Formaldehyde Emissions Testing of Reciprocating Internal Combustion Engines No. 2002 and 2009

Woolfolk Compressor Station

11039 150th Avenue
Big Rapids, Michigan 49307
SRN: B7220

TransCanada
In business to deliver

Prepared for
TransCanada
Houston, Texas

Bureau Veritas Project No. 11014-000243.00

March 9, 2015

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Executive Summary

TransCanada retained Bureau Veritas North America, Inc. (Bureau Veritas) to test air emissions at the ANR Pipeline Company (ANR) Woolfolk Compressor Station at 11039 150th Avenue in Big Rapids, Michigan. ANR operates reciprocating internal combustion engines to compress natural gas for transport via the natural gas pipeline. The purpose of the emission test program is to evaluate compliance with National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines (RICE) (40 CFR Part 63, Subpart ZZZZ) and Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit MI-ROP-B7220-2012a. Formaldehyde emissions were measured at the inlet and outlet of the catalysts of two engines.

The engines are listed under flexible group FG-RICE-818-WLENGINES. The relevant emission standards are presented below:

Emission Standards

Pollutant	Limit	Equipment	USEPA Method	Underlying Applicable Requirements
Formaldehyde	Reduce formaldehyde emissions by 76% or more.	EUWL002 EUWL009	3A and 320	40 CFR Part 63, Subpart ZZZZ

The testing was completed in accordance with United States Environmental Protection Agency (USEPA) Reference Methods 3A and 320. The testing was conducted on February 3, 2015 and consisted of three 60-minute test runs at each source to measure formaldehyde concentrations.

Detailed results are presented in Tables 1 and 2 after the Tables Tab of this report. The results of the testing are summarized in the table on the following page.

Formaldehyde Emissions Results
Compared to Permit Emission Limits

Date (2015)	Source ID	Parameter	Units	Average Result	Emission Limit
EUWL002 Formaldehyde Removal EfficiencyTesting					
Feb. 3	EUWL002 Inlet	O_2	%	5.2	N/A
		Formaldehyde	ppmvd	12.8	N/A
		Formaldehyde	**ppmvd at 15% O_2**	**4.8**	N/A
Feb. 3	EUWL002 Outlet	O_2	%	9.7	N/A
		Formaldehyde	ppmvd	0.45	N/A
		Formaldehyde	**ppmvd at 15% O_2**	**0.27**	N/A
Formaldehyde Removal Efficiency			**%**	**94.5**	**≥76**
EUWL009 Formaldehyde Removal Efficiency Testing					
Feb. 3	EUWL009 Inlet	O_2	%	6.2	N/A
		Formaldehyde	ppmvd	15.3	N/A
		Formaldehyde	**ppmvd at 15% O_2**	**6.2**	N/A
Feb. 3	EUWL009 Outlet	O_2	%	6.7	N/A
		Formaldehyde	ppmvd	2.0	N/A
		Formaldehyde	**ppmvd at 15% O_2**	**0.81**	N/A
Formaldehyde Removal Efficiency			**%**	**86.8**	**≥76**

O_2 oxygen
N/A not applicable
ppmvd part per million by volume, dry basis

The formaldehyde measurements demonstrate that the EUWL002 and EUWL009 engines are operating within allowable limits.

1.0 Introduction

TransCanada retained Bureau Veritas North America, Inc. (Bureau Veritas) to test air emissions at the ANR Pipeline Company (ANR) Woolfolk Compressor Station at 11039 150th Avenue in Big Rapids, Michigan. ANR operates reciprocating internal combustion engines to compress natural gas for transport via the natural gas pipeline. The purpose of the emission test program is to evaluate compliance with National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines (RICE) (40 CFR Part 63, Subpart ZZZZ) and Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit MI-ROP-B7220-2012a. Formaldehyde emissions were measured at the inlet and outlet of the catalysts of two engines.

1.1 Summary of Test Program

TransCanada operates a compressor station in Big Rapids, Michigan. The facility operates reciprocating internal combustion engines compress natural gas for transport via the natural gas pipeline.

The testing was completed in accordance with United States Environmental Protection Agency (USEPA) Reference Methods 3A and 320. Three 60-minute tests were conducted on February 3, 2015 to measure formaldehyde concentrations in part per million by volume, dry basis (ppmvd) corrected to 15% O_2, from which the formaldehyde removal efficiency was calculated.

1.2 Purpose of Testing

The purpose of the emission test program was to evaluate compliance with National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines (RICE) (40 CFR Part 63, Subpart ZZZZ) by measuring the oxygen (O_2) and formaldehyde concentrations from two regulated engines. The engines are listed under flexible group FG-RICE-818-WLENGINES. The relevant emission standards are presented in Table 1-1 on the following page.

Table 1-1
Emission Standards

Pollutant	Limit	Equipment	USEPA Method	Underlying Applicable Requirements
Formaldehyde	Reduce formaldehyde emissions by 76% or more.	EUWL002 EUWL009	3A and 320	40 CFR Part 63, Subpart ZZZZ

1.3 Contact Information

Contact information is listed in Table 1-2 on the following page. Mr. Thom Schmelter, Senior Project Manager with Bureau Veritas, led the emission testing program. TransCanada, provided process coordination and arranged for facility operating parameters to be recorded. The testing was witnessed by Mr. Tom Gasloli, Environmental Quality Analyst with the Michigan Department of Environmental Quality.

Table 1-2
Key Personnel

TransCanada	Bureau Veritas
Pedro Amieva US Plant Reliability **TransCanada** 717 Texas Street Houston, Texas 77002 Telephone: 832.320.5839 pedro_amieva@transcanada.com	Thomas Schmelter Senior Project Manager **Bureau Veritas North America, Inc.** 22345 Roethel Drive Novi, Michigan 48375 Telephone: 248.344.3002 Facsimile: 248.344.2656 thomas.schmelter@us.bureauveritas.com
Michigan Department of Environmental Quality	
Tom Gasloli Environmental Quality Analyst Air Quality Division – Lansing District Office 525 West Allegan Street Lansing, Michigan 48909-7760 Telephone: 517.284.6778 Email: gaslolit@michigan.gov	

2.0 Source and Sampling Locations

2.1 Process Description

ANR operates a natural gas compressor station in Big Rapids, Michigan. The facility operates natural gas-fired, reciprocating internal combustion engines to compress natural gas for transport via a natural gas pipeline. The engines fall under flexible group FG-RICE-818-WLENGINES and are subject to 40 CFR Part 63, Subpart ZZZZ. Engine EUWL002 and Engine EUWL009 were tested.

Engine EUWL002 is a 1,000 horsepower Ingersoll-Rand engine Model KVG-103 that was installed in 1949. Engine EUWL009 is a 1,320 horsepower Ingersoll-Rand engine Model KVG-123 that was installed in 1951. Specifications of the engines are presented in Table 2-1.

Table 2-1
Non-Emergency Area Source RICE Tested

ID	Installation Date	Manufacturer	Model	Serial No.	Rating (hp)	Fuel
EUWL002 (Unit 2002)	1949	Ingersoll-Rand	KVG-103	103HL413	1,000	Natural Gas
EUWL009 (Unit 2009	1951	Ingersoll-Rand	KVG-123	123LL659	1,320	Natural Gas

Operating parameters recorded during testing are included in Appendix E.

2.2 Control Equipment

The exhausts of the engines pass through nonselective catalytic reduction catalysts (NSCR) prior to discharge to the atmosphere. NSCR simultaneously reduce oxides of nitrogen (NOx), carbon monoxide (CO), and hydrocarbons to water, carbon dioxide (CO_2), and nitrogen.

2.3 Flue Gas Sampling Locations

Figure 1 behind the Figures Tab of this report, depicts the EUWL002 and EUWL009 sampling ports and traverse point locations. Descriptions of the source sampling locations are presented in sections 2.3.1 and 2.3.2

2.3.1 EUWL002

The inlet to the EUWL002 catalyst was sampled from one of two sampling ports oriented at 90° to one another. The sampling ports are located in a straight section of a 10-inch-internal-diameter duct. The ports are located:

- 7 feet (8.4 duct diameters) from the nearest downstream disturbance.
- 3 feet (3.6 duct diameters) from the nearest upstream disturbance.

The ports were accessible via a ladder.

The EUWL002 catalyst exhaust was sampled from one of two sampling ports oriented at 90° to one another. The sampling ports are located in a straight section of a 16-inch-internal-diameter duct. The ports are located:

- 3 feet (2.3 duct diameters) from the nearest downstream disturbance.
- 5 feet (3.8 duct diameters) from the nearest upstream disturbance.

The ports were accessible via a manlift.

2.3.2 EUWL009

The inlet to the EUWL009 catalyst was sampled from one of two sampling ports oriented at 90° to one another. The sampling ports are located in a straight section of a 12-inch-internal-diameter duct. The ports are located:

- 7 feet (7 duct diameters) from the nearest downstream disturbance.
- 3 feet (3 duct diameters) from the nearest upstream disturbance.

The ports were accessible via a ladder.

The EUWL009 catalyst exhaust was sampled from one of two sampling ports oriented at 90° to one another. The sampling ports are located in a straight section of a 18-inch-internal-diameter duct. The ports are located:

- 3 feet (2 duct diameters) from the nearest downstream disturbance.
- 5 feet (3.3 duct diameters) from the nearest upstream disturbance.

The ports were accessible via a manlift.

2.4 Process Sampling Locations

Process sampling was not required during this test program. A process sample is a sample that is analyzed for operational parameters, such as calorific value of a fuel (e.g., diesel, natural gas, coal), organic compound content (e.g., paint coatings), or composition (e.g., polymers).

3.0 Summary and Discussion of Results

3.1 Objectives

The testing was performed to evaluate compliance with National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines (RICE) (40 CFR Part 63, Subpart ZZZZ) by measuring the oxygen (O_2) and formaldehyde concentrations from the inlet and the outlet of the two regulated engines. The relevant emission standards are provided in Table 1-1.

3.2 Test Matrix

The emission testing was conducted to evaluate the objectives in Section 3.1. Table 3-1 presents the sampling and analytical test matrix.

Table 3-1
Test Matrix

Sampling Location	No. of Runs	Sample/Type of Pollutant	Sampling Method (USEPA)	Sampling Organization	Test Time (min)	Analytical Method
Inlet and Outlet of EUWL002	3	O_2 Formaldehyde	M3A M320	Bureau Veritas	60	Paramagnetic Fourier Transform Infrared Spectroscopy
Inlet and Outlet of EUWL009	3	O_2 Formaldehyde	M3A M320	Bureau Veritas	60	Paramagnetic Fourier Transform Infrared Spectroscopy

O_2 oxygen

3.3 Field Test Changes and Issues

Field test changes were not required to complete the emission testing.

3.4 Results

The results of the testing are compared to the applicable emission limits in Table 3-2. Detailed results are presented in Tables 1 and 2 after the Tables Tab of this report. Graphs of the measured O_2 and formaldehyde concentrations are presented after the Graphs Tab of this report. Sample calculations are presented in Appendix B.

Table 3-2
Formaldehyde Emissions Results
Compared to Permit Emission Limits

Date (2015)	Source ID	Parameter	Units	Average Result	Emission Limit
EUWL002 Formaldehyde Removal EfficiencyTesting					
Feb. 3	EUWL002 Inlet	O_2	%	5.2	N/A
		Formaldehyde	ppmvd	12.8	N/A
		Formaldehyde	**ppmvd at 15% O_2**	**4.8**	N/A
Feb. 3	EUWL002 Outlet	O_2	%	9.7	N/A
		Formaldehyde	ppmvd	0.45	N/A
		Formaldehyde	**ppmvd at 15% O_2**	**0.27**	N/A
Formaldehyde Removal Efficiency			**%**	**94.3**	**≥76**
EUWL009 Formaldehyde Removal Efficiency Testing					
Feb. 3	EUWL009 Inlet	O_2	%	6.2	N/A
		Formaldehyde	ppmvd	15.3	N/A
		Formaldehyde	**ppmvd at 15% O_2**	**6.2**	N/A
Feb. 3	EUWL009 Outlet	O_2	%	6.7	N/A
		Formaldehyde	ppmvd	2.0	N/A
		Formaldehyde	**ppmvd at 15% O_2**	**0.81**	N/A
Formaldehyde Removal Efficiency			**%**	**86.7**	**≥76**

O_2 oxygen
N/A not applicable
ppmvd part per million by volume, dry basis

The formaldehyde measurements demonstrate that the EUWL002 and EUWL009 engines are operating within allowable limits.

4.0 Sampling and Analytical Procedures

Bureau Veritas measured emissions in accordance with USEPA Methods 3A and 320, identified in Table 4 to Subpart ZZZZ of Part 63—Requirements for Performance Tests. The sampling and analytical methods used during this test program are listed in the following table.

Table 4-1
Sampling and Analytical Test Methods

USEPA Sampling Method	Parameter	Analysis
3A	Oxygen	Paramagnetic
320	Formaldehyde	Extractive Fourier transform infrared spectroscopy (FTIR)

4.1 Test Methods

4.1.1 Oxygen Concentrations (USEPA Method 3A)

USEPA Method 3A "Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrument Analyzer Procedure)" was used to measure O_2 concentrations of the flue gas. Refer to Figure 2 in the Appendix for a drawing of the USEPA 3A sampling train. Flue gas was continuously sampled from the stack and conveyed to a paramagnetic analyzer for O_2 concentration measurements. The flue gas oxygen concentration was measured in order to adjust the formaldehyde concentration to 15% oxygen.

Flue gas was extracted from the stack through:

- A stainless-steel probe.
- A heated Teflon sample line to prevent condensation.
- A chilled Teflon® condenser (equipped with a peristaltic pump) to remove moisture from the flue gas
- A paramagnetic O_2 gas analyzers

Data were recorded at 1-second intervals on a computer equipped with data acquisition software. Recorded concentrations were reported as 1-minute averages over the duration of each test run and included in Appendix D of this report.

A calibration error check was performed on each analyzer by introducing zero-, mid-, and high-level calibration gases directly into the analyzer. The calibration error check was performed to evaluate if the analyzer responds to within ±2% of the calibration span. Prior to each test run, a system-bias test was performed where known concentrations of calibration gases are introduced at the probe tip to measure if the response is within ±5% of the analyzer calibration span.

Instead of performing a stratification test, flue gas was sampled along a traverse line passing through the stack cross section's centroid and at points corresponding to 17, 50, and 83% of the stack diameter.

At the conclusion of each test run, an additional system-bias check was performed to evaluate the analyzer drift from pre- and post-test system-bias checks. The acceptable analyzer drift tolerance is ±3% of the calibration span. The results of the pre- and post-test system bias checks were used to correct the measured pollutant concentrations for analyzer drift.

Calibration data, along with the USEPA Protocol 1 certification sheets for the calibration gases, are included in Appendix A.

4.1.2 Formaldehyde Concentrations (USEPA Method 320)

Formaldehyde emissions were measured using USEPA Method 320, "Measurements of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy." Gaseous samples were withdrawn from the stack and transferred to the FTIR spectrometer. The USEPA Method 320 sampling train is depicted in Figure 3.

The samples were directed through a heated probe, heated filter and heated transfer line connected to the FTIR. The probes, filters, transfer lines, and FTIR were maintained at 191° C (375° F) during testing. Concentrations were measured based on their infrared absorbance compared to reference spectra. The FTIR analyzer scans the sample approximately once per second. A data point consists of the co-addition of 64 scans, with a data point generated every minute.

FTIR quality assurance procedures followed USEPA Method 320. A calibration transfer standard (CTS) was analyzed before and after testing. Acetaldehyde spiking was performed before and after each test run. Section 3.29 of USEPA Method 320 allows the use of a surrogate analyte for spiking. Acetaldehyde was chosen as surrogate to formaldehyde for the following reasons:

- The highest obtainable formaldehyde cylinder is 30 ppm: therefore, the spiked concentration would be 3 ppm (analyte spiking consists of sampling 1 part calibration gas in the presence of 9 parts effluent gas). The formaldehyde concentrations of the source tested has the potential to be much higher than 3 ppm.

- Acetaldehyde's physical and chemical properties are similar to those of formaldehyde. Formaldehyde is the C_1 aldehyde (CH_2O); acetaldehyde is the C_2 aldehyde (CH_3CHO).

The analyte spikes are set to a target dilution ratio of 1:10 or less. Acetaldehyde spike recoveries were within the Method 320 allowance of ±30%.

4.2 Procedures for Obtaining Process Data

Process data were recorded by TransCanada personnel. Refer to Section 2.1 and 2.2 for discussions of process and control device data and Appendix E for the operating parameters recorded during testing.

4.3 Sampling Identification and Custody

Gaseous pollutant concentrations were measured using analyzers processing the flue gas in real time; therefore, recovery and analytic procedures for laboratory samples were not necessary.

5.0 QA/QC Activities

Equipment used in this emissions test program passed quality assurance/quality control (QA/QC) procedures. Refer to Appendix A for equipment calibration and inspection sheets. Field data sheets are presented in Appendix C. Computer-generated Data Sheets are presented within Appendix D.

5.1 Pretest QA/QC Activities

Before testing, the sampling equipment was cleaned, inspected, and calibrated according to procedures outlined in the applicable USEPA sampling methods and USEPA's "Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, Stationary Source Specific Methods."

5.2 QA/QC Audits

The results of select sampling and equipment QA/QC audits and the acceptable tolerance are presented in the following sections. Analyzer calibration and gas certification sheets are presented in Appendix A.

5.2.1 Instrument Analyzer QA/QC Audits

The instrument analyzer sampling trains described in Section 4.1 were audited for measurement accuracy and data reliability. The analyzers passed the applicable calibration criteria. Calibration gas selection, error, bias, and drift checks are included in Appendix A. The gas cylinders used during the test program are presented in Table 5-1.

Table 5-1
Calibration Gas Cylinder Information

Parameter	Gas Vendor	Cylinder Serial Number	Cylinder Value	Expiration Date
Oxygen (O_2)/ Carbon Dioxide (CO_2)	Pangaea Gases	EB0049262	20.01 % O_2 19.89% CO_2	3/6/2022
	Airgas	CC17793	11.11 % O_2 11.23 % CO_2	10/31/2022
Nitrogen (N)	Airgas	CC39741	99.99%	9/25/2022

5.3 QA/QC Blanks

Reagent and field train blanks were not applicable to this test program.

5.4 QA/QC Problems

No QA/QC problems were encountered during this test program.

Limitations

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Table 1
EUWL002 Formaldehyde Removal Efficiency Results
TransCanada - Woolfolk Compressor Station
Big Rapids, Michigan
Bureau Veritas Project No. 11014-000243.00
Sampling Date: February 3, 2015

Parameter		Units	Run 1	Run 2	Run 3	Average
Sample Time			9:50-10:50	11:10-11:33; 11:50-12:27	12:50-13:50	
Duration		min	60	60	60	
Inlet	O_2 Concentration (C_{avg})	%	5.4	5.3	5.2	5.3
	Pre-test system calibration, zero gas (C_O)	%	0.4	0.1	0.1	0.2
	Post-test system calibration, zero gas (C_O)	%	0.1	0.1	0.1	0
	Certified low bracket gas concentration (C_{MA})	%	11.11	11.11	11.11	11.11
	Pre-test system calibration, low bracket gas (C_M)	%	11.1	11.3	11.1	11.2
	Post-test system calibration, low bracket gas (C_M)	%	11.3	11.1	11.3	11.2
	Corrected O_2 Concentration (C_{gas})†	%	**5.2**	**5.2**	**5.2**	**5.2**
	Formaldehyde Concentration	ppmv	11.3	11.0	10.9	11.1
	Moisture Content	%	13.9	13.7	14.0	13.9
	Formaldehyde Concentration	ppmvd	13.1	12.7	12.7	12.8
	Formaldehyde Concentration Corrected to 15% Oxygen	ppmvd	**4.9**	**4.8**	**4.7**	**4.8**
Outlet	O_2 Concentration (C_{avg})	%	9.6	10.8	8.3	9.6
	Pre-test system calibration, zero gas (C_O)	%	0	-0.3	0	-0.1
	Post-test system calibration, zero gas (C_O)	%	-0.3	0	-0.1	-0.1
	Certified low bracket gas concentration (C_{MA})	%	11.11	11.11	11.11	11.11
	Pre-test system calibration, low bracket gas (C_M)	%	11.1	10.9	10.9	11.0
	Post-test system calibration, low bracket gas (C_M)	%	10.9	10.9	10.9	10.9
	Corrected O_2 Concentration (C_{gas})†	%	**9.7**	**11.0**	**8.5**	**9.7**
	Formaldehyde Concentration	ppmv	0.49	0.39	0.47	0.45
	Moisture Content	%	11.3	9.6	11.3	10.7
	Formaldehyde Concentration	ppmvd	0.55	0.43	0.53	0.50
	Formaldehyde Concentration Corrected to 15% Oxygen	ppmvd	**0.29**	**0.26**	**0.25**	**0.27**
Formaldehyde Removal Efficiency		%	**94.1**	**94.6**	**94.7**	**94.5**

† corrected for analyzer drift

C_O average of the initial and final system calibration bias check responses from the low-level (or zero) calibration gas, ppmv

C_{MA} actual concentration of the upscale calibration gas, ppmv

C_M Average of initial and final system calibration bias check responses for the upscale calibration gas, ppmv

C_{gas} Average effluent gas concentration adjusted for bias, ppmv

ppmvd part per million by volume, dry basis

O_2 oxygen

Table 2
EUWL009 Formaldehyde Removal Efficiency Results
TransCanada - Woolfolk Compressor Station
Big Rapids, Michigan
Bureau Veritas Project No. 11014-000243.00
Sampling Date: February 3, 2015

Parameter		Units	Run 1	Run 2	Run 3	Average
Sample Time			17:25-18:25	18:37-19:37	19:45-20:45	
Duration		min	60	60	60	
Inlet	O_2 Concentration (C_{avg})	%	6.1	6.3	6.2	6.2
	Pre-test system calibration, zero gas (C_O)	%	0.1	0.1	0.1	0.1
	Post-test system calibration, zero gas (C_O)	%	0.1	0.1	0.0	0
	Certified low bracket gas concentration (C_{MA})	%	11.11	11.11	11.11	11.11
	Pre-test system calibration, low bracket gas (C_M)	%	11.0	10.9	10.9	10.9
	Post-test system calibration, low bracket gas (C_M)	%	10.9	10.9	10.9	10.9
	Corrected O_2 Concentration (C_{gas})†	%	**6.1**	**6.4**	**6.3**	**6.2**
	Formaldehyde Concentration	ppmv	13.3	13.1	13.3	13.2
	Moisture Content	%	13.5	13.5	13.6	13.5
	Formaldehyde Concentration	ppmvd	15.4	15.1	15.4	15.3
	Formaldehyde Concentration Corrected to 15% Oxygen	ppmvd	**6.1**	**6.1**	**6.2**	**6.2**
Outlet	O_2 Concentration (C_{avg})	%	7.4	6.0	6.0	6.5
	Pre-test system calibration, zero gas (C_O)	%	0	-0.3	-0.3	-0.2
	Post-test system calibration, zero gas (C_O)	%	-0.3	-0.3	-0.2	-0.3
	Certified low bracket gas concentration (C_{MA})	%	11.11	11.11	11.11	11.11
	Pre-test system calibration, low bracket gas (C_M)	%	10.9	10.8	10.8	10.8
	Post-test system calibration, low bracket gas (C_M)	%	10.8	10.8	10.8	10.8
	Corrected O_2 Concentration (C_{gas})†	%	**7.6**	**6.3**	**6.3**	**6.7**
	Formaldehyde Concentration	ppmv	1.5	1.8	1.8	1.7
	Moisture Content	%	13.6	13.8	13.7	13.7
	Formaldehyde Concentration	ppmvd	1.7	2.0	2.1	2.0
	Formaldehyde Concentration Corrected to 15% Oxygen	ppmvd	**0.77**	**0.82**	**0.84**	**0.81**
Formaldehyde Removal Efficiency		%	**87.4**	**86.6**	**86.5**	**86.8**

† corrected for analyzer drift

C_O average of the initial and final system calibration bias check responses from the low-level (or zero) calibration gas, ppmv

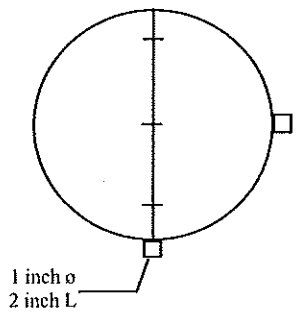
C_{MA} actual concentration of the upscale calibration gas, ppmv

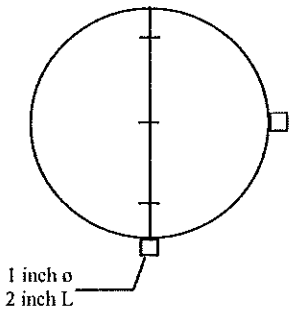
C_M Average of initial and final system calibration bias check responses for the upscale calibration gas, ppmv

C_{gas} Average effluent gas concentration adjusted for bias, ppmv

ppmvd part per million by volume, dry basis

O_2 oxygen





Traverse Point	Distance From Stack Wall (inches)
3	2.7
2	8
1	13.3

Traverse Point	Distance From Stack Wall (inches)
3	3
2	9
1	15

Source	Distance From Ports to Nearest Upstream Bend/Disturbance	Distance From Ports to Nearest Downstream Bend/ Disturbance
EUWL002	60 inches (3.75 diameter)	36 inches (2.25 diameter)
EUWL009	60 inches (3.3 diameter)	36 inches (2 diameter)

Figure 1
EUWL002 and EUWL009 Sampling Ports and Traverse Point Locations

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Woolfolk Compressor Station
Big Rapids, Michigan

Project No. 11014-000243.00

Last Revision:
February 26, 2015

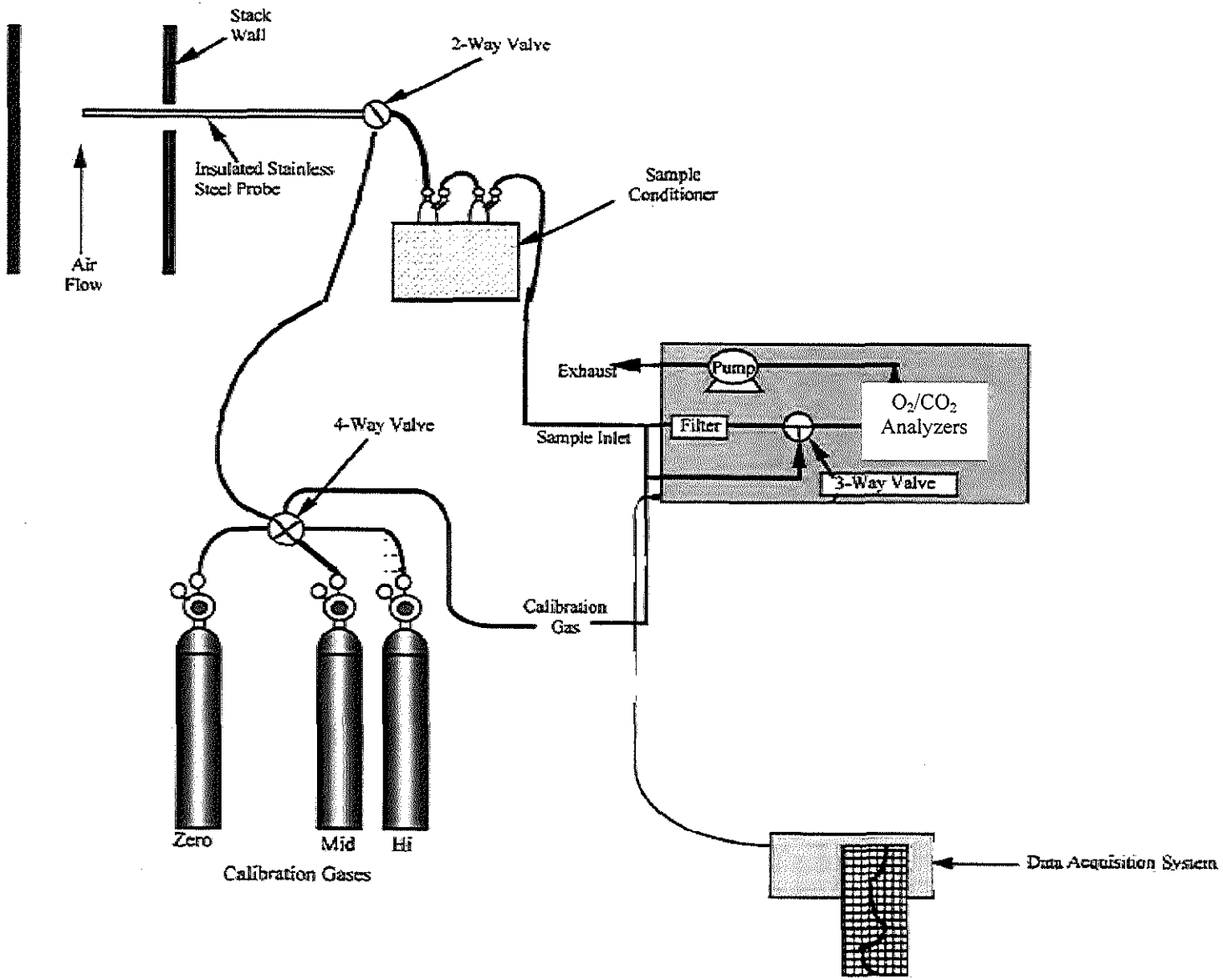

Figure 2
USEPA Method 3A Sampling Train

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TransCanada
Woolfolk Compressor Station
Big Rapids, Michigan

Project No. 11014-000243.00

Last Revision: February 10, 2015

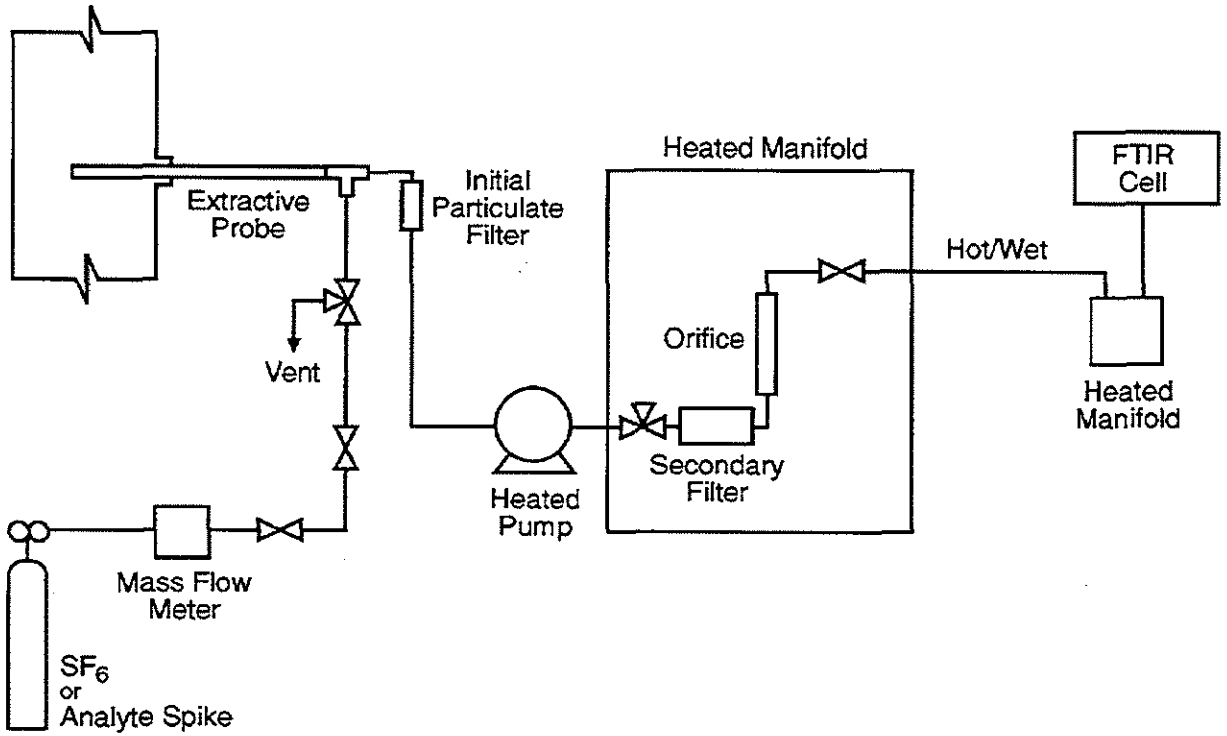

Figure 3
USEPA Method 320 Sampling Train

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TransCanada
Woolfolk Compressor Station
Big Rapids, Michigan

Project No. 11014-000243.00

Last Revision: February 10, 2015