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Memorandum

To:	Seng Phouthakoun, Rickey Bouffard, and Lakisha Stephenson (CTDEEP)
From:	Dana Lowes-Hobson Senior Scientist
Subject:	AGT Cromwell VOC RACT Plan – Response to CTDEEP Requests
Date:	March 15, 2022
CC:	Barry Goodrich (Enbridge), Caitlin Shaw (Enbridge), Phillip Wiedenfeld (Enbridge), Angela Beeson (Enbridge), Kate Brown (Enbridge/TRC), Albert Wilder (TRC), Patrick Fennell (TRC)
Project No.:	456494

CTDEEP requests are listed below with a response.

a) A written explanation of the selected baseline year (2017) and supporting calculations for the baseline PTE (2017).

- The baseline emissions for VOC RACT are representative of sources currently at the facility.
  - The VOC emissions from the 2017 NSR application for the 2019 NOx RACT Project represent facility-wide allowable emissions after the Project was implemented and the configuration of the station as it exists today, with the exception of the VOC emissions from the compressor seals on EU-08.
  - Prior to completion of the NOx RACT Project, allowable emissions from vented sources were 74.7 tpy VOC.
  - Following completion of the NOx RACT Project, allowable emissions from vented sources is 58.2 tpy VOC.

Supporting calculations for the baseline year vented emissions are provided as Attachment 1.

b) A written description of the limitations discussed yesterday for gas recompression and pressure holding.

Recompression of gas from the station is conducted by attaching a portable compressor to the section to be de-pressurized and piping it to another section of the facility that remains pressurized. As the pressure in the de-pressurized section is reduced, the gas flow rate from the de-pressurized section into the pressurized section decreases. While this methodology yields significant reductions in natural gas venting, it will nevertheless require some level of emissions. Additionally, when small sections of the compressor station are to be vented for work, there may not be adequate connection points to use the recompression system.

The dry seal system used on the compressor units at the station represent an alternative to the traditional wet seal system resulting in 95 percent control of seal emissions. In addition, when enhanced with further auxiliary systems, the dry seals allow for extended pressurized holds on the compressors when they are not running. However, each compressor still needs to be depressurized up to 20 times per year to allow for a safe work environment during maintenance and inspection activities.

c) A written description of a normal unit blowdown & station blowdown including the frequency pre-RACT & post-RACT.

Unit blowdowns and station blowdowns represent the venting of gas from different sections of the compressor station. Unit blowdowns refer to the venting of the gas from the compressor unit and associated piping between the unit isolation valves. A station blowdown is the release of gas from the entire compressor station, including compressor units, yard piping, filter/separators, fuel gas systems, etc.

Historically, centrifugal compressors with wet seals and older dry seal systems need to be depressurized any time they are not running. Algonquin is proposing to update all compressors at the site with the latest seal technology that allows for indefinite pressurized holds when the units are not running. This will minimize the number of unit blowdowns required at the facility to those associated with maintenance.

Station blowdowns occur due to two primary reasons: maintenance on equipment that must be depressurized for safety reasons or emergency events.

Based on historical data from 2017 through 2021, the frequency of unit blowdowns at the Cromwell Compressor Station ranged from 32 to 168 per year and the frequency of station blowdowns ranged from 0 to 3 per year.

The historical frequency of unit blowdowns is correlated to the number of starts and stops per unit and is dependent on customer demand. Algonquin compressor stations (Cromwell included) are close to electric generators and historically have had a higher frequency of starts and stops due to that close proximity. A plot showing the relationship between utilization and start/stop cycles for Algonquin compressor units is provided in Attachment 2.

As demonstrated by Table 1 below, EU-07 and EU-08 were used infrequently in 2021, while EU-09 operated almost continuously. Consequently, each of these units had fewer unit blowdowns than EU-10 and EU-11, which were started and stopped more frequently and had the most unit blowdowns in 2021.

Table 1 – Centrifugal Compressor Unit Blowdown Summary Table Cromwell Compressor Station						
		2017	2018	2019	2020	2021
EU-07	Unit Blowdown Frequency	12	48	59	44	17
EU-08	Unit Blowdown Frequency	12	57	72	0	24
EU-09	Unit Blowdown Frequency	8	15	20	25	12
EU-10	Unit Blowdown Frequency			9	62	44
EU-11	Unit Blowdown Frequency			8	30	43
Station Total	Unit Blowdown Frequency	32	120	168	161	140

Following implementation of the VOC RACT Compliance Plan, the frequency of compressor unit blowdowns will significantly decrease. The number of events is anticipated to be less than 20 events per unit per year. The VOC emissions from compressor unit blowdowns will be dependent on gas quality and the number of events.

The frequency of station blowdowns will not change post implementation of the VOC RACT Compliance Plan. However, the quantity of emissions from station blowdowns will decrease due to use of recompression equipment, where appropriate.

As further explained in Response (f), Algonquin has developed an estimate of the total annual volume of vented gas based on extensive knowledge of station operations, with consideration of the limitations of pressurized holds and recompression, while also allowing for adequate compliance margin based on actual VOC content of the gas.

d) The amount of VOC emission releases per unit blowdown event and per station blowdown event.

As explained in Response (c) and provided in further detail in Response (f), the amount of VOC emissions released per unit blowdown and per station blowdown are dependent upon the volume of gas released and the VOC content of the gas at the time of the release.

Based on historical data, emissions from centrifugal compressor unit blowdowns at the Cromwell Compressor Station have ranged from 0.8 to 45 pounds of VOC per blowdown event, and emissions from station blowdowns have ranged from 35 to 902 pounds of VOC per event.

e) Verification of the unregulated VOC fugitive emissions reported in the annual emission statements.

Table 2 presents a summary of actual VOC emissions reported to CTDEEP in the annual emission statements.

Table 2 – Actual VOC Emissions (tpy) from Non-Excludable Sources Cromwell Compressor Station					
	2017	2018	2019	2020	2021
Fugitive Emission Sources	14.99	16.05	13.28	13.27	13.28
Vented Emissions	1.66	2.75	2.67	0.76	1.31
Total Non-Excludable Emissions	13.29	13.29	15.96	14.03	14.59

f) Anticipated reduction of actual VOC emissions from non-excludable sources as a result of RACT.

The reductions in VOC emissions from non-excludable sources proposed in the VOC RACT Compliance Plan are associated with control of vented VOC emissions (i.e., gas releases). Actual emission reductions associated with implementation of the VOC RACT Compliance Plan are difficult to determine due to the variable nature of the compressor station's operation, which are subject to changes in customer demand. Additionally, actual emissions are a function of several variables that are hard to predict on a year-to-year basis, such as gas quality and weather. These variables have led Algonquin to develop a facility model to represent potential emissions for permitting purposes. The use of this model for permitting is explained below.

Vented Emissions

VOC emissions from gas releases are a function of the volume of gas emitted and the VOC content of the gas.

The potential volume of gas released at a standard compressor station is determined through Enbridge's extensive system-wide experience permitting and operating gas compressor facilities. This experience has allowed Algonquin to develop a facility model of gas releases from a gas compressor station that is a function of the number and type (i.e., reciprocating vs centrifugal) of compressors at the facility. For the baseline emissions established in the 2017 NSR application, gas releases at the Cromwell Compressor Station were calculated using the model with an input of five centrifugal compressor units. Modelling results reveal that the vented gas volume at the site is estimated to be 104,645,600 standard cubic feet per year (scf/yr).

The VOC content of natural gas can vary greatly based on the shippers' gas sources. Therefore, when quantifying VOC emissions from gas releases, Algonquin uses a worst-case expected VOC content of natural gas, based on a statistical analysis of gas samples collected across the Enbridge gas transmission system over time. In calculating the baseline VOC emissions from gas releases at the Cromwell Compressor Station, Algonquin assumed a VOC

content of the gas based on the 90th percentile VOC content of the observed samples across the Enbridge gas transmission system. The resultant baseline VOC emissions of 58.2 tpy provide adequate compliance margin when no controls are installed on the equipment because the 90th percentile VOC content is significantly higher than the VOC content that has been historically observed at the facility.

In calculating the post VOC RACT Compliance Plan emission of 8.3 tpy, which represents the allowable VOC emissions from gas releases at the Cromwell Compressor Station, Algonquin continues to assume the 90th percentile VOC content, combined with an estimated total vented gas volume of 14,926,000 scf/yr. Total actual VOC emissions are dependent on gas volume and VOC content. Consequently, if actual VOC content of the natural gas is lower than the VOC content assumed in the calculation of allowable VOC emissions, a greater volume of natural gas can be released and result in the same total mass emissions of VOC.

For example, if the actual annual average VOC content from 2021 (0.12% weight) was used with the same gas volume of 14,926,000 scf/yr, 0.39 tpy VOC would be calculated assuming a gas density of 0.0431 lb/scf.

Given the variable potential VOC content of the gas, and the variable customer demand on the system, actual VOC reductions are hard to quantify, but by implementing the VOC RACT Compliance Plan less natural gas will be released to the atmosphere.

Fugitive Emissions from Piping Components

Fugitive emissions include VOC emissions from piping components that potentially contain one of four process fluids: natural gas, pipeline liquids, heavy oil, and water/oil.

Potential emissions from compressor station piping components are calculated for each type of process fluid that is contained within the piping. These calculations are based upon (i) USEPA's average leak rate emission factors[1]; (ii) the estimated number of piping components based on the number of compressor units at the station; and (iii) the VOC content of each process fluid. For the 2017 NSR application, the potential VOC emissions from piping components were 9.87 tpy.

Algonquin estimates the actual VOC emissions from piping components in natural gas service using (i) USEPA's average leak rate emission factors assuming a leak duration of 8,760 hours per year; (ii) the estimated component counts, and (iii) the actual annual average VOC content of the gas. The only change in reported emissions from year-to-year is the VOC content of the gas assumed for emissions from the components in natural gas service.

Reported emissions could be further refined to account for control efficiencies achieved through the application of NSPS OOOOa LDAR Program.

[1] USEPA, Protocol for Equipment Leak Emission Estimates (EPA 453/R-95-017).

g) Copy of VOC RACT orders issued to Algonquin facilities located in other states, if any.

None of the other Algonquin facilities in New York, Connecticut, Rhode Island, or Massachusetts have VOC RACT orders or are subject to VOC RACT for fugitives or gas releases.

Some Enbridge facilities in Pennsylvania are subject to the VOC RACT requirements found in 25 PA Code 129.96 through 100. Pennsylvania identified presumptive RACT as good operating practices for individual sources that have potential to emit less than 2.7 tpy VOC. Therefore, no additional controls have been required for sources of gas releases at Enbridge compressor stations in Pennsylvania.

ATTACHMENT 1: SUPPORTING CALCULATIONS FOR BASELINE YEAR VENTED EMISSIONS

TABLE G-1B
Gas Releases
Hourly and Annual Emission Estimates

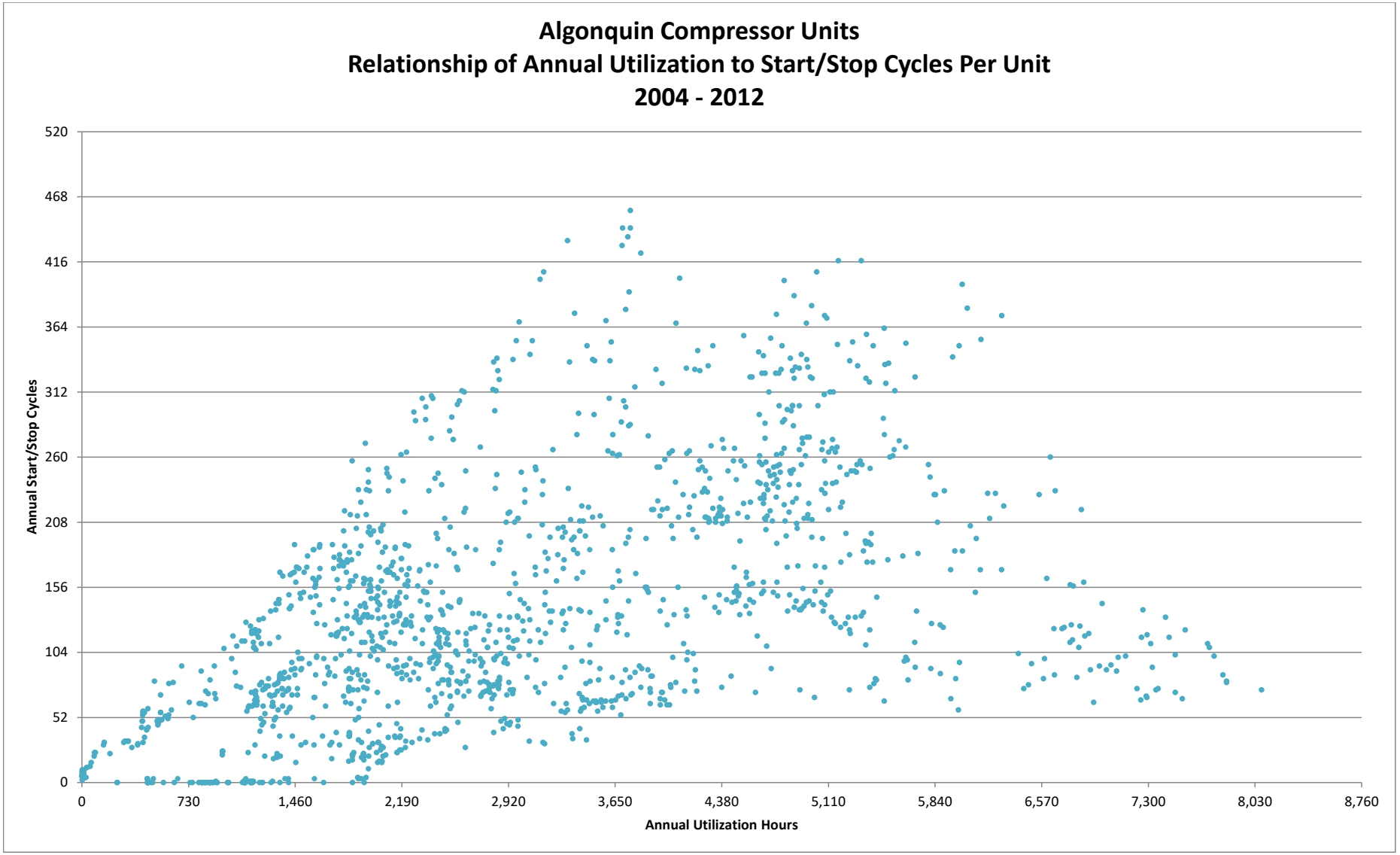
Category	Station Operations					
Source	CROM-GR-ST			CROM-GR-PL		
	Avg. Hourly	Max. Annual	Max. Hourly	Avg. Hourly	Max. Annual	Max. Hourly
Gas Release	10,325 scfh	90,445,600 scf/yr	4,554,560 scfh	1,621 scfh	14,200,000 scf/yr	5,680,000 scfh
	468 lb/hr	4,097,968 lb/yr	222,179 lb/hr	73 lb/hr	643,383 lb/yr	277,080 lb/hr
NO_X						
CO						
SO_2						
$PM_{10/2.5}$						
$CO_{2\text{-}e}$	11,157 lb/hr	48,867 tpy	5,378,819 lb/hr	1,752 lb/hr	7,672 tpy	6,707,935 lb/hr
CO_2	15.9369 lb/hr	69.8037 tpy	10,563.8409 lb/hr	2.5021 lb/hr	10.9592 tpy	13,174.1851 lb/hr
N_2O						
TOC (Total)	468 lb/hr	2,049 tpy	222,179 lb/hr	73 lb/hr	322 tpy	277,080 lb/hr
Methane	446 lb/hr	1,952 tpy	214,730 lb/hr	70 lb/hr	306 tpy	267,790 lb/hr
Ethane	60 lb/hr	261 tpy	43,464 lb/hr	9 lb/hr	41 tpy	54,204 lb/hr
VOC (Total)	10.2829 lb/hr	45.0390 tpy	21,100.9249 lb/hr	3.0040 lb/hr	13.1575 tpy	26,315.0015 lb/hr
VOC (non-HAP)	9.9687 lb/hr	43.6629 tpy	20,605.2435 lb/hr	2.9334 lb/hr	12.8484 tpy	25,696.8363 lb/hr
HAP (Total)	0.3142 lb/hr	1.3761 tpy	495.6814 lb/hr	0.0706 lb/hr	0.3091 tpy	618.1652 lb/hr
Acetaldehyde						
Acrolein						
Benzene	0.0858 lb/hr	0.3760 tpy	177.3145 lb/hr	0.0252 lb/hr	0.1106 tpy	221.1292 lb/hr
Biphenyl						
Butadiene (1,3-)						
Carbon Tetrachloride						
Chlorobenzene						
Chloroform						
Dichloropropene (1,3-)						
Ethylbenzene	0.0385 lb/hr	0.1688 tpy	27.3195 lb/hr	0.0061 lb/hr	0.0265 tpy	34.0702 lb/hr
Ethylene Dibromide						
Formaldehyde						
Hexane (n-)	0.1824 lb/hr	0.7990 tpy	495.6814 lb/hr	0.0706 lb/hr	0.3091 tpy	618.1652 lb/hr
Methanol						
Methylene Chloride						
Methylnaphthalene (2-)						
Naphthalene						
PAH						
Phenol						
Propylene Oxide						
Styrene						
Tetrachloroethane (1,1,2,2-)						
Toluene	0.0967 lb/hr	0.4234 tpy	153.8836 lb/hr	0.0219 lb/hr	0.0960 tpy	191.9085 lb/hr
Trichloroethane (1,1,2-)						
Trimethylpentane (2,2,4-)	0.0322 lb/hr	0.1410 tpy	15.3827 lb/hr	0.0051 lb/hr	0.0221 tpy	19.1838 lb/hr
Vinyl Chloride						
Xylenes	0.1172 lb/hr	0.5134 tpy	232.2156 lb/hr	0.0331 lb/hr	0.1448 tpy	289.5965 lb/hr

NOTES

1. Gas release estimates based on engineering evaluation of several other compressor stations.
2. Data used in estimates is based upon model deemed to be most representative of natural gas at the site.
   There are five (5) models to choose from which are based on laboratory extended analysis of samples collected at various locations along Enbridge pipelines.
   Selected Grouping of Available Samples: **PLQNG** Samples that conform with Tariff
   Number of Samples in Grouping: 421
   States Represented in Grouping: AR, CT, IN, KY, LA, MA, MD, ME, MO, MS, NJ, NS, NY, OH, OK, PA, RI, TN, TX, VA and WV
   Dates Represented in Grouping: 2011 thru 2016
   Selected Class for Grouping: **WC** → Selected Model: **PLQNG: WC**
3. If necessary, customizations (SF) are applied to make the models more representative of natural gas at the site.

	Average		Maximum	
Upper Percentile Limit Applied:	90%	SF	100%	SF
Heating Value (BTU/scf)	1,069 BTU/scf	130%	1,109 BTU/scf	120%
Density (lb/scf) at USEPA Standard Conditions	0.0453 lb/scf	130%	0.0488 lb/scf	120%
VOC (Total)	2.20% by wt.	130%	9.50% by wt.	120%
HAP (Total)	0.07% by wt.	130%	0.22% by wt.	120%

ATTACHMENT 2: RELATIONSHIP BETWEEN UTILIZATION AND START/STOP CYCLES FOR ALGONQUIN COMPRESSOR UNITS


Algonquin Compressor Units
Relationship of Annual Utilization to Start/Stop Cycles Per Unit
2004 - 2012
Annual Start/Stop Cycles
520
468
416
364
312
260
208
156
104
52
0
0
730
1,460
2,190
2,920
3,650
4,380
5,110
5,840
6,570
7,300
8,030
8,760
Annual Utilization Hours