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Annual RICE MACT Performance Emissions Test Report

Upper Michigan Resources Corporation
F. D. Kuester Generating Station
MI-ROP-P0797-2020
EURICE1, EURICE2, EURICE3, EURICE4, EURICE5, EURICE6, EURICE7
Negaunee, Michigan
October 24 through 26, 2023

Report Submittal Date
December 4, 2023

Project No. M234004H

Crown Point, IN | Mendota Heights, MN | Denver, CO | Henderson, NV

Corporate Headquarters
888 Industrial Drive
Elmhurst, Illinois 60126
630-993-2100

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1.0 EXECUTIVE SUMMARY

Mostardi Platt conducted an annual RICE MACT performance formaldehyde emissions test program for Upper Michigan Energy Resources Corporation (UMERC) on October 24 through 26, 2023 at F.D. Kuester Generating Station on the Reciprocating Internal Combustion Engine (EURICE) 1, EURICE2, EURICE3, EURICE4, EURICE5, EURICE6, and EURICE7 Outlet Ducts in Negaunee, Michigan. The purpose of the test program was to meet the ongoing compliance demonstration requirements for emission rates in accordance with Renewable Operating Permit MI-ROP-P0797 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 Dates**	**Test Parameters**
EURICE1	October 25, 2023	Formaldehyde (CH_2O), Moisture and Oxygen (O_2)
EURICE2	October 25, 2023	
EURICE3	October 25, 2023	
EURICE4	October 24, 2023	
EURICE5	October 26, 2023	
EURICE6	October 26, 2023	
EURICE7	October 26, 2023	

F. D. Kuester Generating Station electric generation facility includes seven (7) 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 (NOx) 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 a common stack. Testing was done at the outlet duct to isolate the emissions from each unit.

Selected results of the test program are summarized below on a ppmvd @ 15% O_2 basis. A complete summary of emission test results follows the narrative portion of this report.

TEST RESULTS				
Test Location	**Date**	**Test Parameter**	**Emission Limit**	**Emission Rate**
EURICE1	October 25, 2023	Formaldehyde	14 ppmvd @ 15% O_2	1.21 ppmvd @ 15% O_2
EURICE2	October 25, 2023			2.00 ppmvd @ 15% O_2
EURICE3	October 25, 2023			1.42 ppmvd @ 15% O_2
EURICE4	October 24, 2023			1.28 ppmvd @ 15% O_2
EURICE5	October 26, 2023			1.59 ppmvd @ 15% O_2
EURICE6	October 26, 2023			1.28 ppmvd @ 15% O_2
EURICE7	October 26, 2023			1.41 ppmvd @ 15% O_2

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 F.D. Kuester Generating Station 80 Eagle Mills Road Negaunee, MI 49866	
Testing Company Representative	Mostardi Platt 888 Industrial Drive Elmhurst, Illinois 60126	Mr. Jeffrey Gross Project Supervisor (630) 993-2100 (phone) jgross@mp-mail.com

The test crew consisted of J. Dockins, J. Jimenez, and J. Gross 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_2)

CO_2 and O_2 concentrations were measured to determine stack gas molecular weight and emission rates in ppmvd corrected to 15% O_2 in accordance with Method 3A. An Servomex analyzer was used to determine stack 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 (HCHO) and Moisture (H2O) 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: N2, O2, H2, 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^{-1} 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 is 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 G for FTIR QA/QC Data and instrument linearity validations.

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: 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	Formaldehyde, 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.

The M320 Analyte Direct calibration did not meet the acceptance criteria prior to testing. This occurs due to cylinder stability over time which impacts the tag values as well as corrosion in the regulators which cause a loss of formaldehyde. Consequently, the determined concentration from the direct analysis was used in all system/spike recovery calculations. Performing all of the other health /QA checks of the FTIR showed the instrument working as well as reading the formaldehyde direct properly which validates the data and does not impact the compliance determination.

CALIBRATION GAS STANDARDS				
Components	**Concentration (ppm)**	**Vendor**	**Cylinder #**	**Standard Type**
Ethylene	99.97	Airgas	EB0153619	Certified Standard-Spec +/- 2%
Formaldehyde/ SF6	8.705/5.075	Airgas	EB0146284	Certified Standard +/- 2% (Acetaldehyde/Methanol) Certified Standard +/- 5% (SF_6)
Nitrogen	Zero Gas	Airgas	N/A	UHP Grade

Analyte Spiking
Formaldehyde spiking was performed prior to testing to verify the ability of the sampling system to quantitatively deliver a sample containing formaldehyde 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 formaldehyde concentration to be used in the spike recovery calculations. The analyte spiking gases contained a low concentration of sulfur hexafluoride (SF_6). The determined SF_6 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 formaldehyde. The spike target dilution ratio was 1:10 or less.

The following equation illustrates the percent recovery calculation.

$$DF = \frac{SF6(spk)}{SF6(direct)}$$ (Sec. 9.2.3 (3) USEPA Method 320)

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

DF = Dilution factor of the spike gas
$SF_{6(dir)}$ = SF_6 concentration measured directly in undiluted spike gas
$SF_{6(spk)}$ = Diluted SF_6 concentration measured in a spiked sample
$Spike_{dir}$= 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 G 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	**0.4**	**-**
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 G. Copies of gas cylinder certifications are found in Appendix H. 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 F. D. Kuester Generating Facility EURICE 1 Outlet Duct Formaldehyde Summary								
Test No.	Date	Start Time	End Time	O_2 % (dry)	Moisture, %	CH2O ppmvw	CH2O ppmvd	CH2O ppmvd @ 15% O2
1	10/25/23	16:46	17:53	11.5	10.08	1.81	2.01	1.26
2	10/25/23	18:09	19:08	11.5	10.05	1.70	1.89	1.19
3	10/25/23	19:24	20:23	11.5	10.06	1.67	1.86	1.17
Average				11.5	10.06	1.73	1.92	1.21

Upper Michigan Energy Resources Corporation F. D. Kuester Generating Facility EURICE 2 Outlet Duct Formaldehyde Summary								
Test No.	Date	Start Time	End Time	O_2 % (dry)	Moisture, %	CH2O ppmvw	CH2O ppmvd	CH2O ppmvd @ 15% O2
1	10/25/23	12:21	13:29	11.9	9.76	2.72	3.01	1.96
2	10/25/23	13:44	14:43	11.9	9.76	2.82	3.13	2.04
3	10/25/23	14:59	15:58	11.9	9.77	2.75	3.05	1.99
Average				11.9	9.76	2.76	3.06	2.00

Upper Michigan Energy Resources Corporation F. D. Kuester Generating Facility EURICE 3 Outlet Duct Formaldehyde Summary								
Test No.	Date	Start Time	End Time	O_2 % (dry)	Moisture, %	CH2O ppmvw	CH2O ppmvd	CH2O ppmvd @ 15% O2
1	10/25/23	7:28	8:38	11.5	10.19	2.05	2.29	1.43
2	10/25/23	8:54	9:53	11.5	10.15	2.06	2.29	1.43
3	10/25/23	10:10	11:09	11.5	10.14	1.98	2.21	1.38
Average				11.5	10.16	2.03	2.26	1.42

Upper Michigan Energy Resources Corporation F. D. Kuester Generating Facility EURICE 4 Outlet Duct Formaldehyde Summary									
Test No.	Date	Start Time	End Time	O_2 % (wet)	Moisture, %	O_2 % (dry)	CH2O ppmvw	CH2O ppmvd	CH2O ppmvd @ 15% O2
1	10/24/23	10:25	11:24	10.1	10.40	11.30	2.47	2.75	1.69
2	10/24/23	13:05	14:04	10.2	10.49	11.35	1.53	1.71	1.06
3	10/24/23	17:06	18:05	10.1	10.74	11.33	1.56	1.75	1.08
Average				10.1	10.54	11.33	1.85	2.07	1.28

Upper Michigan Energy Resources Corporation F. D. Kuester Generating Facility EURICE 5 Outlet Duct Formaldehyde Summary								
Test No.	Date	Start Time	End Time	O_2 % (dry)	Moisture, %	CH2O ppmvw	CH2O ppmvd	CH2O ppmvd @ 15% O2
1	10/26/23	7:40	8:49	11.6	9.95	2.23	2.47	1.57
2	10/26/23	9:02	10:01	11.6	9.96	2.28	2.53	1.61
3	10/26/23	10:17	11:16	11.6	10.03	2.24	2.49	1.58
Average				11.6	9.98	2.25	2.50	1.59

Upper Michigan Energy Resources Corporation F. D. Kuester Generating Facility EURICE 6 Outlet Duct Formaldehyde Summary								
Test No.	Date	Start Time	End Time	O_2 % (dry)	Moisture, %	CH2O ppmvw	CH2O ppmvd	CH2O ppmvd @ 15% O2
1	10/26/23	11:58	13:06	11.6	10.09	2.08	2.31	1.47
2	10/26/23	13:21	14:20	11.6	10.26	1.75	1.95	1.23
3	10/26/23	14:35	15:34	11.5	10.33	1.62	1.81	1.14
Average				11.6	10.23	1.82	2.02	1.28

Upper Michigan Energy Resources Corporation F. D. Kuester Generating Facility EURICE 7 Outlet Duct Formaldehyde Summary								
Test No.	Date	Start Time	End Time	O_2 % (dry)	Moisture, %	CH2O ppmvw	CH2O ppmvd	CH2O ppmvd @ 15% O2
1	10/26/23	16:13	17:19	11.6	10.28	2.05	2.28	1.45
2	10/26/23	17:33	18:32	11.6	10.28	1.96	2.18	1.39
3	10/26/23	18:46	19:45	11.6	10.27	1.96	2.18	1.39
Average				11.6	10.28	1.99	2.22	1.41

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

_________________________ Program Manager
Jeffrey M. Gross

_________________________ Quality Assurance
Scott W. Banach

APPENDICES

Appendix A – Plant Operating Data

F.D. Kuester Generating Station
Performance Emissions Testing
40 CFR Part 60 Subpart JJJJ & 63 Subpart ZZZZ (MACT)
October 24 through 26, 2023

EURICE1				
10/25/2023				
Start Time	*1646*	*1809*	*1924*	
End Time	*1753*	*1908*	*2023*	
	Run 1	**Run 2**	**Run 3**	**Average**
Engine (kW)	18,900	18,890	18,879	**18,890**
Engine natural gas use (pound/hour)	6,786	6,782	6,780	**6,783**
SCR/Oxidation catalyst inlet temperature) (deg F)	720	719	719	**719**
Pressure drop across the oxidation catalyst (PSI)	0.15	0.15	0.15	**0.15**
Urea injection rate to the SCR (gallons/hour)	6.5	6.4	6.6	**6.5**

EURICE2				
10/25/2023				
Start Time	*1221*	*1344*	*1459*	
End Time	*1329*	*1443*	*1558*	
	Run 1	**Run 2**	**Run 3**	**Average**
Engine (kW)	18,872	18,875	18,867	**18,871**
Engine natural gas use (pound/hour)	6,735	6,743	6,748	**6,742**
SCR/Oxidation catalyst inlet temperature) (deg F)	690	689	689	**689**
Pressure drop across the oxidation catalyst (PSI)	0.14	0.14	0.14	**0.14**
Urea injection rate to the SCR (gallons/hour)	3.4	3.3	3.4	**4.7**

EURICE3				
10/25/2023				
Start Time	*728*	*854*	*1010*	
End Time	*838*	*953*	*1109*	
	Run 1	**Run 2**	**Run 3**	**Average**
Engine (kW)	18,872	18,778	18,880	**18,843**
Engine natural gas use (pound/hour)	6,762	6,758	6,753	**6,758**
SCR/Oxidation catalyst inlet temperature) (deg F)	716	717	718	**717**
Pressure drop across the oxidation catalyst (PSI)	0.22	0.20	0.21	**0.21**
Urea injection rate to the SCR (gallons/hour)	5.8	5.8	6.0	**5.9**

EURICE4				
10/24/2023				
Start Time	1025	1305	1706	
End Time	1124	1404	1805	
	Run 1	**Run 2**	**Run 3**	**Average**
Engine (kW)	18,875	18,862	18,877	**18,871**
Engine natural gas use (pound/hour)	6,647	6,689	6,675	**6,670**
SCR/Oxidation catalyst inlet temperature) (deg F)	727	724	725	**725**
Pressure drop across the oxidation catalyst (PSI)	0.18	0.18	0.18	**0.18**
Urea injection rate to the SCR (gallons/hour)	7.7	6.6	6.2	**6.9**

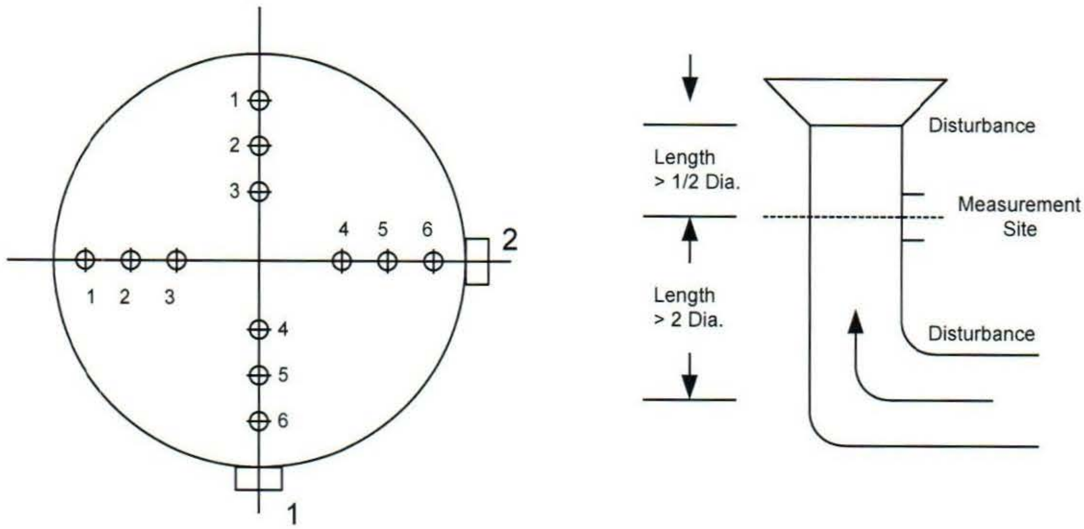
EURICE5				
10/26/2023				
Start Time	*740*	*902*	*1017*	
End Time	*849*	*1001*	*1116*	
	Run 1	**Run 2**	**Run 3**	**Average**
Engine (kW)	18,908	18,913	18,923	**18,915**
Engine natural gas use (pound/hour)	6,757	6,757	6,752	**6,755**
SCR/Oxidation catalyst inlet temperature) (deg F)	702	702	703	**702**
Pressure drop across the oxidation catalyst (PSI)	0.14	0.14	0.14	**0.14**
Urea injection rate to the SCR (gallons/hour)	4.2	4.1	4.1	**4.1**

EURICE6				
10/26/2023				
Start Time	*1158*	*1321*	*1435*	
End Time	*1306*	*1420*	*1534*	
	Run 1	**Run 2**	**Run 3**	**Average**
Engine (kW)	18,934	18,952	18,950	**18,945**
Engine natural gas use (pound/hour)	6,812	6,708	6,670	**6,730**
SCR/Oxidation catalyst inlet temperature) (deg F)	707	712	714	**711**
Pressure drop across the oxidation catalyst (PSI)	0.14	0.14	0.14	**0.14**
Urea injection rate to the SCR (gallons/hour)	4.2	4.7	4.8	**4.6**

EURICE7				
10/26/2023				
Start Time	*1613*	*1733*	*1846*	
End Time	*1719*	*1832*	*1945*	
	Run 1	**Run 2**	**Run 3**	**Average**
Engine (kW)	18,910	18,907	18,897	**18,905**
Engine natural gas use (pound/hour)	6,551	6,548	6,536	**6,545**
SCR/Oxidation catalyst inlet temperature) (deg F)	709	710	710	**710**
Pressure drop across the oxidation catalyst (PSI)	0.21	0.21	0.21	**0.21**
Urea injection rate to the SCR (gallons/hour)	4.2	4.3	4.3	**4.3**

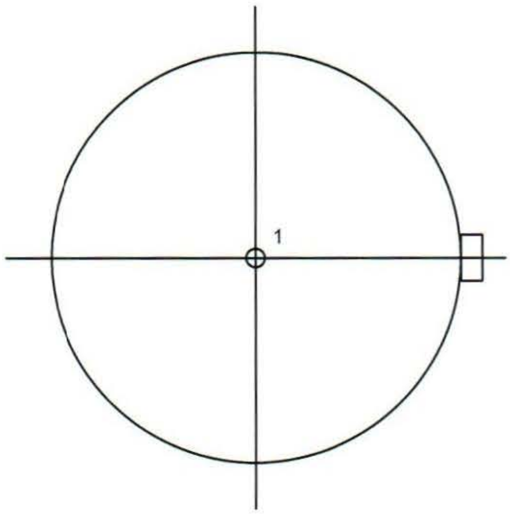
Appendix B - Test Section Diagram

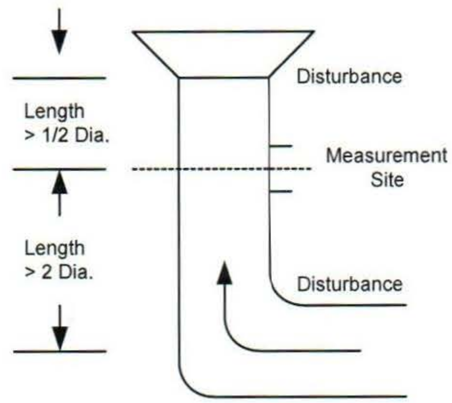
STRATIFICATION TRAVERSE FOR ROUND DUCTS



Job:	Upper Michigan Energy Resources Corporation F.D. Kuester Generating Station
Date:	October 24-26, 2023
Test Locations:	EURICE1, EURICE2, EURICE3, EURICE4, EURICE5, EURICE6, and EURICE7 Outlet Ducts (identical)
Duct Diameter:	5.29 Feet
Duct Area:	21.98 Square Feet
No. Points Across Diameter:	6
No. of Ports:	2
Port Length:	8.0 Inches

GASEOUS TRAVERSE FOR ROUND DUCTS

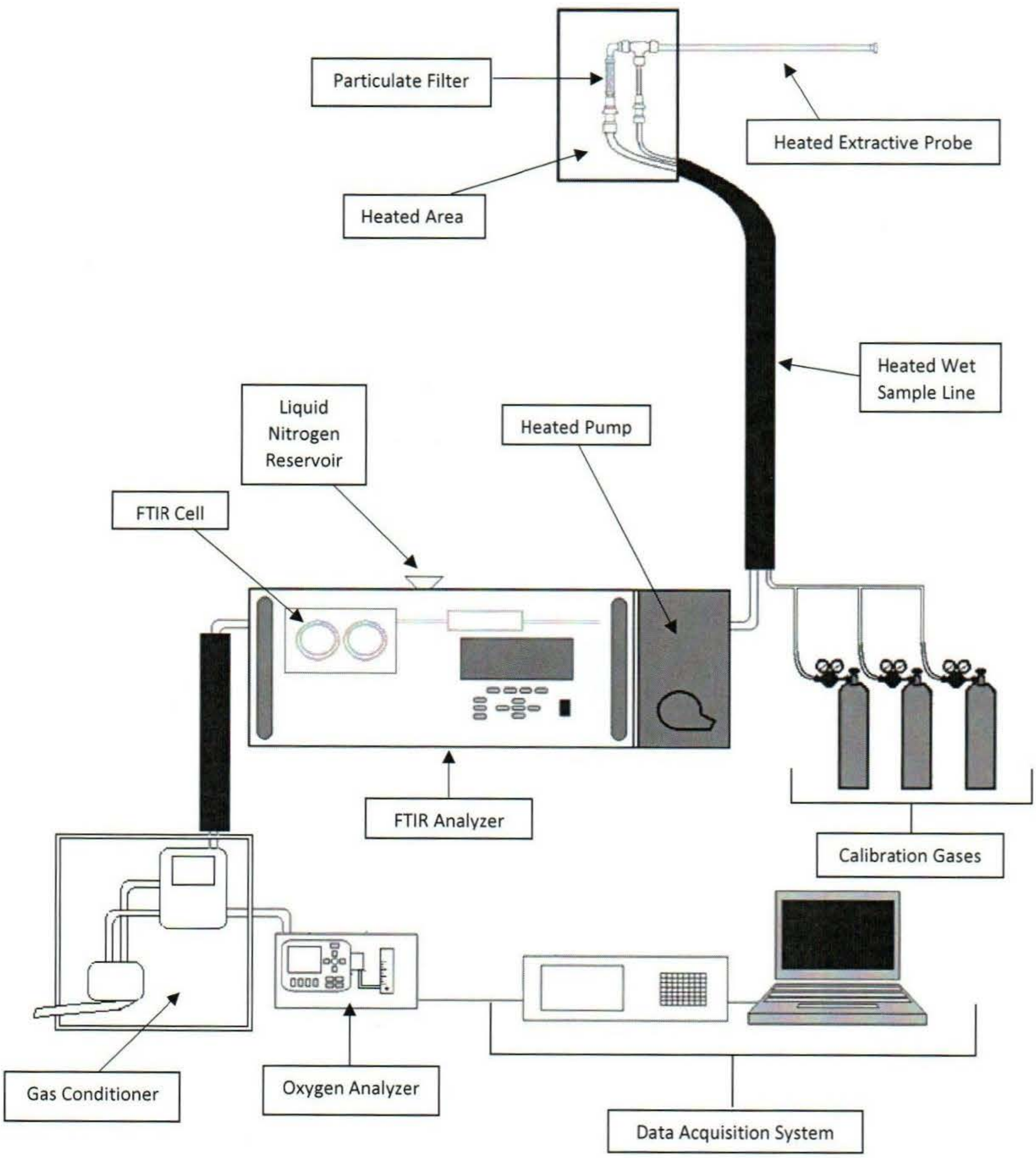




Job:	Upper Michigan Energy Resources Corporation F.D. Kuester Generating Station
Date:	October 24-26, 2023
Test Location:	EURICE1, EURICE2, EURICE3, EURICE4, EURICE5, EURICE6, and EURICE7 Outlet Ducts (identical)
Duct Diameter:	5.29 Feet
Duct Area:	21.98 Square Feet
No. Points Across Diameter:	1
No. of Ports:	1
Port Length:	8.0 Inches

Appendix C - Sample Train Diagram

USEPA Methods 3A and 320 – Sample Train Diagram



Appendix D - Calculation Nomenclature and Formulas