

## 1.0 EXECUTIVE SUMMARY

MOSTARDI PLATT conducted a formaldehyde annual RICE MACT performance emissions test program for Upper Michigan Energy Resources Corporation (UMERC) on June 3 and 4, 2021 at A. J. Mihm Generating Station on the Reciprocating Internal Combustion Engine EURICE1, EURICE2, and EURICE3 Outlet Ducts in Pelkie, Michigan. The purpose of the test program was to meet compliance demonstration requirements for emission rates in accordance with Renewable Operating Permit MI-ROP-P0796-2020 and the RICE MACT 40 CFR Part 63 Subpart ZZZZ. This report summarizes the results of the test program and test methods used.

The test locations, test dates, and test parameters are summarized below.

TEST INFORMATION		
Test Locations	Test Date	Test Parameters
EURICE1	June 3, 2021	Formaldehyde (CH <sub>2</sub> O), Moisture (H <sub>2</sub> O), and Oxygen (O <sub>2</sub> )
EURICE2	June 3, 2021	
EURICE3	June 4, 2021	

A.J. Mihm Generating Station electric generation facility includes three (3) Wärtsilä W18V50SG natural gas-fired, four stroke, lean burn, spark ignition reciprocating internal combustion engines (RICE) coupled to 19,260 kW electric generators, a 1,000 kW natural gas-fired emergency generator, and one natural gas-fired natural gas conditioning heater. The RICE electric generating unit engines utilize pipeline quality natural gas and are equipped with selective catalytic reduction (SCR) for nitrogen oxides (NO<sub>x</sub>) control and oxidation catalyst systems for carbon monoxide (CO), volatile organic compound (VOC), and organic hazardous air pollutant (HAP) control. Each RICE electric generating unit exhausts into an individual stack.

Selected results of the test program are summarized below on a ppmvd @ 15% O<sub>2</sub> basis. A complete summary of emission test results follows the narrative portion of this report.

TEST RESULTS			
Test Location	Test Parameter	Emission Limit	Actual Test Result
EURICE1	CH <sub>2</sub> O	14 ppmvd @ 15% O <sub>2</sub>	0.67 ppmvd @ 15% O <sub>2</sub>
EURICE2			0.62 ppmvd @ 15% O <sub>2</sub>
EURICE3			0.61 ppmvd @ 15% O <sub>2</sub>

Operating Data as provided by the plant is included in Appendix A.



The identifications of the individuals associated with the test program are summarized below.

TEST PERSONNEL INFORMATION		
Location	Address	Contact
Test Coordinator	WEC Energy Group, Inc 231 W. Michigan Street Milwaukee, Wisconsin 53203	Mr. Justin Kowalski Senior Environmental Consultant 414-221-2265 justin.kowalski@wecenergygroup.com
Test Facility	Upper Michigan Energy Resources Corporation A.J. Mihm Generating Station 16017 Sarya Road Pelkie, Michigan 49958	
Testing Company Representative	Mostardi Platt 888 Industrial Drive Elmhurst, Illinois 60126	Mr. Stuart Sands Project Manager (630) 993-2100 (phone) ssands@mp-mail.com

The test crew consisted of Messrs. J. Carlson, J. Lewis, J. Gross and S. Sands of Mostardi Platt.

## 2.0 TEST METHODOLOGY

Emission testing was conducted following the methods specified in 40CFR60, Appendix A and 40CFR63, Appendix A. Schematics of the test section diagrams and sampling trains used are included in Appendix B and C, respectively. Calculation nomenclature and example calculations are included in Appendix D. Reference method test data can be found in Appendix E.

The following methodology was used during the test program:

### Method 3A Oxygen (O<sub>2</sub>) Determination

Oxygen (O<sub>2</sub>) concentrations were measured to determine emission concentrations in ppmvd corrected to 15% O<sub>2</sub> in accordance with Method 3A. Ecom analyzers were used to determine flue gas oxygen. All of the equipment used was calibrated in accordance with the specifications of the Method. Calibration data are presented in Appendix F and copies of gas cylinder certifications are included in Appendix G.

### Method 320 Formaldehyde (CH<sub>2</sub>O) and Moisture (H<sub>2</sub>O) Determination

The Method 320 sampling and measurement system meets the requirements of US EPA Reference Method 320, "Vapor Phase Organic and Inorganic Emissions by Extractive FTIR," 40CFR63, Appendix A. This method applies to the measurement of combustion gas concentrations. With this method, gas samples are extracted from the sample locations through heated Teflon sample lines to the analyzer.

FTIR technology works on the principle that most gases absorb infrared light. This is true for all compounds with the exception of homonuclear diatomic molecules and noble gases such as: N<sub>2</sub>, O<sub>2</sub>, H<sub>2</sub>, He, Ne, and Ar. Vibrations, stretches, bends, and rotations within the bonds of a molecule determine the infrared absorption distinctiveness. The absorption creates a "fingerprint" which is unique to each given compound.



The quantity of infrared light absorbed is proportional to the gas concentration. Most compounds have absorbencies at different infrared frequencies, allowing the simultaneous analysis of multiple compounds at one time. The FTIR software compares each sample spectrum to a user-selected list of calibration references and performs a classical least squares analysis to determine concentration data on a wet volume basis and the spectral residuals for each analyte (the error associated with each measurement). FTIR data was collected using an MKS MultiGas 2030 FTIR spectrometer. The FTIR was equipped with a temperature-controlled, 5.11 meter multi-pass gas cell maintained at 191°C. Gas flows and sampling system pressures were monitored using a rotameter and pressure transducer.

All data was collected at 0.5 cm<sup>-1</sup> resolution. Each spectrum was derived from the coaddition of 62 scans, with a new data point generated approximately every one minute. Analyzer data for each run is present in Appendix E.

SAMPLING SYSTEM PARAMETERS				
MKS Serial #	Sampling Line	Probe Assembly	Particulate Filter Media	Operating Temperatures
111171031	100' 3/8" dia., heated Teflon	Heated 8', 3/8" dia. SS	0.01µ heated borosilicate glass fiber	191°C

QA/QC procedures followed US EPA Method 320. See below for QA/QC procedure details and list of calibration gas standards. All calibration gases were introduced to the analyzer and the sampling system using an instrument grade stainless steel rotameter. All QA/QC procedures were within the acceptance criteria allowance of the applicable EPA methodology. See Appendix F for FTIR QA/QC Data and instrument linearity validations.

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FTIR QA/QC PROCEDURES						
QA/QC Specification	Purpose	Calibration Gas Analyte	Delivery	Frequency	Acceptance Criteria	Result
M320: Zero	Verify that the FTIR is free of contaminants & zero the FTIR	Nitrogen (zero)	Direct to FTIR	pre/post test	< MDL or Noise	Pass
M320: Calibration Transfer Standard (CTS) Direct	Verify FTIR linearity, confirm optical path length	Ethylene	Direct to FTIR	pretest	+/- 5% cert. value	Pass
M320: Analyte Direct	Verify FTIR calibration	Acetaldehyde, Methanol, SF6	Direct to FTIR	pretest	+/- 5% cert. value	Pass
M320: CTS Response	Verify system linearity, recovery, response time	Ethylene	Sampling System	Daily, pre/post test	+/- 5% of Direct Measurement	Pass
M320: Zero Response	Verify sampling system has no bias for analytes of interest	Nitrous Oxide with nitrogen balance	Sampling System	pretest	Bias correct data	Pass
M320: Analyte Spike	Verify system ability to deliver and quantify analyte of interest in the presence of effluent gases	Acetaldehyde, Methanol, SF6	Dynamic Addition to Sampling System, 1:10 effluent	Throughout testing – daily	+/- 30% theoretical recovery	Pass

Note: The determined concentrations from direct analyses were used in all system/spike recovery calculations.

CALIBRATION GAS STANDARDS				
Components	Concentration (ppm)	Vendor	Cylinder #	Standard Type
Ethylene	100	Airgas	XC024041B	Certified Standard-Spec +/- 2%
Acetaldehyde/ Methanol/SF6	198 / 205.9 / 5.122	Airgas	SG9159486BAL	Certified Standard +/- 2% (Acetaldehyde/Methanol) Certified Standard +/- 5% (SF <sub>6</sub> )
Nitrogen	Zero Nitrogen	Airgas	N/A	UHP Grade

### Analyte Spiking

Acetaldehyde and methanol spiking was performed prior to testing to verify the ability of the sampling system to quantitatively deliver a sample containing acetaldehyde and methanol from the base of the probe to the FTIR. Analyte spiking assures the ability of the FTIR sampling system to recover volatile organics in the presence of effluent gas.

As part of the spiking procedure, samples were measured to determine native acetaldehyde and methanol concentrations to be used in the spike recovery calculations. The analyte spiking gases contained a low concentration of sulfur hexafluoride (SF<sub>6</sub>). The determined SF<sub>6</sub> concentration in the spiked sample was used to calculate the dilution factor of the spike and thus used to calculate the concentration of the spiked acetaldehyde and methanol. The spike target dilution ratio was 1:10 or less.



The following equation illustrates the percent recovery calculation.

$$DF = \frac{SF_6(spik)}{SF_6(direct)} \quad (\text{Sec. 9.2.3 (3) USEPA Method 320})$$

$$CS = DF * Spike(dir) + Unspike(1 - DF) \quad (\text{Sec. 9.2.3 (4) USEPA Method 320})$$

- DF = Dilution factor of the spike gas
- SF<sub>6(dir)</sub> = SF<sub>6</sub> concentration measured directly in undiluted spike gas
- SF<sub>6(spik)</sub> = Diluted SF<sub>6</sub> concentration measured in a spiked sample
- Spike<sub>dir</sub> = Concentration of the analyte in the spike standard measure by the FTIR directly
- CS = Expected concentration of the spiked samples
- Unspike = Native concentration of analytes in unspiked samples

**Post Collection Data Validation**

As part of the data validation procedure, reference spectra are manually fit to that of the sample spectra and a concentration is determined. The reference spectra are scaled to match the peak amplitude of the sample, providing a scaling factor. The scaling factor multiplied by the reference spectra concentration is used to determine the concentration value for the sample spectra. Sample pressure and temperature corrections are then applied to compute the final sample concentration. The manually calculated results are then compared with the software-generated results. The data is then validated if the two concentrations are within ± 20% agreement. In some cases, the percent difference between the two analyses is relatively large, but the absolute concentration difference is minimal. If this is not determined to be the case, then the spectra are reviewed for possible spectral interferences or any other possible causes leading to incorrectly quantified data. See Appendix F FTIR QAQC for manual subtractions.

**Detection Limit**

The detection limit of each analyte was calculated following Annex A2 of ASTM D6348-12 procedure using spectra that contained similar amounts of moisture and carbon dioxide.

Analyte	Detection Limit (ppmv wet)	Detection Limit (%v)
Formaldehyde	0.2	-
Moisture	-	0.1

The spectral residuals for each compound is calculated using the classical least squares analysis. When the residual error exceeds the measured concentration, the compound is considered a non-detect, allowing the residual to verify the detection limit. The spectral residual also permits the analyst to determine if there are possible interferences in the sample matrix.

QA/QC data are found in Appendix F. Copies of gas cylinder certifications are found in Appendix G. All concentration data were recorded on a wet, volume basis. The sample and data collection followed the procedures outlined in Method 320.



### 3.0 TEST RESULT SUMMARIES

Upper Michigan Energy Resources Corporation A.J. Mihm Generating Station EURICE1 Outlet Duct Gaseous Summary								
Test No.	Date	Start Time	End Time	O <sub>2</sub> % (dry)	Moisture, %	CH <sub>2</sub> O ppmvw	CH <sub>2</sub> O ppmvd	CH <sub>2</sub> O ppmvd @ 15% O <sub>2</sub>
1	06/03/21	14:45	15:51	11.5	10.6	0.95	1.06	0.67
2	06/03/21	16:23	17:22	11.4	10.5	0.96	1.07	0.67
3	06/03/21	17:55	18:54	11.5	10.6	0.96	1.07	0.67
<b>Average</b>				11.5	10.6	0.96	1.07	0.67

Upper Michigan Energy Resources Corporation A.J. Mihm Generating Station EURICE2 Outlet Duct Gaseous Summary								
Test No.	Date	Start Time	End Time	O <sub>2</sub> % (dry)	Moisture, %	CH <sub>2</sub> O ppmvw	CH <sub>2</sub> O ppmvd	CH <sub>2</sub> O ppmvd @ 15% O <sub>2</sub>
1	06/03/21	09:27	10:32	11.2	10.8	0.86	0.96	0.59
2	06/03/21	11:15	12:14	11.3	10.8	0.97	1.09	0.67
3	06/03/21	12:50	13:49	11.3	10.7	0.90	1.01	0.62
<b>Average</b>				11.3	10.8	0.91	1.02	0.62

Upper Michigan Energy Resources Corporation A.J. Mihm Generating Station EURICE3 Outlet Duct Gaseous Summary								
Test No.	Date	Start Time	End Time	O <sub>2</sub> % (dry)	Moisture, %	CH <sub>2</sub> O ppmvw	CH <sub>2</sub> O ppmvd	CH <sub>2</sub> O ppmvd @ 15% O <sub>2</sub>
1	06/04/21	07:45	08:53	11.3	10.5	0.76	0.85	0.52
2	06/04/21	09:35	10:34	11.3	10.8	0.89	1.00	0.61
3	06/04/21	11:00	11:59	11.3	10.9	1.00	1.12	0.69
<b>Average</b>				11.3	10.7	0.88	0.99	0.61



## 4.0 CERTIFICATION

MOSTARDI PLATT is pleased to have been of service to Upper Michigan Energy Resources Corporation. If you have any questions regarding this test report, please do not hesitate to contact us at 630-993-2100.

As project manager, I hereby certify that this test report represents a true and accurate summary of emissions test results and the methodologies employed to obtain those results, and the test program was performed in accordance with the methods specified in this test report.

MOSTARDI PLATT



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Stuart T. Sands Program Manager



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Scott W. Banach Quality Assurance



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# APPENDICES



## Appendix A – Plant Operating Data

**A.J. Mihm Generating Station  
RICE MACT Emissions Testing  
Summary of Operating Data  
June 3 & 4, 2021**

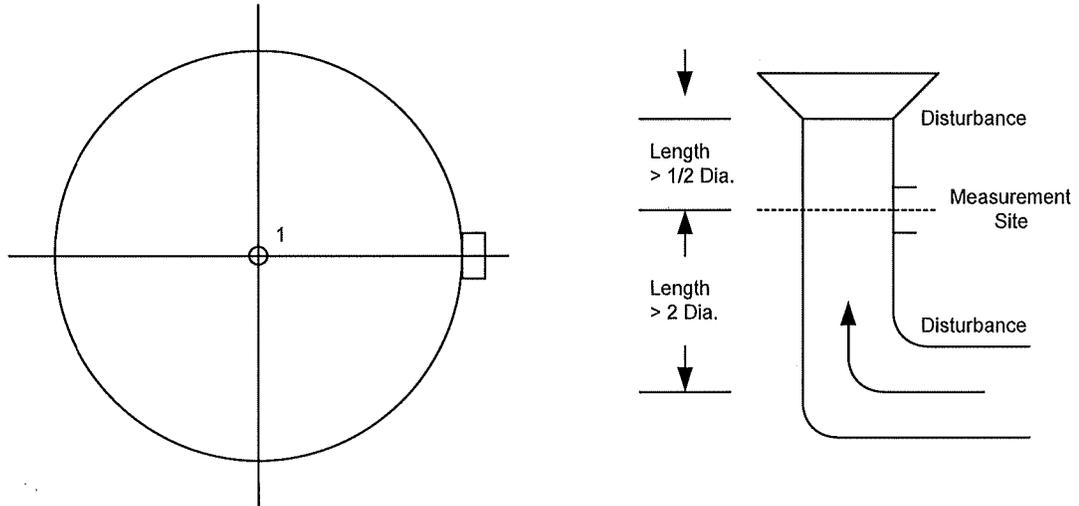
<b>EURICE1</b>				
6/3/2021				
Start Time	1445	1623	1755	
End Time	1551	1722	1854	
	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	<b>Average</b>
Engine (kW)	18,116	18,107	18,118	<b>18,114</b>
Engine natural gas use (pound/hour)	6,580	6,595	6,588	<b>6,588</b>
SCR/Oxidation catalyst inlet temperature) (deg F)	725	722	723	<b>723</b>
Pressure drop across the oxidation catalyst (PSI)	0.07	0.07	0.07	<b>0.07</b>

<b>EURICE2</b>				
6/3/2021				
Start Time	927	1115	1250	
End Time	1032	1214	1349	
	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	<b>Average</b>
Engine (kW)	18,054	18,057	18,060	<b>18,057</b>
Engine natural gas use (pound/hour)	6,586	6,608	6,581	<b>6,592</b>
SCR/Oxidation catalyst inlet temperature) (deg F)	728	721	725	<b>725</b>
Pressure drop across the oxidation catalyst (PSI)	0.15	0.16	0.15	<b>0.15</b>

<b>EURICE3</b>				
6/4/2021				
Start Time	745	935	1100	
End Time	853	1034	1159	
	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	<b>Average</b>
Engine (kW)	18,065.000	18,051	18,065	<b>18,060</b>
Engine natural gas use (pound/hour)	6,478	6,514	6,546	<b>6,513</b>
SCR/Oxidation catalyst inlet temperature) (deg F)	733	724	718	<b>725</b>
Pressure drop across the oxidation catalyst (PSI)	0.10	0.10	0.10	<b>0.10</b>

## Appendix B - Test Section Diagram

## GASEOUS TRAVERSE FOR ROUND DUCTS



Job: Upper Michigan Energy Resources Corporation  
A.J. Mihm Generating Station

Date: June 3 and 4, 2021

Test Locations: EURICE1, EURICE2, EURICE 3 Outlet Ducts (identical)

Duct Diameter: 5.29 Feet

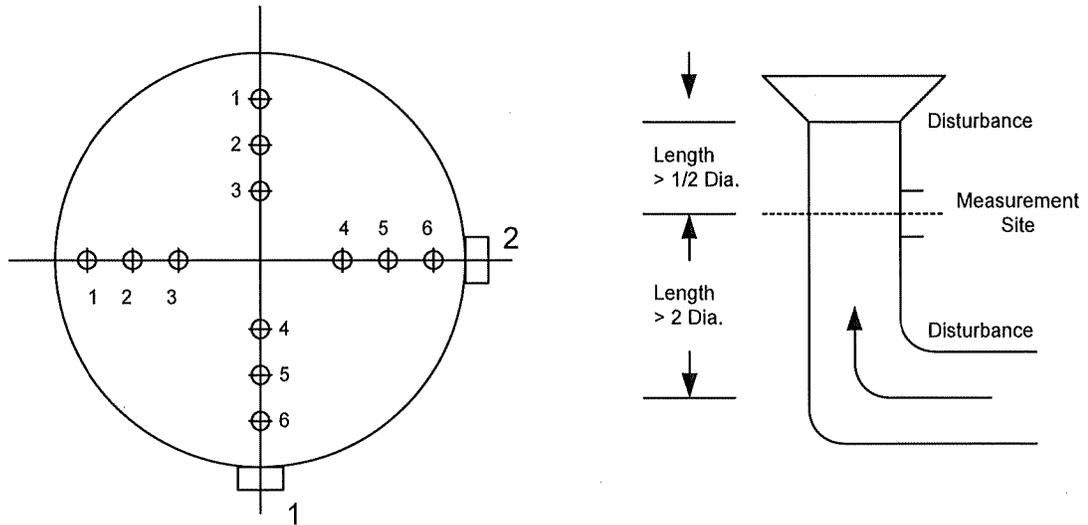
Duct Area: 21.98 Square Feet

No. Points Across Diameter: 1

No. of Ports: 1

Port Length: 8.0 Inches

## STRATIFICATION TRAVERSE FOR ROUND DUCTS



Job: Upper Michigan Energy Resources Corporation  
A.J. Mihm Generating Station

Date: June 3 and 4, 2021

Test Locations: EURICE1, EURICE2, EURICE 3 Outlet Ducts (identical)

Duct Diameter: 5.29 Feet

Duct Area: 21.979 Square Feet

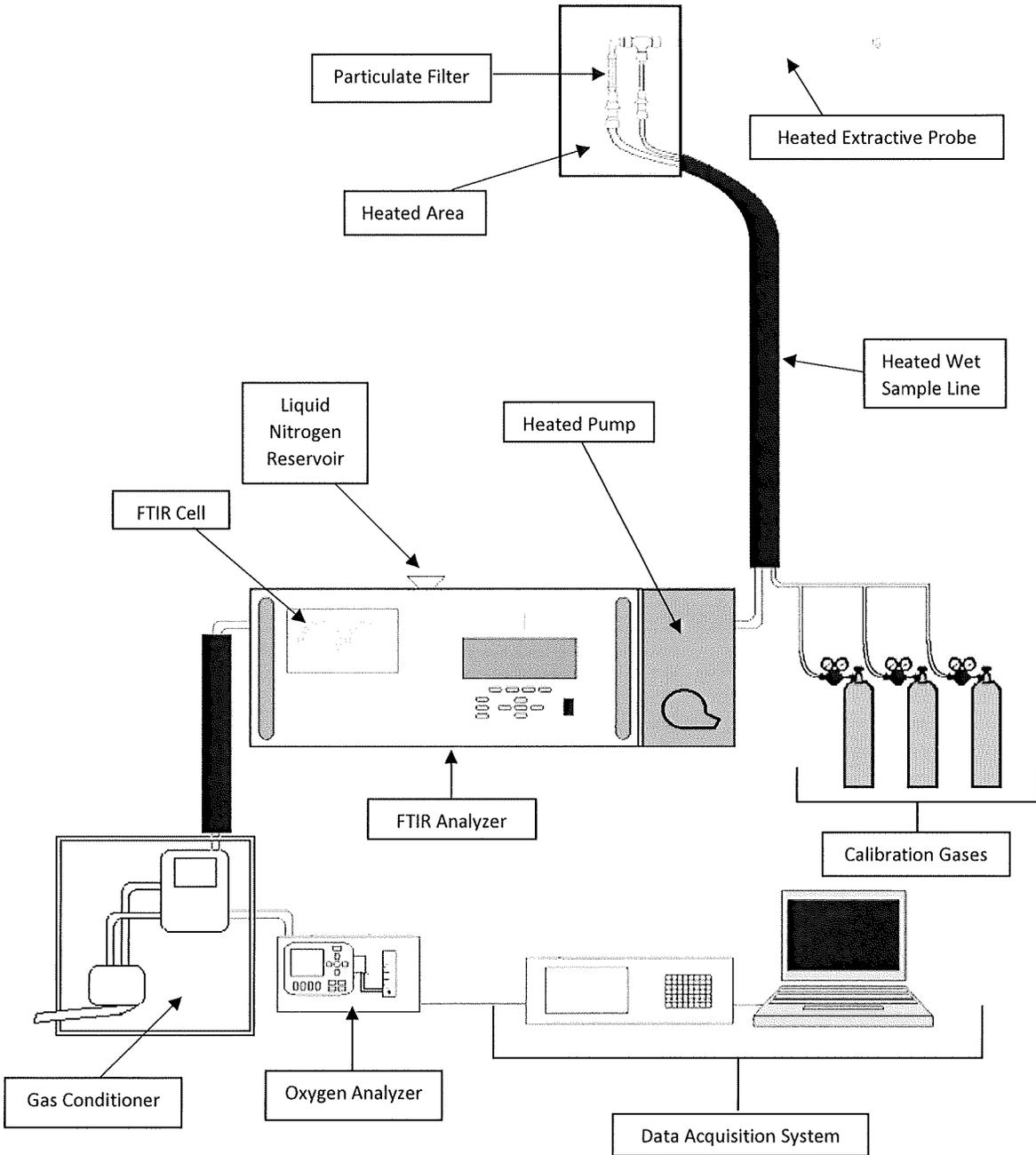
No. Points Across Diameter: 6

No. of Ports: 2

Port Length: 8.0 Inches

## Appendix C - Sample Train Diagram

# USEPA Methods 3A and 320 – Sample Train Diagram



## Appendix D - Calculation Nomenclature and Formulas