 2a shows that the first device appears to be working normally, with very frequent rapid venting and the emission rate quickly returning to zero. Figure 2b shows that the venting mechanism of the second device does not react instantly (it takes several minutes) and the emission rate never returns to zero. This vent pattern is not normal, which indicates that the device is not working properly.

Figure 2a: Gas flow rate versus time for a normally functioning intermittent vent controller



Source: Reference⁶

Figure 2b: Gas flow rate versus time for a defective intermittent value controller



Source: Reference⁶

A recent study⁹ suggested that intermittent-vent controllers should be considered to not be working properly if:

- the venting is slow and gradual rather than being triggered instantly;
- there is continuous venting or a lack of distinct instances of venting;
- emissions do not return to zero between instances of venting, or
- there is any other irregular behavior.
- The same study⁹ suggested that:
- low-bleed devices should be considered to be not working properly if they have emission rates of 0.17scm/h or more; and
- high-bleed devices should be considered to be not working properly if they have emission rates that are higher than the manufacturer's specifications.

Mitigation strategies

- Emissions can be reduced by replacing pneumatic devices with electrical or mechanical devices.
- If pneumatic devices have to be used, methane emissions can be reduced or eliminated by the following mitigation strategies.
 - Using compressed air rather than natural gas to drive the device
 - Replacing high-bleed devices with low-bleed or zero-emission designs
 - Repairing or replacing devices that are not working properly
- Because mitigation strategies prevent or reduce the loss of natural gas, some can pay for themselves within one or two months, while others can cover the cost within years.

These emission mitigation strategies cascade from preventing emissions, to reducing emissions, to identifying and repairing devices that are not working properly. The mitigation strategies are summarized in the table below and more detailed descriptions are given in the following pages. Links to more information are provided in Appendix 2.

Mitigation strategy	Description
1. Replace high-bleed devices with low-bleed or zero-bleed devices.	1a. Replace pneumatic devices with electrical or solar-powered devices.
	1b. Replace pneumatic controllers with mechanical controllers.
	1c. Replace high-bleed devices with intermittent-vent or low-bleed devices.
2. Use compressed air rather than natural gas to drive pneumatic devices Use compressed air generated on-site to drive devices.	Use compressed air generated on-site to drive devices.
3. Carry out regular inspections and repair or replace items where necessary.	A small proportion of controllers that are not working properly may be responsible for the many of the methane emissions associated with controllers. If controllers with high emissions due to faults can be identified, they can be repaired or replaced.

Because mitigation strategies prevent or reduce the loss of natural gas, some can pay for themselves within one or two months, while others can cover the cost within years.

Mitigation strategy 1a: Replace pneumatic devices with electrical or solar-powered devices¹⁰

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

Both types of pumps can be replaced by:

- standard electric pumps, if an electricity supply is available; or
- solar-powered pumps, if there is enough sunlight and a battery unit stores solar power for when there is no sunlight, so the pumps can run continuously.

Similarly, pneumatic controllers can be replaced by electrical devices where electricity is available.

Figure 3b: Solar chemical pump



Source: BP

Reduction in emissions and recovering costs

Natural Gas Star partners¹⁰ have reported that replacing pneumatic circulation pumps with a 3BHP (brake horsepower) electrical pump reduced vent gas by 100,000 to 200,000 standard cubic meters (scm) per year.

With electricity priced in the range of US\$0.075 per kilowatt-hour and gas valued at between US\$0.14 and US\$0.25 per scm, the strategy may pay for itself, through economic savings, within a few months.

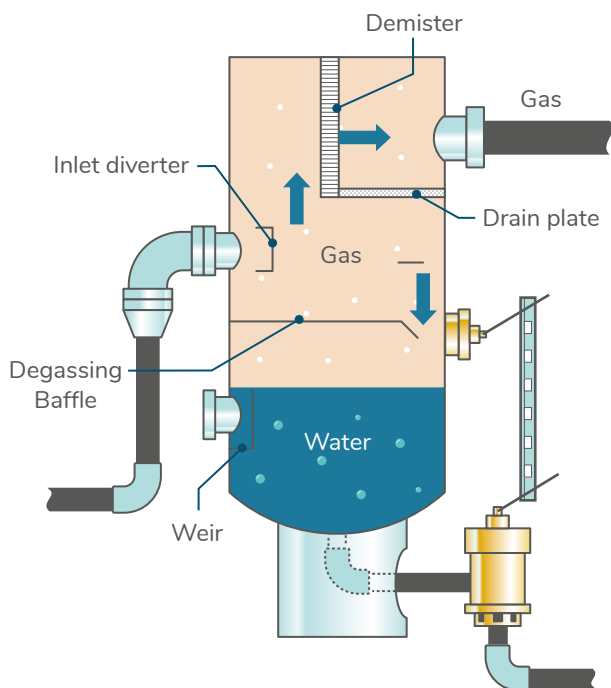
Mitigation strategy 1b: Replace pneumatic controllers with mechanical controllers¹¹

Pneumatic controllers can be replaced with mechanical controllers. As described in a Natural Gas Star Partner Reported Opportunity¹¹, 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.

A high pressure, high flow separator requires the dump valve to be continuously throttled. As well production declines, and pressure and fluid production reduce, the need for pneumatic control mechanisms may be eliminated.

Mechanical controllers use a float on the liquid phase of a gas-liquid separator (see the diagram below). A mechanical link from the float opens and closes a dump valve. The only maintenance needed is to clean and lubricate the mechanical link.

Figure 4: Separator with mechanical dump



Reduction in emissions and recovering costs

The reduction in emissions, and the economic value of the reduction, depends on the type of pneumatic controller that is replaced and the volume of liquid produced during the operating process. A high-bleed pneumatic controller can vent approximately 10,000 scm of gas a year.

Natural Gas Star partners¹¹ have reported equipment and installation costs of US\$3,000 per controller. With gas valued at between US\$0.14 per scm and US\$0.26 per scm, the strategy may pay for itself within 20 to 30 months.

Mitigation strategy 1c: Use compressed air rather than natural gas to drive pneumatic devices¹²

Using compressed air rather than pressurized natural gas to drive pneumatic devices can eliminate methane emissions from venting. Due to the cost of compressed-air systems, they are mostly used at locations where a relatively high volume of pneumatic gases are used.

Compressed-air systems typically consist of a compressor, a power source, a dehydrator and a gas storage tank.

Compressors switch on intermittently to maintain gas pressure in a storage tank. They are typically powered by electricity. At sites without electrical power, solar-powered air compressors can be used.

The dehydrator is a vital part of the compressed-air system. Water vapor in the air can condense when the air is pressurized. If the air is not dehydrated (to remove the water vapor), condensation can cause corrosion in pipes.

Reduction in emissions and recovering costs

Replacing pressurized natural gas with compressed air completely eliminates methane emissions from pneumatic devices.

Natural Gas Star partners¹² report that compressed-air systems should be designed to provide 1.7 scm per hour (1 scf per minute) of compressed air to each controller, and that compressors should be sized so that the air delivered to controllers is approximately two-thirds

of the volume of the atmospheric air drawn into the compressor.

Natural Gas Star partners¹² have reported systems providing from 60scm to more than 1500scm per hour of compressed air, replacing the same volume of natural gas that would otherwise have been used. Based on natural gas being priced at \$0.25 per scm, a compressed-air system can pay for itself within two to seven months.

Mitigation strategy 2: Replace high-bleed pneumatic devices with low-bleed or intermittent-vent devices¹²

High-bleed pneumatic controllers typically have vent rates of more than 1scm per hour, resulting in lost vent gas with a value of more than US\$1000 per year from each device, with gas valued at US\$0.14 per scm. Replacement with low-bleed and intermittent-vent controllers, which have average vent rates of between 0.03scm/hr and 0.4scm/h, can significantly reduce methane emissions and lost vent gas.

In the United States, continuous high-bleed pneumatic devices can no longer be fitted for new and modified installations. Regulations in some regions require high-bleed devices to be replaced, with only a few exceptions. Some organisations have chosen to adopt this policy across all sites, not just new and modified sites.

High-bleed pneumatic controllers can provide fast response times. However, when a fast response time is not necessary, the controller can be replaced with an intermittent-vent or low-bleed alternative. In a few cases, manufacturers of pneumatic

devices may make a 'retrofit kit' of technology, parts and features to convert existing controllers to intermittent-vent controllers. In other cases, the entire controller would need to be replaced.

Reduction in emissions and recovering costs

With vent rates from high-bleed devices typically being higher than 1scm per hour, installing a low-bleed or intermittent-vent controller could prevent losses of more than US\$1000 per year from each device.

The cost of this mitigation strategy depends on whether the controller is:

- being replaced at the end of its useful life;
- being replaced early; or
- being converted with a retrofit kit.

Natural Gas Star partners¹² report the following.

- The cost of replacing a high-bleed controller with an intermittent-vent or low-bleed controller at the end of the high-bleed controller's useful life is between US\$210 and US\$340.
- The cost of replacing a high-bleed controller before the end of its useful life is US\$1850.
- The cost of converting a high-bleed controller with a retrofit kit is US\$675.

These figures mean that costs could be recovered within a period ranging from a few months to two years.

Mitigation strategy 3: Regularly inspect devices and repair or replace those that have emissions that are higher than expected¹³

Several studies have found that a small fraction of pneumatic controllers is responsible for the majority of methane emissions from pneumatic controllers^{3,4,5,6,7,8,9}. Some controllers have high emission rates, but others may be producing higher emissions than expected because they are not working properly.

The pattern of vent gas from a device can indicate whether or not it is not working properly (see page 6).

A targeted inspection and maintenance program for pneumatic devices can reduce emissions by identifying pneumatic devices that are not venting normally and then repairing or replacing them.

A new inspection and maintenance program could be aimed specifically at pneumatic devices, or pneumatic devices could be incorporated into an existing program, such as a current program to detect and repair leaks in equipment.

In the United States, several organisations have voluntarily adopted formal inspection and maintenance programs¹³. Also, the State of Colorado has added pneumatic devices to the scans carried out with Optical Gas Imaging (OGI) cameras. These cameras are used to identify gas leaks, but are now also being used to identify unusual emission behavior for pneumatic devices. This practice is expected to become widespread in 2019.

Reduction in emissions and recovering costs

There has been limited practical experience across industry of targeted inspection and maintenance programs for pneumatic controllers, although this situation is expected to change rapidly. Important issues that need to be addressed include the fraction of devices that can be repaired, the durability of the repairs, and the cost of inspections.

Checklist

The following checklist allows each operator to assess their progress in reducing emissions from pneumatic controllers.

Activity	Mark when completed	Percentage of pneumatic devices included in the activity
Pneumatic controllers		
✓ Produce and keep an accurate inventory of pneumatic controllers driven by natural gas.		
✓ Replace pneumatic controllers with electrical or mechanical devices where practical.		
✓ If pneumatic controllers are used, use compressed air rather than natural gas as the pneumatic fluid.		
✓ If using pneumatic controllers driven by natural gas is the most feasible option, replace high-bleed controllers with low-bleed or intermittent controllers.		
✓ Include pneumatic controllers driven by natural gas in a targeted inspection and maintenance program and record the pattern of vent-gas emissions in an annual inventory.		
Pneumatic pumps		
✓ Produce and keep an accurate inventory of pneumatic pumps driven by natural gas.		
✓ Replace pneumatic pumps with electrical pumps (possibly solar powered)		

Appendix 1

Recent studies measuring emissions from pneumatic devices (adapted and updated from NASEM³)

Sample area	Study details	Source
Natural-gas production sites		
US	The study measured emissions from pneumatic controllers at natural gas well sites.	(4)
British Columbia and Alberta	Study focused on high-bleed controllers. Emissions were reported for different manufacturers and models.	(5)
US	The study measured emissions from controllers at oil and gas well sites in the United States. 19% of controllers accounted for 95% of emissions from the pneumatic controllers in the study.	(6)
Oklahoma	The study measured emissions from controllers at oil and gas sites in Oklahoma. 3.5% of controllers accounted for 73% of emissions from the pneumatic controllers in the study.	(7)
Utah	The study measured emissions from controllers at oil and gas sites in Utah. The majority of emissions came from 14 of the 80 controllers. 11 of the 14 controllers were not working properly.	(8)
Natural gas gathering and processing sites		
US	Emissions from controllers were measured over 72 hours.	(9)

Appendix 2

Links to more information about mitigation strategies

Mitigation Strategy	Description	Link to more information
4. Replace high-bleed devices with low-bleed or zero-bleed devices	1a Replace pneumatic devices with electrical or solar-powered devices.	(10)
	1b Replace pneumatic controllers with mechanical controllers.	(11)
	1c Replace high-bleed devices with intermittent-vent or low-bleed devices.	(12)
5. Use compressed air rather than natural gas to drive pneumatic devices	Use compressed air generated on-site to drive devices.	(12)
6. Carry out regular inspections and repair or replace items where necessary	A small proportion of controllers are responsible for the majority of emissions. If controllers with high emissions due to faults can be identified, they can be repaired or replaced.	(13)

References

- 1 United States Environmental Protection Agency (US EPA) 2019 'Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2017' (April 2019)
- 2 Climate and Clean Air Coalition, Oil & Gas Methane Partnership, Technical Guidance Document Number 1: Natural Gas Driven Pneumatic Controllers and Pumps Available at: www.ccacoalition.org/sites/default/files/resources/2017_OGMP-TGD1-Pneumatic-controls-and-pumps_CCAC.pdf Emission factors (accessed September 22, 2019)
- 3 National Academies of Science, Engineering and Medicine (NASEM) 'Improving Characterization of Anthropogenic Methane Emissions in the United States' National Academy Press, Washington, DC (2018)
- 4 DT Allen, VM Torres, J Thomas, DW Sullivan, M Harrison, A Hendler, SC Herndon, CE Kolb, MP Fraser, AD Hill, BK Lamb, J Miskimins, RF Sawyer, JH Seinfeld 'Measurements of methane emissions at natural gas production sites in the United States' Proceedings of the National Academy of Sciences of the United States of America, 110(44):17768-17773 DOI: 10.1073/pnas.1304880110 (2013)
- 5 Prasino Group 'Final Report for Determining Bleed Rates for Pneumatic Devices in British Columbia' British Columbia Ministry of Environment. Available at www.bccogris.ca/sites/default/files/prasinopneumaticghgefprojectmethodology.pdf (2013, accessed September 22, 2019)
- 6 DT Allen, A Pacsi, D Sullivan, D Zavala-Araiza, M Harrison, K Keen, M Fraser, AD Hill, RF Sawyer, JH Seinfeld 'Methane Emissions from Process Equipment at Natural Gas Production Sites in the United States: Pneumatic Controllers' Environmental Science & Technology, 49 (1), 633–640, doi:10.1021/es5040156 (2015)
- 7 M Gibbs 'Improving oil and gas emissions tool inputs using industry surveys and permit data' Presented at National Oil and Gas Emissions Committee Monthly Call and Industry Outreach (November 12, 2015)
- 8 ED Thoma, P Deshmukh, R Logan, M Stovern, C Dresser, HL Brantley 'Assessment of Uinta Basin Oil and Natural Gas Well Pad Pneumatic Controller Emissions' Journal of Environmental Protection 8:394-415. DOI: 10.4236/jep.2017.84029. (2017)
- 9 B Luck, D Zimmerle, T Vaughn, T Lauderdale, K Keen, M Harrison, A Marchese, L Williams, D Allen 'Multiday Measurements of Pneumatic Controller Emissions Reveal the Frequency of Abnormal Emissions Behavior at Natural Gas Gathering Stations' Environmental Science & Technology, doi: 10.1021/acs.estlett.9b00158 (2019)
- 10 United States Environmental Protection Agency (US EPA) 2019, Natural Gas Star 'Replacing Gas-Assisted Glycol Pumps with Electric Pumps' Available at www.epa.gov/natural-gas-star-program/replacing-gas-assisted-glycol-pumps-electric-pumps (2019)

- 11 United States Environmental Protection Agency (US EPA) 2019c, Natural Gas Star 'Convert Pneumatics to Mechanical Controls' Available at www.epa.gov/natural-gas-star-program/convert-pneumatics-mechanical-controls (2019)
- 12 United States Environmental Protection Agency (US EPA) 2019e, Natural Gas Star 'Convert Gas Pneumatic Controls to Instrument Air' Available at www.epa.gov/sites/production/files/2016-06/documents/II_instrument_air.pdf (2019)
- 13 Doug Jordan, Southwestern Energy, Presentation to the EPA Natural Gas STAR / Methane Challenge Annual Implementation Workshop (October 25, 2017)



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