Review of the General-Purpose Heat Source Module Reduction and Monitoring Processing at INL

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Changing the World's Energy Future

Joe Giglio

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ABSTRACT

A thorough review of the Module Reduction and Monitoring (MRM) process was conducted to evaluate the efficacy of processing. The degree of reduction was calculated using the mass balance of oxygen contained in carbon monoxide (CO) and carbon dioxide (CO₂) removed from all fuel processed between January 2014 through August 2019. The plutonia was slightly reduced from O/Pu ratio of 2.0 to a range of 1.991 to 1.999. The review evaluated publications generated when MRM processing was developed and performed at the Mound Laboratory. A similar degree of reduction was measured at Mound in the 1982 paper authored by Ernie Johnson as well as MRM processing of IHS-60 and some Cassini-era fuel. The original 1982 paper documenting the reduction process reported a mass balance reduction to 1.9931 yet reported a total reduction to ~1.98 (Johnson 1990). The IHS-60 and Cassini reductions were calculated at 1.995 and 1.997 using the number of moles of CO and CO₂ removed as published in a clad pressurization investigation report (Merten, et al 1995). MRM process changes are recommended to improve the accuracy of the CO partial pressure calculation.

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ACRONYMS

AMU	Atomic mass unit
Ar	Argon gas
Atm	atmosphere (pressure)
CO	Carbon Monoxide gas
CO ₂	Carbon Dioxide gas
EG&G	Edgerton, Germeshausen, and Grier, Inc, the contract administrator for the Mound facility
FC	Fuel Clad
GIS	Graphite Impact Shell
GPHS	General Purpose Heat Source
He	Helium gas
IHS	Isotopic Heat Source
INL	Idaho National Laboratory
K	Kelvin
mmoles	1/1000 mole
MMRTG	Multi-Mission Radioisotope Thermoelectric Generator
MOD	Module
MRM	Module Reduction and Monitoring
MRMF	Module Reduction and Monitoring Facility
N ₂	Nitrogen gas
O ₂	Oxygen gas
O/Pu	Ratio of oxygen to plutonium in the fuel
Pa	Pascal
psia	pounds per square inch absolute
Pu	Plutonium
PuO ₂	Plutonium Dioxide
RGA	Residual Gas Analyzer
RPS	Radioisotope Power Systems
RTG	Radioisotope Thermoelectric Generator
SME	Subject Matter Expert
°C	Degree Celsius

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Review of the General-Purpose Heat Source Module Reduction and Monitoring Processing at INL

Introduction

Early work building General Purpose Heat Source-Radioisotope Thermoelectric Generators (GPHS-RTG) determined that the heat source used for Radioisotope Power Systems (RPS), plutonium dioxide (PuO_2), needed to be slightly reduced, estimated at $\text{PuO}_{1.98}$, to limit the amount of oxygen inside the generator during ground handling operations.

This work was performed at Mound Laboratory near Dayton Ohio and later transferred to Idaho National Laboratory (INL). The processing of heat sources at Mound and the acceptance specification is described by Ernest Johnson in the paper “*Post-encapsulation plutonia reduction for Galileo and Ulysses GPHS modules: The module reduction and monitoring facility (MRMF)*” presented at the American Institute of Physics conference in 1991. The heat sources, typically 2 GPHS modules, were loaded into the MRM can with graphite felt used as an insulator, then placed on the Module Reduction Monitoring Facility (MRMF), a vacuum and backfill gas exchange system. The self-heating characteristics of the Pu-238 fuel enabled reduction in an oxygen – carbon reaction at elevated temperatures.

The amount of reduction is dependent on fuel temperature, estimated at 1410 K by Johnson in “*The Behavior of Oxygen Partial Pressure Over Slightly Substoichiometric Plutonia at 1410 K*”. This is an important paper in that it describes the basis for the current MRM process. Additionally, Johnson outlines the thermodynamic calculations governing the reduction process and gives a method to determine the maximum graphite temperature using the ratio of CO and CO_2 .

Reduction occurs when oxygen from the fuel evolves, exits the iridium cladding through the frit vent, and reacts with the carbon from the graphite of the GPHS module creating CO and CO_2 . The ratio of CO and CO_2 is dependent on the maximum graphite temperature of the system assumed to be the floating membrane of the GPHS Graphite Impact Shell (GIS). These gases pass back into the fuel cladding through the frit vent where the CO reacts with the oxygen disassociated from the fuel, forming CO_2 . The cyclic reaction continues until near thermodynamic equilibrium is reached, ~1.98 at a fuel temperature of 1410 K.

According to the post encapsulation paper (Johnson 1991), the gas composition is measured bi-weekly using a Residual Gas Analyzer (RGA) to determine the partial pressure of argon (Ar), helium (He), CO_2 , and CO. The fuel is considered reduced when the reaction products (CO and CO_2) are insignificant, indicated by three consecutive measurements of CO are below 500 pascals. Each MRM canister is evacuated and backfilled with ultra-high purity argon after every gas composition measurement or gas tap.

In practice, data from 1995 in support of the Cassini mission and IHS-60 processing suggests gas composition measurements (gas taps) were conducted on a weekly basis. In addition, calculations in the EG&G Mound Applied Technologies “*Investigation of Apparent Fuel Clad Pressurization During the MRMF Process*”, which Ernest Johnson is a co-author, suggest a significantly lower level of reduction than 1.98. The IHS-60 was estimated to be reduced to 1.994 and the Cassini fuel to 1.997 using the Moles of Gas Released columns in Tables 2.1 and 2.2 of the report (Figure 1 and Figure 2). This lower level of reduction is more in line with the mass balance calculations performed at INL, ~1.998 for the Mars 2020 mission.

Table 2.1. 60 Watt MRMF Gas Release Data

	Partial Pressure (Pa.)		Moles of Gas Released (millimoles) (Engineering estimate)		
	CO	CO ₂	CO	CO ₂	He
Tap #1 2/16/95	18,100	271.4	7	0.3	6.9
Tap #2 2/21/95	1,120	125.7	0.6	0.24	0.37
Tap #3 2/27/95	Insulation added to increase the processing temperature 2/22/95*				
	1,252.3	119	0.6	0.4	0.47
Tap #4 3/2/95	277	138.5	0.2	0.2	0.37
Tap #5 3/9/95	250.8	125.4	0.18	0.18	0.65
Tap #6 3/16/95	248.7	96.7	0.22	0.14	0.62
Tap #7 3/23/95	125.2	83.4	0.2	0.13	0.6
Tap #8 4/3/95	1,185	93.4	0.54	0.14	1.34
Tap #9 4/10/95	318.9	97.1	0.22	0.15	0.51
Tap #10 4/17/95	257.9	87.35	0.2	0.14	0.47
Tap #11 4/24/95	176.95	81.56	0.17	0.13	0.45
Tap #12 5/15/95	366.54	92.33	0.25	0.14	0.96
Tap #13 5/22/95	225	80.06	0.18	0.13	0.47
Tap #14 5/30/95	497.38	77.8	0.27	0.12	0.71
Tap #15 6/6/95	203.45	80.82	0.17	0.12	0.41

*This increased the temperature on the outside of the can from 204 C to 241 C.

Figure 1. Investigation of Apparent Fuel Clad Pressurization IHS-60 MRM data

Table 2.2. Cassini Production Qual Lot MRMF Gas Release Data

	Partial Pressure (Pa.)		Moles of Gas Released (millimoles) (Engineering estimate)		
	CO	CO ₂	CO	CO ₂	He
Tap #1 3/27/95	12,312	833.9	5.5	0.53	2.5
Insulation added to increase the processing temperature 2/22/95*					
Tap #2 4/3/95	954.9	89.8	0.5	0.17	2.57
Tap #3 4/10/95	390.6	94.9	0.28	0.18	0.64
Tap #4 4/17/95	305.96	90.4	0.24	0.16	0.51
Tap #5 4/24/95	242.89	84.67	0.21	0.16	0.5
Tap #6 5/15/95	3,913.48	98.36	1.56	0.17	1.04
Tap #7 5/22/95	381.5	88.79	0.27	0.16	0.51
Tap #8 5/30/95	236.04	75.92	0.21	0.14	0.52
Tap #9 6/6/95	• 169.16	76.26	0.18	0.14	0.47

*This increased the temperature on the outside of the can from 194 C to 294 C.

Figure 2. Investigation of Apparent Fuel Clad Pressurization Cassini MRM data

MRM Processing

Module reduction operations start by calibrating the RGA with a gas of known composition. INL uses SPC-1553-CAL-MRM that includes a known amount of Ar, CO, CO₂, and He (see Table 1). The RGA is calibrated with a consistent gas pressure of 0.50 ± 0.02 psia present in the main manifold. The gas is passed from the main manifold to the RGA test chamber through a variable conductance valve to achieve an RGA test pressure of approximately 1×10^{-5} torr. The calibration is performed prior to all tests and all tests are performed at the 0.50 ± 0.02 psia test pressure.

Table 1 SPC-1553-CAL-MRM gas constituents

RPS Gas ID	Description	Mixture gases (Concentration)			
		Ar (Balance)	CO (9.5-10.5%)	He (1.9-2.1%)	CO ₂ (1.9-2.1%)
CAL-MRM	MRM Gas, 86/10/2/2 Ar/CO/He/CO ₂				

Cans are loaded, welded closed, backfilled with helium and leak checked prior to MRM processing. Each can has a manual isolation valve that is shut and capped after backfilling. These cans are generally processed in batches and connected to a branch manifold, Manifold A, B or C. Each branch manifold connects to the main manifold isolated by solenoid valves. The cans are connected to a station as determined by the MRM subject Matter Expert (SME). Each station is isolated from the branch manifold using a station solenoid valve.

Figure 3. MRMF with multiple cans processing

The system, up to the manual MRM can valve, is evacuated and backfilled with high purity Ar multiple times to ensure minimal impurities are in the system. The manual can valves are opened then the MRM cans are evacuated and backfilled with Ar to 20 psia. The system is configured with the branch manifold solenoid valve closed and the station solenoid valves open to begin processing. Processing always begins with the MRM cans “open to the manifold” where the gas pressure can be monitored. After approximately 24 hours, the cans are insulated to achieve a temperature of 250 to 325°C as measured by a thermocouple contacting the side of each can. Inconsistent thermal loading (quantity of fuel) and felt packing methods can result in variable fuel temperatures.

The first gas tap is taken one week into the processing. The RGA is calibrated and the main manifold evacuated. The branch manifold pressure is noted and the manifold solenoid valve is opened to the main manifold. This pressure of the main manifold is recorded as the release pressure on the data sheet for each can. Processing the data has changed over the years. The release pressure was used at Mound and initially at INL when processing the cans closed to the manifold. This will be described in more detail later. The entire system is then pumped down to 0.50±0.02 psia as read on the main manifold pressure gauge. An

RGA data point is taken. The partial pressure of CO as read on the RGA and the initial branch manifold pressure are used to calculate the partial pressure of CO in the system. After the gas tap, the system is evacuated, backfilled with Ar and the branch manifold valve shut. The processing continues open to the manifold with weekly gas taps.

CO Partial Pressure Equation

$$P_{CO} = P_{man} * (P_{CO_RGA} / P_{RGA}) * (101325 / 14.7)$$

Where

P_{CO} = Partial pressure of CO (Pa)
 P_{man} = Pressure of the branch manifold prior to release (psia)
 P_{CO_RGA} = RGA partial pressure of CO (torr)
 P_{RGA} = Total pressure of the RGA (torr)
 $101325 \text{ Pa/atm} / 14.7 \text{ psia/atm} = 6895 \text{ (Pa/psia)}$

Most of the gas is evolved from the fuel after several gas taps. At this point, the SME will direct the station solenoid valve shut to begin processing “closed to the manifold”. The pressure inside the can is not known and must be estimated during the CO partial pressure calculation. Each can is evacuated and backfilled individually to 20 psia and the station solenoid valve is shut and leak tested. The branch manifold pressure is also set to 20 psia to minimize chance gas exchange with the MRM cans.

Gas taps performed with the cans closed to the manifold are slightly different. Both the branch manifold and main manifold are evacuated. After the branch manifold solenoid valve is shut, the station solenoid valve is opened to release the MRM gas into just the branch manifold. Historically, this release pressure was not recorded, but this changed during processing of the Mars 2020 fuel. The branch manifold gas is then released to the main manifold where this release pressure is recorded. The system is pumped to 0.50 ± 0.02 psia and the RGA sample taken. The partial pressure of CO as read on the RGA and the estimated MRM can pressure is used to calculate the partial pressure of CO in the MRM can. Cans are processed until each one generates less than 500 Pa of CO for three consecutive taps.

$$P_{CO} = P_{can} * (P_{CO_RGA} / P_{RGA}) * 6895$$

Where

P_{can} = Estimated pressure of the MRM can (psia)

Mound document MD-21785, Issue 18, the latest known version of the Module Reduction and Monitoring Facility Operations instructions was reviewed to determine if any differences between processing at Mound vs INL could be identified. The procedures appear consistent including using the same equipment. The only difference noted is that INL processes the MRM can with a surface temperature between 250 and 325°C. The can temperature is not defined in the Mound instructions. Data from the investigation of the IHS-60 apparent pressurization (Merten, et al 1995) shows processing IHS-60 cans at 241°C and Cassini cans at 294°C. It is not known when the temperature range was imposed.

A potential difference in the processing is the packaging of the fuel in the can. The fuel is packaged in the can surrounded by pieces of graphite felt which act as a thermal insulator. The configuration of the felt is not controlled and therefore open to process variation. When the process was transferred to INL, Mound personnel were hired by INL to assure a smooth transition of the method and it is reasonable to assume the same packaging techniques were used. INL personnel span the original Pluto New Horizon GPHS-RTG build to the latest MMRTG build.

Figure 4. Packaging drawing of MRM can L134

A change to packaging configuration occurred in April 2017. The graphite packing methodology was changed from a random stuffing of felt (Figure 4) to felt disks stacked to fill more of the MRM can volume. Cylinder cutouts were provided to suspend each GIS in the approximate center of the MRM can (Figure 5). Historically, assembled modules (2 GIS installed in an aeroshell) were processed, but the IHS-60 heat sources were processed as 3 GIS in one MRM can. Afterwards, the IHS-60 heat sources were removed from the GIS and welded into the heat source form. At INL, GIS were loaded into MRM cans at first using the random felt method, then changed to the stacked disks method.

A second potential difference in processing at INL and Mound is the purity of the gas in the can after completing a gas tap. General use gas bottle regulators from Mound were transferred to INL as part of the MRM process equipment. Slowly, these regulators have been replaced with research grade regulators designed to minimize impurities. Processing MRM cans leaves some room for interpretation of gas purity. A typical evacuation step will lead to evacuate to less than 50 mtorr as measured by the main manifold thermocouple gauge. It is typical to pump the system down lower than the thermocouple gauge can measure. It is not known what effect this has on the pressure inside an MRM can where the can is evacuated through a small diameter tube or the effects of the gas left in the clads that have to pass through the frit vent. It is possible the impurities remaining in the can using present evacuation techniques are different than when processed at Mound.

Figure 5. Updated GIS packaging with 2 GIS post can cutting

Estimating Can Pressures when Closed to the Manifold

Estimating the MRM can pressure during processing closed to the manifold has been performed differently over the years. The difficulty arises due to many factors: the fuel is self-heating, making it difficult to apply the ideal gas law, the gas temperature is not known, the MRM can volume is variable due to, fuel load, felt packing, weld shrinkage and variability in the station flex lines. Mound developed a method of testing the “apparent volume of can” by backfilling the can to a set pressure, allowing the system to become thermally stable, evacuating the manifold then dumping the MRM can gas into the manifold with known volume.

$$V_{app} = P_{rel} * V_{man} / (P_O - P_{rel})$$

Where

V_{app} = Apparent volume of the MRM can (L)

P_{rel} = Release pressure of the manifold and MRM can (psia)

V_{man} = Volume of the manifold (L)

P_O = Initial pressure in the MRM can (psia)

The intent at INL was to perform the calculation as done at Mound. There appears to have been a mistake in interpreting the apparent volume that resulted in a miscalculation of the CO partial pressure. This is documented in the Craig Dees memo dated June 19, 2013 in support of Problem/Failure Review (P/FR) form INL-IP-FY13-913. This memo concluded that calculating the gas pressure was less accurate than using the backfill gas pressure performed on the previous tap. This may not be accurate in the initial gas

taps where a significant amount of helium and oxygen are evolved from the fuel, but is a reasonable assumption during the final 3 gas taps where the CO partial pressure is less than 500 Pa.

Another method of estimating the gas pressure is to use the release pressures of the can into two other known volumes. This was developed and performed during the recent servicing of legacy heat sources at INL. The MRM output has significant noise requiring averaging several data points and has only been used processing the data in this report. The gas pressure, the number of moles of gas in the MRM can, and the variable equal to the average MRM can gas temperature divided by the MRM can volume is determined (see Appendix A for more details). The recent change in recording the release pressures of the can into the branch manifold and the branch manifold / can volume into the main manifold has opened different methods of analyzing the RGA data that will be utilized in subsequent mass balance calculations.

Addition Comments to the Published Literature

Mass balance calculations presented a reduction of 1.9931 (Johnson 1982). Merten et al. (1995) reported data suggesting the IHS-60 fuel was reduced to 1.995 and the Cassini fuel to 1.997. A reduction to 1.997 is consistent with the GPHS F2, F6 and F7 units reported in *Carbon Monoxide Levels in Cassini RTGs* (GESF 7253 1997) where 125.86, 112.17 and 119.74 mmols of oxygen were removed during MRM processing. This level of reduction is repeated in the 1991 Johnson paper, yet there continues to be a declaration that the fuel is being reduced to ~1.98, which seems to contradict the data.

Amount of Plutonia per Fuel Clad

The amount of plutonia present in each fuel clad needs to be determined prior to calculating the reduction of fuel using a mass balance technique. The Los Alamos document LA-UR-00-4157, “*Fabrication of Radioisotope Heat Sources for Space Missions*” gives a typical chemical composition of a fueled clad. Johnson’s 1982 paper used 4.63 moles per MRM can containing 2 GPHS modules. The calculation in Table 2 yields 4.47 moles per MRM can containing two modules. The mass balance calculations performed subsequently use the data from Table 2.

Table 2. Molar concentration of the fuel clad pellet

Isotope	PuO ₂ molecular weight	Composition percentage	Mass assuming 151.1 g pellet weight	Moles per pellet
²³⁸ Pu	270	83.5	126.2	0.467
²³⁹ Pu	271	14.01	21.2	0.078
²⁴⁰ Pu	272	1.98	3.0	0.011
²⁴¹ Pu	273	0.37	0.6	0.002
²⁴² Pu	274	0.14	0.2	0.001
Total (8 pellets)				4.474 mol

CO₂ / CO Measurements

The RGA partial pressure of CO₂ is below the limit of detection during most of the processing at INL. It is not obvious to the user that this value is limited due to the calibration factors used. The displayed partial pressure indicates a reading of 10⁻⁹ torr or higher, which is higher than the oxygen partial pressure of 10⁻¹⁰ torr. However, the calibration factor for CO₂, as low as 3.4 to as high as 19, is multiplied by the RGA reading resulting in a reported value higher than the minimum detectable pressure.

There needs to be a detectable amount of CO₂ and therefore a significant amount of CO to obtain an estimate of the maximum carbon temperature. A note in the 1982 paper at the bottom of Table 4 suggest

CO₂ is not detectable. It appears Mound was also attempting to measure below the detectability of CO₂ with the same instrumentation transferred to INL. Because of this, the calculated maximum carbon temperature appears to decrease with time. There appears to be a limited number of test points in which this method yielded a reasonable maximum carbon temperature. The initial gas tap with multiple cans open to the manifold typically yielded the highest carbon temperature.

CO and nitrogen (N₂) have the same atomic mass units (AMU) of 28 and therefore, one cannot distinguish between the two gases by looking at the primary peaks. Each gas molecule cracks into molecules or in this case individual atoms at a predictable rate and shows up as smaller peaks at different AMUs. CO cracks into a single carbon atom (12 AMU) and a single oxygen atom (16 AMU). These atoms are secondary peaks for other gases in the system and do not give much information. Nitrogen breaks into two individual nitrogen atoms (14 AMU) 7% of the time for a 14% relative intensity as stated on the Dycor® *Mass Spectra Fragmentation Pattern Calculator*. It is current practice to scan AMU 14 as a diagnostic tool to help determine if air is leaking into the system. Air would also allow O₂ into the system creating CO. A quick check to determine if air is leaking into the system is to multiply the AMU 14 partial pressure by 7 (100%/14%) and verify the value is significantly below the AMU 28 pressure.

RGA Calibration Factors

During RGA calibration, the RGA total pressure is scaled to meet the total pressure of the calibrated ion gauge. The individual AMU for each gas species is scaled until the RGA pressures are approximately equal to the theoretical RGA pressures for the specific partial pressure of the calibration gas. The total RGA pressure is not a summation of the partial pressures, it is an independent measurement designed to protect the RGA from operating at too high a pressure and damaging the instrument. Figure 6 demonstrates that the calibration factors trend well with the other gas species and that the ratio of the CO and Ar is reasonably constant at approximately 1.

Calibration factors and ratio of CO/Ar vs. date

Figure 6 - Calibration factors and ratio of CO/Ar vs time

Mass Balance Calculations

The mass balance calculation is a straightforward technique that measures the oxygen in the MRM gas composition and removes that value from the calculated oxygen remaining in the fuel assuming the initial stoichiometry of the fuel is PuO_2 . The partial pressure of CO and CO_2 are calculated and the number of moles of the gases are estimated. Finally, the oxygen is subtracted from the number of moles of PuO_2 .

Three different methods of calculating the number of moles of CO and CO_2 are presented. The primary difference between these methods is how the mole fractions are calculated. The first method aligns with the operating procedure. This method ratios the RGA CO/ CO_2 partial pressure with the overall RGA pressure. As stated above, the overall RGA pressure is independent of the partial pressures of gases present, a design feature to protect the RGA from damage. The second method eliminates this error by using a summation of the calibration gas partial pressures. Analog RGA measurements taken during gas taps indicates the only gases present at significant values are the calibration gases, Ar, He, CO and CO_2 . This is a more accurate comparison to the individual gas partial pressures. Both methods ignore the evolution of He and the production of reactant gases (CO and CO_2) because these methods assume the fill pressure is the only pressure in the can.

The third method to calculate CO/ CO_2 ratio eliminates the error of the evolution of gases from the fuel by using the RGA partial pressure of Ar as the denominator. The can is filled with pure Ar to a set pressure. Ar is neither consumed nor evolved from the fuel and is therefore present at a constant 20 psia throughout processing. The same instrument is used to measure CO/ CO_2 and Ar and all are calibrated with the same gas at the same time. In almost all cases presented, this method yields the highest CO/ CO_2 pressures and therefore the most conservative result, from a processing standpoint.

Using the ideal gas law, the number of moles can be calculated provided the volume is known. The difficulty comes from estimating the apparent volume of the MRM can. This is estimated using the two known volume pressure releases described in Appendix A. This provides a total estimate of moles of gas in the can as well as the temperature to volume (T/V) ratio variable. To minimize the can volume and can temperature error, the reduction calculation uses the measured release pressure to calculate an average T/V ratio over several test points. The release pressure and the volumes of the manifolds at room temperature are used to estimate the number of moles in the MRM system. The release pressure and the T/V ratio are used to calculate the moles remaining in the can. The summation of these two values equals the total number of moles in the system. Finally, as a quality check, the numbers of moles calculated during the two known volume releases and the calculated moles of gas in the MRM can and manifolds at release are compared. The results match within 10% in all cases except for cans processed on the B manifold, which are within 20%.

$$N_{tot} = \frac{P_{rel}}{R} * \left(\frac{1}{\left(\frac{T}{V}\right)_1} + \frac{1}{\left(\frac{T}{V}\right)_2} \dots + \frac{V_{man}}{T_{amb}} \right)$$

Where

N_{tot} = Total number of moles of gas present

P_{rel} = Final release pressure (Pa)

R = Ideal gas constant (J/(Mol*K))

$(T/V)_1$ = The average temperature volume variable calculated from release pressures (K/m³)
for Can 1 and additional cans when processed open to the manifold and only one can
when closed to the manifold.

V_{man} = Volume of the manifold (m³)

T_{amb} = Ambient temperature (298 K)

And

$$N_{CO} = N_{tot} * \left(\frac{P_{CO}}{P_{RGA}} \right) \quad Or \quad N_{CO} = N_{tot} * \left(\frac{P_{CO}}{P_{SUM}} \right)$$

$$N_{CO2} = N_{tot} * \left(\frac{P_{CO2}}{P_{RGA}} \right) \quad Or \quad N_{CO2} = N_{tot} * \left(\frac{P_{CO2}}{P_{SUM}} \right)$$

$$O/Pu = (2 * N_{Pu} - \Sigma(N_{CO} + 2 * N_{CO2}))/N_{Pu}$$

Where

N_{CO} = Number of moles of CO

N_{CO2} = Number of moles of CO₂

P_{CO} = RGA partial pressure reading for CO (torr)

P_{CO2} = RGA partial pressure reading for CO₂ (torr)

P_{RGA} = RGA total pressure

P_{sum} = Sum of the RGA calibration gas partial pressures (torr)

O/Pu = Ratio of oxygen to plutonium

Reduction data from MRM can L1303 was used to calculate the number of moles of gas remaining in the can compared to the total number of moles in the manifold / can system. This can was installed on manifold A without other cans. When processed open to the manifold, only 36% of the gas in the system

remained in the can. When processed closed to the manifold, only 12% of the gas remained in the can. This changed to 13% when the can was moved to storage on manifold C. The can was processed open to the manifold for 3 weeks where the can reduced from 2.0 to 1.997. The total reduction for this can was to 1.991. Therefore, most of the reduction that occurred was closed to the manifold where 88% of the gas was in the known volume of the manifolds, at ambient temperature.

The Ar partial pressure calculation relied on the original 138kPa (20 psia) of Ar loaded into the system and the ratios of the RGA partial pressures of each gas to the partial pressure of Ar. In this case, the volume of the can is not known, so the average T/V value was utilized. Each gas species pressure was calculated and then utilized for the calculation of the number of moles. This method accounts for the additional gases released or generated when processing.

$$P_{CO/CO_2} = 138 \text{ kPa} * \left(\frac{P_{CO/CO_2}}{P_{Ar}} \right)$$

And

$$N_{CO/CO_2} = \frac{P_{CO/CO_2}}{R} * \left(\frac{1}{\left(\frac{T}{V} \right)_1} \right)$$

There is an error in the T/V variable, in that the calculated pressure of the can using the Appendix A method divided by the sum of the gas partial pressures averages 88% on cans processed on manifolds A and C. Cans processed on manifold B averaged 140%. Evaluation of the branch manifold pressure transducer readings to the main manifold transducer suggests the manifold B pressure transducer pressure reading was not accurate. In addition, this method assumes Ar is not added or removed. This is not the case for cans where pressure checks were performed. These cans generated significant CO pressures during this time, so Ar was likely vented as the manual valve was cycled.

Assumptions

Processing the can open to the manifold exposes several heat sources to the same volume. The amount of oxygen removed is assumed to be evenly distributed even if the heat sources have different can temperatures.

Manifold volumes in Table 3 are based on the Munns memo titled “MRM Can Internal Volume Determination”, dated May 15, 2005.

Table 3. MRMF Manifold Volumes

Manifold	Volume (L)
A	1.79
B	1.87
C	2.27
Main	5.05

Typical Data Sheet

A marked-up copy of the April 27, 2017 RGA scan of can L1308 is shown in Figure 7. This gas tap yielded a high partial pressure of CO that was measured after prolonged storage at a can temperature 100 °C cooler than during processing. The printout shows the masses of the constituent gasses, the calibration factors, and the partial pressures of each gas. The secondary peak of nitrogen (N) is two orders of

magnitude low, indicating that N is not the cause of the high CO interpretation. The CO₂ value when adjusted for the calibration factor shows a value equivalent to oxygen, which is undetectable. Previous records indicate the can was filled to 20.23 psia during the last processing cycle. The partial pressures using different molar ratios are displayed showing 4 to 7 kPa of CO present.

Figure 7 - April 27, 2107 RGA scan of can L1308

Results

The reduction calculation for all fuel processed since 2014 is shown in Table 4. Only one can, L1303, saw a significant reduction, due mostly to the large reaction products that occurred over a 74 day inactivity period. Reduction levels are consistent with the mass balance calculations performed at Mound but are an order of magnitude less than the 1.98 suggested in early papers.

Figure 8 through Figure 20 show the can histories and reduction at each gas tap. The left axis is the CO pressure calculated using the three different methods described above. The value of this axis varies for each can processed. The right axis is the calculated O/Pu value typically ranging from 1.98 to 2.0. The exception is the flight modules where little additional reduction was detected above the GIS processing. Five of the thirteen cans show a tendency for additional reduction after the processing was declared complete. These five cans are the earliest cans reviewed.

Using the ratio of P_{CO}/P_{Ar} and 138 kPa fill pressure to calculate the partial pressure of CO is the most accurate and easiest method when performing weekly and monthly gas taps. The CO pressure reduces to $138\text{kPa} \cdot (P_{CO}/P_{Ar})$ and can be accomplished using the upgraded MRM system RGA output. This method is not accurate when pressure checks that do not maintain gas isolation are involved since the partial pressure of Ar is no longer known.

More information could be obtained during this process. An electron multiplier on the RGA may allow the CO_2 partial pressure to be measured, thus allowing for a reliable maximum carbon temperature calculation. This maximum temperature is located at the floating membrane and close to the hot operating temperature of the fueled clad. Cans are now stored on the MRM system for years and understanding the clad temperature may be beneficial. Until the 2017 felt packing change, there was no real method of calculating the clad temperature analytically due to the variability of the packing. Controlling the felt configuration and minimizing gaps opens the ability to thermally model the can. Having a reasonable estimate of the floating membrane temperature allows independent verification of the model. In addition, helium is evolving from the fuel during processing. Known fuel temperatures could strengthen helium release models used by RPS providers.

There have been several occasions where processing was deemed complete followed by excessively high levels of CO after periods of inactivity at both Mound and INL.

1. IHS-60 Tap #8 on 4/3/95 (Figure 1). This is an intriguing event in that the period of inactivity is only 11 days. In the four weeks prior to the 11-day period, the CO pressure measured 277, 251, 249 and 125 Pa. If we assume 250 Pa of pressure build over 7 days and project that to 11 days, the CO pressure should have measured 393 Pa. There was 1185 Pa measured on day 11. The evolution was 130% the projected rate.
2. Cassini Tap #6 on 5/15/95 (Figure 2). This event had a period of inactivity of 21 days. Taps 1 – 5 measured 12,313, 955, 390, 306 and 243 Pa. If one assumes 400 Pa weekly gas pressure projected to 21 days yields 1200 Pa of CO. Tap #6 was 3913 Pa. The evolution was 66% the projected rate.
3. INL Can L1303 tap# 10 on 11/6/17 (Figure 14). The previous 4 weekly taps measured 156 to 160 Pa of CO. At 160 Pa per week projected over 74 days yields 1691 Pa where 32,812 Pa was measured (using the RGA partial pressure of Ar). The evolution was 100% the projected rate.
4. Figure 10 through Figure 13 also shows this behavior, but the extended period of monthly gas checks prevents detailed analysis. However, the plots show an excessively high value considering the can storage temperature is 100°C lower than the processing temperature. Two of these cans also show a rise in CO over the same 74-day period of can L1303.

Table 4 - Reduction calculation for all fuel processed since 2014.

MRM Can	Contents	GIS/MOD ID	FC ID	Reduction Method		
				RGA Total pressure	Sum of Partial Pressures	Argon pressure
L126	3 GIS	3173 3174 3180	FC0455 / FC0459 FC0446 / FC0454 FC0452 / FC0453	1.998	1.997	1.997
L134	3 GIS	3175 3177 3179	FC0448 / FC0442 FC0441 / FC0457 FC0449 / FC0451	1.998	1.997	1.997
L1301	3 GIS	F3219 F3213 F3214	FC0494 / FC0503 FC0501 / FC0504 FC0498 / FC0505	1.999	1.999	1.999
L1303	2 GIS	F3211 F3212	FC0478 / FC0477 FC0479 / FC0480	1.995	1.991	1.990
L1306	2 GIS	F3215 F3216	FC0496 / FC0499 FC0497 / FC0502	1.999	1.999	1.999
L1307	3 GIS	F3208 F3209 F3210	FC0461 / FC0466 FC0464 / FC0465 FC0471 / FC0467	1.999	1.998	1.998
L1308	3 GIS	3181 3188 F3207	FC0472 / FC0458 FC0469 / FC0468 FC0450 / FC0473	1.998	1.998	1.997
L1311	2 GIS	F3217 F3218	FC0506 / FC0508 FC0507 / FC0509	1.999	1.999	1.999
L1701	3 GIS	3090A 3166 3183	FC0482 / FC0487 FC0485 / FC0488 FC0492 / FC0493	2.000	1.999	1.999
L1702	2 Modules	F8138 F8139	FC0471/FC0467/ FC0497/FC0502 FC0496/FC0499/ FC0464/FC0465	1.999 ¹	1.998 ¹	1.998 ¹
L1704	2 Modules	F8134 F8135	FC0479/FC0480/ FC0485/FC0488 FC0482/FC0487/ FC0461/FC0466	1.998 ¹	1.997 ¹	1.997 ¹
L1707	2 Modules	F8132 F8133	FC0501/FC0504/ FC0469/FC0468 FC0454/FC0446/ FC0498/FC0505	1.999 ¹	1.998 ¹	1.999 ¹
L1708	2 Modules	F8136 F8137	FC0450/FC0473/ FC0494/FC0503 FC0492/FC0493/ 30C0478/FC0477	1.998 ¹	1.997 ¹	1.996 ¹
¹ No significant reduction was calculated at the module level. Reported values are of the average reduction at the GIS level.

Figure 8 - MRM Can L126 CO Pressure and Stoichiometry vs Gas Tap

Figure 9 - MRM Can L134 CO Pressure and Stoichiometry vs Gas Tap

Figure 10 - MRM Can L1307 CO Pressure and Stoichiometry vs Gas Tap

Figure 11 - MRM Can L1308 CO Pressure and Stoichiometry vs Gas Tap

Figure 12 - MRM Can L1303 CO Pressure and Stoichiometry vs Gas Tap

Figure 13 - MRM Can L1701 CO Pressure and Stoichiometry vs Gas Tap

Figure 14 - MRM Can L1301 CO Pressure and Stoichiometry vs Gas Tap

Figure 15 - MRM Can L1306 CO Pressure and Stoichiometry vs Gas Tap

Figure 16 - MRM Can L1311 CO Pressure and Stoichiometry vs Gas Tap

Figure 17 - MRM Can L1702 CO Pressure and Stoichiometry vs Gas Tap

Figure 18 - MRM Can L1704 CO Pressure and Stoichiometry vs Gas Tap

Figure 19 - MRM Can L1707 CO Pressure and Stoichiometry vs Gas Tap

Figure 20 - MRM Can L1708 CO Pressure and Stoichiometry vs Gas Tap

Recommendations

The following recommendations are derived from the preceding discussion:

Use the partial pressure of Ar instead of the overall RGA pressure value as the denominator in the acceptance criteria. The Ar value can be scaled against the charge pressure without needing to understand if other gases are evolving. The Ar is not reacting with other gases and there is no Ar source other than the charge pressure. In addition, the overall RGA pressure measurement is independent of the partial pressure measurements, not the summation of the partial pressures. Using the overall pressure and the partial pressure of CO adds another potential source of error.

Change the calibration method of the RGA to a more detailed procedure rather than the current, less consistent method. Set the Ar calibration factor to a nominal value and then ratio the other gases to match the molar concentrations reported on the gas analysis certificate. Tracking the ratio of the calibration factors between CO and Ar should be performed to determine if an acceptance criterion during calibration is necessary.

Evaluate if reduction of the fuel to a set value such as 1.98 should be the requirement. The benefits listed in the papers (Johnson 1982 and 1991) appear to have been met by the low level of reduction. Figure 21 published in the paper “*Thermodynamic Modeling of the plutonium-Oxygen System*” (Guéneau 2008) demonstrates multiple orders of magnitude lower oxygen potential with slightly substoichiometric oxygen values. A more detailed evaluation of the target value should be performed.

Figure 21 - Calculated O_2 partial pressure versus O/Pu ratio (Fig 11 Guéneau 2008)

If reduction of the fuel is a requirement, then a more robust method of felt packing that is more predictable and repeatable is warranted. Additionally, after processing, the level of reduction of the fuel should be calculated and documented to prevent process creep.

Current manual operations require 20 ± 1 psia is backfilled into the can, but in practice 20 ± 0.1 is used. The updated MRM system can achieve this pressure consistently and accurately. Consider eliminating the previous weeks fill pressure and use 20 psia for the basis of the acceptance calculation. At ± 0.1 psi, the error in the calculated CO pressure is only $\pm 0.5\%$.

Can temperature and felt packaging can have significant impact on fuel temperature and therefore, the thermodynamic limit of the reduction. More effort should be made evaluating the actual temperature of the fuel during the MRM process. This could be performed analytically using the ratio of CO to CO₂, however, the current RGA used needs to be improved to lower the detectability range of CO₂. Currently, the CO₂ measurement appears to be below the detectability limit of the current RGA. Changing the MRM RGA to include an electron multiplier may allow for more accurate measurement of CO₂ constituency.

Effort should be made to investigate the phenomenon where the CO partial pressure builds after periods of inactivity. CO build up during RTG pre-flight storage has been detected and could be detrimental to the internal components of past and future generator designs. Understanding this phenomenon may open processing methods that better control CO or be used as justification for periodic gas servicing, post-fueling.

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Appendix A
**Double release method of determining the initial gas
pressure in an unknown volume at unknown average
gas temperature**

Subscript “C” is for the MRM can, subscript 1 is for the branch manifold and subscript 2 is for the main manifold. The manifold volumes are assumed to be evacuated at an ambient temperature of 298 K, thus does not contribute any gas to the system.

$$P_c = N \cdot R \cdot T_c / V_c = N \cdot R \cdot X$$

N = number of moles of all gas species in the can

$$R = 8.314 \text{ J/(mol} \cdot \text{K)}$$

$$\text{Let } X = T_c / V_c$$

Where

T_c = the average gas temperature of the can and flex line to the manifold solenoid (K)

V_c = the can and flex line volume (m^3)

Open the can solenoid valve to combine V_c and V_1 . The pressure (P_1) is read at the manifold. The same amount of gas, N , is now in both volumes.

$$N = P_1 \cdot V_1 / (R \cdot T_{\text{amb}}) + P_1 / (R \cdot X)$$

Where

V_1 = branch manifold volume

$$\text{Branch A} = 1.79 \text{ L} = 1.79 \times 10^{-3} \text{ m}^3$$

$$\text{Branch B} = 1.87 \text{ L} = 1.87 \times 10^{-3} \text{ m}^3$$

$$\text{Branch C} = 2.27 \text{ L} = 2.27 \times 10^{-3} \text{ m}^3$$

The branch manifold solenoid valve is open

$$N = P_2 \cdot (V_1 + V_2) / (R \cdot T_{\text{amb}}) + P_2 / (R \cdot X)$$

The number of moles is equal in both cases

$$P_2 \cdot (V_1 + V_2) / (R \cdot T_{\text{amb}}) + P_2 / (R \cdot X) = P_1 \cdot V_1 / (R \cdot T_{\text{amb}}) + P_1 / (R \cdot X)$$

$$P_2 / (R \cdot X) - P_1 / (R \cdot X) = P_1 \cdot V_1 / (R \cdot T_{\text{amb}}) - P_2 \cdot (V_1 + V_2) / (R \cdot T_{\text{amb}})$$

$$(P_2 - P_1) / (R \cdot X) = (P_1 \cdot V_1 - P_2 \cdot (V_1 + V_2)) / (R \cdot T_{\text{amb}})$$

$$X = (P_2 - P_1) \cdot T_{\text{amb}} / (P_1 \cdot V_1 - P_2 \cdot (V_1 + V_2))$$

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Appendix B

MRM Can History

MRM Can Location History					
MRM Can	Contents	GIS/MOD ID	FC ID	Location	Dates
Retired Cans (Cans Opened for Assembly)					
L126	3 GIS	3173 3174 3180	FC0455 / FC0459 FC0446 / FC0454 FC0452 / FC0453	Manifold A Station 4 Manifold C Station 21	May 19, 2014 – March 16, 2017 March 28, 2017 – March 7, 2019
L134	3 GIS	3175 3177 3179	FC0448 / FC0442 FC0441 / FC0457 FC0449 / FC0451	Manifold A Station 3 Manifold C Station 22	May 19, 2014 – March 16, 2017 Mar 28, 2017 – Mar 12, 2019
L1301	3 GIS	F3219 F3213 F3214	FC0494 / FC0503 FC0501 / FC0504 FC0498 / FC0505	Manifold B Station 11	Aug 29, 2018 – Feb 26, 2019
L1303	2 GIS	F3211 F3212	FC0478 / FC0477 FC0479 / FC0480	Manifold A Station 3 Manifold C Station 27	May 22, 2017 – March 6, 2018 March 6, 2018 – Feb 26, 2019
L1306	2 GIS	F3215 F3216	FC0496 / FC0499 FC0497 / FC0502	Manifold B Station 13	Aug 29, 2018 – Feb 26, 2019
L1307	3 GIS	F3208 F3209 F3210	FC0461 / FC0466 FC0464 / FC0465 FC0471 / FC0467	Manifold B Station 11 Manifold C Station 25	Dec 2, 2014 – March 16, 2017 March 28, 2017 – Feb 26, 2019
L1308	3 GIS	3181 3188 F3207	FC0472 / FC0458 FC0469 / FC0468 FC0450 / FC0473	Manifold B Station 12 Manifold C Station 26	Dec 2, 2014 – March 16, 2017 March 28, 2017 – Feb 26, 2019
L1311	2 GIS	F3217 F3218	FC0506 / FC0508 FC0507 / FC0509	Manifold B Station 15	Aug 29, 2018 – Mar 12, 2019
L1701	3 GIS	3090A 3166 3183	FC0482 / FC0487 FC0485 / FC0488 FC0492 / FC0493	Manifold A Station 3	April 18, 2018 – Feb 26, 2019
L1702	2 Module	F8138 F8139	FC0471/FC0467/FC0497/FC0502 FC0496/FC0499/FC0464/FC0465	Manifold A Station 3	April 15, 2019 - Aug 6, 2019
L1704	2 Module	F8134 F8135	FC0479/FC0480/FC0485/FC0488 FC0482/FC0487/FC0461/FC0466	Manifold A Station 4	April 15, 2019 - Aug 6, 2019
L1707	2 Module	F8132 F8133	FC0501/FC0504/FC0469/FC0468 FC0454/FC0446/FC0498/FC0505	Manifold A Station 7	April 15, 2019 - Aug 6, 2019
L1708	2 Module	F8136 F8137	FC0450/FC0473/FC0494/FC0503 FC0492/FC0493/FC0478/FC0477	Manifold A Station 8	April 15, 2019 – Aug 6, 2019

Last updated: 11/14/2019

Appendix C

MRM RGA Data

Date	Comments	MRM Can Sampled	Total press	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8	Ch 9	Ch 10	Ch 11	Ch 12	Ion pressure
			AMU/ch g	4	28	40	44	20	16	17	18	32	36	12	14	
6/17/2014	station 4	L126	8.90E-06	5.678E-08	1.193E-08	5.011E-06	1.618E-09	4.867E-07		9.045E-10	5.617E-09	3.332E-10	3.713E-09			5.80E-06
6/17/2014	station 4	L126	7.80E-06	5.198E-08	1.013E-08	5.843E-06	1.618E-09	5.401E-07		8.569E-10	5.712E-09	1.428E-10	3.808E-09			5.80E-06
6/26/2014	station 4	L126	9.60E-06	9.237E-08	2.125E-08	7.811E-06	4.046E-09	6.119E-07		2.818E-09	1.490E-08	3.808E-10	4.141E-09			5.90E-06
6/26/2014	station 4	L126	8.60E-06	8.118E-08	1.816E-08	8.094E-06	4.046E-09	6.340E-07		2.570E-09	1.409E-08	3.332E-10	4.046E-09			5.90E-06
7/2/2014	station 4	L126	8.90E-06	6.150E-08	1.593E-08	5.469E-06	2.285E-09	4.965E-07		2.237E-09	1.161E-08	2.856E-10	4.141E-09			6.00E-06
7/2/2014	station 4	L126	7.90E-06	5.503E-08	1.319E-08	5.900E-06	1.713E-09	5.336E-07		2.094E-09	1.137E-08	2.856E-10	4.903E-09			6.00E-06
7/9/2014	station 4	L126	9.60E-06	7.026E-08	2.800E-08	5.000E-07	2.140E-09	5.550E-07		3.142E-09	1.578E-08	4.204E-10	5.900E-09			5.90E-06
7/9/2014	station 4	L126	8.30E-06	6.212E-08	1.861E-08	7.304E-06	2.499E-09	5.690E-07		2.856E-09	1.485E-08	3.332E-10	6.284E-09			5.90E-06
7/16/2014	station 4	L126	1.00E-05	7.883E-08	2.217E-08	7.888E-06	2.856E-09	5.503E-07		3.618E-09	1.885E-08	5.236E-10	6.617E-09			6.10E-06
7/16/2014	station 4	L126	8.40E-06	7.026E-08	2.168E-08	8.883E-06	2.856E-09	5.645E-07		3.618E-09	1.813E-08	2.856E-10	7.093E-09			6.10E-06
3/28/2017	Station 21	L126	1.10E-05	5.770E-06	4.650E-08	4.350E-06	1.477E-09	2.613E-07		4.284E-10	2.427E-09	2.380E-10	3.237E-09			4.50E-06
4/27/2017	Station 21	L126	1.00E-05	9.908E-07	3.926E-07	6.155E-06	3.213E-09	4.008E-07		5.236E-10	3.094E-09	4.760E-10	6.236E-09	2.142E-09	4.579E-09	5.90E-06
5/25/2017	Station 21	L126	7.10E-06	1.012E-06	3.507E-08	4.352E-06	4.855E-10	4.866E-07		1.904E-10	1.809E-09	4.284E-10	5.712E-09	1.904E-10	2.856E-10	6.50E-06
6/21/2017	Station 21	L126	1.10E-05	5.934E-07	2.483E-08	7.962E-06	1.047E-09	6.046E-07	9.521E-11	9.521E-11	2.189E-09	1.904E-10	4.951E-09	9.521E-11	2.380E-10	8.00E-06
7/25/2017	Station 21	L126	1.30E-05	5.491E-07	1.756E-08	1.085E-05	1.713E-09	6.273E-07	9.521E-11	9.521E-11	2.047E-09	1.428E-10	5.332E-09	1.428E-10	2.380E-10	8.00E-06
8/24/2017	Station 21	L126	1.50E-05	4.670E-07	1.188E-08	5.185E-06	1.385E-09	5.550E-07	1.428E-10	1.428E-10	1.856E-09	1.428E-10	4.903E-09	4.760E-11	1.428E-10	8.30E-06
11/6/2017	Station 21	L126	1.40E-05	1.376E-06	3.020E-08	6.861E-06	1.261E-09	5.825E-07	4.284E-10	8.569E-10	6.188E-09	4.284E-10	8.093E-09	1.904E-10	5.236E-10	7.80E-06
1/10/2018	Station 21	L126	1.60E-05	1.216E-06	2.224E-08	6.962E-06	1.475E-09	6.455E-07	6.665E-10	2.094E-09	1.175E-08	5.236E-10	7.855E-09	2.380E-10	6.188E-10	8.30E-06
3/5/2018	Station 21	L126	1.50E-05	1.024E-06	2.995E-08	8.172E-06	3.427E-09	7.879E-07	1.237E-09	6.331E-09	3.156E-08	6.188E-10	1.042E-08	2.856E-10	1.142E-09	8.70E-06
4/4/2018	Station 21	L126	2.30E-05	5.004E-07	1.095E-08	6.792E-06	6.188E-10	7.124E-07	9.521E-11	3.808E-10	3.856E-09	4.760E-10	6.427E-09	4.760E-11	2.856E-10	1.40E-05
5/2/2018	Station 21	L126	2.50E-05	6.786E-07	1.809E-08	1.072E-05	1.199E-09	9.372E-07	2.380E-10	1.142E-09	7.188E-09	6.665E-10	8.378E-09	4.760E-11	4.284E-10	1.20E-05
6/6/2018	Station 21	L126	3.00E-05	6.187E-07	1.262E-08	1.021E-05	6.855E-10	7.972E-07	1.428E-10	3.332E-10	3.380E-09	3.808E-10	1.009E-08	1.428E-10	1.904E-10	1.30E-05
7/11/2018	Station 21	L126	2.50E-05	8.389E-07	2.325E-08	1.108E-05	2.970E-09	8.225E-07	5.712E-10	4.332E-09	2.089E-08	5.712E-10	1.133E-08	1.904E-10	5.712E-10	1.30E-05
8/7/2018	Station 21	L126	2.30E-05	5.802E-07	1.428E-08	1.072E-05	1.237E-09	7.565E-07	2.380E-10	1.523E-09	8.759E-09	4.760E-10	9.854E-09	9.521E-11	3.332E-10	1.30E-05
9/6/2018	Station 21	L126	2.00E-05	3.999E-07	7.598E-09	9.457E-06	9.521E-10	9.098E-07	1.428E-10	9.521E-11	2.047E-09	1.904E-10	9.759E-09	9.521E-11	1.428E-10	1.40E-05
10/4/2018	Station 21	L126	2.30E-05	6.985E-07	1.649E-08	1.194E-05	1.313E-09	1.089E-06	2.380E-10	8.569E-10	6.569E-09	6.188E-10	1.456E-08	9.521E-11	2.856E-10	1.40E-05
11/12/2018	Station 21	L126	2.00E-05	9.363E-07	1.838E-08	1.281E-05	1.842E-09	1.167E-06	4.760E-10	1.761E-09	1.090E-08	6.188E-10	1.580E-08	9.521E-11	4.284E-10	1.30E-05
12/12/2018	Station 21	L126	2.40E-05	6.958E-07	1.579E-08	1.171E-05	1.561E-09	9.175E-07	3.332E-10	1.333E-09	8.474E-09	7.141E-10	1.475E-08	4.760E-11	3.808E-10	1.30E-05

Date	Comments	MRM Can Sampled	Total press	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8	Ch 9	Ch 10	Ch 11	Ch 12	Ion pressure
1/9/2019	Station 21	L126	1.90E-05	3.976E-07	1.385E-08	9.723E-06	1.028E-09	9.446E-07	1.904E-10	5.712E-10	4.903E-09	7.141E-10	1.294E-08	9.521E-11	2.380E-10	1.20E-05
5/28/2014	Man A	L126 and L134	8.70E-06	1.232E-06	8.939E-08	7.251E-06	6.331E-09	4.813E-07	5.379E-09	3.094E-09	1.456E-08	3.808E-10	3.284E-09	0.000E+00	0.000E+00	5.70E-06
5/28/2014	Man A	L126 and L134	8.10E-06	1.199E-06	1.106E-07	8.820E-06	4.522E-09	5.237E-07	5.236E-09	2.999E-09	1.504E-08	1.904E-10	3.475E-09	0.000E+00	0.000E+00	5.70E-06
6/4/2014	Man A	L126 and L134	9.00E-06	1.519E-07	2.619E-08	1.026E-05	5.998E-09	6.011E-07	5.665E-09	3.437E-09	1.694E-08	3.808E-10	4.141E-09	0.000E+00	0.000E+00	6.00E-06
6/4/2014	Man A	L126 and L134	7.80E-06	1.527E-07	2.399E-08	1.199E-05	5.998E-09	6.619E-07	5.570E-09	3.284E-09	1.699E-08	2.856E-10	4.141E-09	0.000E+00	0.000E+00	6.00E-06
6/11/2014	Man A	L126 and L134	8.60E-06	4.358E-08	2.297E-08	6.004E-06	4.284E-09	5.590E-07	4.855E-09	3.142E-09	1.566E-08	4.760E-10	4.379E-09	0.000E+00	0.000E+00	5.90E-06
6/11/2014	Man A	L126 and L134	7.30E-06	4.318E-08	1.971E-08	7.108E-06	4.284E-09	6.054E-07	4.617E-09	2.999E-09	1.580E-08	2.854E-10	4.284E-09	0.000E+00	0.000E+00	5.90E-06
9/20/2018	Station 11	L1301	2.20E-05	1.629E-07	2.881E-08	1.314E-05	4.070E-09	1.307E-06	7.141E-10	4.427E-09	2.380E-08	8.093E-10	1.513E-08	1.428E-10	8.093E-10	1.40E-05
9/27/2018	Station 11	L1301	1.80E-05	1.675E-07	2.699E-08	1.224E-05	2.999E-09	1.207E-06	5.712E-10	3.760E-09	2.013E-08	8.569E-10	1.409E-08	1.428E-10	6.188E-10	1.30E-05
10/4/2018	Station 11	L1301	2.10E-05	1.697E-07	2.799E-08	1.356E-05	3.722E-09	1.316E-06	6.188E-10	4.237E-09	2.270E-08	7.141E-10	1.513E-08	1.904E-10	5.712E-10	1.50E-05
10/11/2018	Station 11	L1301	2.50E-05	2.106E-07	2.949E-08	1.545E-05	4.475E-09	1.398E-06	6.665E-10	4.046E-09	2.237E-08	7.141E-10	1.709E-08	1.428E-10	5.236E-10	1.50E-05
11/13/2018	Station 11	L1301	2.20E-05	5.414E-07	8.169E-09	8.233E-06	2.047E-10	7.076E-07	9.521E-11	2.380E-10	2.713E-09	3.808E-10	9.426E-09	9.521E-11	2.856E-10	1.30E-05
12/12/2018	Station 11	L1301	2.20E-05	8.607E-07	2.243E-08	1.261E-05	3.318E-09	9.856E-07	6.188E-10	3.380E-09	1.780E-08	7.141E-10	1.556E-08	9.521E-11	5.236E-10	1.30E-05
1/9/2019	Station 11	L1301	2.00E-05	4.829E-07	1.571E-08	1.078E-05	1.371E-09	1.035E-06	2.856E-10	8.569E-10	6.474E-09	8.569E-10	1.413E-08	9.521E-11	3.808E-10	1.20E-05
9/5/2018	Man B	L1301, L1306, L1311	2.00E-05	6.924E-07	2.647E-07	9.290E-06	1.428E-09	9.748E-07	3.332E-10	1.428E-10	2.475E-09	5.236E-10	1.014E-08	1.047E-09	6.665E-10	1.40E-05
9/13/2018	Man B	L1301, L1306, L1311	2.10E-05	6.898E-08	3.645E-08	1.236E-05	3.480E-09	1.208E-06	5.712E-10	3.475E-09	1.932E-08	9.045E-10	1.561E-08	2.380E-10	6.188E-10	1.40E-05
5/31/2017	Station 3	L1303	8.70E-06	1.013E-07	1.727E-07	4.945E-06	8.426E-10	5.309E-07	6.665E-10	2.856E-10	1.904E-09	4.284E-10	5.189E-09	1.094E-09	6.665E-10	6.90E-06
5/31/2017	Station 3	L1303	8.90E-06	9.730E-08	2.179E-07	5.295E-06	5.617E-10	5.484E-07	7.141E-10	9.521E-11	2.047E-09	4.760E-10	5.332E-09	1.237E-09	8.093E-10	6.90E-06
6/8/2017	Station 3	L1303	8.50E-06	1.666E-08	1.366E-08	6.168E-06	1.285E-09	5.921E-07	1.428E-10	1.904E-10	2.523E-09	2.380E-10	5.474E-09	1.428E-10	2.856E-10	7.40E-06
6/8/2017	Station 3	L1303	8.40E-06	1.866E-08	1.759E-08	6.687E-06	8.569E-10	6.315E-07	2.856E-10	1.904E-10	2.427E-09	3.332E-10	6.046E-09	9.521E-11	2.380E-10	7.30E-06
6/8/2017	Station 3	L1303	8.30E-06	1.799E-08	2.309E-08	7.448E-06	8.569E-10	6.422E-07	2.380E-10	9.521E-11	2.570E-09	5.712E-10	6.379E-09	9.521E-11	3.808E-10	7.30E-06
6/14/2017	Station 3	L1303	1.00E-05	1.399E-08	9.854E-09	5.940E-06	1.333E-09	6.492E-06	1.428E-10	1.904E-10	2.808E-09	1.904E-10	3.570E-09	4.760E-11	2.856E-10	8.00E-06

Date	Comments	MRM Can Sampled	Total press	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8	Ch 9	Ch 10	Ch 11	Ch 12	Ion pressure
6/14/2017	Station 3	L1303	1.00E-05	1.333E-08	8.997E-09	6.584E-06	0.000E+00	6.962E-06	1.904E-10	1.904E-10	2.761E-09	1.428E-10	4.141E-09	1.428E-10	1.904E-10	7.90E-06
6/21/2017	Station 3	L1303	1.00E-05	5.641E-08	1.127E-08	8.563E-06	1.571E-09	6.719E-07	1.428E-10	1.904E-10	2.237E-09	2.856E-10	5.522E-09	9.521E-11	1.904E-10	8.00E-06
6/28/2017	Station 3	L1303	1.10E-05	5.332E-08	9.331E-09	3.250E-06	1.047E-09	6.241E-07	1.904E-10	1.428E-10	2.237E-09	1.428E-10	4.379E-09	1.428E-10	2.856E-10	8.30E-06
6/28/2017	Station 3	L1303	1.00E-05	4.732E-08	6.855E-09	3.291E-06	5.236E-10	6.576E-07	2.380E-10	9.521E-11	2.380E-09	1.904E-10	4.522E-09	9.521E-11	1.428E-10	8.30E-06
7/6/2017	Station 3	L1303	1.00E-05	5.570E-08	8.912E-09	5.481E-06	1.237E-09	5.912E-07	2.380E-10	4.760E-11	2.142E-09	1.904E-10	3.808E-09	4.760E-11	2.380E-10	8.10E-06
7/12/2017	Station 3	L1303	9.90E-06	4.598E-08	8.278E-09	9.883E-06	1.142E-09	6.737E-07	1.428E-10	1.428E-10	2.427E-09	2.856E-10	5.427E-09	9.521E-11	2.380E-10	8.10E-06
7/19/2017	Station 3	L1303	1.00E-05	5.398E-08	9.397E-09	1.121E-05	1.713E-09	6.959E-07	1.904E-10	1.904E-10	2.427E-09	1.428E-10	5.379E-09	4.760E-11	1.428E-10	8.20E-06
7/19/2017	Station 3	L1303	1.00E-05	4.598E-08	8.597E-09	1.149E-05	5.712E-10	7.146E-07	9.521E-11	9.521E-11	2.475E-09	1.428E-10	5.808E-09	4.760E-11	1.904E-10	8.20E-06
7/25/2017	Station 3	L1303	1.00E-05	4.465E-08	7.712E-09	1.039E-05	5.712E-10	6.797E-07	1.428E-10	1.904E-10	2.332E-09	1.428E-10	5.332E-09	9.521E-11	2.380E-10	8.10E-06
8/2/2017	Station 3	L1303	9.90E-06	6.284E-08	7.779E-09	6.747E-06	9.521E-10	6.696E-07	1.904E-10	1.904E-10	2.285E-09	1.428E-10	6.093E-09	9.521E-11	9.521E-11	8.00E-06
8/9/2017	Station 3	L1303	9.80E-06	5.855E-08	8.393E-09	7.203E-06	1.142E-09	7.374E-07	1.428E-10	1.904E-10	2.332E-09	1.428E-10	6.284E-09	4.760E-11	1.428E-10	8.40E-06
8/16/2017	Station 3	L1303	1.00E-05	5.712E-08	8.355E-09	7.388E-06	9.235E-10	7.061E-07	1.904E-10	1.428E-10	2.475E-09	9.521E-11	6.569E-09	9.521E-11	1.428E-10	8.30E-06
8/16/2017	Station 3	L1303	9.80E-06	4.713E-08	1.002E-08	8.483E-06	4.617E-10	7.658E-07	9.521E-11	1.428E-10	2.523E-09	2.856E-10	7.331E-09	9.521E-11	1.904E-10	8.30E-06
8/24/2017	Station 3	L1303	1.10E-05	6.855E-08	9.283E-09	8.046E-06	9.235E-10	7.383E-07	1.428E-10	4.760E-11	2.380E-09	1.428E-10	7.045E-09	4.760E-11	1.904E-10	8.60E-06
11/6/2017	Station 3	L1303	1.50E-05	5.255E-07	1.406E-06	5.919E-06	2.270E-09	5.079E-07	2.332E-09	1.190E-09	6.998E-09	3.808E-10	6.903E-09	9.616E-09	4.475E-09	7.70E-06
12/6/2017	Station 3	L1303	1.30E-05	3.119E-07	6.582E-08	8.173E-06	3.094E-09	7.323E-07	1.047E-09	4.998E-09	2.532E-08	6.188E-10	9.426E-09	4.284E-10	9.997E-10	8.20E-06
1/10/2018	Station 3	L1303	1.30E-05	3.849E-07	3.260E-08	8.887E-06	4.132E-09	8.079E-07	1.237E-09	5.760E-09	2.961E-08	5.236E-10	1.009E-08	1.904E-10	1.047E-09	8.80E-06
2/7/2018	Station 3	L1303	1.40E-05	3.335E-07	2.844E-08	8.874E-06	3.142E-09	8.966E-07	1.190E-09	5.522E-09	2.865E-08	5.236E-10	1.147E-08	2.856E-10	9.045E-10	9.40E-06
3/5/2018	Station 3	L1303	1.70E-05	2.747E-07	1.532E-08	6.773E-06	1.142E-09	6.902E-07	7.141E-10	1.285E-09	8.140E-09	4.284E-10	8.424E-09	1.428E-10	3.808E-10	8.80E-06
4/4/2018	Station 27	L1303	2.20E-05	2.442E-07	1.002E-08	7.150E-06	9.283E-10	7.428E-07	1.904E-10	3.332E-10	3.713E-09	3.332E-10	6.712E-09	4.760E-11	2.380E-10	1.50E-05
5/2/2018	Station 27	L1303	2.20E-05	4.021E-07	1.618E-08	9.959E-06	1.199E-09	9.640E-07	1.904E-10	7.141E-10	5.332E-09	5.712E-10	7.807E-09	4.760E-11	2.856E-10	1.30E-05
6/6/2018	Station 27	L1303	3.00E-05	3.470E-07	9.064E-09	8.324E-06	6.855E-10	6.230E-07	2.380E-10	2.856E-10	2.523E-09	3.808E-10	8.426E-09	4.760E-11	1.904E-10	1.30E-05
7/11/2018	Station 27	L1303	2.40E-05	4.755E-07	1.162E-08	9.149E-06	1.142E-09	6.642E-07	2.380E-10	1.094E-09	6.617E-09	3.808E-10	9.140E-09	4.760E-11	2.856E-10	1.30E-05
8/7/2018	Station 27	L1303	1.90E-05	3.288E-07	1.256E-08	1.031E-05	7.426E-10	6.997E-07	2.380E-10	9.990E-10	5.665E-09	4.284E-10	9.664E-09	4.760E-11	2.856E-10	1.30E-05
9/6/2018	Station 27	L1303	2.10E-05	3.016E-07	1.159E-08	8.810E-06	4.760E-10	8.560E-07	4.760E-11	1.428E-10	1.904E-09	5.236E-10	9.331E-09	9.521E-11	1.904E-10	1.40E-05
10/4/2018	Station 27	L1303	2.20E-05	4.431E-07	1.649E-08	1.157E-05	1.094E-09	1.048E-06	1.904E-10	6.665E-10	5.474E-09	7.617E-10	1.452E-08	9.521E-11	2.856E-10	1.40E-05
11/12/2018	Station 27	L1303	1.80E-05	5.613E-07	1.523E-08	1.188E-05	1.228E-09	1.027E-06	1.904E-10	9.997E-10	6.855E-09	7.141E-10	1.437E-08	4.760E-11	2.856E-10	1.30E-05
12/12/2018	Station 27	L1303	2.40E-05	4.049E-07	1.534E-08	1.062E-05	5.855E-10	8.333E-07	2.380E-10	9.045E-10	6.188E-09	7.141E-10	1.356E-08	1.428E-10	3.332E-10	1.20E-05
1/9/2019	Station 27	L1303	2.00E-05	2.467E-07	1.299E-08	8.280E-06	6.855E-10	8.217E-07	1.428E-10	4.760E-10	3.808E-09	6.188E-10	1.142E-08	9.521E-11	3.332E-10	1.20E-05

Date	Comments	MRM Can Sampled	Total press	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8	Ch 9	Ch 10	Ch 11	Ch 12	Ion pressure
9/20/2018	Station 13	L1306	2.10E-05	1.249E-07	2.784E-08	1.277E-05	2.570E-09	1.201E-06	4.760E-10	2.189E-09	1.333E-08	7.141E-10	1.466E-08	9.521E-11	5.236E-10	1.30E-05
9/27/2018	Station 13	L1306	1.70E-05	1.281E-07	3.149E-08	1.533E-05	3.427E-09	1.319E-06	7.141E-10	3.237E-09	1.813E-08	8.093E-10	1.618E-08	1.428E-10	6.188E-10	1.30E-05
10/4/2018	Station 13	L1306	2.40E-05	1.281E-07	2.499E-08	1.464E-05	3.503E-09	1.433E-06	5.712E-10	3.380E-09	1.951E-08	5.236E-10	1.775E-08	1.904E-10	5.712E-10	1.50E-05
10/11/2018	Station 13	L1306	2.40E-05	1.571E-07	2.849E-08	1.477E-05	3.132E-09	1.350E-06	5.236E-10	3.332E-09	1.851E-08	9.045E-10	1.737E-08	1.904E-10	5.712E-10	1.50E-05
11/13/2018	Station 13	L1306	2.10E-05	3.445E-07	2.199E-08	8.594E-06	4.094E-10	7.315E-07	1.904E-10	2.856E-10	2.713E-09	5.712E-10	9.569E-09	1.428E-10	2.856E-10	1.30E-05
12/12/2018	Station 13	L1306	2.20E-05	5.258E-07	3.394E-08	1.276E-05	2.732E-09	1.001E-06	4.760E-10	2.666E-09	1.542E-08	7.617E-10	1.613E-08	1.428E-10	5.712E-10	1.30E-05
1/9/2019	Station 13	L1306	1.90E-05	2.89E-07	1.956E-08	1.060E-05	1.028E-09	1.043E-06	2.856E-10	8.093E-10	5.998E-09	9.045E-10	1.447E-08	1.904E-10	3.808E-10	1.30E-05
12/22/2014	Station 11	L1307	1.00E-05	8.397E-08	1.582E-08	6.674E-06	9.902E-10	4.941E-07	8.093E-10	2.380E-10	2.951E-09	6.665E-10	8.950E-09	0.000E+00	0.000E+00	6.00E-06
12/22/2014	Station 11	L1307	9.30E-06	7.604E-08	1.011E-08	6.246E-06	1.485E-09	4.958E-07	9.045E-10	2.380E-10	2.856E-09	3.332E-10	8.759E-09	0.000E+00	0.000E+00	6.00E-06
1/7/2015	Station 11	L1307	1.00E-05	2.024E-07	1.828E-08	5.430E-06	2.970E-09	4.290E-07	4.570E-09	3.040E-09	1.460E-08	5.713E-10	6.760E-09	0.000E+00	0.000E+00	6.10E-06
1/7/2015	Station 11	L1307	1.10E-05	1.842E-07	1.526E-08	5.239E-06	2.970E-09	4.320E-07	4.475E-09	2.904E-09	1.397E-08	4.760E-10	6.613E-09	0.000E+00	0.000E+00	6.10E-06
1/14/2015	Station 11	L1307	8.10E-06	6.838E-08	1.138E-08	5.750E-06	1.237E-09	5.610E-07	2.142E-09	2.850E-10	3.094E-09	4.284E-10	8.333E-09	0.000E+00	0.000E+00	6.10E-06
1/21/2015	Station 11	L1307	8.00E-06	6.069E-08	8.707E-09	5.703E-06	8.569E-10	4.703E-07	1.094E-09	1.423E-10	2.333E-09	3.808E-10	5.998E-09	0.000E+00	0.000E+00	6.30E-06
1/28/2015	Station 11	L1307	9.10E-06	8.879E-08	5.590E-09	3.400E-06	2.375E-09			3.320E-09		3.000E-10		0.000E+00	0.000E+00	6.60E-06
3/28/2017	Station 25	L1307	8.10E-06	4.020E-06	2.133E-07	7.832E-06	1.809E-09	4.009E-07	1.142E-09	3.808E-10	2.904E-09	1.904E-10	4.808E-09	0.000E+00	0.000E+00	5.60E-06
4/27/2017	Station 25	L1307	1.10E-05	6.802E-07	1.638E-07	5.570E-06	1.928E-09	4.093E-07	7.617E-10	3.808E-10	2.475E-09	4.284E-10	5.427E-09	1.047E-09	2.466E-09	6.10E-06
5/25/2017	Station 25	L1307	7.00E-06	7.607E-07	1.565E-08	4.565E-06	6.474E-10	5.050E-07	5.236E-10	1.904E-10	1.951E-09	3.332E-10	5.522E-09	2.380E-10	2.380E-10	6.60E-06
6/21/2017	Station 25	L1307	1.20E-05	4.734E-07	1.127E-08	5.314E-06	5.236E-10	5.755E-07	1.428E-10	4.760E-11	2.142E-09	1.904E-10	4.855E-09	4.760E-11	1.904E-10	7.90E-06
7/25/2017	Station 25	L1307	1.40E-05	4.865E-07	9.426E-09	5.923E-06	1.713E-09	5.370E-07	9.521E-11	1.428E-10	1.809E-09	2.380E-10	4.475E-09	1.428E-10	9.521E-11	8.00E-06
8/24/2017	Station 25	L1307	1.50E-05	4.348E-07	1.114E-08	6.350E-06	9.235E-10	5.702E-07	4.760E-11	9.521E-11	1.904E-09	1.904E-10	5.236E-09	4.760E-11	2.380E-10	8.40E-06
11/6/2017	Station 25	L1307	1.40E-05	1.443E-06	3.959E-08	6.672E-06	1.261E-09	5.770E-07	4.284E-10	7.141E-10	5.427E-09	3.808E-10	7.950E-09	2.856E-10	5.236E-10	7.70E-06
1/10/2018	Station 25	L1307	1.50E-05	1.252E-06	4.676E-08	7.356E-06	1.770E-09	6.792E-07	6.665E-10	1.571E-09	9.283E-09	3.808E-10	8.188E-09	3.332E-10	5.712E-10	8.60E-06
3/5/2018	Station 25	L1307	1.70E-05	9.896E-07	3.589E-08	7.085E-06	2.285E-09	7.002E-07	7.617E-10	2.047E-09	1.185E-08	5.712E-10	8.902E-09	1.904E-10	6.188E-10	8.70E-06
4/4/2018	Station 25	L1307	2.20E-05	5.304E-07	1.782E-08	6.997E-06	6.188E-10	7.211E-07	1.428E-10	4.760E-10	3.713E-09	3.332E-10	6.522E-09	1.428E-10	2.380E-10	1.40E-05
5/2/2018	Station 25	L1307	2.30E-05	6.692E-07	2.113E-08	1.072E-05	8.997E-10	9.597E-07	3.332E-10	9.997E-10	5.903E-09	6.188E-10	8.236E-09	1.428E-10	2.856E-10	1.20E-05
6/6/2018	Station 25	L1307	2.90E-05	4.953E-07	9.064E-09	9.313E-06	6.855E-10	6.652E-07	1.428E-10	2.380E-10	2.904E-09	2.856E-10	9.569E-09	4.760E-11	2.380E-10	1.20E-05
7/11/2018	Station 25	L1307	2.60E-05	8.337E-07	2.078E-08	1.081E-05	1.828E-09	7.890E-07	4.284E-10	2.475E-09	1.323E-08	5.236E-10	1.104E-08	9.521E-11	4.760E-10	1.30E-05

Date	Comments	MRM Can Sampled	Total press	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8	Ch 9	Ch 10	Ch 11	Ch 12	Ion pressure
8/7/2018	Station 25	L1307	2.10E-05	5.802E-07	1.542E-08	1.056E-05	1.237E-09	7.379E-07	2.380E-10	1.285E-09	7.093E-09	5.236E-10	9.854E-09	9.521E-11	3.808E-10	1.30E-05
9/6/2018	Station 25	L1307	2.20E-05	4.833E-07	1.219E-08	8.208E-06	2.380E-10	8.313E-07	9.521E-11	1.428E-10	1.904E-09	4.284E-10	9.238E-09	4.760E-11	1.428E-10	1.40E-05
10/4/2018	Station 25	L1307	2.20E-05	6.974E-07	1.766E-08	1.207E-05	1.094E-09	1.090E-06	2.380E-10	7.617E-10	6.093E-09	7.141E-10	1.490E-08	4.760E-11	2.856E-10	1.40E-05
11/12/2018	Station 25	L1307	1.90E-05	9.352E-07	1.869E-08	1.245E-05	1.228E-09	1.109E-06	3.808E-10	1.380E-09	8.902E-09	6.188E-10	1.528E-08	1.428E-10	3.332E-10	1.30E-05
12/12/2018	Station 25	L1307	2.20E-05	6.478E-07	1.505E-08	1.117E-05	9.759E-10	8.835E-07	2.380E-10	1.047E-09	7.141E-09	8.093E-10	1.413E-08	9.521E-11	3.808E-10	1.30E-05
1/9/2019	Station 25	L1307	1.90E-05	3.869E-07	1.356E-08	9.266E-06	8.569E-10	9.077E-07	1.904E-10	6.188E-10	4.522E-09	8.093E-10	1.252E-08	1.428E-10	2.856E-10	1.20E-05
12/10/2014	Man B	L1307, L1308	6.70E-06	1.488E-06	8.899E-08	6.037E-06	3.199E-09	5.415E-07	1.285E-09	5.712E-10	3.522E-09	4.284E-10	7.712E-09	0.000E+00	0.000E+00	5.70E-06
12/10/2014	Man B	L1307, L1308	6.30E-06	1.371E-06	1.008E-07	6.249E-06	2.285E-09	5.406E-07	1.285E-09	5.712E-10	3.522E-09	3.808E-10	7.331E-09	0.000E+00	0.000E+00	5.80E-06
12/17/2014	Man B	L1307, L1308	9.50E-06	1.337E-07	1.225E-08	5.248E-06	7.426E-10	5.368E-07	9.997E-10	2.380E-10	2.523E-09	4.284E-10	6.617E-09	0.000E+00	0.000E+00	6.00E-06
12/17/2014	Man B	L1307, L1308	8.40E-06	1.256E-07	1.250E-08	5.692E-06	9.902E-10	5.271E-07	9.521E-10	3.332E-10	2.618E-09	4.760E-10	6.950E-09	0.000E+00	0.000E+00	6.00E-06
12/22/2014	Station 12	L1308	9.30E-06	6.298E-08	1.475E-08	6.345E-06	1.237E-09	4.785E-07	7.141E-10	3.330E-10	2.713E-09	4.234E-10	8.569E-09	0.000E+00	0.000E+00	6.00E-06
1/7/2015	Station 12	L1308	1.20E-05	1.650E-07	1.413E-07	6.240E-06	3.200E-09	4.000E-07	4.570E-09	2.710E-09	8.470E-09	3.520E-09	6.330E-09	0.000E+00	0.000E+00	6.00E-06
1/14/2015	Station 12	L1308	9.20E-06	5.989E-08	1.697E-08	5.323E-06	1.237E-09	4.956E-07	1.428E-10	2.380E-10	2.713E-09	3.880E-10	6.950E-09	0.000E+00	0.000E+00	6.10E-06
1/21/2015	Station 12	L1308	9.30E-06	5.098E-08	1.136E-08	5.148E-06	8.569E-10	4.302E-07	8.529E-10	2.856E-10	2.285E-09	2.856E-10	5.236E-09	0.000E+00	0.000E+00	6.30E-06
1/28/2015	Station 12	L1308	1.10E-05	5.879E-08	1.254E-08	6.226E-06	9.283E-10	4.951E-07	7.517E-10	1.428E-10	2.237E-09	3.308E-10	6.089E-09	0.000E+00	0.000E+00	6.60E-06
3/28/2017	Station 26	L1308	8.50E-06	3.121E-06	2.247E-07	7.898E-06	2.170E-09	4.119E-07	1.047E-09	5.742E-10	2.999E-09	6.188E-10	4.855E-09	0.000E+00	0.000E+00	5.70E-06
4/27/2017	Station 26	L1308	1.00E-05	6.252E-07	2.870E-07	5.726E-06	1.713E-09	3.895E-07	6.188E-10	3.808E-10	2.523E-09	3.808E-10	5.474E-09	1.523E-09	2.994E-09	6.10E-06
5/25/2017	Station 26	L1308	7.00E-06	8.688E-07	2.319E-08	4.565E-06	4.855E-10	5.055E-07	4.284E-10	1.428E-10	1.856E-09	3.332E-10	5.950E-09	2.380E-10	3.332E-10	6.60E-06
6/21/2017	Station 26	L1308	1.20E-05	5.098E-07	1.585E-08	4.913E-06	1.571E-09	5.514E-07	1.428E-10	1.428E-10	1.951E-09	1.428E-10	4.570E-09	9.521E-11	2.380E-10	7.80E-06
7/25/2017	Station 26	L1308	1.40E-05	5.158E-07	1.328E-08	6.471E-06	5.712E-10	5.495E-07	1.904E-10	9.521E-11	1.856E-09	1.428E-10	4.665E-09	9.521E-11	9.521E-11	8.10E-06
8/24/2017	Station 26	L1308	1.40E-05	4.541E-07	1.188E-08	6.405E-06	9.235E-10	5.712E-07	9.521E-11	4.760E-11	1.904E-09	1.428E-10	5.236E-09	4.760E-11	1.904E-10	8.40E-06
11/6/2017	Station 26	L1308	1.40E-05	1.822E-06	1.002E-08	6.371E-06	7.569E-10	5.631E-07	3.808E-10	8.093E-10	5.093E-09	2.380E-10	7.474E-09	9.521E-11	3.332E-10	7.50E-06
1/10/2018	Station 26	L1308	1.40E-05	1.217E-06	1.233E-08	6.786E-06	1.770E-09	6.556E-07	3.808E-10	1.380E-09	8.521E-09	4.281E-10	7.664E-09	9.521E-11	4.284E-10	8.30E-06
3/5/2018	Station 26	L1308	1.70E-05	9.729E-07	1.725E-08	7.202E-06	1.142E-09	7.139E-07	6.665E-10	1.761E-09	1.066E-08	4.760E-10	8.950E-09	1.428E-10	5.236E-10	8.70E-06
4/4/2018	Station 26	L1308	2.20E-05	5.304E-07	9.654E-09	7.099E-06	3.094E-10	7.256E-07	1.904E-10	3.808E-10	3.618E-09	3.808E-10	6.617E-09	1.904E-10	1.904E-10	1.40E-05
5/2/2018	Station 26	L1308	2.30E-05	6.430E-07	1.618E-08	9.960E-06	1.499E-09	9.245E-07	2.380E-10	8.569E-10	5.522E-09	5.712E-10	7.760E-09	4.760E-11	3.332E-10	1.20E-05
6/6/2018	Station 26	L1308	3.00E-05	5.587E-07	9.064E-09	8.099E-06	4.570E-10	6.223E-07	1.428E-10	2.856E-10	2.666E-09	3.332E-10	8.236E-09	9.521E-11	2.380E-10	1.20E-05

Date	Comments	MRM Can Sampled	Total press	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8	Ch 9	Ch 10	Ch 11	Ch 12	Ion pressure
7/11/2018	Station 26	L1308	2.70E-05	7.593E-07	1.109E-08	8.873E-06	1.142E-09	6.428E-07	2.856E-10	1.285E-09	7.045E-09	3.808E-10	8.950E-09	4.760E-11	3.332E-10	1.30E-05
8/7/2018	Station 26	L1308	2.00E-05	5.519E-07	1.294E-08	1.074E-05	9.902E-10	7.223E-07	1.904E-10	9.997E-10	6.331E-09	4.284E-10	9.616E-09	9.521E-11	2.380E-10	1.30E-05
9/6/2018	Station 26	L1308	2.10E-05	4.558E-07	9.597E-09	8.024E-06	2.380E-10	8.057E-07	9.521E-11	9.521E-11	1.904E-09	3.332E-10	8.759E-09	4.760E-11	1.428E-10	1.40E-05
10/4/2018	Station 26	L1308	2.20E-05	6.821E-07	1.616E-08	1.162E-05	1.094E-09	1.056E-06	2.856E-10	7.141E-10	5.570E-09	7.141E-10	1.442E-08	9.521E-11	2.856E-10	1.40E-05
11/12/2018	Station 26	L1308	1.90E-05	9.122E-07	1.555E-08	1.208E-05	1.228E-09	1.064E-06	2.380E-10	1.142E-09	7.617E-09	7.141E-10	1.475E-08	9.521E-11	3.332E-10	1.30E-05
12/12/2018	Station 26	L1308	2.40E-05	6.310E-07	1.460E-08	1.050E-05	7.800E-10	8.380E-07	3.330E-10	9.040E-10	6.520E-09	7.610E-10	1.340E-08	4.760E-11	3.330E-10	1.20E-05
1/9/2019	Station 26	L1308	1.90E-05	3.922E-07	1.299E-08	8.703E-06	6.855E-10	8.603E-07	2.380E-10	4.284E-10	4.141E-09	6.665E-10	1.185E-08	9.521E-11	3.332E-10	1.20E-05
9/20/2018	Station 15	L1311	2.00E-05	9.097E-08	2.152E-08	1.281E-05	2.142E-09	1.199E-06	4.284E-10	1.856E-09	1.118E-08	7.141E-10	1.461E-08	9.521E-11	4.284E-10	1.30E-05
9/27/2018	Station 15	L1311	2.10E-05	1.029E-07	2.599E-08	1.429E-05	2.785E-09	1.269E-06	5.236E-10	2.475E-09	1.432E-08	8.569E-10	1.609E-08	9.521E-11	5.236E-10	1.30E-05
10/4/2018	Station 15	L1311	2.30E-05	1.138E-07	2.366E-08	1.476E-05	2.627E-09	1.394E-06	4.760E-10	2.713E-09	1.594E-08	8.093E-10	1.756E-08	1.428E-10	5.236E-10	1.50E-05
10/11/2018	Station 15	L1311	2.50E-05	1.452E-07	2.749E-08	1.532E-05	2.685E-09	1.363E-06	5.712E-10	2.713E-09	1.628E-08	9.521E-10	1.809E-08	9.521E-11	5.712E-10	1.50E-05
11/13/2018	Station 15	L1311	2.00E-05	3.330E-07	8.640E-09	8.674E-06	6.141E-10	7.401E-07	1.428E-10	2.380E-10	2.666E-09	4.284E-10	9.711E-09	9.521E-11	2.380E-10	1.30E-05
12/12/2018	Station 15	L1311	2.20E-05	5.098E-07	1.992E-08	1.280E-05	1.951E-09	9.905E-07	4.760E-10	2.237E-09	1.342E-08	8.093E-10	1.585E-08	9.521E-11	4.760E-10	1.30E-05
1/9/2019	Station 15	L1311	1.80E-05	2.765E-07	1.528E-08	1.007E-05	1.028E-09	9.968E-07	2.380E-10	6.665E-10	5.379E-09	7.617E-10	1.371E-08	4.760E-11	3.332E-10	1.20E-05
6/17/2014	Station 3	L134	8.50E-06	6.078E-08	1.573E-08	6.981E-06	4.046E-09	5.943E-07	3.808E-10	1.997E-09	1.875E-08	3.884E-10	4.475E-09	0.000E+00	0.000E+00	5.90E-06
6/17/2014	Station 3	L134	7.30E-06	5.558E-08	1.330E-08	6.799E-06	3.237E-09	6.296E-07	3.618E-09	1.999E-09	1.071E-08	2.380E-10	4.475E-09	0.000E+00	0.000E+00	5.90E-06
6/26/2014	Station 3	L134	8.50E-06	9.397E-08	2.262E-08	8.475E-06	4.046E-09	6.395E-07	6.141E-09	4.427E-09	2.247E-08	3.808E-10	4.332E-09	0.000E+00	0.000E+00	5.90E-06
6/26/2014	Station 3	L134	8.10E-06	8.477E-08	1.885E-08	8.701E-06	5.665E-09	6.730E-07	5.998E-09	4.332E-09	2.185E-08	1.904E-10	4.284E-09	0.000E+00	0.000E+00	5.90E-06
7/2/2014	Station 3	L134	9.00E-06	6.838E-08	1.970E-08	6.093E-06	3.427E-09	5.578E-07	4.951E-09	3.520E-09	1.785E-08	3.302E-10	4.808E-09	0.000E+00	0.000E+00	6.20E-06
7/2/2014	Station 3	L134	7.60E-06	6.069E-08	1.576E-08	6.221E-06	5.141E-09	5.860E-07	4.855E-09	3.475E-09	1.718E-08	3.380E-10	5.236E-09	0.000E+00	0.000E+00	6.20E-06
7/9/2014	Station 3	L134	9.30E-06	7.369E-08	2.055E-08	5.201E-06	2.499E-09	5.818E-07	6.046E-09	4.617E-09	2.308E-08	5.236E-10	6.141E-09	0.000E+00	0.000E+00	6.00E-06
7/9/2014	Station 3	L134	7.80E-06	6.469E-08	1.877E-08	7.654E-06	2.499E-09	6.116E-07	5.808E-09	4.332E-09	2.189E-08	4.284E-10	6.569E-09	0.000E+00	0.000E+00	6.00E-06
7/16/2014	Station 3	L134	9.00E-06	8.226E-08	2.233E-08	7.749E-06	3.570E-09	5.714E-07	6.474E-09	5.552E-09	2.737E-08	3.236E-10	6.855E-09	0.000E+00	0.000E+00	6.20E-06
7/16/2014	Station 3	L134	7.90E-06	7.241E-08	2.039E-08	7.772E-06	3.927E-09	5.746E-07	6.141E-09	5.046E-09	2.518E-08	3.808E-10	6.807E-09	0.000E+00	0.000E+00	6.20E-06
3/28/2017	Station 22	L134	9.50E-06	4.370E-06	7.133E-08	6.482E-06	1.809E-09	3.705E-07	8.569E-10	4.284E-10	2.951E-09	7.617E-10	4.475E-09	0.000E+00	0.000E+00	5.30E-06
4/27/2017	Station 22	L134	1.10E-05	1.000E-06	3.854E-07	5.220E-06	1.928E-09	3.616E-07	6.188E-10	3.808E-10	2.427E-09	3.808E-10	4.855E-09	2.047E-09	3.699E-09	5.80E-06
5/25/2017	Station 22	L134	7.00E-06	1.190E-06	2.685E-08	4.687E-06	3.237E-10	4.977E-07	4.760E-10	1.428E-10	1.904E-09	3.808E-10	6.046E-09	1.904E-10	2.380E-10	6.60E-06

Date	Comments	MRM Can Sampled	Total press	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8	Ch 9	Ch 10	Ch 11	Ch 12	Ion pressure
6/21/2017	Station 22	L134	1.10E-05	6.705E-07	2.201E-08	8.364E-06	1.047E-09	6.246E-07	1.428E-10	9.521E-11	2.047E-09	1.428E-10	5.474E-09	9.521E-11	2.380E-10	7.90E-06
7/25/2017	Station 22	L134	1.40E-05	6.385E-07	1.306E-08	5.832E-06	1.142E-09	5.417E-07	9.521E-11	9.521E-11	1.904E-09	1.904E-10	4.522E-09	4.760E-11	9.521E-11	8.10E-06
8/24/2017	Station 22	L134	1.50E-05	5.491E-07	1.429E-08	7.497E-06	9.235E-10	6.008E-07	9.521E-11	9.521E-11	1.809E-09	2.856E-10	5.093E-09	1.428E-10	2.380E-10	8.50E-06
11/6/2017	Station 22	L134	1.40E-05	1.864E-06	1.105E-08	6.408E-06	1.009E-09	5.699E-07	4.284E-10	8.093E-10	5.617E-09	3.332E-10	7.426E-09	9.521E-11	3.332E-10	7.50E-06
1/10/2018	Station 22	L134	1.50E-05	1.322E-06	1.416E-08	7.137E-06	8.854E-10	6.618E-07	6.665E-10	1.761E-09	9.997E-09	3.808E-10	7.950E-09	9.521E-11	4.284E-10	8.40E-06
3/5/2018	Station 22	L134	1.70E-05	1.087E-06	2.526E-08	8.087E-06	3.713E-09	7.798E-07	9.521E-10	4.284E-09	2.232E-08	6.665E-10	1.009E-08	1.904E-10	9.997E-10	8.80E-06
4/4/2018	Station 22	L134	2.20E-05	5.218E-07	1.132E-08	6.997E-06	6.188E-10	7.246E-07	9.521E-11	3.332E-10	3.665E-09	3.808E-10	6.522E-09	9.521E-11	3.332E-10	1.40E-05
5/2/2018	Station 22	L134	2.10E-05	6.493E-07	1.713E-08	1.116E-05	1.199E-09	9.787E-07	3.808E-10	9.521E-10	9.331E-09	6.188E-10	8.712E-09	9.521E-11	2.856E-10	1.20E-05
6/6/2018	Station 22	L134	2.90E-05	6.229E-07	1.213E-08	1.057E-05	6.855E-10	7.705E-07	2.856E-10	3.808E-10	3.522E-09	5.236E-10	1.056E-08	1.428E-10	2.856E-10	1.20E-05
7/11/2018	Station 22	L134	2.60E-05	8.808E-07	1.972E-08	1.085E-05	2.285E-09	8.069E-07	4.284E-10	3.094E-09	1.604E-08	5.236E-10	1.104E-08	1.428E-10	3.808E-10	1.30E-05
8/7/2018	Station 22	L134	2.20E-05	6.074E-07	1.352E-08	1.056E-05	1.237E-09	7.428E-07	2.856E-10	1.285E-09	7.664E-09	4.760E-10	9.759E-09	4.760E-11	3.332E-10	1.30E-05
9/6/2018	Station 22	L134	2.20E-05	5.061E-07	1.119E-08	8.346E-06	2.380E-10	8.531E-07	9.521E-11	9.521E-11	1.951E-09	4.760E-10	9.426E-09	4.760E-11	1.904E-10	1.40E-05
10/4/2018	Station 22	L134	2.20E-05	7.281E-07	1.566E-08	1.207E-05	1.094E-09	1.083E-06	1.904E-10	7.617E-10	6.236E-09	8.093E-10	1.471E-08	9.521E-11	2.856E-10	1.40E-05
11/12/2018	Station 22	L134	2.00E-05	1.004E-06	1.885E-08	1.296E-05	1.637E-09	1.158E-06	3.808E-10	1.618E-09	9.997E-09	7.617E-10	1.609E-08	9.521E-11	3.332E-10	1.30E-05
12/12/2018	Station 22	L134	2.30E-05	6.918E-07	1.549E-08	1.132E-05	1.171E-09	8.846E-07	3.808E-10	1.190E-09	7.712E-09	7.141E-10	1.418E-08	4.760E-11	2.856E-10	1.20E-05
1/9/2019	Station 22	L134	1.90E-05	4.258E-07	1.371E-08	9.618E-06	8.569E-10	9.373E-07	1.428E-10	5.712E-10	4.808E-09	7.617E-10	1.290E-08	4.760E-11	2.856E-10	1.20E-05
4/25/2018	Station 3	L1701	2.10E-05	1.203E-06	4.255E-08	1.192E-05	3.884E-09	1.015E-06	6.665E-10	3.713E-09	1.980E-08	6.188E-10	1.014E-08	2.380E-10	6.665E-10	1.30E-05
5/2/2018	Station 3	L1701	2.30E-05	5.132E-08	3.275E-08	1.203E-05	2.699E-09	1.121E-06	5.236E-10	3.284E-09	1.728E-08	9.521E-10	1.009E-08	4.428E-10	6.665E-10	1.20E-05
5/9/2018	Station 3	L1701	1.90E-05	1.439E-07	1.294E-08	9.199E-06	1.428E-09	9.141E-07	1.428E-10	4.760E-10	3.856E-09	3.808E-10	7.617E-09	1.428E-10	2.380E-10	1.30E-05
5/16/2018	Station 3	L1701	1.70E-05	1.171E-07	1.188E-08	1.019E-05	8.569E-10	9.219E-07	9.521E-11	1.904E-10	2.475E-09	3.808E-10	7.664E-09	9.521E-11	2.380E-10	1.30E-05
5/22/2018	Station 3	L1701	1.80E-05	1.549E-07	3.304E-08	1.325E-05	4.070E-09	1.330E-06	7.141E-10	4.475E-09	2.261E-08	8.093E-10	1.199E-08	1.428E-10	7.141E-10	1.30E-05
5/30/2018	Station 3	L1701	2.40E-05	1.754E-07	2.929E-08	1.241E-05	3.941E-09	9.920E-07	7.141E-10	5.189E-09	2.666E-08	7.141E-10	1.252E-08	1.428E-10	6.665E-10	1.30E-05
6/6/2018	Station 3	L1701	2.30E-05	1.431E-07	1.392E-08	1.120E-05	1.371E-09	1.013E-06	2.380E-10	3.808E-10	3.856E-09	4.284E-10	1.085E-08	1.904E-10	3.332E-10	1.30E-05
7/11/2018	Station 3	L1701	2.20E-05	7.163E-07	9.335E-09	8.270E-06	9.140E-10	5.995E-07	1.904E-10	7.617E-10	4.903E-09	3.332E-10	8.093E-09	4.760E-11	2.380E-10	1.30E-05
8/7/2018	Station 3	L1701	2.70E-05	7.059E-07	2.494E-08	1.215E-05	3.713E-09	8.769E-07	6.188E-10	4.332E-09	2.161E-08	5.712E-10	1.133E-08	1.428E-10	4.760E-10	1.30E-05
9/6/2018	Station 3	L1701	2.40E-05	5.027E-07	9.197E-09	7.606E-06	7.141E-10	7.958E-07	1.428E-10	1.904E-10	1.904E-09	3.332E-10	8.664E-09	9.521E-11	1.904E-10	1.40E-05
10/4/2018	Station 3	L1701	2.30E-05	8.026E-07	1.699E-08	1.273E-05	1.313E-09	1.154E-06	2.856E-10	1.094E-09	7.990E-09	7.141E-10	1.542E-08	9.521E-11	3.808E-10	1.40E-05
11/12/2018	Station 3	L1701	2.10E-05	1.178E-06	2.875E-08	1.337E-05	3.889E-09	1.213E-06	6.188E-10	4.808E-09	2.470E-08	8.569E-10	1.566E-08	1.428E-10	6.665E-10	1.30E-05
12/12/2018	Station 3	L1701	1.80E-05	8.857E-07	2.907E-08	1.304E-05	4.684E-09	1.007E-06	8.093E-10	5.950E-09	2.832E-08	8.093E-10	1.485E-08	1.904E-10	7.617E-10	1.30E-05

Date	Comments	MRM Can Sampled	Total press	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8	Ch 9	Ch 10	Ch 11	Ch 12	Ion pressure
1/9/2019	Station 3	L1701	1.80E-05	5.568E-07	2.013E-08	1.142E-05	2.570E-09	1.118E-06	4.760E-10	1.713E-09	1.009E-08	8.569E-10	1.528E-08	1.428E-10	4.760E-10	1.20E-05
5/1/2019	Station 3	L1702	4.10E-06	7.451E-07	3.684E-08	2.754E-05	4.189E-09	2.663E-06	1.904E-10	5.236E-10	4.665E-09	6.665E-10	1.294E-08	4.760E-11	2.856E-10	3.50E-05
5/8/2019	Station 3	L1702	3.40E-06	5.996E-07	2.985E-08	2.759E-05	3.142E-09	2.829E-06	2.380E-10	5.236E-10	4.094E-09	4.284E-10	1.290E-08	9.521E-11	1.428E-10	3.40E-05
5/15/2019	Station 3	L1702	3.30E-06	5.750E-07	3.046E-08	2.637E-05	3.999E-09	2.818E-06	9.521E-11	3.808E-10	6.618E-09	5.236E-10	1.218E-08	9.521E-11	1.428E-10	3.30E-05
4/24/2019	Man A	L1702, L1704, L1707, L1708	4.50E-06	6.708E-07	5.698E-08	2.667E-05	5.712E-09	2.818E-06	3.808E-10	1.285E-09	7.855E-09	1.142E-09	1.409E-08	1.904E-10	4.760E-10	3.30E-05
5/1/2019	Station 4	L1704	4.20E-06	6.089E-07	3.193E-08	2.706E-05	2.618E-09	2.660E-06	2.380E-10	5.712E-10	4.808E-09	5.712E-10	1.309E-08	4.760E-11	2.856E-10	3.50E-05
5/8/2019	Station 4	L1704	3.60E-06	4.765E-07	2.706E-08	2.645E-05	3.142E-09	2.786E-06	1.904E-10	4.284E-10	4.094E-09	5.236E-10	1.256E-08	9.521E-11	1.904E-10	3.40E-05
5/15/2019	Station 4	L1704	4.00E-06	4.907E-07	3.427E-08	2.417E-05	2.850E-09	2.722E-06	1.428E-10	3.808E-10	3.570E-09	5.712E-10	1.171E-08	9.521E-11	2.856E-10	3.30E-05
5/1/2019	Station 7	L1707	4.50E-06	6.659E-07	2.825E-08	2.560E-05	2.094E-09	2.557E-06	2.380E-10	5.712E-10	4.760E-09	4.760E-10	1.275E-08	4.760E-11	2.380E-10	3.50E-05
5/8/2019	Station 7	L1707	3.90E-06	5.315E-07	2.985E-08	2.624E-05	2.618E-09	2.697E-06	1.904E-10	4.760E-10	4.141E-09	5.236E-10	1.242E-08	9.521E-11	2.856E-10	3.40E-05
5/15/2019	Station 7	L1707	3.70E-06	4.970E-07	2.951E-08	2.374E-05	2.856E-09	2.389E-06	1.428E-10	3.808E-10	3.142E-09	3.808E-10	1.028E-08	1.428E-10	1.904E-10	3.30E-05
5/1/2019	Station 8	L1708	5.30E-06	5.916E-07	3.275E-08	2.443E-05	2.094E-09	2.474E-06	2.380E-10	5.712E-10	4.570E-09	6.665E-10	1.252E-08	9.521E-11	2.856E-10	3.50E-05
5/8/2019	Station 8	L1708	4.00E-06	4.686E-07	2.985E-08	2.634E-05	2.618E-09	2.666E-06	1.428E-10	4.760E-10	3.951E-09	5.712E-10	1.213E-08	9.521E-11	2.856E-10	3.40E-05
5/15/2019	Station 8	L1708	3.80E-06	4.123E-07	2.666E-08	2.395E-05	1.713E-09	2.343E-06	9.521E-11	3.332E-10	3.142E-09	4.760E-10	9.997E-09	4.760E-11	1.428E-10	3.30E-05

Appendix D

MRM RGA Calibration Data

Date	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8	Ch 9	Ch 10	Ch 11	Ch 12
AMU	4	28	40	44	20	16	17	18	32	36	12	14
5/28/2014	8.6	4.1	15	19	1.7		1	1	1	1		
6/4/2014	8.3	4.2	15	18	1.7		1	1	1	1		
6/11/2014	8.3	3.8	8	18	1.5		1	1	1	1		
6/17/2014	8.3	3.8	8.2	17	1.6		1	1	1	1		
6/26/2014	8.3	3.6	9.5	17	1.6		1	1	1	1		
7/2/2014	8.5	3.6	6.5	12	1.3		1	1	1	1		
7/9/2014	9	3.4	4.8	7.5	1.3		1	1	1	1		
7/16/2014	9	3.4	4.8	7.5	1.2		1	1	1	1		
12/10/2014	10	2.6	2.9	4.8	1.5		1	1	1	1		
12/17/2014	10	2.6	2.8	5.2	1.3		1	1	1	1		
12/22/2014	9.8	2.5	2.7	5.2	1.2		1	1	1	1		
1/7/2015	9.8	2.4	2.9	5.2	1.1		1	1	1	1		
1/14/2015	8.5	2.3	2.7	5.2	1.1		1	1	1	1		
1/21/2015	8.5	3.1	3.3	6	1.2		1	1	1	1		
1/28/2015	9.5	3.1	3.3	6.5	1.2		1	1	1	1		
3/28/2017	11	3.7	5.5	7.6	1.3		1	1	1	1		
4/27/2017	11	3	3.2	4.5	1.3		1	1	1	1	1	3.7
5/25/2017	19	2.4	2.5	3.4	1.6		1	1	1	1	1	1
5/31/2017	14	2.9	3.2	5.9	1.4		1	1	1	1	1	1
6/8/2017	14	3.3	3.9	9	1.4	1	1	1	1	1	1	1
6/14/2017	14	4.5	9.3	14	16	1	1	1	1	1	1	1
6/21/2017	15	3.7	5.5	11	1.5	1	1	1	1	1	1	1
6/28/2017	14	4	4.5	11	1.5	1	1	1	1	1	1	1
7/6/2017	13	4.8	9	13	1.5	1	1	1	1	1	1	1
7/12/2017	14	3.7	6.5	12	1.5	1	1	1	1	1	1	1
7/19/2017	14	4.2	7.5	12	1.5	1	1	1	1	1	1	1
7/25/2017	14	4.5	7.5	12	1.5	1	1	1	1	1	1	1
8/2/2017	15	3.8	4.3	10	1.5	1	1	1	1	1	1	1
8/9/2017	15	4.1	4.7	12	1.6	1	1	1	1	1	1	1
8/16/2017	15	3.9	4.5	9.7	1.5	1	1	1	1	1	1	1
8/24/2017	15	3.9	4.5	9.7	1.5	1	1	1	1	1	1	1
11/6/2017	12	2.7	3.1	5.3	1.1	1	1	1	1	1	1	1
12/6/2017	13	3.1	3.5	6.5	1.2	1	1	1	1	1	1	1
1/10/2018	13	3.2	3.6	6.2	1.2	1	1	1	1	1	1	1
2/7/2018	13	2.9	3.2	6	1.2	1	1	1	1	1	1	1
3/5/2018	13	2.9	3.2	6	1.2	1	1	1	1	1	1	1
4/4/2018	18	3.9	4.2	6.5	1.5	1	1	1	1	1	1	1
4/25/2018	18	4.1	4.3	6.8	1.6	1	1	1	1	1	1	1
5/2/2018	22	4	4.5	6.3	1.9	1	1	1	1	1	1	1
5/9/2018	21	4	4.3	6	1.9	1	1	1	1	1	1	1
5/16/2018	20	3.9	4.3	6	1.9	1	1	1	1	1	1	1

Date	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8	Ch 9	Ch 10	Ch 11	Ch 12
5/22/2018	21	3.9	4.1	5.7	1.9	1	1	1	1	1	1	1
5/30/2018	19	3.4	3.7	4.6	1.5	1	1	1	1	1	1	1
6/6/2018	18	3.4	3.7	4.8	1.6	1	1	1	1	1	1	1
7/11/2018	22	3.7	3.8	4.8	1.7	1	1	1	1	1	1	1
8/7/2018	22	4	4.2	5.2	1.8	1	1	1	1	1	1	1
9/6/2018	24	4.2	3.8	5	2.4	1	1	1	1	1	1	1
9/13/2018	21	3.1	3.1	4.3	1.7	1	1	1	1	1	1	1
9/20/2018	21	3.4	3.4	4.5	1.9	1	1	1	1	1	1	1
9/27/2018	23	3.5	3.4	4.5	1.9	1	1	1	1	1	1	1
10/4/2018	23	3.5	3.4	4.6	1.9	1	1	1	1	1	1	1
10/11/2018	25	3.5	3.5	4.7	1.9	1	1	1	1	1	1	1
11/12/2018	22	3.3	3.3	4.3	1.9	1	1	1	1	1	1	1
11/13/2018	22	3.3	3.3	4.3	1.9	1	1	1	1	1	1	1
12/12/2018	21	3.1	3.2	4.1	1.6	1	1	1	1	1	1	1
1/9/2019	16	3	2.9	3.6	1.9	1	1	1	1	1	1	1
4/24/2019	52	9	8	10	5.2	1	1	1	1	1	1	1
5/1/2019	52	8.6	8	11	5.2	1	1	1	1	1	1	1
5/8/2019	55	9.8	8.3	11	5.7	1	1	1	1	1	1	1
5/15/2019	61	10	8.5	12	6	1	1	1	1	1	1	1

Appendix D

MRM Can Temperature Data

Date	Station 3	Station 4	Station 11	Station 12	Station 13	Station 15	Station 21	Station 22	Station 25	Station 26	Station 27	Station 7	Station 8
6/17/2014	288	298											
6/17/2014	288	298											
6/26/2014	289	297											
6/26/2014	289	297											
7/2/2014	289	297											
7/2/2014	289	297											
7/9/2014	291	296											
7/9/2014	291	296											
7/16/2014	295	295											
7/16/2014	295	295											
3/28/2017	No Data	No Data	No Data	No Data			No Data	No Data	No Data	No Data			
4/27/2017							189	212	160	173			
5/25/2017	288						193	212	165	175			
6/21/2017	286						195	212	166	175			
7/25/2017	286						196	212	166	174			
8/24/2017	288						257	321	263	314			
11/6/2017	286						254	316	261	316			
1/10/2018	289						265	314	260	317			
3/5/2018	291						263	313	258	313			
4/4/2018							259	313	269	314	288		
5/2/2018	299						262	313	270	314	288		
6/6/2018	302						267	312	270	315	288		
7/11/2018	300						262	312	270	316	287		
8/7/2018	305						257	311	270	314	287		
9/6/2018	305		300		297	317	265	306	267	313	281		
10/4/2018	306		300		295	317	262	306	266	313	281		
11/12/2018	307		296		296	315	257	300	264	312	279		
12/12/2018	308		296		296	317	251	301	265	313	279		
1/9/2019	322		301		305	323	256	307	263	312	287		
5/28/2014	283	288											
5/28/2014	283	288											
6/4/2014	290	296											
6/4/2014	290	296											
6/11/2014	287	295											
6/11/2014	287	295											

Date	Station 3	Station 4	Station 11	Station 12	Station 13	Station 15	Station 21	Station 22	Station 25	Station 26	Station 27	Station 7	Station 8
9/20/2018	304		301		296	317	263	307	267	313	281		
9/27/2018	304		298		294	316	263	308	266	313	281		
10/4/2018	304		296		395	316	263	306	266	313	280		
10/11/2018	307		296		296	316	260	304	266	313	280		
11/13/2018	307		296		295	315	258	302	264	312	279		
12/12/2018	308		291		296	317	258	303	265	313	280		
1/9/2019	323		297		306	323	263	306	264	312	287		
9/5/2018	304		296		294	315	265	306	267	314	280		
9/13/2018	305		303		298	318	264	308	267	314	281		
5/31/2017	285						192	211	163	174			
5/31/2017	285						192	211	163	174			
6/8/2017	290						193	212	164	174			
6/8/2017	290						193	212	164	174			
6/8/2017	290						193	212	164	174			
6/14/2017	288						192	210	162	174			
6/14/2017	288						192	210	162	174			
6/21/2017	286						195	212	166	175			
6/28/2017	285						196	210	164	173			
6/28/2017	285						196	210	164	173			
7/6/2017	285						195	211	164	173			
7/12/2017	285						196	212	165	174			
7/19/2017	287						195	211	166	174			
7/19/2017	287						195	211	166	174			
7/25/2017	286						196	212	166	174			
8/2/2017	286						196	211	164	173			
8/9/2017	285						196	211	164	173			
8/16/2017	286						196	210	164	173			
8/16/2017	286						196	210	164	173			
8/24/2017	286						196	210	164	173			
11/6/2017	285						264	317	261	316			
12/6/2017	286						262	313	258	314			
1/10/2018	289						265	314	260	317			
2/7/2018	291						264	313	259	313			
3/5/2018	291/219						263	314	258	313			
4/4/2018							264	312	268	314	288		
5/2/2018	299						267	314	270	314	289		

Date	Station 3	Station 4	Station 11	Station 12	Station 13	Station 15	Station 21	Station 22	Station 25	Station 26	Station 27	Station 7	Station 8
6/6/2018	300						267	313	270	309	288		
7/11/2018	302						267	312	270	316	288		
8/7/2018	305						266	310	270	315	287		
9/6/2018	304		299		296	316	266	309	267	309	281		
10/4/2018	306		300		297	317	264	308	266	307	281		
11/12/2018	307		296		295	315	258	302	264	306	279		
12/12/2018	308		296		296	316	257	303	264	313	279		
1/9/2019	322		301		306	323	262	306	264	312	287		
9/20/2018	305		301		292	317	264	307	267	313	281		
9/27/2018	304		298		294	316	263	308	266	313	281		
10/4/2018	304		300		292	316	262	307	266	313	280		
10/11/2018	307		293		296	315	260	304	266	313	280		
11/13/2018	307		291		295	315	257	302	263	312	279		
12/12/2018	309		296		290	317	259	302	265	313	279		
1/9/2019	322		302		303	324	262	306	264	312	287		
12/22/2014	191	223	305	308									
12/22/2014	191	223	305	308									
1/7/2015	192	226	295	307									
1/7/2015	192	226	295	307									
1/14/2015	194	221	304	306									
1/21/2015	185	227	298	309									
1/28/2015	191	221	304	305									
3/28/2017	No Data	No Data	No Data	No Data			No Data	No Data	No Data	No Data			
4/27/2017							189	212	160	173			
5/25/2017	288						193	212	165	175			
6/21/2017	286						195	212	166	175			
7/25/2017	286						196	212	166	174			
8/24/2017	286						266	322	256	317			
11/6/2017	286						265	314	252	316			
1/10/2018	289						265	314	260	317			
3/5/2018	291						263	313	258	313			
4/4/2018							268	315	262	314	288		
5/2/2018	299						269	315	264	314	289		
6/6/2018	300						268	313	270	316	288		
7/11/2018	300						267	313	271	316	287		

Date	Station 3	Station 4	Station 11	Station 12	Station 13	Station 15	Station 21	Station 22	Station 25	Station 26	Station 27	Station 7	Station 8
8/7/2018	304						267	313	264	314	287		
9/6/2018	305		301		297	317	267	303	267	314	281		
10/4/2018	306		300		297	317	264	299	266	313	281		
11/12/2018	307		296		295	315	259	295	264	313	279		
12/12/2018	308		296		296	316	260	303	259	313	279		
1/9/2019	322		301		306	323	262	306	257	312	287		
12/10/2014	191	224	302	303									
12/10/2014	191	224	302	303									
12/17/2014	193	224	306	308									
12/17/2014	193	224	306	308									
12/22/2014	191	223	305	308									
1/7/2015	192	226	295	307									
1/14/2015	194	221	304	306									
1/21/2015	185	227	298	309									
1/28/2015	191	221	304	305									
3/28/2017	No Data	No Data	No Data	No Data			No Data	No Data	No Data	No Data			
4/27/2017							189	212	160	173			
5/25/2017	288						193	212	165	175			
6/21/2017	286						195	212	166	175			
7/25/2017	286						196	212	166	174			
8/24/2017	286						267	322	264	317			
11/6/2017	286						265	315	260	311			
1/10/2018	289						265	314	260	317			
3/5/2018	291						263	313	258	313			
4/4/2018							267	315	269	306	287		
5/2/2018	299						268	315	271	308	289		
6/6/2018	300						268	313	264	315	288		
7/11/2018	300						268	313	271	309	287		
8/7/2018	304						267	313	271	307	286		
9/6/2018	304		299		296	317	266	309	268	314	282		
10/4/2018	306		300		297	317	264	306	260	313	281		
11/12/2018	307		296		295	315	259	302	258	313	279		
12/12/2018	308		296		296	317	258	303	264	306	279		
1/9/2019	322		301		306	323	262	306	264	305	287		
9/20/2018	305		300		296	317	264	308	267	314	281		

Date	Station 3	Station 4	Station 11	Station 12	Station 13	Station 15	Station 21	Station 22	Station 25	Station 26	Station 27	Station 7	Station 8
9/27/2018	304		298		294	316	263	308	266	313	281		
10/4/2018	304		300		297	316	262	307	266	313	280		
10/11/2018	307		299		292	315	260	304	266	313	280		
11/13/2018	307		295		290	316	257	302	263	312	279		
12/12/2018	308		297		295	315	259	303	265	313	279		
1/9/2019	322		302		307	323	261	306	264	312	287		
6/17/2014	288	298											
6/17/2014	288	298											
6/26/2014	289	297											
6/26/2014	289	297											
7/2/2014	289	297											
7/2/2014	289	297											
7/9/2014	291	296											
7/9/2014	291	296											
7/16/2014	295	295											
7/16/2014	295	295											
4/27/2017							189	212	160	173			
5/25/2017	288						193	212	165	175			
6/21/2017	286						195	212	166	175			
7/25/2017	286						196	212	166	174			
8/24/2017	288						268	315	264	316			
11/6/2017	286						255	315	261	316			
1/10/2018	289						265	314	260	317			
3/5/2018	291						263	313	258	313			
4/4/2018							269	308	269	314	288		
5/2/2018	299						269	308	270	314	289		
6/6/2018	301						260	312	270	316	288		
7/11/2018	300						268	305	268	316	287		
8/7/2018	305						268	304	269	314	287		
9/6/2018	305		299		295	316	261	306	267	314	281		
10/4/2018	306		300		296	317	258	305	266	313	281		
11/12/2018	307		296		295	315	251	301	264	312	279		
12/12/2018	308		296		295	317	259	294	264	312	279		
1/9/2019	322		301		306	323	264	300	264	312	287		
4/25/2018	292						268	314	269	313	288		
5/2/2018	298						266	314	270	315	288		

Date	Station 3	Station 4	Station 11	Station 12	Station 13	Station 15	Station 21	Station 22	Station 25	Station 26	Station 27	Station 7	Station 8
5/9/2018	297						270	314	271	314	289		
5/16/2018	298						268	313	270	314	288		
5/22/2018	297						268	312	270	313	287		
5/30/2018	297						267	312	270	314	287		
6/6/2018	302						268	313	270	315	288		
7/11/2018	304						267	311	270	317	287		
8/7/2018	305						266	311	269	315	286		
9/6/2018	303		300		297	317	265	307	268	313	282		
10/4/2018	305		300		297	317	262	306	266	313	281		
11/12/2018	307		295		294	315	258	301	263	312	279		
12/12/2018	307		295		295	317	260	303	265	313	279		
1/9/2019	321		302		307	325	262	307	264	312	288		
5/1/2019	304	308										313	303
5/8/2019	304	308										314	303
5/15/2019	304	308										315	302
4/24/2019	304	309										315	303
5/1/2019	304	308										313	303
5/8/2019	304	308										314	303
5/15/2019	304	308										315	302
5/1/2019	304	308										313	303
5/8/2019	304	308										314	303
5/15/2019	304	308										315	302
5/1/2019	304	308										313	303
5/8/2019	304	308										314	303
5/15/2019	304	308										315	302

Appendix E

MRM Pressure Release Data

Pressure Data from Executed Procedures			Manifold pressure	Man Prel	Man rel	Release P	Calculation P	CO Pr
Manifold / Station	Date	Can ID	psia	psia	psia	psia	psia	Pa
A	5/28/2014	L126 , L134	26.8			10.99		2523.1
A	6/4/2014	L126 , L134	20.28			8.29		430.1
A	6/11/2014	L126 , L134	19.76			8.08		367.9
A/4	6/17/2014	L126		2.03		2.26	20.06	179.63
A/4	6/26/2014	L126		2.03		2.26	20.05	290.96
A/4	7/2/2014	L126		2.03		2.23	20.06	230.9
A/4	7/9/2014	L126		2.04		2.25	20.05	309.97
A/4	7/16/2014	L126		2.03		2.23	20.05	356.8
C/21	4/27/2017	L126		7.23	2.87	2.97	20.11	5443.7
C/21	5/25/2017	L126		6.28	2.52	2.53	20.09	684.21
C/21	6/21/2017	L126		6.13	2.48	2.38	20.02	311.6
C/21	7/25/2017	L126		6.21	2.5	2.41	20.06	186.8
C/21	8/24/2017	L126		6.32	2.49	2.39	20	109.2
C/21	11/6/2017	L126		5.93	2.31	2.27	20.02	297.8
C/21	1/10/2018	L126		5.68	2.2	2.15	20.06	192.3
C/21	3/5/2018	L126		5.57	2.14	2.09	20.18	277.8
C/21	4/4/2018	L126		5.35	2.05	2.03	20.07	65.9
C/21	5/2/2018	L126		5.35	2.05	2.09	20.02	112.6
C/21	6/6/2018	L126		5.36	2.05	2.08	20.04	58.1
C/21	7/11/2018	L126		5.35	2.03	2.08	19.99	128.1
C/21	8/7/2018	L126		5.34	2.03	2.05	19.99	85.6
C/21	9/6/2018	L126		5.43	2.15	2.01	20.09	52.5
C/21	10/4/2018	L126		5.37	2.14	1.99	19.99	98.8
C/21	11/12/2018	L126		5.52	2.2	2.08	20.05	127
C/21	12/12/2018	L126		5.43	2.16	2.06	20.04	90.9
C/21	1/9/2019	L126		5.52	2.19	2.09	20.09	101
A/3	6/17/2014	L134		1.97		2.19	20.03	253.13
A/3	6/26/2014	L134		1.98		2.2	20.04	320.7
A/3	7/2/2014	L134		1.98		2.17	20.04	286.5
A/3	7/9/2014	L134		1.98		2.2	20.05	332.67
A/3	7/16/2014	L134		1.98		2.17	20.05	356.8
C/22	4/27/2017	L134		7.14	2.82	2.92	20.17	4872
C/22	5/25/2017	L134		6.3	2.53	2.54	20.11	531.85
C/22	6/21/2017	L134		6.13	2.45	2.39	20.05	276.6
C/22	7/25/2017	L134		6.2	2.52	2.39	20.05	128.9
C/22	8/24/2017	L134		6.41	2.49	2.39	20.01	131.4
C/22	11/6/2017	L134		6	2.32	2.28	20.02	109
C/22	1/10/2018	L134		5.56	2.14	2.05	20.06	130.6
C/22	3/5/2018	L134		5.4	2.04	2.01	20.15	206.4
C/22	4/4/2018	L134		5.19	1.97	1.95	20.06	71.2

Pressure Data from Executed Procedures			Manifold pressure	Man Prel	Man rel	Release P	Calculation P	CO Pr
C/22	5/2/2018	L134		5.19	1.99	2.01	20.01	127.32
C/22	6/6/2018	L134		5.2	1.97	2	20.04	57.8
C/22	7/11/2018	L134		5.19	1.95	2.01	20	104.6
C/22	8/7/2018	L134		5.18	1.98	1.99	20	84.7
C/22	9/6/2018	L134		5.27	2.08	1.94	20.07	70.4
C/22	10/4/2018	L134		5.25	2.05	1.92	19.99	98.1
C/22	11/12/2018	L134		5.36	2.12	2.01	20.05	130.3
C/22	12/12/2018	L134		5.3	2.08	2	20.05	93.1
C/22	1/9/2019	L134		5.35	2.12	2.03	20.09	100
B	12/10/2014	L1307, L1308	23.55			9.76		2598.00
B	12/17/2014	L1307, L1309	20.35			8.41		208.80
B/11	12/22/2014	L1307			1.92	2.22	20.06	150.36
B/11	1/7/2015	L1307			1.94	2.23	20.06	198.20
B/11	1/14/2015	L1307			1.92	2.22	20.00	193.70
B/11	1/21/2015	L1307			1.92	2.21	20.05	150.46
B/11	1/28/2015	L1307			1.93	2.20	20.07	130.20
C/25	4/27/2017	L1307		6.83	2.74	2.82	20.18	2071.90
C/25	5/25/2017	L1307		6.37	2.58	2.60	20.12	310.15
C/25	6/21/2017	L1307		6.26	2.54	2.45	20.04	129.80
C/25	7/25/2017	L1307		6.36	2.60	2.48	20.05	93.10
C/25	8/24/2017	L1307		6.57	2.59	2.49	20.02	102.50
C/25	11/6/2017	L1307		6.13	2.41	2.34	20.02	390.40
C/25	1/10/2018	L1307		5.87	2.28	2.22	20.02	431.40
C/25	3/5/2018	L1307		5.71	2.20	2.17	20.16	293.50
C/25	4/4/2018	L1307		5.52	2.11	2.09	20.06	112.00
C/25	5/2/2018	L1307		5.49	2.10	2.15	20.01	127.32
C/25	6/6/2018	L1307		5.51	2.10	2.15	20.01	43.10
C/25	7/11/2018	L1307		5.48	2.08	2.15	19.99	110.20
C/25	8/7/2018	L1307		5.46	2.08	2.09	19.99	101.20
C/25	9/6/2018	L1307		5.54	2.20	2.06	20.07	76.70
C/25	10/4/2018	L1307		5.52	2.19	2.05	19.99	110.60
C/25	11/12/2018	L1307		5.63	2.25	2.14	20.06	136.10
C/25	12/12/2018	L1307		5.56	2.21	2.11	20.05	94.60
C/25	1/9/2019	L1307		5.63	2.25	2.15	20.07	98.80
B/12	12/22/2014	L1308			1.99	2.28	20.02	218.93
B/12	1/7/2015	L1308			2.04	2.33	20.04	1627.00
B/12	1/14/2015	L1308			1.97	2.27	19.99	254.20
B/12	1/21/2015	L1308			1.99	2.27	20.02	170.45
B/12	1/28/2015	L1308			1.99	2.25	20.09	157.90
C/26	4/27/2017	L1308		6.97	2.80	2.88	20.23	4003.20
C/26	5/25/2017	L1308		6.41	2.60	2.61	20.12	459.60

Pressure Data from Executed Procedures			Manifold pressure	Man Prel	Man rel	Release P	Calculation P	CO Pr
C/26	6/21/2017	L1308		6.30	2.55	2.45	20.06	182.70
C/26	7/25/2017	L1308		6.39	2.60	2.49	20.06	131.20
C/26	8/24/2017	L1308		6.68	2.60	2.52	20.05	117.30
C/26	11/6/2017	L1308		6.18	2.42	2.37	20.04	98.90
C/26	1/10/2018	L1308		5.78	2.22	2.17	20.09	122.00
C/26	3/5/2018	L1308		5.56	2.14	2.09	20.17	141.70
C/26	4/4/2018	L1308		5.34	2.04	2.01	20.02	60.70
C/26	5/2/2018	L1308		5.35	2.05	2.08	20.01	97.06
C/26	6/6/2018	L1308		5.36	2.05	2.08	20.02	41.70
C/26	7/11/2018	L1308		5.35	2.03	2.08	19.99	56.60
C/26	8/7/2018	L1308		5.31	2.03	2.05	19.99	89.20
C/26	9/6/2018	L1308		5.40	2.10	1.99	20.06	63.20
C/26	10/4/2018	L1308		5.37	2.14	1.99	19.99	101.20
C/26	11/12/2018	L1308		5.51	2.19	2.06	20.06	113.20
C/26	12/12/2018	L1308		5.42	2.16	2.06	20.06	84.20
C/26	1/9/2019	L1308		5.43	2.19	2.08	20.06	94.60
A/3	5/31/2017	L1303	21.17		7.42	7.45	21.16	2896.16
A/3	6/8/2017	L1303	20.01		7.02	7	20.01	221.7
A/3	6/14/2017	L1303	19.96		7.03	6.92	19.98	135.7
A/3	6/21/2017	L1303		6.78	2.42	2.36	20.04	155.7
A/3	6/28/2017	L1303		6.78	2.43	2.34	20.02	117.1
A/3	7/6/2017	L1303		6.78	2.42	2.37	20.01	123
A/3	7/12/2017	L1303		6.79	2.43	2.38	20.05	115.6
A/3	7/19/2017	L1303		6.76	2.42	2.34	20.01	129.6
A/3	7/25/2017	L1303		6.76	2.42	2.37	20.06	106.7
A/3	8/2/2017	L1303		6.78	2.43	2.38	20.02	108.5
A/3	8/9/2017	L1303		6.75	2.42	2.33	20.02	118.2
A/3	8/16/2017	L1303		6.78	2.42	2.36	20.05	115.5
A/3	8/24/2017	L1303		6.48	2.32	2.26	20	116.4
A/3	11/6/2017	L1303		8.32	2.95	2.89	20.04	12952
A/3	12/6/2017	L1303		6.65	2.38	2.32	20.07	700.6
A/3	1/10/2018	L1303		6.62	2.34	2.28	20.05	346.7
A/3	2/7/2018	L1303		6.67	2.36	2.26	20.03	280.6
A/3	3/5/2018	L1303		6.26	2.26	2.22	20	124.3
C/27	4/4/2018	L1303		6.84	2.65	2.61	20.09	63.1
C/27	5/2/2018	L1303		5.64	2.2	2.21	20.01	101.5
C/27	6/6/2018	L1303		5.64	2.17	2.22	20.02	41.7
C/27	7/11/2018	L1303		5.62	2.16	2.21	20	66.8
C/27	8/7/2018	L1303		5.63	2.17	2.2	20	91.2
C/27	9/6/2018	L1303		5.69	2.27	2.16	20.07	76.4
C/27	10/4/2018	L1303		5.57	2.27	2.14	19.98	103.3

Pressure Data from Executed Procedures			Manifold pressure	Man Prel	Man rel	Release P	Calculation P	CO Pr
C/27	11/12/2018	L1303		5.79	2.32	2.21	20.06	117
C/27	12/12/2018	L1303		5.73	2.3	2.2	20.06	88.4
C/27	1/9/2019	L1303		5.8	2.33	2.23	20.06	89.8
A/3	4/25/2018	L1701	24.4		8.32	8.32	24.4	340.88
A/3	5/2/2018	L1701	20.12		6.84	6.86	20.12	197.54
A/3	5/9/2018	L1701		6.23	2.14	2.15	20.06	94.2
A/3	5/16/2018	L1701		6.25	2.15	2.16	20.12	96.95
A/3	5/22/2018	L1701		6.21	2.14	2.15	20.05	253.8
A/3	5/30/2018	L1701		6.2	2.12	2.15	20.02	168.5
A/3	6/6/2018	L1701		5.95	2.04	2.06	20.04	83.6
A/3	7/11/2018	L1701		6.24	2.16	2.12	20.11	58.8
A/3	8/7/2018	L1701		6.15	2.12	2.1	20.11	128.1
A/3	9/6/2018	L1701		6.13	2.14	2.05	20.07	53
A/3	10/4/2018	L1701		6.11	2.12	2.03	19.99	101.8
A/3	11/12/2018	L1701		6.24	2.19	2.14	20.07	189.5
A/3	12/12/2018	L1701		6.13	2.16	2.09	20.04	223.1
A/3	1/9/2019	L1701		6.18	2.15	2.15	20.12	155.1
B	9/5/2018	L1301, L1306, L1311	28.41		13.22	13.33	28.42	2593.5
B	9/13/2018	L1301, L1306, L1311	20.1		9.26	9.43	20.1	240.6
B/11	9/20/2018	L1301		5.81	1.87	2.06	19.99	180.5
B/11	9/27/2018	L1301		5.78	1.83	2.1	19.99	206.7
B/11	10/4/2018	L1301		5.78	1.81	2.06	19.99	183.7
B/11	10/11/2018	L1301		5.48	1.68	1.97	20.01	162.7
B/11	11/13/2018	L1301		5.59	1.72	2.08	19.74	50.5
B/11	12/12/2018	L1301		5.67	1.73	2.09	20.09	141.2
B/11	1/9/2019	L1301		5.76	1.79	2.11	20.09	108.8
B/13	9/20/2018	L1306		6.35	2.11	2.33	19.99	182.7
B/13	9/27/2018	L1306		6.37	2.08	2.37	19.99	255.3
B/13	10/4/2018	L1306		6.3	2.04	2.31	19.99	143.5
B/13	10/11/2018	L1306		6.01	1.84	2.12	20.02	163.9
B/13	11/13/2018	L1306		6.04	1.93	2.28	19.74	142.5
B/13	12/12/2018	L1306		6.12	1.95	2.31	20.09	213.7
B/13	1/9/2019	L1306		6.23	2.01	2.34	20.09	142.6
B/15	9/20/2018	L1311		6.36	2.11	2.33	20.01	148.5
B/15	9/27/2018	L1311		6.35	2.09	2.34	20.01	170.7
B/15	10/4/2018	L1311		6.3	2.05	2.31	20.01	141.9
B/15	10/11/2018	L1311		5.91	1.89	2.16	20.01	151.7
B/15	11/13/2018	L1311		5.93	1.88	2.25	19.74	58.8
B/15	12/12/2018	L1311		6.02	1.9	2.27	20.09	125.4
B/15	1/9/2019	L1311		6.12	1.98	2.31	20.09	117.6
A	4/24/2019	L1702, L1704, L1707, L1708	20.48		9.44	9.37	20.48	243.8

Pressure Data from Executed Procedures			Manifold pressure	Man Prel	Man rel	Release P	Calculation P	CO Pr
A / 3	5/1/2019	L1702		5.32	1.77	1.59	20.01	146.02
A / 3	5/8/2019	L1702		5.34	1.79	1.72	20.11	121.7
A / 3	5/15/2019	L1702		5.31	1.77	1.73	20.07	127.7
A / 4	5/1/2019	L1704		5.35	1.78	1.67	20.006	126.18
A / 4	5/8/2019	L1704		5.38	1.82	1.75	20.01	109.8
A / 4	5/15/2019	L1704		5.38	1.81	1.76	20.09	143.8
A / 7	5/1/2019	L1707		5.25	1.76	1.65	20.1	111.86
A / 7	5/8/2019	L1707		5.3	1.78	1.71	20.01	121.1
A / 7	5/15/2019	L1707		5.3	1.77	1.73	20.04	123.6
A / 8	5/1/2019	L1708		5.38	1.82	1.7	20.06	129.42
A / 8	5/8/2019	L1708		5.41	1.82	1.75	20.05	121.4
A / 8	5/15/2019	L1708		5.4	1.81	1.77	20.07	111.8

Appendix F
MRM Can L1303 Reduction Calculation using the RGA
Vacuum Pressure

Method	RGA Pressure		Data from executed procedures						Partial Pressure calculations				
			Manifold pressure	Man Prel A,B or C	Man rel A, B or C	Release pres	Calc Pr	CO Pr	Calc CO (tot P)	Calc He (tot P)	Calc CO2 (tot P)	CO+He (tot P)	Tmax (Tot P)
Date	Manifold / Station	MRM Can Sampled	psia	psia	psia	psia	psia	Pa	Pa	Pa	Pa	psia	K
5/31/2017	A/3	L1303	21.17		7.42	7.45	21.16	2896	2897	1699	14	1	1068
6/8/2017	A/3	L1303	20.01		7.02	7.00	20.01	222	222	270	21	0	830
6/14/2017	A/3	L1303	19.96		7.03	6.92	19.98	136	136	193	18	0	802
6/21/2017	A/3	L1303		6.78	2.42	2.36	20.04	156	156	779	22	0	806
6/28/2017	A/3	L1303		6.78	2.43	2.34	20.02	117	117	669	13	0	804
7/6/2017	A/3	L1303		6.78	2.42	2.37	20.01	123	123	768	17	0	798
7/12/2017	A/3	L1303		6.79	2.43	2.38	20.05	116	116	642	16	0	797
7/19/2017	A/3	L1303		6.76	2.42	2.34	20.01	130	130	745	24	0	792
7/25/2017	A/3	L1303		6.76	2.42	2.37	20.06	107	107	617	8	0	814
8/2/2017	A/3	L1303		6.78	2.43	2.38	20.02	109	108	876	13	0	798
8/9/2017	A/3	L1303		6.75	2.42	2.33	20.02	118	118	824	16	0	798
8/16/2017	A/3	L1303		6.78	2.42	2.36	20.05	116	115	789	13	0	804
8/24/2017	A/3	L1303		6.48	2.32	2.26	20.00	116	116	859	12	0	807
11/6/2017	A/3	L1303		8.32	2.95	2.89	20.04	12952	12948	4839	21	3	1235
12/6/2017	A/3	L1303		6.65	2.38	2.32	20.07	701	700	3319	33	1	897
1/10/2018	A/3	L1303		6.62	2.34	2.28	20.05	347	347	4092	44	1	835
2/7/2018	A/3	L1303		6.67	2.36	2.26	20.03	281	280	3289	31	1	832
3/5/2018	A/3	L1303		6.26	2.26	2.22	20.00	124	124	2228	9	0	818
4/4/2018	C/27	L1303		6.84	2.65	2.61	20.09	63	63	1537	6	0	790
5/2/2018	C/27	L1303		5.64	2.20	2.21	20.01	102	101	2521	8	0	812
6/6/2018	C/27	L1303		5.64	2.17	2.22	20.02	42	42	1596	3	0	784
7/11/2018	C/27	L1303		5.62	2.16	2.21	20.00	67	67	2731	7	0	790
8/7/2018	C/27	L1303		5.63	2.17	2.20	20.00	91	91	2386	5	0	816
9/6/2018	C/27	L1303		5.69	2.27	2.16	20.07	76	76	1987	3	0	822
10/4/2018	C/27	L1303		5.57	2.27	2.14	19.98	103	103	2774	7	0	816
11/12/2018	C/27	L1303		5.79	2.32	2.21	20.06	117	117	4312	9	1	814
12/12/2018	C/27	L1303		5.73	2.30	2.20	20.06	88	88	2333	3	0	829
1/9/2019	C/27	L1303		5.80	2.33	2.23	20.06	90	90	1706	5	0	819

Release Pressures				Can pressure - double rel.					Reduction Calculation						
Manifold pressure	Man Prel A,B or C	Man rel A, B or C	Release pres	Variable (T/V)	N (MRM can)	P (calc)	P (calc)	Can Temp	# mol gas	#mol CO	#mol CO2	#mol of "O"	O2 portion PuO2 mol	PuOx	Ratio of mol calc
Pa	Pa	Pa	Pa			Pa	psia	K	mol						
145922	0	51145	51352					558	1.65E-01	3.27E-03	1.60E-05	3.31E-03	4.47	1.9985	
137926	0	48388	48250					563	1.56E-01	2.51E-04	2.36E-05	2.98E-04	4.47	1.9984	
137581	0	48457	47699					561	1.56E-01	1.53E-04	2.07E-05	1.95E-04	4.47	1.9983	
0	46734	16681	16267	294329	5.28E-02	129315	18.76	559	5.15E-02	5.81E-05	8.10E-06	7.43E-05	4.47	1.9983	1.03
0	46734	16750	16129	289176	5.32E-02	127869	18.55	558	5.11E-02	4.33E-05	4.86E-06	5.31E-05	4.47	1.9982	1.04
0	46734	16681	16336	294329	5.28E-02	129315	18.76	558	5.17E-02	4.61E-05	6.40E-06	5.89E-05	4.47	1.9982	1.02
0	46803	16750	16405	291002	5.31E-02	128570	18.65	558	5.20E-02	4.35E-05	5.99E-06	5.54E-05	4.47	1.9982	1.02
0	46596	16681	16129	290623	5.29E-02	127896	18.55	560	5.11E-02	4.80E-05	8.75E-06	6.55E-05	4.47	1.9982	1.04
0	46596	16681	16336	290623	5.29E-02	127896	18.55	559	5.17E-02	3.99E-05	2.96E-06	4.58E-05	4.47	1.9981	1.02
0	46734	16750	16405	289176	5.32E-02	127869	18.55	559	5.20E-02	4.08E-05	5.00E-06	5.08E-05	4.47	1.9981	1.02
0	46527	16681	16060	288793	5.30E-02	127196	18.45	558	5.09E-02	4.36E-05	5.93E-06	5.54E-05	4.47	1.9981	1.04
0	46734	16681	16267	294329	5.28E-02	129315	18.76	559	5.15E-02	4.31E-05	4.76E-06	5.26E-05	4.47	1.9981	1.03
0	44666	15991	15578	290497	5.07E-02	122565	17.78	559	4.93E-02	4.16E-05	4.14E-06	4.99E-05	4.47	1.9980	1.03
0	57349	20334	19920	302934	6.42E-02	161650	23.45	558	6.31E-02	5.91E-03	9.55E-06	5.93E-03	4.46	1.9954	1.02
0	45838	16405	15991	290948	5.20E-02	125905	18.27	559	5.07E-02	2.56E-04	1.21E-05	2.81E-04	4.46	1.9953	1.03
0	45631	16129	15716	307060	5.08E-02	129751	18.82	562	4.98E-02	1.25E-04	1.58E-05	1.56E-04	4.46	1.9952	1.02
0	45975	16267	15578	305733	5.13E-02	130364	18.91	564	4.93E-02	1.00E-04	1.11E-05	1.22E-04	4.46	1.9951	1.04
0	43149	15578	15302	280414	4.97E-02	115792	16.80	564	4.85E-02	4.37E-05	3.26E-06	5.02E-05	4.46	1.9951	1.02
0	47147	18266	17990	322703	6.07E-02	162985	23.65	563	6.05E-02	2.75E-05	2.55E-06	3.26E-05	4.46	1.9951	1.00
0	38876	15164	15233	310686	5.07E-02	130834	18.98	561	5.12E-02	3.77E-05	2.79E-06	4.32E-05	4.46	1.9951	0.99
0	38876	14958	15302	335728	4.95E-02	138246	20.06	562	5.14E-02	1.55E-05	1.18E-06	1.79E-05	4.46	1.9951	0.96
0	38738	14889	15233	337808	4.93E-02	138369	20.07	561	5.12E-02	2.48E-05	2.44E-06	2.97E-05	4.46	1.9951	0.96
0	38807	14958	15164	332313	4.96E-02	136992	19.87	561	5.10E-02	3.37E-05	1.99E-06	3.77E-05	4.46	1.9951	0.97
0	39220	15647	14889	275580	5.30E-02	121511	17.63	560	5.00E-02	2.76E-05	1.13E-06	2.99E-05	4.46	1.9950	1.06
0	38393	15647	14751	247677	5.38E-02	110792	16.07	554	4.96E-02	3.72E-05	2.47E-06	4.21E-05	4.46	1.9950	1.09
0	39910	15991	15233	269485	5.44E-02	121795	17.67	554	5.12E-02	4.33E-05	3.49E-06	5.03E-05	4.46	1.9950	1.06
0	39496	15854	15164	267088	5.40E-02	119812	17.38	552	5.10E-02	3.26E-05	1.24E-06	3.51E-05	4.46	1.9950	1.06
0	39979	16060	15371	265986	5.47E-02	120940	17.55	552	5.17E-02	3.36E-05	1.77E-06	3.71E-05	4.46	1.9950	1.06
				294601	Average										

RGA Data						
Total press	Ch 1	Ch 2	Ch 3	Ch 4	Ch 12	Ion pressure
AMU/chg	4	28	40	44	14	torr
8.70E-06	1.0E-07	1.7E-07	4.9E-06	8.4E-10	6.7E-10	6.90E-06
8.50E-06	1.7E-08	1.4E-08	6.2E-06	1.3E-09	2.9E-10	7.40E-06
1.00E-05	1.4E-08	9.9E-09	5.9E-06	1.3E-09	2.9E-10	8.00E-06
1.00E-05	5.6E-08	1.1E-08	8.6E-06	1.6E-09	1.9E-10	8.00E-06
1.10E-05	5.3E-08	9.3E-09	3.3E-06	1.0E-09	2.9E-10	8.30E-06
1.00E-05	5.6E-08	8.9E-09	5.5E-06	1.2E-09	2.4E-10	8.10E-06
9.90E-06	4.6E-08	8.3E-09	9.9E-06	1.1E-09	2.4E-10	8.10E-06
1.00E-05	5.4E-08	9.4E-09	1.1E-05	1.7E-09	1.4E-10	8.20E-06
1.00E-05	4.5E-08	7.7E-09	1.0E-05	5.7E-10	2.4E-10	8.10E-06
9.90E-06	6.3E-08	7.8E-09	6.7E-06	9.5E-10	9.5E-11	8.00E-06
9.80E-06	5.9E-08	8.4E-09	7.2E-06	1.1E-09	1.4E-10	8.40E-06
1.00E-05	5.7E-08	8.4E-09	7.4E-06	9.2E-10	1.4E-10	8.30E-06
1.10E-05	6.9E-08	9.3E-09	8.0E-06	9.2E-10	1.9E-10	8.60E-06
1.50E-05	5.3E-07	1.4E-06	5.9E-06	2.3E-09	4.5E-09	7.70E-06
1.30E-05	3.1E-07	6.6E-08	8.2E-06	3.1E-09	1.0E-09	8.20E-06
1.30E-05	3.8E-07	3.3E-08	8.9E-06	4.1E-09	1.0E-09	8.80E-06
1.40E-05	3.3E-07	2.8E-08	8.9E-06	3.1E-09	9.0E-10	9.40E-06
1.70E-05	2.7E-07	1.5E-08	6.8E-06	1.1E-09	3.8E-10	8.80E-06
2.20E-05	2.4E-07	1.0E-08	7.2E-06	9.3E-10	2.4E-10	1.50E-05
2.20E-05	4.0E-07	1.6E-08	1.0E-05	1.2E-09	2.9E-10	1.30E-05
3.00E-05	3.5E-07	9.1E-09	8.3E-06	6.9E-10	1.9E-10	1.30E-05
2.40E-05	4.8E-07	1.2E-08	9.1E-06	1.1E-09	2.9E-10	1.30E-05
1.90E-05	3.3E-07	1.3E-08	1.0E-05	7.4E-10	2.9E-10	1.30E-05
2.10E-05	3.0E-07	1.2E-08	8.8E-06	4.8E-10	1.9E-10	1.40E-05
2.20E-05	4.4E-07	1.6E-08	1.2E-05	1.1E-09	2.9E-10	1.40E-05
1.80E-05	5.6E-07	1.5E-08	1.2E-05	1.2E-09	2.9E-10	1.30E-05
2.40E-05	4.0E-07	1.5E-08	1.1E-05	5.9E-10	3.3E-10	1.20E-05
2.00E-05	2.5E-07	1.3E-08	8.3E-06	6.9E-10	3.3E-10	1.20E-05

Appendix G

MRM Can L1303 Reduction Calculation using the Calibration Gas Sum of the RGA Partial Pressure

Method	P _{SUM} Pressure		Data from executed procedures						Partial Pressure calculations				
Date	Manifold / Station	Can	Manifold pressure	Man Prel A,B or C	Man rel A, B or C	Release pres	Calc Pr	CO Pr	Calc CO (sum PP)	Calc He (sum PP)	Calc CO2 (sum PP)	CO+He (sum PP)	Tmax (sum PP)
			psia	psia	psia	psia	psia	Pa	Pa	Pa	Pa	psia	K
5/31/2017	A/3	L1303	21.17		7.42	7.45	21.16	2896	4828	2832	24	1.11	1097
6/8/2017	A/3	L1303	20.01		7.02	7.00	20.01	222	304	371	29	0.10	841
6/14/2017	A/3	L1303	19.96		7.03	6.92	19.98	136	228	323	31	0.08	819
6/21/2017	A/3	L1303		6.78	2.42	2.36	20.04	156	180	903	25	0.16	810
6/28/2017	A/3	L1303		6.78	2.43	2.34	20.02	117	389	2220	44	0.38	843
7/6/2017	A/3	L1303		6.78	2.42	2.37	20.01	123	222	1385	31	0.23	817
7/12/2017	A/3	L1303		6.79	2.43	2.38	20.05	116	115	639	16	0.11	797
7/19/2017	A/3	L1303		6.76	2.42	2.34	20.01	130	115	660	21	0.11	788
7/25/2017	A/3	L1303		6.76	2.42	2.37	20.06	107	102	591	8	0.10	812
8/2/2017	A/3	L1303		6.78	2.43	2.38	20.02	109	157	1272	19	0.21	810
8/9/2017	A/3	L1303		6.75	2.42	2.33	20.02	118	159	1111	22	0.18	807
8/16/2017	A/3	L1303		6.78	2.42	2.36	20.05	116	155	1059	17	0.18	813
8/24/2017	A/3	L1303		6.48	2.32	2.26	20.00	116	158	1163	16	0.19	817
11/6/2017	A/3	L1303		8.32	2.95	2.89	20.04	12952	24732	9244	40	4.93	1285
12/6/2017	A/3	L1303		6.65	2.38	2.32	20.07	701	1064	5044	50	0.89	913
1/10/2018	A/3	L1303		6.62	2.34	2.28	20.05	347	484	5714	61	0.90	846
2/7/2018	A/3	L1303		6.67	2.36	2.26	20.03	281	425	4984	47	0.78	847
3/5/2018	A/3	L1303		6.26	2.26	2.22	20.00	124	299	5361	22	0.82	848
4/4/2018	C/27	L1303		6.84	2.65	2.61	20.09	63	187	4567	17	0.69	825
5/2/2018	C/27	L1303		5.64	2.20	2.21	20.01	102	215	5344	16	0.81	837
6/6/2018	C/27	L1303		5.64	2.17	2.22	20.02	42	144	5516	11	0.82	823
7/11/2018	C/27	L1303		5.62	2.16	2.21	20.00	67	166	6802	16	1.01	819
8/7/2018	C/27	L1303		5.63	2.17	2.20	20.00	91	163	4255	10	0.64	835
9/6/2018	C/27	L1303		5.69	2.27	2.16	20.07	76	176	4573	7	0.69	850
10/4/2018	C/27	L1303		5.57	2.27	2.14	19.98	103	189	5073	13	0.76	836
11/12/2018	C/27	L1303		5.79	2.32	2.21	20.06	117	169	6230	14	0.93	826
12/12/2018	C/27	L1303		5.73	2.30	2.20	20.06	88	192	5071	7	0.76	856
1/9/2019	C/27	L1303		5.80	2.33	2.23	20.06	90	210	3994	11	0.61	848

Release Pressures				Can pressure - double rel.					Reduction Calculation							
Manifold pressure	Man rel A,BorC	Man rel A,BorC	Release pres	Variable (T/V)	N (MRM can)	P (calc)	P(calc)	Can Temp	# mol gas	# mol gas	% in can	#mol CO	#mol CO2	#mol of "O"	O2 portion PuO2 mol	PuOx
Pa	Pa	Pa	Pa			Pa	psia	K	mol	mol	ratio	mol	mol	mol		
145922	0	51145	51352					558	1.65E-01	5.96E-02	36%	5.76E-03	2.81E-05	5.82E-03	4.47	1.9974
137926	0	48388	48250					563	1.56E-01	5.63E-02	36%	3.45E-04	3.25E-05	4.10E-04	4.47	1.9972
137581	0	48457	47699					561	1.56E-01	5.62E-02	36%	2.58E-04	3.49E-05	3.28E-04	4.47	1.9971
0	46734	16681	16267	294329	5.28E-02	129315	18.76	559	5.15E-02	6.64E-03	13%	6.78E-05	9.45E-06	8.67E-05	4.47	1.9970
0	46734	16750	16129	289176	5.32E-02	127869	18.55	558	5.11E-02	6.59E-03	13%	1.47E-04	1.65E-05	1.80E-04	4.47	1.9969
0	46734	16681	16336	294329	5.28E-02	129315	18.76	558	5.17E-02	6.67E-03	13%	8.41E-05	1.17E-05	1.07E-04	4.47	1.9969
0	46803	16750	16405	291002	5.31E-02	128570	18.65	558	5.20E-02	6.70E-03	13%	4.35E-05	6.00E-06	5.55E-05	4.47	1.9969
0	46596	16681	16129	290623	5.29E-02	127896	18.55	560	5.11E-02	6.59E-03	13%	4.28E-05	7.81E-06	5.84E-05	4.46	1.9969
0	46596	16681	16336	290623	5.29E-02	127896	18.55	559	5.17E-02	6.67E-03	13%	3.84E-05	2.84E-06	4.41E-05	4.46	1.9968
0	46734	16750	16405	289176	5.32E-02	127869	18.55	559	5.20E-02	6.70E-03	13%	5.99E-05	7.33E-06	7.46E-05	4.46	1.9968
0	46527	16681	16060	288793	5.30E-02	127196	18.45	558	5.09E-02	6.56E-03	13%	5.93E-05	8.07E-06	7.54E-05	4.46	1.9968
0	46734	16681	16267	294329	5.28E-02	129315	18.76	559	5.15E-02	6.64E-03	13%	5.83E-05	6.44E-06	7.12E-05	4.46	1.9967
0	44666	15991	15578	290497	5.07E-02	122565	17.78	559	4.93E-02	6.36E-03	13%	5.64E-05	5.66E-06	6.77E-05	4.46	1.9967
0	57349	20334	19920	302934	6.42E-02	161650	23.45	558	6.31E-02	8.13E-03	13%	1.13E-02	2.42E-05	1.13E-02	4.45	1.9916
0	45838	16405	15991	290948	5.20E-02	125905	18.27	559	5.07E-02	6.53E-03	13%	3.90E-04	1.92E-05	4.28E-04	4.45	1.9914
0	45631	16129	15716	307060	5.08E-02	129751	18.82	562	4.98E-02	6.42E-03	13%	1.74E-04	2.31E-05	2.21E-04	4.45	1.9913
0	45975	16267	15578	305733	5.13E-02	130364	18.91	564	4.93E-02	6.36E-03	13%	1.52E-04	1.75E-05	1.87E-04	4.45	1.9913
0	43149	15578	15302	280414	4.97E-02	115792	16.80	564	4.85E-02	6.25E-03	13%	1.05E-04	8.17E-06	1.21E-04	4.45	1.9912
0	47147	18266	17990	322703	6.07E-02	162985	23.65	563	6.05E-02	7.35E-03	12%	8.18E-05	7.85E-06	9.75E-05	4.45	1.9912
0	38876	15164	15233	310686	5.07E-02	130834	18.98	561	5.12E-02	6.22E-03	12%	7.98E-05	6.16E-06	9.22E-05	4.45	1.9911
0	38876	14958	15302	335728	4.95E-02	138246	20.06	562	5.14E-02	6.25E-03	12%	5.37E-05	4.24E-06	6.22E-05	4.45	1.9911
0	38738	14889	15233	337808	4.93E-02	138369	20.07	561	5.12E-02	6.22E-03	12%	6.17E-05	6.39E-06	7.45E-05	4.45	1.9911
0	38807	14958	15164	332313	4.96E-02	136992	19.87	561	5.10E-02	6.19E-03	12%	6.01E-05	3.67E-06	6.74E-05	4.45	1.9910
0	39220	15647	14889	275580	5.30E-02	121511	17.63	560	5.00E-02	6.08E-03	12%	6.36E-05	2.70E-06	6.90E-05	4.45	1.9910
0	38393	15647	14751	247677	5.38E-02	110792	16.07	554	4.96E-02	6.02E-03	12%	6.80E-05	4.69E-06	7.73E-05	4.45	1.9910
0	39910	15991	15233	269485	5.44E-02	121795	17.67	554	5.12E-02	6.22E-03	12%	6.26E-05	5.29E-06	7.32E-05	4.45	1.9909
0	39496	15854	15164	267088	5.40E-02	119812	17.38	552	5.10E-02	6.19E-03	12%	7.08E-05	2.81E-06	7.64E-05	4.45	1.9909
0	39979	16060	15371	265986	5.47E-02	120940	17.55	552	5.17E-02	6.28E-03	12%	7.86E-05	4.28E-06	8.71E-05	4.45	1.9909
				294601	Average											

	RGA Data							
Ratio of mol calc	P (sum PP)	Total press	Ch 1	Ch 2	Ch 3	Ch 4	Ch 12	Ion pressure
	torr	AMU/chg	4	28	40	44	14	
	5.22E-06	8.70E-06	1.01E-07	1.73E-07	4.95E-06	8.43E-10	6.67E-10	6.90E-06
	6.20E-06	8.50E-06	1.67E-08	1.37E-08	6.17E-06	1.29E-09	2.86E-10	7.40E-06
	5.97E-06	1.00E-05	1.40E-08	9.85E-09	5.94E-06	1.33E-09	2.86E-10	8.00E-06
1.03	8.63E-06	1.00E-05	5.64E-08	1.13E-08	8.56E-06	1.57E-09	1.90E-10	8.00E-06
1.04	3.31E-06	1.10E-05	5.33E-08	9.33E-09	3.25E-06	1.05E-09	2.86E-10	8.30E-06
1.02	5.55E-06	1.00E-05	5.57E-08	8.91E-09	5.48E-06	1.24E-09	2.38E-10	8.10E-06
1.02	9.94E-06	9.90E-06	4.60E-08	8.28E-09	9.88E-06	1.14E-09	2.38E-10	8.10E-06
1.04	1.13E-05	1.00E-05	5.40E-08	9.40E-09	1.12E-05	1.71E-09	1.43E-10	8.20E-06
1.02	1.04E-05	1.00E-05	4.47E-08	7.71E-09	1.04E-05	5.71E-10	2.38E-10	8.10E-06
1.02	6.82E-06	9.90E-06	6.28E-08	7.78E-09	6.75E-06	9.52E-10	9.52E-11	8.00E-06
1.04	7.27E-06	9.80E-06	5.86E-08	8.39E-09	7.20E-06	1.14E-09	1.43E-10	8.40E-06
1.03	7.45E-06	1.00E-05	5.71E-08	8.36E-09	7.39E-06	9.24E-10	1.43E-10	8.30E-06
1.03	8.12E-06	1.10E-05	6.86E-08	9.28E-09	8.05E-06	9.24E-10	1.90E-10	8.60E-06
1.02	7.85E-06	1.50E-05	5.26E-07	1.41E-06	5.92E-06	2.27E-09	4.48E-09	7.70E-06
1.03	8.55E-06	1.30E-05	3.12E-07	6.58E-08	8.17E-06	3.09E-09	1.00E-09	8.20E-06
1.02	9.31E-06	1.30E-05	3.85E-07	3.26E-08	8.89E-06	4.13E-09	1.05E-09	8.80E-06
1.04	9.24E-06	1.40E-05	3.34E-07	2.84E-08	8.87E-06	3.14E-09	9.05E-10	9.40E-06
1.02	7.06E-06	1.70E-05	2.75E-07	1.53E-08	6.77E-06	1.14E-09	3.81E-10	8.80E-06
1.00	7.41E-06	2.20E-05	2.44E-07	1.00E-08	7.15E-06	9.28E-10	2.38E-10	1.50E-05
0.99	1.04E-05	2.20E-05	4.02E-07	1.62E-08	9.96E-06	1.20E-09	2.86E-10	1.30E-05
0.96	8.68E-06	3.00E-05	3.47E-07	9.06E-09	8.32E-06	6.86E-10	1.90E-10	1.30E-05
0.96	9.64E-06	2.40E-05	4.76E-07	1.16E-08	9.15E-06	1.14E-09	2.86E-10	1.30E-05
0.97	1.07E-05	1.90E-05	3.29E-07	1.26E-08	1.03E-05	7.43E-10	2.86E-10	1.30E-05
1.06	9.12E-06	2.10E-05	3.02E-07	1.16E-08	8.81E-06	4.76E-10	1.90E-10	1.40E-05
1.09	1.20E-05	2.20E-05	4.43E-07	1.65E-08	1.16E-05	1.09E-09	2.86E-10	1.40E-05
1.06	1.25E-05	1.80E-05	5.61E-07	1.52E-08	1.19E-05	1.23E-09	2.86E-10	1.30E-05
1.06	1.10E-05	2.40E-05	4.05E-07	1.53E-08	1.06E-05	5.86E-10	3.33E-10	1.20E-05
1.06	8.54E-06	2.00E-05	2.47E-07	1.30E-08	8.28E-06	6.86E-10	3.33E-10	1.20E-05

Appendix H
MRM Can L1303 Reduction Calculation using the Fill Pressure
and RGA Partial Pressure of Argon

Method	P _{Ar} Pressure		Data from executed procedures						Partial Pressure calculations				
			Manifold pressure	Man rel A,B or C	Man rel A,B or C	Release pres	Calc Pr	CO Pr	Cal CO (Ar P)	Cal He (Ar P)	Calc CO2 (Ar P)	CO+He (Ar P)	Tmax (Ar P)
Date	Manifold / Station		psia	psia	psia	psia	psia	Pa	Pa	Pa	Pa	psia	K
									20	20	20		
5/31/2017	A/3	L1303	21.17		7.42	7.45	21.16	2896	4815	2824	23	1.11	1097
6/8/2017	A/3	L1303	20.01		7.02	7.00	20.01	222	305	373	29	0.10	841
6/14/2017	A/3	L1303	19.96		7.03	6.92	19.98	136	228	324	31	0.08	819
6/21/2017	A/3	L1303		6.78	2.42	2.36	20.04	156	182	910	25	0.16	811
6/28/2017	A/3	L1303		6.78	2.43	2.34	20.02	117	396	2264	44	0.39	844
7/6/2017	A/3	L1303		6.78	2.42	2.37	20.01	123	224	1402	31	0.24	817
7/12/2017	A/3	L1303		6.79	2.43	2.38	20.05	116	116	643	16	0.11	797
7/19/2017	A/3	L1303		6.76	2.42	2.34	20.01	130	116	664	21	0.11	788
7/25/2017	A/3	L1303		6.76	2.42	2.37	20.06	107	103	594	8	0.10	813
8/2/2017	A/3	L1303		6.78	2.43	2.38	20.02	109	159	1285	19	0.21	810
8/9/2017	A/3	L1303		6.75	2.42	2.33	20.02	118	161	1122	22	0.19	807
8/16/2017	A/3	L1303		6.78	2.42	2.36	20.05	116	156	1069	17	0.18	813
8/24/2017	A/3	L1303		6.48	2.32	2.26	20.00	116	159	1175	16	0.19	817
11/6/2017	A/3	L1303		8.32	2.95	2.89	20.04	12952	32812	12264	53	6.54	1308
12/6/2017	A/3	L1303		6.65	2.38	2.32	20.07	701	1114	5279	52	0.93	915
1/10/2018	A/3	L1303		6.62	2.34	2.28	20.05	347	507	5986	64	0.94	848
2/7/2018	A/3	L1303		6.67	2.36	2.26	20.03	281	442	5189	49	0.82	848
3/5/2018	A/3	L1303		6.26	2.26	2.22	20.00	124	312	5591	23	0.86	850
4/4/2018	C/27	L1303		6.84	2.65	2.61	20.09	63	194	4730	18	0.71	826
5/2/2018	C/27	L1303		5.64	2.20	2.21	20.01	102	224	5569	17	0.84	838
6/6/2018	C/27	L1303		5.64	2.17	2.22	20.02	42	150	5753	11	0.86	824
7/11/2018	C/27	L1303		5.62	2.16	2.21	20.00	67	175	7165	17	1.06	821
8/7/2018	C/27	L1303		5.63	2.17	2.20	20.00	91	168	4396	10	0.66	836
9/6/2018	C/27	L1303		5.69	2.27	2.16	20.07	76	182	4736	7	0.71	852
10/4/2018	C/27	L1303		5.57	2.27	2.14	19.98	103	196	5275	13	0.79	838
11/12/2018	C/27	L1303		5.79	2.32	2.21	20.06	117	177	6533	14	0.97	828
12/12/2018	C/27	L1303		5.73	2.30	2.20	20.06	88	200	5272	8	0.79	858
1/9/2019	C/27	L1303		5.80	2.33	2.23	20.06	90	217	4120	11	0.63	849

Release Pressures				Can pressure - double release						
Manifold pressure	Man Prel A,B or C	Man rel A, B or C	Release pres	Variable (T/V)	N (MRM can)	P (calc)	P (calc)	Can Temp	Total pressure (CO+HE +Ar)	P(calc) /sum gas
Pa	Pa	Pa	Pa			Pa	psia	K		
145922	0	51145	51352					558	21.17	
137926	0	48388	48250					563	20.11	
137581	0	48457	47699					561	20.06	
0	46734	16681	16267	294329	5.28E-02	129315	18.76	559	20.20	0.93
0	46734	16750	16129	289176	5.32E-02	127869	18.55	558	20.41	0.91
0	46734	16681	16336	294329	5.28E-02	129315	18.76	558	20.25	0.93
0	46803	16750	16405	291002	5.31E-02	128570	18.65	558	20.16	0.93
0	46596	16681	16129	290623	5.29E-02	127896	18.55	560	20.12	0.92
0	46596	16681	16336	290623	5.29E-02	127896	18.55	559	20.16	0.92
0	46734	16750	16405	289176	5.32E-02	127869	18.55	559	20.23	0.92
0	46527	16681	16060	288793	5.30E-02	127196	18.45	558	20.21	0.91
0	46734	16681	16267	294329	5.28E-02	129315	18.76	559	20.23	0.93
0	44666	15991	15578	290497	5.07E-02	122565	17.78	559	20.19	0.88
0	57349	20334	19920	302934	6.42E-02	161650	23.45	558	26.58	0.88
0	45838	16405	15991	290948	5.20E-02	125905	18.27	559	21.00	0.87
0	45631	16129	15716	307060	5.08E-02	129751	18.82	562	20.99	0.90
0	45975	16267	15578	305733	5.13E-02	130364	18.91	564	20.85	0.91
0	43149	15578	15302	280414	4.97E-02	115792	16.80	564	20.86	0.81
0	47147	18266	17990	322703	6.07E-02	162985	23.65	563	20.80	1.14
0	38876	15164	15233	310686	5.07E-02	130834	18.98	561	20.85	0.91
0	38876	14958	15302	335728	4.95E-02	138246	20.06	562	20.88	0.96
0	38738	14889	15233	337808	4.93E-02	138369	20.07	561	21.06	0.95
0	38807	14958	15164	332313	4.96E-02	136992	19.87	561	20.66	0.96
0	39220	15647	14889	275580	5.30E-02	121511	17.63	560	20.78	0.85
0	38393	15647	14751	247677	5.38E-02	110792	16.07	554	20.77	0.77
0	39910	15991	15233	269485	5.44E-02	121795	17.67	554	21.03	0.84
0	39496	15854	15164	267088	5.40E-02	119812	17.38	552	20.85	0.83
0	39979	16060	15371	265986	5.47E-02	120940	17.55	552	20.69	0.85
				294601	Avverage				Average	0.90

Reduction Calculation							RGA Data							
# mol gas	#mol CO	#mol CO2	#mol of "O"											
mol	mol	mol		PuO2 mol	PuOx	Ratio of mol	Total pressure Pa	torr	Total press AMU/chg	Ch 1 4	Ch 2 28	Ch 3 40	Ch 4 44	Ch 12 14
1.64E-01	5.44E-03	2.80E-05	5.50E-03	4.47	1.9975		145519	5.22E-06	8.70E-06	1.01E-07	1.73E-07	4.95E-06	8.43E-10	6.67E-10
1.57E-01	3.45E-04	3.26E-05	4.11E-04	4.47	1.9974		138564	6.20E-06	8.50E-06	1.67E-08	1.37E-08	6.17E-06	1.29E-09	2.86E-10
1.56E-01	2.58E-04	3.51E-05	3.28E-04	4.47	1.9972		138441	5.97E-06	1.00E-05	1.40E-08	9.85E-09	5.94E-06	1.33E-09	2.86E-10
5.67E-02	7.42E-05	1.03E-05	9.49E-05	4.47	1.9972	0.93	138974	8.63E-06	1.00E-05	5.64E-08	1.13E-08	8.56E-06	1.57E-09	1.90E-10
5.74E-02	1.62E-04	1.82E-05	1.98E-04	4.47	1.9971	0.93	140562	3.31E-06	1.10E-05	5.33E-08	9.33E-09	3.25E-06	1.05E-09	2.86E-10
5.70E-02	9.16E-05	1.27E-05	1.17E-04	4.47	1.9970	0.93	139514	5.55E-06	1.00E-05	5.57E-08	8.91E-09	5.48E-06	1.24E-09	2.38E-10
5.66E-02	4.73E-05	6.52E-06	6.03E-05	4.47	1.9970	0.94	138632	9.94E-06	9.90E-06	4.60E-08	8.28E-09	9.88E-06	1.14E-09	2.38E-10
5.66E-02	4.72E-05	8.61E-06	6.44E-05	4.47	1.9970	0.94	138658	1.13E-05	1.00E-05	5.40E-08	9.40E-09	1.12E-05	1.71E-09	1.43E-10
5.66E-02	4.19E-05	3.10E-06	4.81E-05	4.47	1.9969	0.94	138562	1.04E-05	1.00E-05	4.47E-08	7.71E-09	1.04E-05	5.71E-10	2.38E-10
5.69E-02	6.50E-05	7.95E-06	8.09E-05	4.47	1.9969	0.94	139321	6.82E-06	9.90E-06	6.28E-08	7.78E-09	6.75E-06	9.52E-10	9.52E-11
5.68E-02	6.56E-05	8.93E-06	8.35E-05	4.47	1.9969	0.93	139162	7.27E-06	9.80E-06	5.86E-08	8.39E-09	7.20E-06	1.14E-09	1.43E-10
5.68E-02	6.38E-05	7.05E-06	7.79E-05	4.46	1.9968	0.93	139099	7.45E-06	1.00E-05	5.71E-08	8.36E-09	7.39E-06	9.24E-10	1.43E-10
5.68E-02	6.49E-05	6.46E-06	7.79E-05	4.46	1.9968	0.89	139207	8.12E-06	1.10E-05	6.86E-08	9.28E-09	8.05E-06	9.24E-10	1.90E-10
7.47E-02	1.34E-02	2.16E-05	1.34E-02	4.45	1.9908	0.86	182986	7.85E-06	1.50E-05	5.26E-07	1.41E-06	5.92E-06	2.27E-09	4.48E-09
5.89E-02	4.55E-04	2.14E-05	4.98E-04	4.45	1.9906	0.88	144303	8.55E-06	1.30E-05	3.12E-07	6.58E-08	8.17E-06	3.09E-09	1.00E-09
5.90E-02	2.07E-04	2.62E-05	2.59E-04	4.45	1.9905	0.86	144414	9.31E-06	1.30E-05	3.85E-07	3.26E-08	8.89E-06	4.13E-09	1.05E-09
5.86E-02	1.81E-04	2.00E-05	2.21E-04	4.45	1.9904	0.88	143537	9.24E-06	1.40E-05	3.34E-07	2.84E-08	8.87E-06	3.14E-09	9.05E-10
5.87E-02	1.27E-04	9.49E-06	1.46E-04	4.45	1.9903	0.85	143783	7.06E-06	1.70E-05	2.75E-07	1.53E-08	6.77E-06	1.14E-09	3.81E-10
5.83E-02	7.92E-05	7.34E-06	9.39E-05	4.45	1.9903	1.04	142799	7.41E-06	2.20E-05	2.44E-07	1.00E-08	7.15E-06	9.28E-10	2.38E-10
5.87E-02	9.15E-05	6.78E-06	1.05E-04	4.45	1.9902	0.86	143667	1.04E-05	2.20E-05	4.02E-07	1.62E-08	9.96E-06	1.20E-09	2.86E-10
5.87E-02	6.13E-05	4.64E-06	7.06E-05	4.45	1.9902	0.84	143771	8.68E-06	3.00E-05	3.47E-07	9.06E-09	8.32E-06	6.86E-10	1.90E-10
5.93E-02	7.15E-05	7.03E-06	8.55E-05	4.45	1.9901	0.83	145214	9.64E-06	2.40E-05	4.76E-07	1.16E-08	9.15E-06	1.14E-09	2.86E-10
5.82E-02	6.86E-05	4.05E-06	7.67E-05	4.45	1.9901	0.85	142431	1.07E-05	1.90E-05	3.29E-07	1.26E-08	1.03E-05	7.43E-10	2.86E-10
5.83E-02	7.43E-05	3.05E-06	8.04E-05	4.45	1.9901	0.91	142783	9.12E-06	2.10E-05	3.02E-07	1.16E-08	8.81E-06	4.76E-10	1.90E-10
5.85E-02	8.01E-05	5.32E-06	9.08E-05	4.45	1.9900	0.92	143341	1.20E-05	2.20E-05	4.43E-07	1.65E-08	1.16E-05	1.09E-09	2.86E-10
5.90E-02	7.24E-05	5.84E-06	8.40E-05	4.45	1.9900	0.92	144582	1.25E-05	1.80E-05	5.61E-07	1.52E-08	1.19E-05	1.23E-09	2.86E-10
5.85E-02	8.15E-05	3.11E-06	8.78E-05	4.45	1.9899	0.92	143336	1.10E-05	2.40E-05	4.05E-07	1.53E-08	1.06E-05	5.86E-10	3.33E-10
5.81E-02	8.86E-05	4.67E-06	9.79E-05	4.45	1.9899	0.94	142205	8.54E-06	2.00E-05	2.47E-07	1.30E-08	8.28E-06	6.86E-10	3.33E-10