Brief description of the source

Natural gas driven pneumatic controllers are used in some segments and regions of the oil and natural gas industry, to automatically control liquid level, temperature, pressure, and flow in production, gathering, processing, transmission and storage, and distribution of natural gas and petroleum products. They are typically more prevalent in areas where sites are remote and dispersed, and where access to reliable electricity grid connection can be challenging. Control valves are used in the oil and gas value chain to support automation of several equipment. These control valves can be actuated and powered by natural gas pressure powered (i.e. pneumatic) control instruments. A pneumatic controller uses gas pressure to open or close a mechanical device, such as a valve, when it senses the need to regulate a process condition. Supply gas serves as both a process measurement signal and a valve actuator to adjust the flow of liquid or gas to maintain a desired process target (set point). By design, some types of these pneumatic controllers vent (i.e. *'bleed'*) natural gas to the atmosphere as part of their normal, designed operation or simply actuate a valve open or closed (shut-off valves).. Other types vent gas back into the process (gas pressure regulators).

Bleeding pneumatic controllers can be designed to release supply-gas continuously or intermittently. These controllers have devices that measure the process parameter (such as liquid level, temperature, pressure, etc) and translates the measurement into a modulated gas pressure signal to the valve actuator. This signal is known as the *'bleed stream'*, that opens or closes the valve depending on the measurement. Pneumatic controllers are classified as continuous-bleed or intermittent-vent depending on the bleed stream.

1. Continuous bleed: when the bleed stream flow continuously to the valve controller and periodically to the atmosphere, in regulation position.
    - Low bleed: By definition, bleed rates are at or lower than 6 scfh (0.17 sm^3/h)
    - High bleed: By definition, bleed rates are higher than 6 scfh (0.17 sm^3/h)

2. Intermittent vent: bleed stream flows to the actuator only when the process parameter needs to be adjusted by opening or closing the valve. There is no vent or bleed of gas if the valve is stationary.

Shutoff valves do not have a process signal, and are normally manually activated to fully open or close a valve. Some small shutoff valves, which can be present throughout the industry, are typically infrequently actuated. Large compressors in processing and transmission are started and shut down for operations or maintenance, and can have large shutoff valves, called “unit isolation” and “station isolation” valves. To turn these large valves against high pressure differential, they can be “pneumatic/hydraulic” or “turbine” actuators. These are activated more frequently and require a larger amount of gas for each cycle.

Oil and gas facilities also use natural gas driven pneumatic chemical injection pumps to inject methanol and other chemicals into wells and pipelines, transfer liquids, and circulate freeze protection fluids. Pneumatic pumps use gas pressure to alternately push on either side of a diaphragm connected to a piston pump or to push a plunger to discharge fluids. Natural gas is vented to the atmosphere at each pump or plunger stroke.

Alternatively, controllers, shut off valves and pumps may be powered by compressed air or electricity. These types of controllers do not have associated methane emissions.

System boundaries

Methane that is vented to atmosphere from pneumatic controllers, large pneumatic shutoff valves, emergency shutdown valves, pneumatic pumps and instruments are considered herein. Small shutoff valves (typically, other than station isolation valves and unit isolation valves) operated infrequently can be considered de minimis emissions and need not be reported. Large shutoff valves (typically station isolation valves and unit isolation valves), regardless of the frequency of operation, are considered herein. Methane emissions from pneumatic controllers that are captured and reintegrated into the process, i.e. not vented, are not to be reported. Methane emissions captured and routed to flare should be reported under Flaring (see *Flaring TGD*). This TGD has been developed for equipment which is functioning properly. Emissions resulting from malfunctioning equipment are to be reported under Incidents and malfunctions category (see *Incidents and malfunctions TGD).* Emissions resulting from leaks are to be reported under Leaks (see *Leaks TGD).*

Guidance on materiality is presented in the *General principles TGD.*

Level 3 Quantification Methodologies

Emission factors

Accepted emissions quantification methodologies, as defined in the *General Principles TGD*, or those prescribed by local regulation are considered as providing Level 3 estimates, provided they are specific for the source type. They typically represent a volume of methane emitted per duration and per device. Partners are encouraged to use emission factors that best represent conditions and practices at their facilities and adjust the estimation methods, where warranted, to more accurately estimate emissions given differences between the reference system on which the methodology is based, and their systems.

The following tables present examples of emission factors which can be used to estimate methane emissions from pneumatic controllers.

Source	Segment	GHG reporting program 1996[1]	
		scfh/ device	sm^3/h/ device
High continuous bleed pneumatic controller vents	Production and Gathering and boosting	37.3	1.06
Low continuous bleed pneumatic controller vents		1.39	0.04
Intermittent bleed pneumatic controller vents		13.5	0.38
High continuous bleed pneumatic controller vents	Transmission / Storage	18.20	0.52
Low continuous bleed pneumatic controller vents		1.37	0.04
Intermittent bleed pneumatic controller vents		2.35	0.07

[1] Subpart W rulemaking and summary results (Tables W-1A, W-3B and W-4B) https://www.law.cornell.edu/cfr/text/40/part-98/subpart-W

Source		GRI/EPA Study 1996[2]	
		scf/year/ device	sm^3/year/ device
Pneumatic/ hydraulic rotary vane valve actuators		5627	159.34
Turbine valve actuators		67599	1914.19

Other examples of emission factors can be found in:

- Allen et. Al. 2013[3]
- Allen et. Al. 2015[4]
- Prasino Group 2013[5]

The following table presents examples of emission factors which can be used to estimate methane emissions from pneumatic pumps at oil and gas production sites

Source[6]	Scfh /pump	sm^3/h / pump
Pneumatic pumps – diaphragm	18.58	0.53
Pneumatic pumps – piston	2.03	0.06

Activity data collection should be conducted based on the data required by the selected emission factor. In the examples presented above, data on number of controllers or pumps per type.

Manufacturer estimates

Manufacturer estimates can also be used to quantify methane emissions from pneumatic controllers, shut off valves, pumps and measurement devices at Level 3. A non-exhaustive list is available with the most commonly used devices (brand and model) and their gas bleed rate information provided by manufacturers[7]

[2] Methane Methane Emissions from the Natural Gas Industry, Volume 12: Pneumatic Devices (epa.gov) , Tables 4-7 and 4-8.
[3] Measurements of methane emissions at natural gas production sites in the United States. Allen, David, T., et al. 2013. www.pnas.org/content/early/2013/09/10/1304880110.full.pdf+html
[4] Methane Emissions from Process Equipment at Natural Gas Production Sites in the United States: Pneumatic Controllers. Allen et al., 2015, http://pubs.acs.org/doi/abs/10.1021/es5040156
[5] Determining Bleed Rates for Pneumatic Devices in British Columbia; Final Report. The Prasino Group. 2013, https://www.deslibris.ca/ID/240635
[6] Subpart W rulemaking and summary results https://www.law.cornell.edu/cfr/text/40/part-98/subpart-W/appendix-TableW-1A from GRI/EPA Study 1996, Volume 13: Chemical Injection Pumps
[7] Natural gas STAR – Lessons learned, *Option For Reducing Methane Emissions From Pneumatic Devices In The Natural Gas Industry – Appendix A,* https://www.epa.gov/sites/production/files/2016-06/documents/ll_pneumatics.pdf

Activity data collection should be conducted based on the data required by the selected emission factor provided by the manufacturer. In the example presented above, data on the number of controllers or pumps of each brand and model.

Level 4 Quantification Methodologies

Direct measurement and Measurement-based Emission factors

Measurements (including continuous or periodic monitoring) or emission factors developed based on representative measured emissions are considered Level 4 emissions quantification. Measurements must be taken that represent the total flow of whole gas and associated methane content of each gas stream that is vented to atmosphere. Methane content can be determined based on accepted technologies and methodologies, as described in the *General Principles TGD*.

Direct measurement should start with an engineering analysis (field observation) of pneumatic control loop, pump or instrument to determine how the control loop operates and where the bleed or vent emissions occur. This allows measurement points to be accurately identified and measurements to completely capture a device's methane emissions. An infrared red camera can also allow to visualize emissions and determine more precisely where measurements should be taken. A unit or station isolation valve and chemical injection pump typically vents methane locally and has no other equipment associated with its emissions.

Accepted measurement equipment and techniques, as defined in the *General Principles TGD,* for determining gas flow from controllers, pumps and instruments are to be employed. Following is a non-exhaustive list of such measurement solutions[8] [9]:

- Direct measurement by upstream flow meter in the supply gas line
- High flow sampler
- Calibrated vent bag
- Recording turbine meter or ePV meter
- Positive displacement diaphragm meter.

It is suggested that measurements encompass multiple valve cycles, at least 15 minutes for controllers, or, in the case of pneumatic chemical injection pump, it is suggested that the measurement of the volume of gas emitted lasts long enough to include several cycles of pumping strokes. For pneumatic/hydraulic and turbine valve operators, measurements should be made on both the opening and closing cycles.

Level 4 emissions quantification can also be based on measurements conducted on a representative sample. System configurations, environmental and operating conditions (e.g. type, brand, model, supply gas pressure) should be considered in determining 'like' systems that carry common emission factors. Each system that is not 'like' will require determination of a separate value for that system, based on the appropriate measurement studies. For guidelines on the methodology to develop a statistically representative sample, please refer to the [*Uncertainty and reconciliation guidance].*

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[8] More details on various detection and measurement equipment can be found at CCAC, *Conduction Emissions Surveys, Including Emission Detection and Quantification Equipment – Appendix A of the OGMP Technical Guidance Document,* 2017

[9] More details on various detection and measurement equipment can be found at Methane Guiding Principles, *Reducing Methane Emissions: Best Practice Guide – Identification, Detection, Measurement and Quantification.* 2020

Engineering calculations

Engineering calculations can also be used to quantify emissions at Level 4 for intermittent vent controllers and pneumatic/hydraulic operators on unit and station isolation valves.

For example, intermittent vent controllers in on/off service (i.e. snap-acting controls or dump-valves) vent the same volume of gas every time the device shifts from “on” to “off. This volume per actuation (Vol_a) can be calculated by

$$Vol_a = \left(\frac{\pi}{4} ID_{pipe}^2 * L_{pipe} + \Delta Vol_i\right) * \left(\frac{P_{control} + P_{atm}}{P_{std}}\right) \qquad E_i = N_a * Vol_a$$

Vol_a = Volume per actuation (scm/scf)

ID_{pipe} = Inside diameter of piping (m/ft)

ΔVol_i = The change in the physical volume of a pneumatic valve actuator when changed from at rest to fully actuated, or change in hydraulic oil vessels for pneumatic valve operators (scm/scf)

P_{atm} = Local atmospheric pressure (kPaa/psia)

$P_{control}$ = Pressure of the supply gas system (kPag/psig)

P_{std} = Pressure designated by proper authority to represent the standard pressure to be used for aggregating volumes (kPaa/psia)

E_i = Annual emissions from an intermittent vent controller

N_a = Estimated number of actuations per device per year

This approach requires a count of the number of actuations for each device per year in order to calculate annual emissions. Therefore, an estimated number of actuations per year can be developed employing onsite knowledge. If the process is highly variable or cyclic throughout the year, estimation of the number of actuations per year can be inaccurate. Throttling intermittent controllers may not lend themselves to engineering estimates presented above as the bonnet volume partial displacement and the frequency of actuation are both highly variable.

Another example of calculation which can be used to quantify the emissions of an pneumatic valve, relying on inner valve volume is:

$$E_v = Vol_{int} * P_{valve} * N_A$$

E_v = Annual emissions from pneumatic valve at atmospheric pressure (sm^3)

Vol_{int} = Inner volume of the valve (m^3)

P_{valve} = Pressure at the valve (bars)

N_a = Number of actuations per device per year

The methane content of the vented gas should be measured. This can be done through sampling and analysis of the vented gas. As defined in the *General Principles TGD,* in cases where the methane content can be assumed to meet a regulated specification (e.g. underground gas storage, gas transmission, gas distribution and LNG terminals), the gas specification compositions may be applied[10].

[10] For example, within the EU, regulated specifications and quality standards may be applied