Estimating Venting and Fugitive Emissions

Guideline PNG035

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1. Introduction

The Saskatchewan Ministry of Energy and Resources (ER) has updated the definitions of fuel gas, flare gas and vent gas effective January 1, 2020 for measurement and reporting in *Directive PNG017: Measurement Requirements for Oil and Gas Operations* (Directive PNG017). These changes affect how fuel gas, flare gas and vent gas are categorized and how the volumes are reported. This Guideline has been created to aid industry in estimating and reporting vent gas, which includes estimating and reporting fugitive emissions. All operators in Saskatchewan are subject to these new fuel gas, flare gas and vent gas definitions and are required to measure and report according to Directive PNG017.

2. Vent Gas

Vent Gas is defined in Directive PNG017 "as uncombusted gas that is released to the atmosphere at upstream oil and gas operations". The vent gas volume must be measured either by estimating or metering depending on the volumes as per Directive PNG017.

2.1 Reporting Vent Gas to Petrinex

As per *Directive PNG032: Volumetric, Valuation and Infrastructure Reporting in Petrinex* (Directive PNG032), an operator must submit VENT to report the volume of gas vented during well or facility operations. The operator of the facility must identify where the vent occurred by entering the linked well completion ID, compressor station (CS) facility ID, oil satellite facility ID, or the reporting facility ID.

Operators can use the following decision tree to determine where the volumes need to be reported in Petrinex. See Figure 1 on the following page.

Figure 1: Decision Tree for reporting vent gas to Petrinex

3. Fugitive Emissions

Fugitive Emissions are defined in Directive PNG017 as an “unintentional release of hydrocarbons to the atmosphere”. As per Directive PNG017, fugitive emissions when they are discovered must be estimated and reported as VENT.

Emissions from tanks with control equipment installed (controlled tanks) are considered fugitive emissions and must be reported as VENT as per Directive PNG017. For example, continuous emissions from a faulty thief hatch seal, improperly sealed thief hatch, or open thief hatch outside of the time needed for pressure relief are all considered fugitive emissions and as per Directive PNG017 must be estimated and reported as vent gas.

Vent gas rates for fugitive emissions may be determined following the guidance outlined in Section 4. ER acknowledges that new publications with updated average vent gas rates for fugitive emissions will become available over time, and the use of available up-to-date information is encouraged.

4. Estimating Vent Gas and Fugitive Emissions

Unless otherwise required to meter or test as per Directive PNG017, vent gas may be estimated using vent gas factors or rates, the equations included within this document, or engineering estimates as described in the report Canada (2016) in Appendix 1.

Site- and equipment-specific data should be used when quantifying vent gas. While not a requirement, continuous direct measurement or periodic testing of individual vent gas sources is encouraged where possible and where these solutions would result in more accurate reporting of vent gas than the methods discussed in this document.

Vent gas rates are commonly used to estimate a volume of vent gas over a specified unit of time. Vent gas rates are referenced throughout this document for individual components, equipment, or processes. They are generally expressed as a volumetric vent gas rate per unit of time, actuation, or event.

The subsections within Section 4 breakdown types of venting by equipment type. Not all of these subsections are applicable for every facility for every production month. There may be occasions when gas is being vented at some equipment, for some months, but not others. For example, gas is always being vented from a storage tank and should be reported as vent gas unless the gas is collected from the storage tanks with the use of a Vapour Recovery Unit (VRU) and is flared or sent to another facility. Water tanks should not emit hydrocarbons, and detected emissions are indicative of unintended natural gas carry-through from the upstream vessel. Emissions from water tanks must be reported as VENT as per Directive PNG017. However, equipment used to control vent gas, including flares and vapour recovery units (VRUs) can experience periods of inactivity due to maintenance, power outages, low flow rates, or facility shut downs. When a control device is inactive, the uncontrolled vent gas volumes are considered to be “upset” vent gas volumes and must be attributed to vent gas volumes and reported as VENT as per Directive PNG017.

4.1 Gas Venting Calculations

4.1.1 Storage Tank Venting

This section provides guidance for vents off tanks. Liquids stored in uncontrolled tanks (without vapour recovery units or vapour destruction) can be a source of vent gas through flashing, breathing losses, and working losses.

Vent gas from uncontrolled, open atmospheric tanks that arise due to the processes described in the following subsections should be estimated based on best available information and the methods described below and reported as VENT on a monthly basis to Petrinex.

Vent gas from controlled tanks that arise due to maintenance or periodic, planned, or unplanned shutdowns of vapour recovery or vapour destruction systems should be determined by engineering estimates and reported as VENT on a monthly basis to Petrinex.

Vent gas from controlled tanks that arise due to stuck or malfunctioning thief hatches or failures of equivalent pressure-management devices should be determined by engineering estimates and reported as VENT on a monthly basis to Petrinex. These are considered fugitive emissions.

Vent gas may be emitted from tank vents when pneumatic level controllers upstream of the tank malfunction. This may entrain undesired gas volumes in liquid flow lines to tanks, which may then be vented through tank vents (i.e. gas carry-through). If detected, these abnormal process vent gas should be determined by engineering estimates and reported as VENT on a monthly basis to Petrinex. These are considered fugitive emissions.

Fixed-roof tanks are the primary equipment for storing hydrocarbon liquids (oil and condensate) in the upstream oil and gas industry. If a tank is equipped with a vapour collection system, there is still potential for some vent gas due to potential inefficiencies of the vapour collection system (e.g. overloading of the system due to inadequate sizing for peak vent gas rates, down time of the end control device, fouling of the vapour collection piping, etc.). Additionally, tanks connected to vapour collection systems can be a source of fugitive equipment leaks (mostly due to leakage around the thief hatch or level gauge seal).

Venting from fixed-roof tanks includes contributions from the following:

- flashing losses;
- breathing losses;
- working losses; and
- blanket gas losses

For quantification of produced gas, if a gas-in-solution (GIS) factor is determined that represents the vented gas volumes, it may be used. For sites configured with multiple pressure drops, commingled streams, or other liquids processing reportable vent volumes may not equate well to GIS factors determined for production measurement requirements. In these cases, other methods for estimating vent volumes are provided below for each of the types of losses: flashing, breathing, and working.

4.1.1.1 Flashing Losses

Flashing may occur when liquids with dissolved gases that have a vapour pressure greater than local barometric pressure are produced into vented storage tanks. When the liquid first enters a tank, a rapid boiling or flashing process occurs as the liquid tends towards a more stable state and the volatile components vapourize. The dissolved gas that flashes out of the liquid is called GIS. A GIS factor is given in Equation 1.

$$V_{GIS} = V_{liq} \times GIS \qquad (1)$$

V_{GIS} GIS venting in a month (m³)
GIS GIS factor for the stored hydrocarbon product (m³ of gas/m³ of oil) where gas volumes are presented on a dry basis at reference conditions 101.325 kPa and 15°C
V_{liq} Monthly volume of liquid hydrocarbon entering the subject tank (m³)

All methods of quantifying vent gas that are listed in Section 4 are acceptable for determining the GIS factor. For estimation methods based on publicly available studies, if the oil can be assumed to be saturated with gas, and conditions are relevant to the dataset used to develop the correlation, a bubble point pressure correlation may be used. Otherwise use estimation methods based on engineering specifications or where appropriate, use the GIS factor “rule of thumb” from Directive PNG017 when applicable.

Bubble-Point Pressure Correlation – Vazquez and Beggs

Repeated analyses of various production oils have been compiled into useful references for estimating the GIS that will evolve from saturated oils as they undergo pressure drop. The Vazquez and Beggs correlation is widely cited as the most accurate and comprehensive. Other correlations include Lasater or Standing correlations but are not referenced here further. Operators may use the Vazquez and Beggs correlation to estimate vent gas from flashing saturated oils to atmospheric pressure in tanks (Vazquez and Beggs 1980).

The Vasquez and Beggs correlation is based on a regression of experimentally determined bubble-point pressures for a variety of crude oil systems. The range of parameters for which the correlation is derived is presented in Table 1. It is accurate to within 10 per cent, more than 85 per cent of the time when input data is in the range of values listed in Table 16.

If a suitable correlation is not available, the Operator may apply other methods to determine vent gas rates described in Section 4 or the GIS factor “rule of thumb” from Directive PNG017 when applicable.

Table 1: Range of data used to develop the
Vasquez & Beggs Correlation (from Vasquez & Beggs 1980)

Parameter	Range
Size of dataset	5008
Bubble pressure, kPa	345 to 36,190
Reservoir temperature, °C	21 to 146
Solution gas-to-oil ratio at bubble point pressure, m³/m³	3.5 to 369
Oil API gravity, °API	16 to 58
Oil Specific gravity, (-)	0.56 to 1.18

4.1.1.2 Breathing and Working Losses

Evaporative losses promoted by daily temperature or barometric pressure changes during the storage of hydrocarbons are known as breathing losses. Evaporative losses during filling and emptying operations are known as working losses and are caused by the displacement of tank vapours during changes in liquid level. Breathing and working losses occur for both stable and unstable products. However, if the product is unstable the latter type of loss is obscured by the flashing losses. Accordingly, storage losses at oil wells or batteries are taken to be the sum of breathing and flashing losses. Storage losses at gas processing plants and pipeline terminals (i.e. facilities storing stable products) are taken to be the sum of breathing and working losses.

Mass emissions of product vapours from tanks (i.e. breathing and working) containing weathered or stabilized hydrocarbon liquids are estimated using the "Evaporative Loss from Fixed-Roof Tanks" algorithms (US EPA 2006).

Blanket gas may be added to a tank's dead space to maintain a safe atmosphere above the liquids. For tanks equipped with a blanket gas system, the volume of blanket gas supplied to a tank is a reasonable analogue for estimating working and breathing losses.

4.1.2 Hydrocarbon Liquid Loading Losses

Tank trucks transport low-vapour-pressure (LVP) products such as crude oil, condensate, and pentanes plus. Vent gas due to the displacement of tank vapours (i.e. evaporated product) can occur during the loading or unloading of these carriers. The volume of vent gas depends on the vapour pressure of the liquid product, the recent loading history and the method of loading. When not metered or when the estimation approaches discussed in Section 4 are not employed, LVP carrier emissions may be quantified using Equation 2.

$$V_{LL} = \frac{SF \times P_v \times T_{std}}{P_{std} \times T_t} \times V_{oil} \qquad (2)$$

V_{LL} volume of gas vented from evaporation losses during LVP product loading in a month (m^3)
SF saturation factor in Table 2 to account for the method of loading (dimensionless)
V_{oil} monthly volume of the VLP product loaded (m^3)
P_{std} standard reference pressure (101.325 kPa)
P_v true vapour pressure of the VLP product (kPa) determined using Equation 3
T_{std} standard reference temperature (288.15 °K)
T_t truck tank operating temperature (°K)

Table 2: Saturation factors for calculating liquid loading losses (from US EPA 2008)

Cargo carrier	Mode of operation	Saturation factor (dimensionless)
Tank trucks and rail tank cars	Submerged loading of a clean cargo tank	0.50
	Submerged loading: dedicated normal service	0.60
	Submerged loading: dedicated vapour balance service	1.00
	Splash loading of a clean cargo tank	1.45
	Splash loading: dedicated normal service	1.45
	Splash loading: dedicated vapour balance service	1.00

The true vapour pressure at bulk liquid temperature may be determined by Equation 3.

$$P_v = 6.8929\, exp\left[\left(\frac{1555}{T} - 2.227\right)(log_{10}(RVP) - 0.8384) - \frac{4033.89}{T} + 12.82\right] \tag{3}$$

RVP Reid vapour pressure of liquid (kPa) (if site specific liquid properties are not known, typical values presented in Table 3 may be applied)
T average liquid temperature (K)

Typical properties that may be used for the above equation is presented in Table 3.

Table 3: Typical properties for liquid products

Liquid product	Oil specific gravity	Reid vapour pressure (kPa)	Vapour molecular weight (kg/kmole)
Condensate	0.7150	76.6	28.2
Light/medium crude oil	0.8315	54.8	44.2
Heavy crude oil	0.9153	40.5	19.9
Thermal crude oil	0.9153	40.5	30.6
Cold bitumen	0.9282	39.7	23.3

4.1.3 Online Gas Analyzer Purge Vents

Process analyzers are used to monitor gas quality and ensure that desired process or pipeline quality specifications are achieved. They include analyzers to measure for H_2S, H_2O, O_2/CO_2, hydrocarbon dew point, and natural gas composition. More than 85 per cent of venting gas from this source is related to the use of bypass or fast-response purge gas loops. When not metered, the estimation approaches discussed in Section 4 may be used. If using an average vent gas rate, a value of 68.9 m^3 vent gas/month (CEPEI 2018) may be used for each analyzer.

4.1.4 Solid Desiccant Dehydrators

Solid desiccant dehydrators consist of at least two vessels that operate in a cyclical manner alternating between drying and regeneration. Gas is vented each time the vessel is depressurized (or “blown down”) for desiccant refilling. When not metered or when the estimation approaches discussed in Section 4 are not employed, the desiccant dehydrator blowdown volume may be estimated using Equation 4.

$$V_{DD} = \left(\frac{H \times D^2 \times \pi \times P_2 \times G}{4 \times P_1}\right) \times f \tag{4}$$

V_{DD} volume of desiccant dehydrator vent gas in a month (m^3)
H height of the dehydrator vessel (m)
D diameter of the dehydrator vessel (m)
P_2 pressure of the gas (kPa [g])
P_1 atmospheric pressure (kPa [a])
G fraction of the vessel that is filled with gas (dimensionless)
f frequency of refilling (cycles per month)

4.1.5 Pig Trap Openings and Purges

Pigging operations require a pig trap to be depressurized, opened, loaded, purged and re-pressurized.

Vent gas volumes from pig traps may be metered or estimated using one of the approaches discussed in Section 4, or quantified using the following equations. Actual process conditions before each blowdown event should be used when calculating vent gas. Equation 5 is used if the equipment volume is depressurized but not purged with gas prior to re-pressurization and all gas is vented to atmosphere.

$$V_{PT} = \sum_{i=1}^{N} V_v \left[\frac{(273.15 + T_S)(P_{a,1} - P_{a,2})}{(273.15 + T_a)P_s}\right]_i \qquad (5)$$

Equation 6 is used if the equipment volume is depressurized and purged with gas before re-pressurization and all purge gas is vented to atmosphere.

$$V_{PT} = \sum_{i=1}^{N} V_v \left[\frac{(273.15 + T_s)(P_{a,1} - P_{a,2})}{(273.15 + T_a)P_s} + M\right]_i \qquad (6)$$

V_{PT} volume of natural gas vented by the subject vessel or pipe due to blowdowns or depressurization in a month (m^3);
V_v total physical volume (m^3) of equipment chambers between isolation valves being depressurized (including pig traps, pipes, compressors, and vessels);
T_s temperature 15°C at standard conditions (°C);
T_a initial temperature of gas at actual conditions in the equipment system (°C) before depressurization;
P_s absolute pressure 101.325 kPa(a) at standard conditions (kPa[a]);
$P_{a,1}$ gauge pressure at actual conditions in the equipment system (kPa[g]) before depressurization;
$P_{a,2}$ gauge pressure at actual conditions in the equipment system after depressurization; 0 if equipment is purged upon depressurization using inert gas (kPa[g]);
N number of blowdown events for the subject month and vessel;
M number of purges for the subject blowdown event

4.1.6 Pneumatic Devices

Pneumatic devices include instruments and pumps that are used to provide control or pumping functions and require a supply of pneumatic gas that is commonly vented, including the following:

- Transducers;
- Pressure controllers and regulators;
- Positioners;
- Level controllers; and
- Corrosion inhibitor or hydrate inhibitor (methanol) injection pumps

Operators must calculate and record pneumatics vent gas per site per month as per Directive PNG017. Pneumatic vent gas volume is reported as part of VENT to Petrinex.

If after an inspection the vent gas rates are higher than first reported the operator must start reporting the higher volumes as per Directive PNG017.

If not metered, vent gas emitted from pneumatic devices is calculated using Equation 12, where the vent gas rate used is specific to the make, model, and operating conditions of the instrument or pump (m^3 vent gas/hour) and time use is number of hours the device was in operation each month (hours/month).

If direct measurement or testing is completed on pneumatic devices, refer to Alberta (2017) in Appendix 1 for field vent rate sampling guidance. The following sections for pneumatic instruments and pumps include examples of average vent gas rates and manufacturer-specified vent rates. ER acknowledges that new publications with updated average vent gas rates for pneumatic devices will become available over time and the use of more accurate information as it becomes available is encouraged.

4.1.6.1 Pneumatic Instruments

For pneumatic instruments where the supply pressure is known, the average vent gas rate is calculated using Equation 7.

$$ER_i = m \times SP \qquad (7)$$

ER_i	the average vent gas rate specific to the make, model, and operating conditions of the instrument (m^3 vent gas/hour)
m	supply pressure coefficient for the specific make and model of pump from Table 4 (m^3/hr/kPa gauge)
SP	supply pressure to the instrument (kPa gauge)

Table 4: Pneumatic instrument average vent gas rates (from Prasino 2013)

Type	Manufacturer and model	Supply pressure coefficient
Pressure controllers	Fisher 4150	0.0019
	Fisher 4160	
	CVS 4150	
	CVS 4160	
	Fisher C1	0.0003
Level controllers	Fisher 2500	0.0011
	Fisher 2680	0.0014
	Murphy L1200	0.0012
	Murphy L1100	
Positioners	Fisher FIELDVUE™ DVC 6000	0.0011
	Fisher FIELDVUE™ DVC 6010	
	Fisher FIELDVUE™ DVC 6020	
	Fisher FIELDVUE™ DVC 6030	
Transducers	Fisher 546	0.0017
	Fairchild TXI 7800	0.0009
	Fairchild TXI 7850	
	Fisher i2P-100 (1st generation)	0.0009

For pneumatic instruments where average vent gas rates from publicly available studies are used and the supply pressure is unknown, Table 5 has been prepared as a combination of average vent gas rates from multiple sources.

Table 5: Pneumatic instrument average vent gas rates*

Type	Manufacturer and model	Published average sampled vent rate (m^3 vent gas/hr)
Pressure controllers	Fisher 4150	0.4209
	Fisher 4160	
	CVS 4150	
	CVS 4160	
	Fisher 4660	0.0151
	Fisher C1	0.0649
Level controllers	Fisher 2500	0.3967
	Fisher 2680	0.2679
	Fisher 2900	0.1447
	Murphy L1200	0.2619
	Murphy L1100	
	SOR 1530	0.0531
	Fisher L2 actuating 0-15 mins	0.75
	Fisher L2 actuating > 15 mins	0.19
	Fisher L2 (improved low vent relay)	0.10
	Norriseal 1001	0.193
	Norriseal 1001A	
Positioners	Fisher FIELDVUE™ DVC 6000	0.2649
	Fisher FIELDVUE™ DVC 6010	
	Fisher FIELDVUE™ DVC 6020	
	Fisher FIELDVUE™ DVC 6030	
Temperature controllers	Kimray HT	0.0351
Transducers	Fisher 546	0.3547
	Fairchild TXI 7800	0.1543
	Fairchild TXI 7850	
	Fisher i2P-100 (1st generation)	0.2157

*References include Prasino (2013), Spartan Controls (2018), and Greenpath (2018).

If a particular pneumatic instrument is not listed in either of these tables, use manufacturer-specified vent gas rates. Manufacturer-specified vent gas rates should be chosen to represent the operating conditions (supply pressure, configuration) of the instrument or if the operating conditions are unknown then use the highest vent gas rate available. Some rates from manufacturers are included in Table 5.

In some situations, with very old equipment the make and model of the pneumatic instrument may not be available. In case the make and model cannot be determined by visual examination of the instrument, the generic vent gas rates in Table 6 may be used.

Table 6: Generic vent gas rates for pneumatic instruments if make and model are unavailable (from AER 2018b)

Type of pneumatic instrument	Vent gas rate (m^3 vent gas/hr)
Level controller	0.3508
Positioner	0.2627
Pressure controller	0.3217
Transducer	0.2335
Generic pneumatic instrument	0.3206

4.1.6.2 Pneumatic Pumps

Table 7 has been taken from Prasino 2013 and can be used with Equation 8 to determine pneumatic pump average vent gas rates when the supply pressure, discharge pressure, and strokes per minute are available. The average vent gas rate for pneumatic pumps is calculated using Equation 8.

$$ER_P = (g \times SP) + (n \times DP) + (p \times SPM) \qquad (8)$$

- ER_P the average vent gas rate specific to the make, model, and operating conditions of the pump (m^3 vent gas/hour)
- g supply pressure coefficient for the specific make and model of pump, from Table 7 (m^3/hr/kPa gauge)
- SP supply pressure of the pump (kPa gauge)
- n discharge pressure coefficient for the specific make and model of pump, from Table 7 (m^3/hr/kPa gauge)
- DP discharge pressure of the pump (kPa gauge)
- p strokes per minute coefficient for the specific make and model of pump, from Table 7 (m^3/hr/stroke per minute)
- SPM the strokes per minute of the pump (strokes/minute)

Table 7: Coefficients for determining pneumatic pump vent gas rates (from Prasino 2013)

Pump type	Supply pressure coefficient (g)	Injection pressure coefficient (n)	Strokes per minute coefficient (p)
Diaphragm	0.00202	0.000059	0.0167
Piston	0.00500	0.000027	0.0091
Morgran HD312	0.00418	0.000034	0.0073
Texsteam 5100	0.00030	0.000034	0.0207
Williams P125	0.00019	0.000024	0.0076
Williams P250	0.00096	0.000042	0.0079
Williams P500	0.00224	-0.000031	0.0046

If the operating conditions are not known, Table 8 may be used to determine average vent gas rates.

Table 8: Vent gas rates for pneumatic pumps if operating conditions are unavailable (from Prasino 2013)

Type of pump	Vent gas rate (m^3 vent gas/hr)
Morgan HD312	1.1292
Texsteam 5100	0.9670
Williams P125	0.4098
Williams P250	0.8022
Williams P500	0.6969

Pneumatic pump manufacturers commonly publish charts and graphs in product brochures that can be used to determine the air or gas consumption for each make and model of pump and for a variety of operating conditions. The following method (Equations 9 and 10) was derived from multiple manufacturer brochures to simplify the process of determining vent gas rates from manufacturer brochures. Operator may choose to use the following equations or to determine pneumatic pump vent gas rates directly from manufacturer-specified material.

$$V_{PP} = ER_{PM} \times L \qquad (9)$$

VPP volume of vent gas from pneumatic pumps at a site in a month (m^3)
ER_{PM} vent gas rate of gas-driven pneumatic pumps, shown in Equation 10 (m^3 vent gas/litre/pump)
L monthly volume of liquid injected by the pump (litres)

$$ER_{PM} = (P_2 \times CIP^2) + (P_1 \times CIP) + P_0 \qquad (10)$$

CIP chemical injection pressure (kPa gauge)
P_2 P_2 coefficient, provided in Table 15 (dimensionless)
P_1 P_1 coefficient, provided in Table 15 (dimensionless)
P_0 P_0 coefficient, provided in Table 15 (dimensionless)

If the preceding options are not available because the make and model of the pneumatic pump are unknown, the vent gas rates for generic devices shown in Table 9 can be used.

Table 9: Vent gas rates for pneumatic pumps if operating conditions are unavailable (from Prasino 2013)

Type of pump	Vent gas rate (m^3 vent pump gas/hr)
Generic piston pump	0.5917
Generic diaphragm pump	1.0542

4.1.7 Reciprocating and Centrifugal Compressors

Reciprocating and centrifugal compressor types have seals that vent gas as part of normal operation. Gas vented to the atmosphere should be quantified according to this section. Operators must calculate and record compressor seal vent gas per site per month as per Directive PNG017 and reported to Petrinex as per Directive PNG032.

4.1.7.1 Reciprocating Compressors

Vent gas from a reciprocating compressor seal (RCS) occurs as part of normal operation when the process gas in the cylinder head migrates through the piston-rod packing and into piston-rod-packing vent and drain, distance piece vent and drain, or the compressor crankcase vent. Vent gas from reciprocating compressors whose distance piece vent and drains and piston-rod packing vent and drains are tied to a control device are not required to test their vents, and vent gas from the compressor crank case in this circumstance is considered fugitive emissions.

Vent gas from reciprocating compressors is calculated using Equation 12, where the vent gas rate is from RCS for a given reciprocating compressor (m^3 vent gas/hour) and the time is the pressurized hours in a month for a reciprocating compressor (hours).

To determine the vent gas rate from an RCS based on periodic testing, the rate is calculated from all the throws of the unit and all potential venting paths. RCS vent and drain systems can be piped in a variety of ways.

If a compressor piston-rod packing is replaced on one throw of an RCS after a test is completed, venting from that throw can be estimated by following the guidance outlined in Section 4. If an average vent gas rate is used, a value of 0.16 m^3 vent gas per hour per throw (from Accurata 2018) can be used until the next test is completed. This value was chosen as it is assumed that a new seal performs similarly to the lowest 25 per cent of measurements analyzed within the Accurata study.

Before the first test is completed, vent gas rates can be estimated by following the guidance outlined in Section 4. If an average vent gas rate is used, a value of 1.28 m^3 vent gas per hour per throw (adapted from Accurata 2018) can be used until the first test is completed. This value is the mean vent gas rate of reciprocating compressors that were analyzed within the Accurata study.

4.1.7.2 Centrifugal Compressors

Vent gas from centrifugal compressor seals occurs as part of normal operation when the process gas migrates through the seal at the drive shaft and compressor case interface. Centrifugal compressors have seals that are either wet or dry. Equation 12 may be used to estimate centrifugal compressor seal vents, where the vent gas rate is from a centrifugal compressor seal (m^3 vent gas/hour) and time is pressurized hours in a month for a centrifugal compressor (hours).

To determine the vent gas rate from a centrifugal compressor based on periodic testing, the rate is calculated from all potential venting paths from the unit.

If a centrifugal compressor seal is replaced after a test is completed, venting from that seal can be estimated by following the guidance outlined in Section 4. If an average vent gas rate is used, a value of 1.27 m^3 vent as per hour per unit (developed from Accurata 2018) can be used until the next test is completed.

4.1.8 Glycol Dehydrators

Glycol dehydrators use circulating glycol at varying pressures and temperatures to absorb moisture from process gas and release it, along with other absorbed chemicals in a reboiler. Glycol dehydrator vent gas includes the following:

- Glycol dehydrators flash tank vents, and reboiler still column vents (including glycol regenerators operating as refrigeration units); and
- Gas vent resulting from the use of energy exchange pumps that pump glycol in glycol dehydrators

Glycol dehydrator vent gas is determined by using *Guideline S-18: Guideline to Reduce Benzene Emissions from Glycol Dehydrators*. Vent gas volumes from glycol dehydrators are included in the monthly reporting of vent gas to Petrinex.

4.1.9 Blowdowns

Blowdown venting for planned or emergency depressurization (e.g. emergency shutdown [ESD] events) or to take equipment out of service for maintenance is estimated using guidance in Section 4 or Equations 5 and 6.

Continuous gas loss observed from a blowdown vent stack indicates an equipment leak that should be quantified according to Section 4.2.6, "Fugitive Emissions."

4.1.10 Well Testing, Completions, and Workovers

Vent gas volumes from well testing, completions, or workovers must be measured and reported monthly as vent gas into Petrinex as per Directive PNG017 and Directive PNG032.

4.1.11 Well Venting for Liquids Unloading

Some gas wells have an accumulation of liquids and require liquids unloading in order to maintain production. During this process, vent gas is either tied into a sales line, flared, or vented. When not metered or when the estimation approaches discussed in Section 4 are not employed, the monthly volume released for each subject well may be estimated using Equation 11 (adapted from WCI 2011).

$$V_{WLU} = \sum_{i=1}^{N} \left[\left(7.854 \times 10^{-5} \times D_t^2 \times WD \times \left[\frac{P_{shut-in}}{101.325} \right] \right) + \left(Q_{sfr} \times t_{open} \right) \right]_i \quad (11)$$

V_{WLU}	volume of gas vented from liquids unloading at standard reference conditions (m^3)
D_t	casing inside diameter (cm)
WD	well depth (m)
$P_{shut-in}$	well shut-in pressure (kPa[g])
Q_{sfr}	maximum monthly production rate as observed over the last 12 months from production records at standard conditions (m^3/hr)
t_{open}	hours that the well was left open with natural gas flowing to the atmosphere; periods when the well was blocked or when inert gas (such as nitrogen) dominated the flowback composition should not be included (hr)

N number of unloading events for the well each month

4.1.12 Engine or Turbine Starts

Pneumatic starters are widely used to start reciprocating engines or turbines. Specific starting gas requirements will vary according to the pressure of the start gas, the condition of the engine or turbine, the size of the compressor or generator that is being driven, the number of starters installed, the start duration, ambient air temperature, oil viscosity, fuel type and design cranking speed. When not metered, the estimation approaches discussed in Section 4 may be used. If using a manufacturer-specified vent gas rate, Equation 12 can be used.

$$V = ER \times t \qquad (12)$$

V volume of vent gas from engine and turbine start sources released from a site in a month (m^3)
ER vent gas rate for the device from Tables 12 or 13 (m^3 vent gas/min or m^3 vent gas/hour)
t amount of time in each month the starter is in use (min or hour)

4.1.13 Other Vent Gas Sources

Any vent gas sources not described in the sections above should be determined using guidance in Section 4 or through engineering estimates and reported. The volume of venting must be measured and reported as per Directive PNG017 and Directive PNG032.

Table 10: Other sources

Type of pneumatic instrument	Emission rate (m^3 vent gas/hr)
Level controller	0.3508
Positioner	0.2627
Pressure controller	0.3217
Transducer	0.2335
Generic pneumatic instrument	0.3206

4.1.14 Determining Fugitive Emission Volumes

Vent gas rates for fugitive emissions may be determined following the guidance outlined in Section 4 or through quantification methods listed in this section. Direct measurement options may include calibration bags, high flow sampler, tracer techniques or other commercially available quantification methods. Alternatively, fugitive emission leak factors in Table 18 may be used to estimate vent gas from leaks detected but not metered. ER acknowledges that new publications with updated average vent gas rates for fugitive emissions will become available over time, and the use of more accurate information as it becomes available is encouraged.

Vent gas from abnormal process fugitive emissions are commonly linked to hydrocarbon storage tanks. The following lists other examples of abnormal process vents:

- Unlit flares (ignitors and pilots);

- Malfunctioning pneumatic instruments (e.g. level controller venting excessively in its static-state due to controller almost calling for a dump but not enough liquid present in the separator);
- Conservation units out of operation when they are expected to be in operation (such as vapour recovery units that are not running); and
- Emissions occurring from equipment components located upstream of equipment that is actively controlling vent gas.

Abnormal process fugitive emissions should be directly measured or determined through engineering estimates.

Table 11: Fugitive emission detection and quantification methods

<table>
<tr><th>Detection method</th><th>Quantification method</th></tr>
<tr><td>Direct measurement of the whole facility</td><td>The total quantified volume minus the estimated vent gas volume for the site</td></tr>
<tr><td>Surveys completed using a gas imaging infrared camera

Or

Screenings using audio, visual, or olfactory methods; soap solution; or other methods capable of detecting fugitive emissions</td><td>Leaking components:
Directly measured
Estimated using leaker rates as per Alberta Energy Regulator (AER) Manual 015 (AER 2018) Section 4.7.2
Abnormal process conditions:
Determined using engineering estimates
Surface casing vent flow/gas migration (SCVF/GM) quantified and reported as ID 2003-01</td></tr>
<tr><td>Surveys completed using organic vapour analyzers in accordance with EPA's Method 21 (US EPA 2017)</td><td>Leaking components:
Directly measured
Estimated using published vent gas rates
Three-stratum vent gas rates
Published leak-rate correlation
Unit-specific leak-rate correlation
Leaker rates as per AER 2018 Section 4.7.2
Abnormal process conditions:
Determined using engineering estimates
SCVF/GM quantified and reported as per ID 2003-01</td></tr>
</table>

Fugitive emissions from leaking components that are identified through qualitative means (soap test, OGI camera, etc.) are estimated using Equation 12, where the emission rate is for a leaking component (m^3 vent gas/hour) and the time of duration of the leak (hours).

As per Directive PNG017, the duration of the fugitive emission is determined from the date found to the date repaired. If the date repaired is not within the production month that is being reported, then the last day of the month is when the fugitive emission is calculated to. For example, if the fugitive emission was found on January 1^{st} but not repaired until February 10^{th} of the next month then the duration of the fugitive emission is 31 days. In February the duration of the fugitive emission would be 10 days.

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Appendix 2: Tables of Vent Gas Rates

Table 12: Pneumatic starter natural gas consumption rate for turbines

Turbine		Pneumatic starter		Supply Pressure (kPag)	Natural gas consumption rate	
Manufacturer	**Model**	**Manufacturer**	**Model**		**m^3 vent gas/min**	**m^3 vent gas/hr**
Allison	501-KB	Ingersoll Rand	TS799B	1034	80	4822
	501-KC	Tech Development	56K (low pressure)	345	33	1954
			56K (standard pressure)	621	55	3288
	570	Ingersoll Rand	TS766G	621	51	3068
Dresser Clark	DC990	Tech Development	56B (low pressure)	345	36	1954
			56B (standard pressure)	1034	86	5172
Dresser-Rand	DR990	Tech Development	56B (low pressure)	345	36	1954
	DJ50		56B (standard pressure)	1034	86	5172
Garrett	IE831	Ingersoll Rand	TS999G	621	47	2849
General Electric	LM500	Tech Development	56G (low pressure)	345	33	1954
	LM1000		56G (standard pressure)	1034	86	5172
	LM1600					
	LM2500					
	LM5000					
	LM6000					
Pratt & Whitney	GG3/F13	Ingersoll Rand	TS799B	1034	80	4822
	GG4/G14					
	GG3	Tech Development	56A (low pressure)	345	33	1954
	GG4					
	FT4		56A (standard pressure)	1034	86	5172
	FT8					
Rolls Royce	AVON	Tech Development	56A (low pressure)	345	33	1954
	SPEY		56A (standard pressure)	1034	86	5172
Solar Turbines	Saturn 20	Ingersoll Rand	TS725	1551	27	1644
			TS750	1034	44	2652
		Tech Development	56S	1034	29	1725
	Centaur 40	Ingersoll Rand	TS1401-102	1551	62	3726

Turbine		Pneumatic starter		Supply Pressure (kPag)	Natural gas consumption rate	
Manufacturer	**Model**	**Manufacturer**	**Model**		**m³ vent gas/min**	**m³ vent gas/hr**
	Centaur 50		TS1435	1551	69	4164
	Taurus 60		TS1450	1034	91	5479
	Taurus 65	Tech Development	T100C	1034	64	3844
	Taurus 70					
	Mars 90	Recommended by Solar Turbines		2758	127	7620
	Mars 100					

* Consumption rates are from manufacturer specifications. Vendors typically assume compressed air is used as the working medium when reporting flow rate requirements. Thus, air consumption rates have been multiplied by 1.29 for equivalent natural gas consumption rates.

Table 13: Pneumatic starter natural gas consumption rate for reciprocating engines

Reciprocating engine		Pneumatic starter		Supply Pressure (kPag)	Natural gas consumption rate	
Manufacturer	**Model**	**Manufacturer**	**Model**		**m³ vent gas/min**	**m³ vent gas/hr**
Caterpillar	G3406	Austart	ATS63	1034	16	964
	G342	Austart	ATS73	1034	22	1293
	G379					
	G3412					
	G399	Austart	ATS83	1034	22	1293
	G3612	Austart	ATS93	1034	48	2871
	G3616					
	G3616	Austart	ATS103	1034	56	3353
	G-342	Ingersoll Rand	150BM	1034	25	1490
	G3516	Ingersoll Rand	ST599	1034	45	2718
			ST950	1034	47	2849
	G3616	Ingersoll Rand	ST950	1034	47	2849
	G3612	Ingersoll Rand	SS815	1034	62	3726
	G3616					
	G-398					
	G-399					
	G3406	Tech Development	T3506-I	827	17	1048
	G3408					
	G3408C					
	G3606	Tech Development	T112-V	1034	54	3226
	G3608		T121-V	621	59	3520
	G3612					
	G3616					
	C280					
Cooper Ajax	DPC-140	Austart	ATS73	1034	22	1293
	DPC-180					

Reciprocating engine		Pneumatic starter		Supply Pressure (kPag)	Natural gas consumption rate	
Manufacturer	Model	Manufacturer	Model		m^3 vent gas/min	m^3 vent gas/hr
	DPC-360 DPC-600	Austart	ATS83	1034	22	1293
	DP-125 DP-165 DPC-180 DPC-60	Ingersoll Rand	150BM	1034	25	1490
	DPC-280 DPC-230 DPC-250 DPC-325 DPC-360 DPC-600 DPC-800	Tech Development	T112-B	621	57	3419
			T121-B	1034	5	298
Cooper Bessemer	GMX	Austart	ATS93	1034	48	2871
	GMSC		ATS103	1034	56	3535
	10W330 12V-250 GMVA GMVW MVWC GMXF	Ingersoll Rand	ST950	1034	47	2849
	GMXE GMXF GMXH	Ingersoll Rand	SS850	1034	47	2794
Cooper Superior	6G-825 8G-825 8GT	Austart	ATS83	1034	22	1293
	12SGT 16SGY	Austart	ATS93	1034	48	2871
	825 Series 1700 Series 2400 Series	Tech Development	T112-V	1034	54	3226
			T121-V	621	59	3520
Dresser-Rand	512KV PSVG-12	Ingersoll Rand	ST950	1034	47	2849
Int Harvester	RD372 RD450	Ingersoll Rand	3BMG	1034	12	712
Wartsila	34SG	Ingersoll Rand	ST775	1034	47	2849
Waukesha	H24L	Austart	ATS73	1034	22	1293
	5790 7042 8LAT27G	Austart	ATS83	1034	22	1293
	P9390G	Austart	ATS93	1034	48	2871

Reciprocating engine		Pneumatic starter		Supply Pressure (kPag)	Natural gas consumption rate	
Manufacturer	**Model**	**Manufacturer**	**Model**		**m^3 vent gas/min**	**m^3 vent gas/hr**
	12VAT27G					
	16VAT25G					
	12VAT27G	Austart	ATS103	1034	56	3353
	16VAT25G	Austart	ATS103	1034	56	3353
	16VAT27G	Austart	ATS103	1034	56	3353
	145GZ	Ingersoll Rand	150T	1034	26	1556
	6GAK	Ingersoll Rand	150T	1034	26	1556
	6WAK	Ingersoll Rand	150T	1034	26	1556
	F1197G	Ingersoll Rand	150T	1034	26	1556
	F119G	Ingersoll Rand	150T	1034	26	1556
	H1077G	Ingersoll Rand	150T	1034	26	1556
	H24L	Ingersoll Rand	150T	1034	26	1556
	H867D	Ingersoll Rand	150T	1034	26	1556
	2895G (SI/L)	Ingersoll Rand	ST950	1034	47	2849
	H24GL (D)	Ingersoll Rand	ST950	1034	47	2849
	12VAT25GL	Ingersoll Rand	ST950	1034	47	2849
	16VAT25GL	Ingersoll Rand	ST950	1034	47	2849
	7042 (SI/L)	Ingersoll Rand	ST950	1034	47	2849
	8LAT27GL	Ingersoll Rand	ST950	1034	47	2849
	F2895	Ingersoll Rand	ST950	1034	47	2849
	F3521	Ingersoll Rand	ST950	1034	47	2849
	L36GL (D)	Ingersoll Rand	ST950	1034	47	2849
	L7040G	Ingersoll Rand	ST950	1034	47	2849
	P9390G	Ingersoll Rand	ST950	1034	47	2849
	12VAT25GL	Ingersoll Rand	ST999	1034	62	3726
	F2895	Ingersoll Rand	ST999	1034	62	3726
	F3521	Ingersoll Rand	ST999	1034	62	3726
	L36GL (D)	Ingersoll Rand	ST999	1034	62	3726
	195GL	Ingersoll Rand	3BMG	1034	12	712
	6BL	Ingersoll Rand	3BMG	1034	12	712
	V1K	Ingersoll Rand	3BMG	1034	12	712
	V1L	Ingersoll Rand	3BMG	1034	12	712
	VRG283	Ingersoll Rand	3BMG	1034	12	712
	VRG310	Ingersoll Rand	3BMG	1034	12	712
	140GZ	Ingersoll Rand	5BMH	1034	11	679
	140HK	Ingersoll Rand	5BMH	1034	11	679
	6SRK	Ingersoll Rand	5BMH	1034	11	679
	6SRB	Ingersoll Rand	SS175G	1034	18	1096
	F11G (SI)	Ingersoll Rand	SS350G	1034	33	1973
	F18GL (D)	Ingersoll Rand	SS350G	1034	33	1973
	H24GL (D)	Ingersoll Rand	SS350G	1034	33	1973

Reciprocating engine		Pneumatic starter		Supply Pressure (kPag)	Natural gas consumption rate	
Manufacturer	**Model**	**Manufacturer**	**Model**		**m^3 vent gas/min**	**m^3 vent gas/hr**
	145GZ		150BM	1034	25	1490
	6GAK					
	6WAK					
	F1197G					
	F119G					
	H1077G					
	H24L	Ingersoll Rand				
	7044	Ingersoll Rand	SS815	1034	62	3726
	7042G (SI/L)					
	8LAT25D					
	8LAT25GLF 2895G (SI)					
	F3521H (SI)					
	12VAT27GL	Ingersoll Rand	SS825	1034	49	2959
	16AT27GL					
	16VAT25GL					
	P9390G					
	L5788	Tech Development	T112-B	621	57	3419
	L5040		T121-B	1034	5	298
	L7042G					
	L7044G					
	8LAT27G	Tech Development	T112-V	1034	54	3226
	12VAT25G		T121-V	621	59	3520
	12VAT27G					
	16VAT27G					
	P9390G					
White	RXC	Ingersoll Rand	5BMG	1034	11	679
	RXLD					
	RXLX					
	TDXC					

* Consumption rates are from manufacturer specifications. Vendors typically assume compressed air is used as the working medium when reporting flow rate requirements. Thus, air consumption rates have been multiplied by 1.29 for equivalent natural gas consumption rates.

Table 14: Manufacturer-specified vent gas rates for pneumatic instruments (developed from Alberta, 2017)

Description	Manufacturer and Model	Supply Pressure (psi)	Average sampled vent rate (m^3 vent gas/hr)
Pressure controllers	Ametek Series 40	20	0.22
		35	0.22
	Bristol Babcock Series 5453-Model 10F	20	0.11
		35	0.11
	Bristol Babcock Series 5455-Model 624-III	20	0.07
		35	0.11
	Bristol Babcock Series 502 A/D (recording controller)	20	0.22
		35	0.22
	Dynaflo 4000LB	20	0.06
		35	0.09
	Fisher 4100 Series (Large Orifice)	20	1.83
		35	1.83
	Fisher 4194 Series (Differential Pressure)	20	0.13
		35	0.18
	Fisher 4195	20	0.13
		35	0.18
	Foxboro 43AP	20	0.66
		35	0.66
	ITT Barton 338	20	0.22
		35	0.22
	ITT Barton 335P	20	0.22
		35	0.22
	Natco CT	20	1.28
		35	1.28
Transducers	Bristol Babcock Series 9110-00A	20	0.02
		35	0.02
	Fisher i2P-100LB	20	0.08
		35	0.11
	Fisher 646	20	0.04
		35	0.04
	Fisher 846	20	0.04
		35	0.04
Level Controllers	Dynaflo 5000	20	0
		35	0
	Fisher 2660 Series	20	0.03
		35	0.04
	Fisher 2100 Series	20	0.03
		35	0.04
	Invalco CT Series	20	0.05
		35	1.46
	Wellmark 2001	20	0.01
		35	0.01

Description	Manufacturer and Model	Supply Pressure (psi)	Average sampled vent rate (m^3 vent gas/hr)
Positioners	Fisher 3582	20	0.51
		35	0.66
	Fisher 3661	20	0.32
		35	0.44
	Fisher 3590 (electro-pneumatic)	20	0.88
		35	1.32
	Fisher 3582i (electro-pneumatic)	20	0.63
		35	0.88
	Fisher 3620J (electro-pneumatic)	20	0.66
		35	1.28
	Fisher 3660	20	0.22
		35	0.29
	Fisher FIELDVUE DVC5000	20	0.37
		35	0.55
	Masoneilan SVI Digital	20	0.04
		35	0.04
	Moore Products - Model 750P	20	0.00
		35	1.53
	Moore Products – 73 – B PtoP	20	1.32
		35	0.00
	PMV D5 Digital	20	0.04
		35	0.04
	Sampson 3780 Digital	20	0.04
		35	0.04
	Siemens PS2	20	0.04
		35	0.04
	VRC Model VP7000 PtoP	20	0.04
		35	0.04

Table 15: Vent gas rates for pneumatic pumps derived from manufacturer specifications

Manufacturer	Model	Plunger diameter (in.)	Stroke Length (in.)	P_2 coeff.	P_1 coeff.	P_0 coeff.
ARO	66610	120 psi supply		0	8.579 E-06	7.700E-03
Bruin	BR 5000	0.25	0.5	0	2.448E-05	4.603E+00
		0.25	1.25	0	9.530E-06	1.848E+00
		0.375	0.5	0	2.467E-05	2.049E+00
		0.375	1.25	0	9.615E-06	8.266E-01
		0.5	0.5	0	2.474E-05	1.133E+00
		0.5	1.25	0	9.731E-06	4.711E-01
		0.75	0.5	0	2.480E-05	5.102E-01
		0.75	1.25	0	9.899E-06	2.042E-01
		1	0.5	0	2.480E-05	2.868E-01
		1	1.25	0	9.932E-06	1.150E-01
		1.25	0.5	0	2.496E-05	1.821E-01
		1.25	1.25	0	9.923E-06	7.243E-02
	BR 5100	0.1875	1	0	9.905E-06	2.054E+00
		0.25	1	0	1.005E-05	1.155E+00
		0.375	1	0	1.009E-05	5.137E-01
		0.5	1	0	1.008E-05	2.887E-01
Checkpoint	1250	0.125	0.94	2.360E-10	2.278E-05	1.184E+00
		0.25	0.94	2.224E-10	1.129E-05	2.773E-01
		0.375	0.94	1.255E-10	1.224E-05	1.025E-01
		0.5	0.94	-1.266E-21	1.190E-05	7.104E-02
	1500	0.5	1	4.069E-11	2.733E-05	5.143E-01
		0.75	1	1.335E-10	1.945E-05	1.729E-01
		1	1	-9.817E-11	2.083E-05	1.123E-01
	LPX-04	0.25		0	0	3.464E-01
	LPX-08	0.125		0	0	1.409E+00
Linc	84T-10-x1	0.1875	1	0	1.513E-05	3.872E-01
	84T-11-x1	0.25	1	0	1.071E-05	1.646E-01
	84T-11-x2	0.25	1	0	1.190E-05	2.925E-01
	84T-12-x2	0.5	1	0	1.190E-05	7.313E-02
	84T-12-x4	0.5	1	0	1.058E-05	1.300E-01
	84T-14-x4	1	1	0	1.134E-05	3.250E-02
	87TA-11-x1	1	1	0	9.921E-06	8.545E-02
	85T-10	0.25	1	0	1.498E-05	1.648E-01
	85T-11	0.5	1	0	1.512E-05	7.393E-02
Morgan	HD187-3K-TR2		0.5	-3.059E-11	5.192E-05	3.526E-01
	HD187-TR2		0.5	-1.049E-09	7.424E-05	2.494E-03
	HD312-3K-TR2		1	-4.013E-25	2.558E-05	1.058E-01
	HD312-K5-TR2		1	-2.368E-12	2.545E-05	2.546E-01

Manufacturer	Model	Plunger diameter (in.)	Stroke Length (in.)	P_2 coeff.	P_1 coeff.	P_0 coeff.
	HD312-TR2		1	2.655E-09	2.198E-05	-3.868E-03
SandPiper	G05	0.5		7.635E-09	2.563E-05	6.379E-03
	SB-1 and SB-25		1	3.226E-08	-1.070E-05	7.688E-03
Texsteam	5002	0.25	0.5	-1.949E-10	5.935E-05	5.222E+00
		0.25	1.25	-2.601E-11	2.817E-05	2.087E+00
	5003	0.375	0.5	-1.078E-11	1.399E-05	2.652E+00
		0.375	1.25	-1.075E-11	1.398E-05	1.044E+00
	5004	0.75	0.5	-4.756E-10	4.049E-05	6.351E-01
		0.75	1.25	-2.109E-10	2.697E-05	2.495E-01
	5005	0.5	0.5	-1.160E-13	1.303E-05	1.496E+00
		0.5	1.25	3.412E-26	1.302E-05	5.985E-01
	5006	1	0.5	-1.293E-25	1.302E-05	3.741E-01
		1	1.25	1.666E-25	1.302E-05	1.496E-01
	5007	1.25	0.5	-7.148E-25	1.302E-05	2.394E-01
		1.25	1.25	-1.293E-25	1.302E-05	9.726E-02
	5101	0.25	0.33	1.499E-09	6.724E-05	5.467E+00
		0.25	1	4.995E-11	2.241E-05	1.822E+00
	5103	0.375	0.33	1.202E-11	1.471E-04	2.592E+00
		0.375	1	4.007E-12	4.902E-05	8.641E-01
	5104	0.1875	0.33	-1.076E-09	1.240E-04	9.996E+00
		0.1875	1	-3.851E-10	4.208E-05	3.330E+00
	5105	0.5	0.33	5.241E-11	3.741E-05	1.159E+00
		0.5	1	1.747E-11	1.247E-05	3.864E-01
	9001	30 psi supply		1.475E-08	8.510E-07	3.167E-03
		50 psi supply		1.102E-08	8.300E-07	4.553E-03
Timberline	2515		1	0	1.176E-05	5.212E-02
	2522		1	0	1.164E-05	9.879E-02
	2530		1	0	1.114E-05	1.627E-01
	5030		1	0	1.100E-05	5.155E-02
	5040		1	0	1.255E-05	3.346E-02
Western	DFF	0.375	0.875	0	1.636E-05	7.795E-01
	DFF	0.625	0.875	0	1.742E-05	3.097E-01
Wilden	P1 Metal	Rubber/PFTE fitted		3.286E-08	-1.261E-05	6.708E-03
Williams	CP125V125	1.25	1	0	0	7.716E-01
	CP250V225	2.25	1	0	0	6.173E-01
	CP250V300	3	1	0	0	1.138E+00
	CP500V225	2.25	1	0	0	1.531E-01
	CP500V300	3	1	0	0	2.822E-01
	CRP1000V4	4	1	0	0	1.224E-01
	CRP1000V6	6	1	0	0	2.472E-01
	CRP1000V8	8	1	0	0	4.360E-01
	CRP500V40	4	1	0	0	4.832E-01

Manufacturer	Model	Plunger diameter (in.)	Stroke Length (in.)	P_2 coeff.	P_1 coeff.	P_0 coeff.
	CRP750V40	4	1	0	0	2.227E-01

Table 16: Vent gas rates for estimating equipment leaks at upstream oil and gas (from AER 2018b)*

Sector	Component Type	Service	Leaking component emission rate (kg THC/h/source)
All	Connector	Process gas	0.13281
All	Connector	Light liquid	0.05906
All	Control Valve	Process gas	0.16213
All	Meter	Process gas	0.07201
All	Open-Ended line	Process gas	0.98904
All	Pressure relief valve	Process gas	0.69700
All	Pump seal	Process gas	0.23659
All	Regulator	Process gas	0.10275
All	Valve	Process gas	0.31644
All	Valve	Light liquid	0.23098

* If fugitive emissions are detected at equipment in heavy liquid service, apply the light liquid vent gas rate.

Appendix 3

In this Appendix, there are sample calculations using hypothetical examples to walk through how vented gas (which includes fugitive emissions) would be estimated and reported for the production month of January. In these examples there is a producing well completion; an oil satellite location that is licensed. two compressors, one located at the oil satellite (compressor is not licensed as the horse power is below 250) and one at the battery (this compressor is licensed as the horse power is above 250); and a multi-well battery with a facility licence.

The facility IDs are as follows:

- Produced well completion (SK WI U);
- Oil satellite (SK SA Z);
- Compressor at the oil satellite (no facility ID as this compressor is not licensed);
- Compressor at the battery (SK CS Y); and
- Battery (SK BT X)

Table 17 shows which vent sources are assumed applicable for the well completion, oil satellite, compressor and battery.

Table 17: Well Completion, oil satellite, licensed compressor, and battery vent gas sources

	Producing Well Completion (SK WI U)	Oil Satellite (SK SA Z)	Compressor at Battery (SK CS Y)	Battery (SK BT X)
Oil well head*	✓	✗	✗	✗
Uncontrolled tank	✗	✓	✗	✓
Online gas analyzer	✗	✓	✗	✗
Solid desiccant dehydrator	✗	✓	✗	✗
Pig trap	✗	✓	✗	✗
Pneumatic device	✗	✓	✗	✓
Compressor**	✗	✓	✓	✓
Glycol dehydrator	✗	✓	✗	✓
Blowdowns	✗	✓	✗	✓
Well Testing, Completions and Workovers	✗	✓	✗	✗
Well venting for liquid unloading	✗	✓	✗	✗
Engine or Turbine Starts	✗	✓	✗	✓
Fugitive emissions	✗	✓	✗	✓
Facility Turnaround	✗		✗	✓

*Well head is not at the same location of the oil satellite.

**The compressor at the oil satellite is not licensed; therefore, volumes must be reported under the oil satellite facility. The compressor located at the battery is licensed; therefore, volumes must be associated with the compressor facility ID.

The following calculations show how to estimate the vent volume for one month. VENT gas is calculated as the sum of associated gas venting, storage tank venting, hydrocarbon liquid loading losses, online gas analyzer purge vents, solid desiccant dehydrators, pig trap, opening and purges, and other vent sources.

Vent Sources (occurring on a monthly basis)

Oil Well head – Associated Gas venting

In this example, there is an oil well completion that is venting all the produced gas, which was measured at 100 m^3 of vent gas for the month. The battery (SK BT X) has no associated gas vented as there are no wells.

Storage Tank Venting – Flashing Losses

For the tank at the oil satellite (SK SA Z), the values in Table 18 are used to calculate the flashing losses for the tank.

Table 18: Parameters for storage tank venting – flashing losses example

Parameter	Description	Value	Units
V_{liq}	Monthly volume of produced liquid hydrocarbon product	350	m^3
GIS	Gas-in-solution (GIS) factor (calculated using Vazquez and Beggs correlation)	6.8	m^3 of gas/m^3 of oil

Flashing losses are calculated for the month using Equation 13 (from Section 4.1.1.1, Equation 1):

$$V_{GIS} = 350 \; x \; 6.8 = 2380 \; m^3 \qquad (13)$$

For the purpose of calculating storage tank venting for SK BT X, assume the battery's storage tank venting from flashing is 3,400 m^3.

Storage Tank Venting – Breathing and Working Losses

The breathing and working losses were determined for the oil satellite (SK SA Z) and the battery (SK BT X) to be 50 m^3 and 100 m^3 of vent gas, respectively, for the month using the "Evaporative Loss from Fixed-Roof Tank" algorithm (US EPA 2006).

Storage Tank Venting – Blanket Gas Venting

Assume for this example that blanket gas venting that was determined through an engineering estimate and is 0 m^3 for the oil satellite (SK SA Z) and 150 m^3 for the battery (SK BT X) for the month.

Table 19 (see following page) summarizes the storage tank vent gas volumes for the oil satellite (SK SA Z) and the battery (SK BT X) for January.

Table 19: Summary of storage tank venting for SK SA Z and SK BT X

Site	Description	Value (m^3/month)
Oil Satellite (SK SA Z)	Flashing losses	2380
	Breathing and working losses	50
	Blanket gas venting	0
Battery (SK BT X)	Flashing losses	3400
	Breathing and working losses	100
	Blanket gas venting	150

Hydrocarbon Liquid Loading Losses

For the tank at the battery (SK BT X), the values shown in Table 20 are used to calculate the hydrocarbon liquid loading losses for one month.

Table 20: Parameters for hydrocarbon liquid loading losses example

Parameter	Description	Value	Units
RVP	Reid vapour pressure of liquid (from Table 19)	40.5	kPa
T	Average liquid temperature	283.15	K
V_{oil}	Monthly volume of the LVP product loaded	100	m^3
P_{std}	Standard reference pressure	101.325	kPa
SF	Saturation factor (from Table 17)	0.5	Dimensionless

Step 1: The true vapour pressure, P_v, is calculated using Equation 14 (from Section 4.1.2, Equation 3):

$$P_v = 6.8929 \times exp\left[\left(\frac{1555}{283.15} - 2.227\right) \times (\log_{10} 40.5 - 0.8384) - \frac{4033.89}{283.15} + 12.82\right]$$

$$= 20.385\ kPa \qquad (14)$$

Step 2: The saturation factor is determined from Table 2 to be 0.5. Assume the cargo carriers are tank trucks and rail tank cars, and the mode of operation is submerged loading of a clean cargo tank.

Step 3: The vent gas from hydrocarbon liquid loading losses is calculated using Equation 15 (from Section 4.1.2, Equation 2).

$$V_{LL} = \frac{0.50 \times 20.385 \times 288.15}{101.325 \times 283.15} \times 100 = 10.2\ m^3 \qquad (15)$$

There are no hydrocarbon liquid loading losses at the oil satellite (SK SA Z).

Online Gas Analyzer Purge Vents

In this example, the oil satellite (SK SA Z) has two online gas analyzers and the battery (SK BT X) has zero. Using the average vent gas rate from Section 4.1.3, the vent gas volume from online gas analyzer purges for the oil satellite (SK SA Z) for the month is calculated using Equation 16:

$$V_{OGA} = 68.9\ m^3\ of\ vent\frac{gas}{month} \times 2 = 137.8\ m^3 \qquad (16)$$

Solid Desiccant Dehydrators
In this example, the oil satellite (SK SA Z) has one solid desiccant dehydrator and the battery (SK BT X) has zero. Table 21 provides the values used to calculate the volume of vent gas from the solid desiccant V_{DD}, using Equation 17 (from Section 4.1.4, Equation 4).

Table 21: Parameters for solid desiccant dehydrator example

Parameter	Description	Value	Units
H	Height of the dehydrator vessel	0.8	m
D	Diameter of the dehydrator vessel	0.6	m
P_2	Pressure of the gas	1200	kPa(g)
P_1	Atmospheric pressure	101.325	kPa(a)
G	Fraction of the vessel that is filled with gas	0.7	
F	Frequency of refilling	5	Cycles per month

$$V_{DD} = \left(\frac{0.8 \times 0.6^2 \times 3.14159 \times 1200 \times 0.7}{4 \times 101.325}\right) \times 5 = 9.376\ m^3 \qquad (17)$$

The vent volume from solid desiccant dehydrators for the month is 9.376 m^3 for the oil satellite (SK SA Z) and 0 m^3 for the battery (SK BT X).

Pig Trap Opening and Purges
In this example, the oil satellite (SK SA Z) has one pig trap and the battery (SK BT X) does not have any pig traps. The values shown in Table 22 are used to calculate the vent gas volume from one event during the month.

Table 22: Parameters for pig trap opening example

Parameter	Description	Value	Units
V_v	Total physical volume of equipment chambers between isolation valves being depressurized	3.693	m^3
T_s	Temperature at standard conditions	15	°C
T_a	Initial temperature of gas at actual conditions	10	°C
P_s	Absolute pressure at standard conditions	101.325	kPa(a)
$P_{a,1}$	Gauge pressure at actual conditions in the equipment system (kPa(a)) prior to depressurization	260	kPa(g)
$P_{a,2}$	Gauge pressure at actual conditions in the equipment system after depressurization	50	kPa(g)

Step 1: The pig trap's total physical volume is calculated as the volume of a vessel, V_v (see Equation 18). Assume the pig trap has a 168.3 mm outer diameter, with 4 mm wall thickness, and is 6 feet (1.83 m^3) long.

$$V_V = \pi \times \left(\frac{\frac{168.3}{2} - 4}{100}\right)^2 \times 1.83 = 3.693\ m^3 \qquad (18)$$

Step 2: Venting from the pig trap opening, V_{PT}, is calculated using Equation 19, assuming the pig trap is not purged (from Section 4.1.5, Equation 5):

$$V_{PT} = 3.693 \times \left[\frac{(273.15+15)\times(260-50)}{(273.15+10)\times 101.325}\right] = 7.789\ m^3 \qquad (19)$$

Pneumatic Pumps

To calculate the vent gas volume from one pneumatic pump on the oil satellite (SK SA Z) in January where the supply pressure, discharge pressure and strokes per minute are known the parameters in Table 23 are used with Equation 20 (from Section 4.1.6.2, Equation 8). The volume is then converted to a monthly volume with Equation 21 (from Section 4.1.12, Equation 12).

Table 23: Parameters for pneumatic pump example with operating conditions known

Parameter	Description	Value	Units
	Make	Texsteam	
	Model	5100	
SP	Supply pressure	206.8	kPa
DP	Discharge pressure	6894.8	kPa
SPM	Strokes per min	10	strokes/min
g	Supply pressure coefficient	0.0003	
n	Discharge pressure coefficient	0.000034	
p	Strokes per min coefficient	0.0207	
T	Operating hours	720	hours

$$ER = (g \times SP) + (n \times DP) + (p \times SPM) \qquad (20)$$
$$= (0.0003 \times 206.8) + (0.000034 \times 6894.8) + (0.0207 \times 10)$$
$$= 0.503\ m^3/hour$$

$$V_{PP} = ER_P \times t = 0.503 \times 720 = 362\ m^3/month \qquad (21)$$

To calculate the vent gas volume from one pneumatic pump at the battery (SK BT X) for the month of January where manufacturer specifications (Equations 9 and 10 from Section 4.1.6.2) are used, the parameters in Table 24 are used (see Equations 22 and 23 below).

Table 24: Parameters for pneumatic pump example using manufacturer specifications

Parameter	Description	Value	Units
	Make	Bruin	
	Model	BR 5000	
CIP	Chemical injection pressure	10,000	kPa
	Plunger diameter	0.25	In
	Stroke length	1	In
P_2		0	
P_1		0.0000245	
P_0		4.60	
L	Monthly volume of chemical pumped	15	L/month

$$ER_{PM} = (P_2 \times CIP^2) + (P_1 \times CIP) + P_0 \qquad (22)$$
$$= (0 \times 10000^2) + (0.0000245 \times 10000) + 4.60$$
$$= 4.85\ m^3\ vent\ gas/litre$$

$$V_{PP} = ER_{PM} \times L = 4.85 \times 15 = 72.7\ m^3/month \qquad (23)$$

Based on the calculations above, the pneumatic vent gas volume for the oil satellite (SK SA Z) and the battery (SK BT X) for the month of January is shown in Table 25.

Table 25: Summary of pneumatic device vent gas volume for SK SA Z and SK BT X

Category	Oil Satellite (SK SA Z) Vent Gas Volume (m^3)	Battery (SK BT X) Vent Gas Volume (m^3)
Pneumatic instruments (V_{PI})	283	397
Pneumatic pumps (V_{PP})	362	73
Total Pneumatic devices	645	470

Compressor Seals

A test was done by the operator and determined that the estimated vent gas rate is 1.63 m^3/hr. There is one compressor at the oil satellite (SK SA Z) and one at the battery (SK BT X). Each has some vent gas rate but only the oil satellite (SK SA Z) was pressurized for the full 720 hours in January and the other one at the battery (SK BT X) was pressurized for 672 hours. Based on the statement above, the compressor seals vent gas volumes for the oil satellite (SK SA Z) and the battery (SK BT X) for the month of January are shown in Table 26. Only the compressor (SK CS Y) at the battery (SK BT X) is licensed.

Table 26: Compressor event example

	Test rate (m^3/hr)	Pressurized time (hours)	Vent Volume (m^3)
Oil Satellite (SK SA Z) Vent Gas Volume (m^3)	1.63	720	1173.6
Battery (SK BT X) Vent Gas Volume (m^3)	1.63	672	1095.4

Glycol Dehydrators

Glycol Dehydration vent gas estimates should be produced from GRI-GlyCALC or equivalent software. Tables 27 and 28 are sample inputs for a glycol dehydrator.

Table 27: Glycol dehydrator summary of input values

Input	Unit	Value
Temperature and pressure in the absorber column	F/psig	82.40 deg. F/0.23 psig
Type of glycol pump	Electric/Energy Exchange	Electric
Type of glycol	TEG or DEG	TEG
Stripping gas (if used)	Scfm	0.283
Wet gas composition	Per cent volume	See Table 28

Table 28: Glycol dehydrator wet gas composition

Component	Composition (vol %)	Component	Composition (vol %)
Carbon dioxide	1.3900	Isobutane	0.4700
Nitrogen	0.2300	n-Butane	0.5700
Methane	84.8600	Isopentane	0.2500
Ethane	8.4000	n-Pentane	0.1900
Propane	2.7800	n-Hexane	0.2300
Cyclohexane	0.0460	Toluene	0.0820
Other Hexanes	0.1050	Ethylbenzene	0.0020
Methylcyclohexane	0.1160	Xylenes	0.0220
2,2,4-Trimethylpentane	0.0090		
Benzene	0.0460		

The resulting output methane mass for this glycol dehydrator is 3.1072 tonnes/year for 8760 hours of operation in a year. Use Equation 24 to convert mass to volume and Equation 25 to convert the methane portion from a yearly to monthly volume:

$$M = V \times \emptyset_{CH4} \times \rho_{CH4} \qquad (24)$$

M the mass of methane (kg CH_4)
V the volume of gas, corrected to standard conditions (m^3)
$\emptyset_{CH4}$ the volumetric concentration
ρ_{CH4} the density of methane at standard conditions is 0.67850 (kg/m^3)

$$V_{D,site\ A,Dehy\ 1} = \frac{3.1072 \frac{tonnes}{year} \times 1000 \frac{kg}{tonne} \times \frac{1\ year}{12\ month}}{\left(84.86\% \times 0.67850 \frac{kg}{m^3}\right)} = 449.7\ m^3/month \qquad (25)$$

The calculated vent gas volume of all glycol dehydrators at a facility ID is then given in Table 29.

Table 29: Summary of glycol dehydrator vent volumes for SK BT X

Site	Dehydrator ID	Mass of methane (kg/year)	Vent volume (m^3/month)	
Oil Satellite, SK SA Z	1	3107.2	449.7	
Oil Satellite, SK SAZ	4	2400.5	347.4	
		SK SA Z Total:	797.1	
B	3	1500.0	217.1	
		SK BT X Total:	217.1	

Vent Sources (occurring only occasionally)

The following sample calculations show how to estimate the vent volume for one month. The vent volume is calculated as the sum of blowdowns; well testing, completions and workovers; well venting for liquids unloading; engine or turbine starts; and other sources.

Blowdowns

In this example, both the oil satellite (SK SA Z) and the battery (SK BT X) had a blowdown event on January 6. The values shown in Table 30 are used to calculate the vent gas volume from one event during the month.

Table 30: Parameters for blowdowns example

Parameter	Description	Value	Units
V_v	Total physical volume of equipment chambers between isolation valves being depressurized	1000	m^3
T_S	Temperature at standard conditions	15	°C
T_a	Initial temperature of gas at actual conditions	10	°C
P_S	Absolute pressure at standard conditions	101.325	kPa(a)
$P_{a,1}$	Gauge pressure at actual conditions in the equipment system (kPa[a]) prior to depressurization	260	kPa(g)
$P_{a,2}$	Gauge pressure at actual conditions in the equipment system after depressurization	50	kPa(g)

Similar to pig trap opening and purges calculation, calculate blowdown venting V_{BD} for the oil satellite (SK SA Z) using Equation 26 (from Section 4.1.5, Equation 5).

$$V_{BD} = 1000 \times \left[\frac{(273.15+15)\times(260-50)}{(273.15+10)\times 101.325}\right] = 2109\ m^3 \qquad (26)$$

For the battery (SK BT X), the total physical volume of equipment chambers between isolation valves being depressurized, V_V, is 1200 m^3. Blowdown vent gas volume for the battery (SK BT X) is 2531 m^3.

Well Testing, Completions, and Workover

In this example, there is a producing well completion (SK WI U) that is venting from workover activities, which was measured to vent 100 m^3 of vent gas for the month. The battery (SK BT X) has no vent gas from well testing, completions, and workovers because there is no well on site.

Well Venting for Liquid Unloading

Well Completion (SK WI U) had a liquids unloading event on January 28. The values shown in Table 31 are used to calculate the vent gas volume from one event during the month.

Table 31: Parameters for well venting for liquids unloading example

Parameter	Description	Value	Units
D_t	Production string diameter	22	Cm
WD	Well depth	2000	M
$P_{shut\text{-}in}$	Well shut-in pressure	1200	kPa(g)
Q_{sfr}	Average sales flow rate of gas well at standard conditions	50	m^3/hr
t_{open}	Hours that well was left open	0.5	hours

Well venting for liquids unloading volume is calculated for the month using Equation 27 (from Section 4.1.11, Equation 11).

$$V_{WLU} = \left(7.854 \times 10^{-5} \times 22^2 \times 2000 \times \frac{1200}{101.325}\right) + (50 \times 0.5) = 925.4\ m^3 \quad (27)$$

Well venting for liquids unloading volume for the oil satellite (SK SA Z) and the battery (SK BT X) is 0 because there are no wells on these sites.

Engine or Turbine Starts
In this example, there are three engine or turbine start events on the oil satellite (SK SA Z) for January. The type, manufacturer, and model are shown in Table 32 along with the corresponding maximum natural gas consumption rates from Tables 12 and 13.

Table 32: Inventory for engine or turbine starts example for site A

	Engine/Turbine			**Pneumatic starter**		**Supply press-ure (kPag)**	**Max natural gas consumption rate**	
	Type	Manufacturer	Model	Manufacturer	Model		(m^3/min)	(m^3/hr)
1	Turbine*	Garrett	IE831	Ingersoll Rand	TS999G	621	47	2849
2	Turbine*	Solar Turbines	Saturn 20	Tech Development	56S	1034	29	1725
3	Reciprocating engine†	Waukesha	7042G (SI/L)	Ingersoll Rand	SS815	1034	62	3726

*Data from Table 12
†Data from Table 13

The operating time of each engine or turbine is shown in Table 33.

Table 33: Parameters for engine or turbine starts vent gas volume calculations example

Engine or turbine #	**Max natural gas consumption rate (m3/min)**	**Operating time (min)**	**Vent gas volume (m^3)**
1	47	6	282
2	29	9	261
3	62	5	310
Total on site A			**853**

Vent gas volume for each engine or turbine start is calculated by multiplying the maximum natural gas consumption rate with its operating time for each event and summed over the month, using Equation 28 (from Section 4.1.12, Equation 12).

$$V_{ETS} = 47\ m^3/min\ \times 6\ min + 29\ m^3/min \times 9\ min\ + 62\ m^3/min \times 5\ min = 853\ m^3 \quad (28)$$

Engine or turbine starts vent volume for the oil satellite (SK SA Z) is 853 m^3. The engine or turbine starts vent volume for the battery (SK BT X) is 1012 m^3.

Fugitive Emissions
After a fugitive emission survey at both the oil satellite (SK SA Z) and the battery (SK BT X) was conducted on January 1st. Each component or equipment type was fixed either in January or February. Fugitive emissions are only required to be estimated from the date found to the date

repaired. Sixteen leaks were found across the oil satellite (SK SA Z) and the battery (SK BT X) associated with this facility ID and are listed below in Table 34 based on the component type and site where they were found.

Table 34: Summary of fugitive emission for SK SA Z and SK BT X

Site	Component /equipment type	Emission rate (m^3/hr)	Date found	Date repaired	Duration of fugitive emissions	Fugitive emissions (m^3)
SK SA Z	Valve	0.138752565	January 1	January 15	15	2.08
SK SA Z	Flange	0.116099085	January 1	January 15	15	1.74
SK SA Z	Connector (other)	0.036811905	January 1	January 17	17	0.63
SK SA Z	Open-ended line 2	0.07928718	January 1	January 18	18	1.43
SK SA Z	Pressure relief valve	0.127425825	January 1	February 10	31	3.95
SK SA Z	Pump seal	0.104772345	January 1	February 10	31	3.25
SK SA Z	Other 3	0.127425825	January 1	February 10	31	3.95
SK SA Z	Valve	0.09061392	January 1	January 15	15	1.36
SK SA Z	Flange	0.076455495	January 1	January 15	15	1.15
SK SA Z	Connector (other)	0.02831685	January 1	January 17	17	0.48
SK SA Z	Open-ended line	0.04530696	January 1	January 18	18	0.82
SK SA Z	Pump	0.104772345	January 1	February 10	31	3.25
SK SA Z	Agitator seal	0.104772345	January 1	February 10	31	3.25
SK SA Z	SCVF serious	12.70833333	January 1	February 10	31	393.96
Total fugitive emissions at SK SA Z						421.3
SK BT X	Valve	0.09061392	January 1	January 15	15	1.36
SK BT X	Flange	0.076455495	January 1	January 15	15	1.15
Total fugitive emissions at SK BT X						2.51

Other Vent Volumes

In this example, it is assumed that the oil satellite (SK SA Z) does not have other venting activities. The battery (SK BT X) had a facility turnaround during January, causing 200 m^3 of vent volume.

Reporting to Petrinex

Table 36: Summary of VENT volume reported to Petrinex for the oil well completion (SK WI U), the licensed compressor (SK CS Y), the oil satellite (SK SA Z) and the battery (SK BT X), for production month of January

	Producing Well Completion (SK WI U) (m^3 of gas)	Oil Satellite (SK SA Z) (m^3 of gas)	Licensed Compressor (SK CS Y) (m^3 of gas)	Battery (SK BT X) (m^3 of gas)
Oil well head-Associated Gas Venting* (good)	100			0
Uncontrolled tank - Flashing Losses (good)		2380		3400
Uncontrolled tank - Breathing and working losses (good)		50		100
Uncontrolled tank - Blanket Gas Venting (good)		0		150
Hydrocarbon Liquid Loading Losses (good)		0		10.2
Online gas analyzer (good)		137.8		0
Solid desiccant dehydrator (good)		9.376		0
Pig trap (good)		7.789		0
Pneumatic device - Pneumatic instruments		283		397
Pneumatic device - Pneumatic pumps		362		73
Compressor**		1173.6	1095.4	
Glycol dehydrator		797.1		217.1
Blowdowns		2109		2531
Well Testing, Completions and Workover	100	0		0
Well venting for liquid unloading	925.4			0
Engine or Turbine Starts		853		1012
Fugitive emissions		421.30		2.51
Facility Turnaround		0		200
TOTAL:	1125.4	8584.0	1095.4	8092.8

*The well head is not at the same location of the oil satellite

**The compressor at the oil satellite (SK SA Z) is not licensed; therefore, volumes must be reported under the oil satellite. The compressor located at the battery (SK BT X) is licensed; therefore, volumes must be reported under the compressor (SK CS Y).

Total vent gas for the oil well completion (SK WI U) is 1125.4 m^3. This volume would be reported to Petrinex under the battery facility ID (SK BT X) and associated with the well completion ID (SK WI U) with a volume of 1.1 $10^3 m^3$ as per Figure 2.

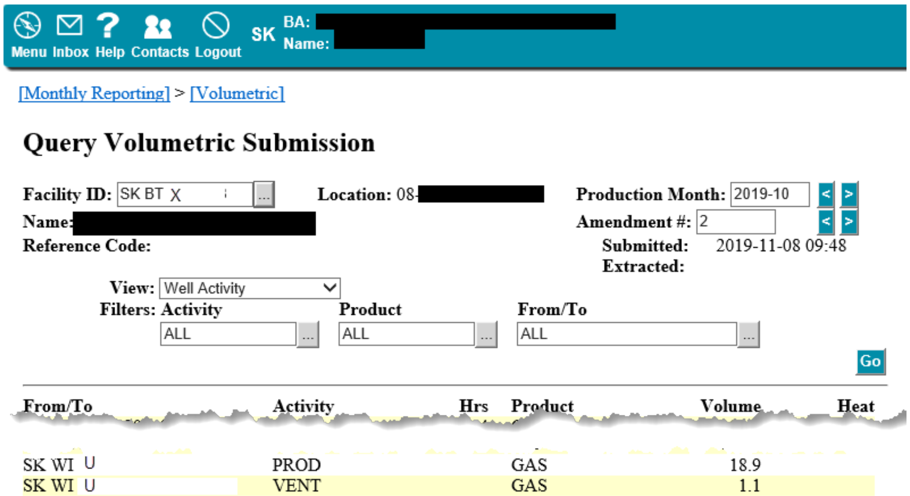


Figure 2: How to report vent gas to well completion ID, SK WI U

Total vent gas for the oil satellite (SK SA Z) is 8584.0 m^3. This volume would be reported to Petrinex under the battery facility ID (SK BT X) and associated with the oil satellite facility ID (SK SA Z) with a volume of 8.6 $10^3 m^3$ as per Figure 3.

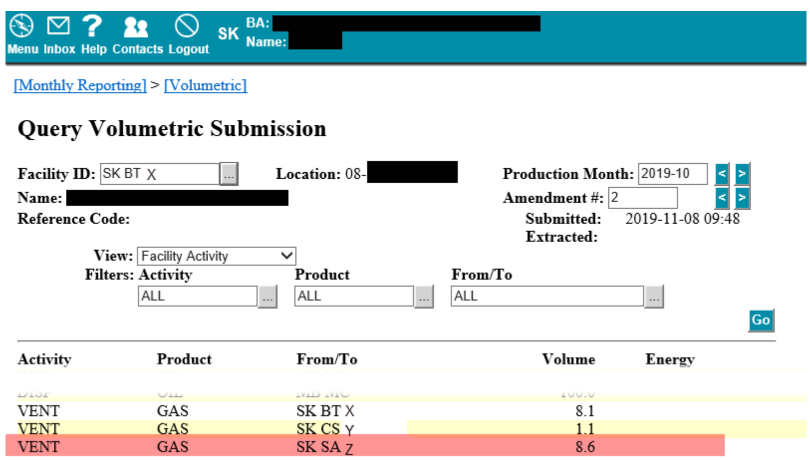
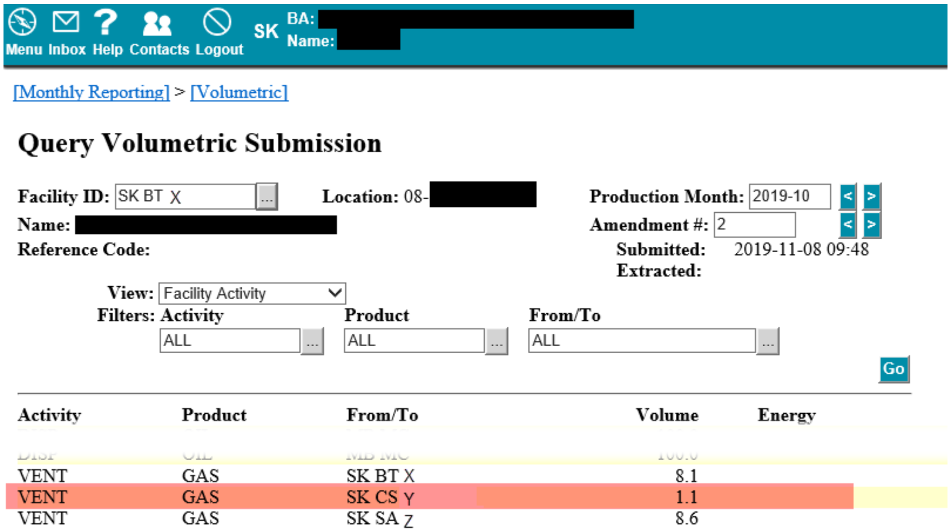


Figure 3: How to report vent gas to an oil satellite

Total vent gas for compressor (SK CS Y) is 1095.4 m^3. This volume and would be reported to Petrinex under the battery facility ID (SK BT X) and associated with the compressor facility ID (SK CS Y) with a volume of 1.1 $10^3 m.^3$ See Figure 4.


Menu Inbox Help Contacts Logout SK BA: [redacted] Name: [redacted]

[Monthly Reporting] > [Volumetric]

Query Volumetric Submission

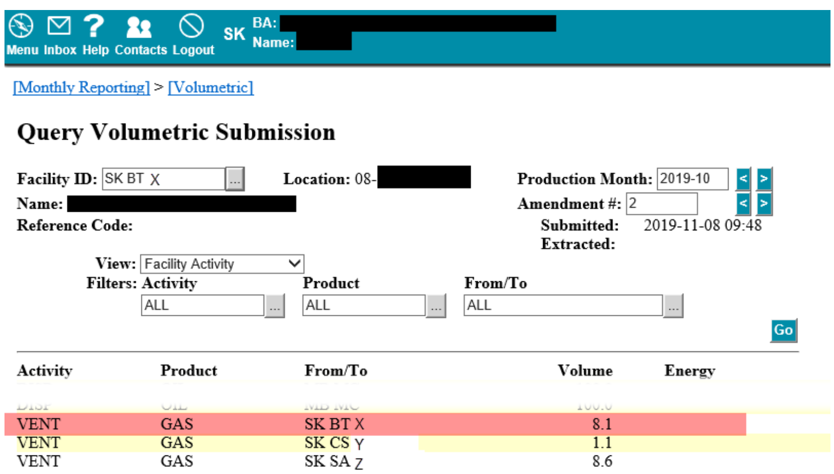
Facility ID: SK BT X Location: 08-[redacted] Production Month: 2019-10
Name: [redacted] Amendment #: 2
Reference Code: Submitted: 2019-11-08 09:48
Extracted:

View: Facility Activity
Filters: Activity ALL Product ALL From/To ALL
Go

Activity	Product	From/To	Volume	Energy
VENT	GAS	SK BT X	8.1	
VENT	GAS	SK CS Y	1.1	
VENT	GAS	SK SA Z	8.6	

Figure 4: How to report vent gas to a licenced compressor

The remainder of the gas was vented at the battery (SK BT X). Therefore, the total vent gas for the battery (SK BT X) is 8092.8 m^3. This volume would be reported to Petrinex under the battery facility ID (SK BT X) and reported at the battery facility ID (SK BT X) with a volume of 8.1 10^3m^3 as per Figure 5.


Menu Inbox Help Contacts Logout SK BA: [redacted] Name: [redacted]

[Monthly Reporting] > [Volumetric]

Query Volumetric Submission

Facility ID: SK BT X Location: 08-[redacted] Production Month: 2019-10
Name: [redacted] Amendment #: 2
Reference Code: Submitted: 2019-11-08 09:48
Extracted:

View: Facility Activity
Filters: Activity ALL Product ALL From/To ALL
Go

Activity	Product	From/To	Volume	Energy
VENT	GAS	SK BT X	8.1	
VENT	GAS	SK CS Y	1.1	
VENT	GAS	SK SA Z	8.6	

Figure 5: How to report vent gas to a battery