mostardi platt

Performance and Emission Rate Test Report

Performed for: Upper Michigan Energy Resources Corporation
At The: F.D. Kuester Generating Station
Permit No. 35-17
EURICE4 Outlet Duct
Negaunee, Michigan
October 24, 2023

Report Submittal Date
December 1, 2023

Project No. M234004D

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 a performance and emission rate test program for Upper Michigan Energy Resources Corporation (UMERC) on October 24, 2023 at F.D. Kuester Generating Station on the Reciprocating Internal Combustion Engine 4 (EURICE4) Outlet Duct in Negaunee, Michigan. The purpose of the test program was to meet the ongoing compliance demonstration requirements for emission rates in accordance with Permit to Install 35-17 and 40 CFR Part 60 Subpart JJJJ. This report summarizes the results of the test program and test methods used.

The test location, test date, and test parameters are summarized below.

Test Location	Test Date	Test Parameters
EURICE4 Outlet Duct	10/24/2023	Nitrogen Oxides (NO_x), Carbon Monoxide (CO), Carbon Dioxide (CO_2), Oxygen (O_2), Volatile Organic Compounds (VOCs), Total Particulate Matter (TPM), Volumetric Flow, and Moisture

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 18,817 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.

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. The emissions of the VOC as ppmv were calculated to be less than the method detection for each of the runs. The method detection was used for the emission rate based on the standard deviation of the calibrations of 2.5 ppmv.

TEST RESULTS				
Test Location	Test Date	Test Parameter	Emission Limit	Emission Rate
EURICE4 Outlet Duct	10/24/2023	NO_x	82 ppmvd @ 15% O_2	1.9 ppmvd @ 15% O_2
			3.0 lb/hr	1.0 lb/hr
		CO	270 ppmvd @ 15% O_2	5.9 ppmvd @ 15% O_2
			5.5 lb/hr	2.0 lb/hr
		VOC (as C_3H_8)	60 ppmvd @ 15% O_2	< 1.7 ppmvd @ 15% O_2
			5.5 lb/hr	< 0.9 lb/hr
		TPM	3.72 lb/hr	0.070 lb/hr

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 M. 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 Code of Federal Regulations, Title 40, Part 60, Appendix A (40CFR60), 40CFR51, and 40CFR63. Schematics of the test section diagrams and sampling trains used are included in Appendix B and C, respectively. Calculation examples and nomenclature are included in Appendix D. Copies of analyzer print-outs and field data sheets for each test run are included in Appendices E and F, respectively.

The following methodologies were used during the test program:

Method 1 Traverse Point Determination

Test measurement points were selected in accordance with Method 1. The characteristics of the measurement location are summarized below.

TEST POINT INFORMATION						
Location	**Diameter (Feet)**	**Area (Square Feet)**	**Upstream Distance (Inches)**	**Downstream Distance (Inches)**	**Test Parameter**	**Number of Sampling Points**
EURICE4 Outlet Duct	5.29	21.979	>0.5	>2.0	Volumetric Flow	16
					NO_x/CO/VOC/O_2/CO_2	12 (strat), 3
					TPM	24

A null point pitot traverse check was performed utilizing a Type S pitot tube prior to any testing to verify the absence of cyclonic flow at each test location per USEPA Method 1, Section 11.4. The null point at the test location averaged 3.8 degrees which meets the requirements. The results can be found in Appendix E.

Method 2 Volumetric Flowrate Determination

Gas velocity was measured following Method 2, for purposes of calculating stack gas volumetric flow rate. An S-type pitot tube, differential pressure gauge, thermocouple and temperature readout were used to determine gas velocity at each sample point. All of the equipment used was calibrated in accordance with the specifications of the Method. Calibration data are presented in Appendix G.

Method 3A Oxygen (O_2)/Carbon Dioxide (CO_2) Determination

Flue gas O_2 was determined in accordance with Method 3A. An ECOM analyzer was used to determine stack gas oxygen content connected to the outlet of the FTIR analyzer.

Flue gas carbon dioxide concentrations and emission rates were determined in accordance with Method 3A. An MKS MultiGas 2030 FTIR spectrometer was used to determine the CO_2 concentrations, in the manner specified in the Method. Nitrogen content was determined from the difference of CO_2 and O_2.

Stack gas was delivered to the analyzer via a Teflon® sampling line, heated to a minimum temperature of 375°F. The entire system was calibrated in accordance with the Method, using certified calibration gases introduced at the probe, before and after each test run.

All of the equipment used was calibrated in accordance with the specifications of the Method and calibration data are included in Appendix G. Copies of the gas cylinder certifications are included in Appendix J.

Method 5 Particulate Determination

Stack gas particulate concentrations and emission rates were determined in accordance with Method 5, 40 CFR, Part 60, Appendix A at the test location. An Environmental Supply Company, Inc. sampling train was used to sample stack gas at an isokinetic rate, as specified in the Method. Particulate matter in the sample probe was recovered using an acetone rinse. The probe wash and filter catch were analyzed by Mostardi Platt in accordance with the Method in the Elmhurst, Illinois laboratory. Laboratory data are found in Appendix H. All of the equipment used was calibrated in accordance with the specifications of the Method. Field data sheets are provided in Appendix E and calibration data are presented in Appendix G.

Method 7E Nitrogen Oxide (NO_X) Determination

Flue gas nitrogen oxide concentrations and emission rates were determined in accordance with Method 7E. An MKS MultiGas 2030 FTIR spectrometer was used to determine nitrogen oxide concentrations, in the manner specified in the Method.

Stack gas was delivered to the analyzer via a Teflon® sampling line, heated to a minimum temperature of 375°F. The entire system was calibrated in accordance with the Method, using certified calibration gases introduced at the probe, before and after each test run.

A list of calibration gases used and the results of all calibration and other required quality assurance checks can be found in Appendix G. Copies of calibration gas certifications can be found in Appendix J.

Method 10 Carbon Monoxide (CO) Determination

Flue gas nitrogen oxide concentrations and emission rates were determined in accordance with Method 10. An MKS MultiGas 2030 FTIR spectrometer was used to determine carbon monoxide concentrations, in the manner specified in the Method.

Stack gas was delivered to the analyzer via a Teflon® sampling line, heated to a minimum temperature of 375°F. The entire system was calibrated in accordance with the Method, using certified calibration gases introduced at the probe, before and after each test run.

A list of calibration gases used and the results of all calibration and other required quality assurance checks can be found in Appendix G. Copies of calibration gas certifications can be found in Appendix J.

Method 25A Volatile Organic Compound (VOC) Determination

Total hydrocarbon (THC) concentrations and emission rates were determined in accordance with Method 25A. A Thermo Fisher 51i analyzer was used to determine THC concentrations. Stack gas was delivered to the system via a Teflon® sampling line, heated to a minimum temperature of 375°F.

Methane and ethane concentrations were determined in accordance with Method 320 and then subtracted from the THC concentrations in order to comply with non-methane, non-ethane hydrocarbon criteria as specified in the permit. The methane concentration was also corrected for a response factor for the TECO 51i analyzer. These results can be found in Appendix G along with the calibration data.

The system was calibrated before and after each test run using certified calibration gases of propane for the THC determination. Copies of gas certifications are presented in Appendix J.

Method 202 Condensable Particulate Determination

Stack gas condensable particulate matter concentrations and emission rates were determined in accordance with USEPA Method 202, in conjunction with Method 5 filterable particulate sampling. This method applies to the determination of condensable particulate matter (CPM) emissions from stationary sources. It is intended to represent condensable matter as material that condenses after passing through a filter and as measured by this method.

The CPM was collected in the impinger portion of the Method 5 (Appendix A, 40CFR60) type sampling trains. The impinger contents were immediately purged after each run with nitrogen (N_2) to remove dissolved sulfur dioxide (SO_2) gases from the impinger contents. The impinger solution was then extracted with hexane. The organic and aqueous fractions were then taken to dryness and the residues weighed. A correction was made for any ammonia present due to laboratory analysis procedures. The total of both fractions represents the CPM.

All sample recovery was performed at the test site by the test crew. Mostardi Platt personnel at the laboratory in Elmhurst, Illinois, performed all final particulate sample analyses. Laboratory data are found in Appendix H. All of the equipment used was calibrated in accordance with the specifications of the Method. Calibration data are presented in Appendix G.

Method 320 Fourier Transform Infrared (FTIR) Detector for Methane and Ethane Determination

Flue gas methane, ethane, and moisture concentrations and emission rates were determined in accordance with Method 320. 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**
019088128	100' 3/8" dia., heated Teflon	Heated 3', 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 I for FTIR QA/QC Data.

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 stability, confirm optical path length	Ethylene	Direct to FTIR	pretest	+/- 5% cert. value	**Pass**
M320: CTS Response	Verify system stability, recovery, response time	Ethylene	Sampling System	Daily, pre/post test	+/- 5% of Direct Measurement	**Pass**
M320: Zero Response	Verify system is free of system bias	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	Primary +/- 1%
Formaldehyde/ SF6	8.705/5.075	Airgas	EB0146284	Certified Standard-Spec +/- 5%
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.

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

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

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, thus providing a scale factor. The scale 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. If there is a difference greater than ± 20% the spectra are reviewed for possible spectra interferences or any other possible causes leading to incorrectly quantified data.

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)
Methane	**1.0**	**-**
Ethane	**0.5**	**-**
Moisture	**-**	**0.1**

QA/QC data are found in Appendix I. Copies of gas cylinder certifications are found in Appendix J. 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 SUMMARY

Upper Michigan Energy Resources Corporation
F. D. Kuester Generating Facility
EURICE 4 Outlet Duct
October 24, 2023
Reference Method Test Data

Test No.	Start Time	End Time	NOx ppmvw		VOC ppmvw as C_3H_8*	CO ppmvw	Moisture, %	NOx ppmvd @ 15% O_2		VOC ppmvd as C_1H_8 @ 15% O_2	CO ppmvd @15% O_2	O_2 % (dry)	Flow, SCFM	Flow, SCFH	NOx lb/hr		VOC lb/hr	CO lb/hr
1	10:25	11:24	2.8	≤	2.5	8.3	10.40	1.9	≤	1.7	5.7	11.3	52,874	3,172,440	1.1	≤	0.9	1.9
2	13:05	14:04	2.9	≤	2.5	8.8	10.49	2.0	≤	1.7	6.1	11.3	53,174	3,190,440	1.1	≤	0.9	2.0
3	17:06	18:05	2.5	≤	2.5	8.8	10.74	1.7	≤	1.7	6.1	11.3	54,066	3,243,960	1.0	≤	0.9	2.1
Average			**2.7**	≤	**2.5**	**8.6**	**10.54**	**1.9**	≤	**1.7**	**5.9**	**11.3**	**53,371**	**3,202,280**	**1.0**	≤	**0.9**	**2.0**

* Non detect - method detection of 2.5 ppmv used in the calculations

Client: Upper Michigan Energy Resources Corporation
Facility: F.D. Kuester Generating Station
Test Location: EURICE4
Test Method: 5/202

Source Condition	Normal	Normal	Normal	
Date	10/24/23	10/24/23	10/24/23	
Start Time	10:25	13:05	15:55	
End Time	12:35	15:16	18:05	
	Run 1	Run 2	Run 3	Average
Stack Conditions				
Average Gas Temperature, °F	721.8	718.0	720.8	720.2
Flue Gas Moisture, percent by volume	8.7%	7.8%	9.4%	8.6%
Average Flue Pressure, in. Hg	28.93	28.93	28.93	28.93
Gas Sample Volume, dscf	80.199	80.796	81.512	80.836
Average Gas Velocity, ft/sec	92.814	93.040	94.820	93.558
Gas Volumetric Flow Rate, acfm	122,395	122,694	125,041	123,377
Gas Volumetric Flow Rate, dscfm	48,255	49,029	48,960	48,748
Gas Volumetric Flow Rate, scfm	52,874	53,174	54,066	53,371
Average $\%CO_2$ by volume, dry basis	5.3	4.7	5.6	5.2
Average $\%O_2$ by volume, dry basis	11.0	13.1	11.2	11.8
Isokinetic Variance	101.1	100.3	101.3	100.9
Standard Fuel Factor Fd, dscf/mmBtu	8,710.0	8,710.0	8,710.0	8,710.0
Filterable Particulate Matter (Method 5)				
grams collected	0.00040	0.00045	0.00180	0.00088
mg/dscm	0.176	0.197	0.780	0.3842
grains/acf	0.0000	0.0000	0.0001	0.0000
grains/dscf	0.0001	0.0001	0.0003	0.0002
lb/hr	0.032	0.036	0.143	0.070
lb/mmBtu (Standard Fd Factor)	0.0002	0.0003	0.0009	0.0005

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, 2023

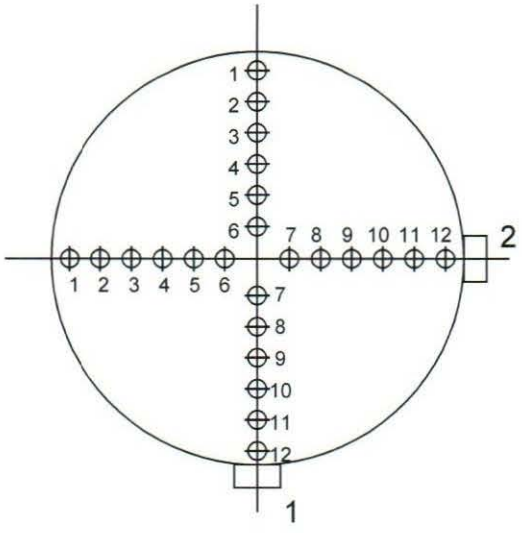
EURICE4				
10/24/2023				
Start Time	1025	1305	1706	
End Time	1124	1404	1805	
	Run 1	**Run 2**	**Run 3**	**Average**
Engine (kW)	18,875	18,862	18,877	**18,871**
Engine natural gas use (pound/hour)	6,647	6,689	6,675	**6,670**
SCR/Oxidation catalyst inlet temperature) (deg F)	727	724	725	**725**
Pressure 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**

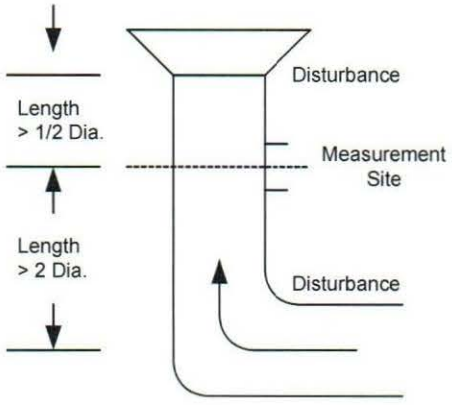
F.D. Kuester Generating Station
Performance Emissions Testing
40 CFR Part 60 Subpart JJJJ (Total Particulate Matter)
October 24 through 26, 2023

EURICE4				
10/24/2023				
Method 5/202				
Start Time	1025	1305	1555	
End Time	1235	1516	1805	
	Run 1	**Run 2**	**Run 3**	**Average**
Engine (kW)	18,876	18,866	18,877	**18,873**
Engine natural gas use (pound/hour)	6,653	6,693	6,686	**6,677**
SCR/Oxidation catalyst inlet temperature) (deg F)	726	724	725	**725**
Pressure drop across the oxidation catalyst (PSI)	0.18	0.18	0.19	**0.18**
Urea injection rate to the SCR (gallons/hour)	7.5	6.5	6.2	**6.7**

Appendix B - Test Section Diagrams

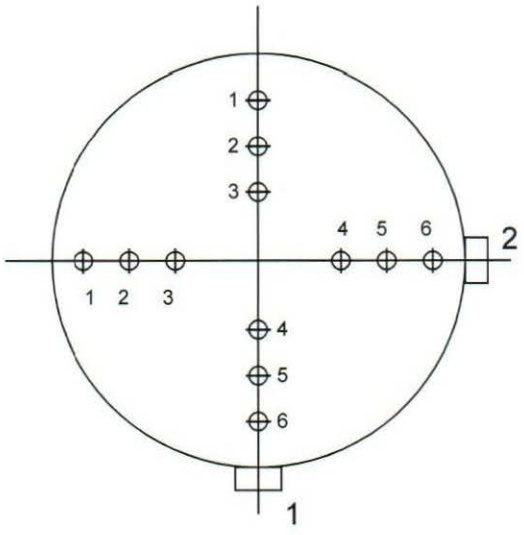
TPM TRAVERSE FOR ROUND DUCTS

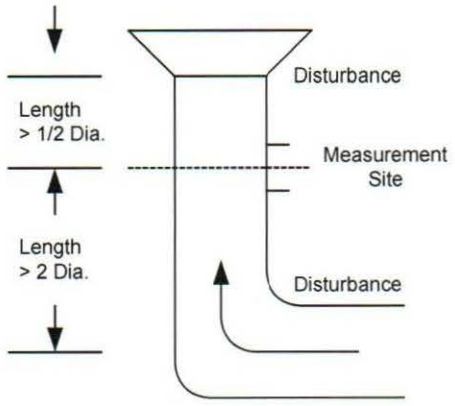




Job:	Upper Michigan Energy Resources Corporation F.D. Kuester Generating Station
Date:	October 24, 2023
Test Location:	EURICE4 Outlet Duct
Duct Diameter:	5.29 Feet
Duct Area:	21.979 Square Feet
No. Points Across Diameter:	24
No. of Ports:	2
Port Length:	8.0 Inches

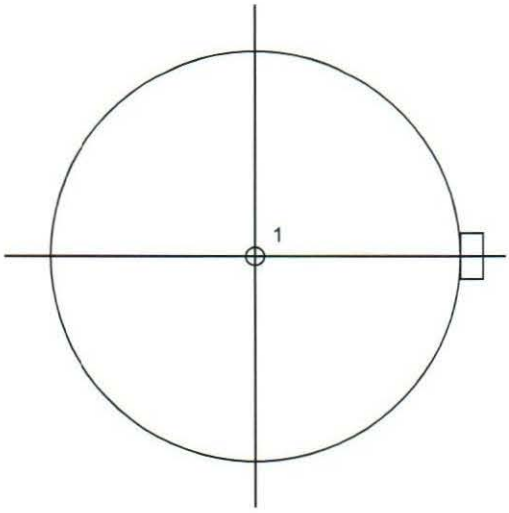
STRATIFICATION TRAVERSE FOR ROUND DUCTS

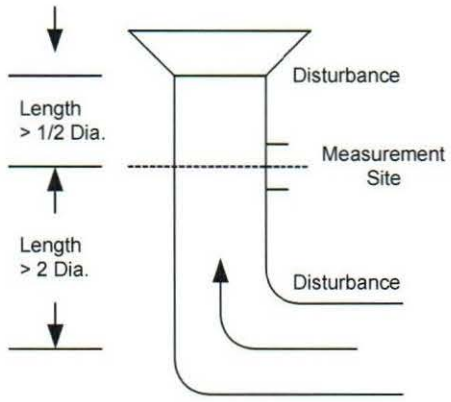




Job:	Upper Michigan Energy Resources Corporation F.D. Kuester Generating Station
Date:	October 24, 2023
Test Location:	EURICE4 Outlet Duct
Duct Diameter:	5.29 Feet
Duct Area:	21.979 Square Feet
No. Points Across Diameter:	6
No. of Ports:	2
Port Length:	8.0 Inches

GASEOUS TRAVERSE FOR ROUND DUCTS

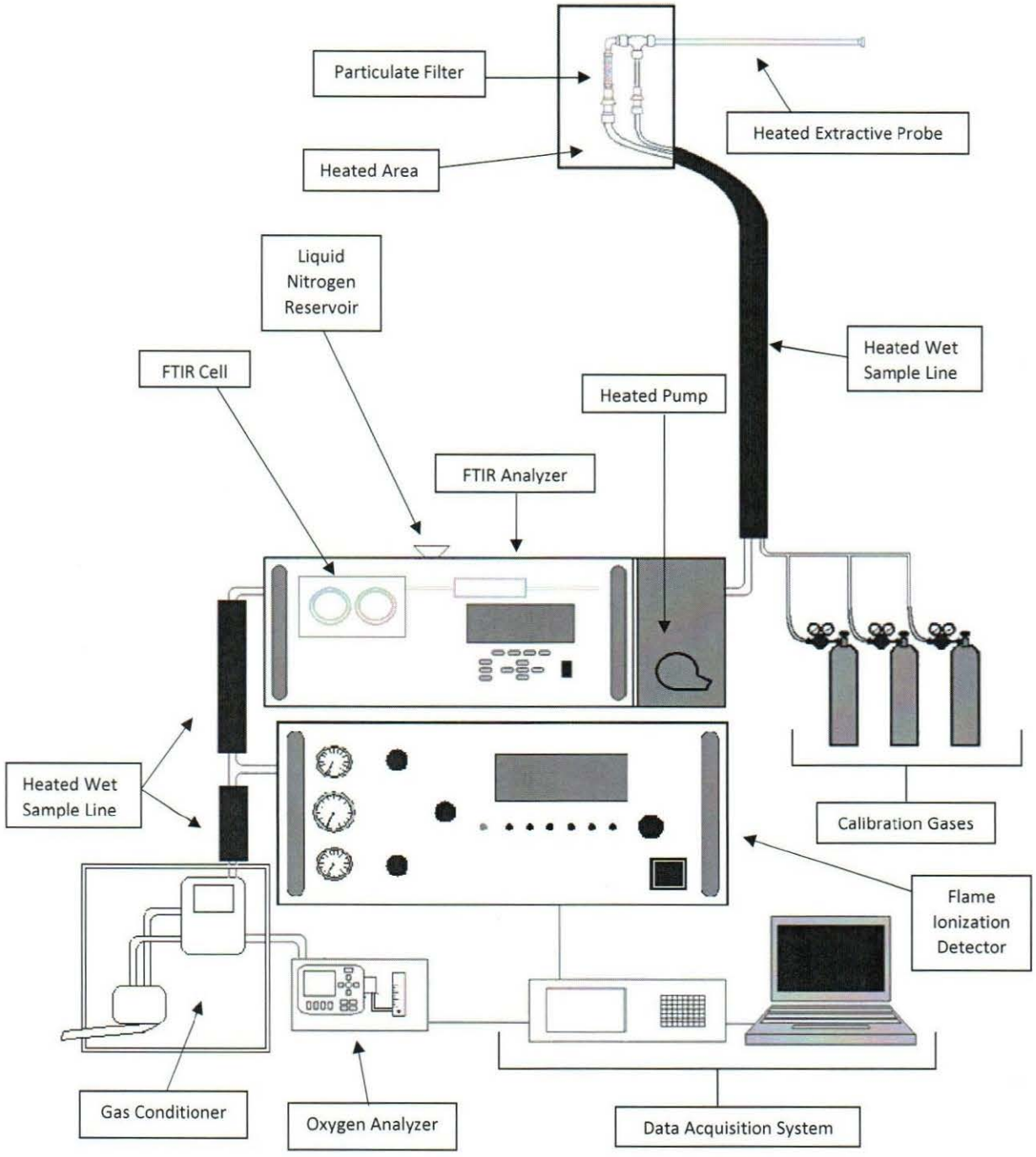




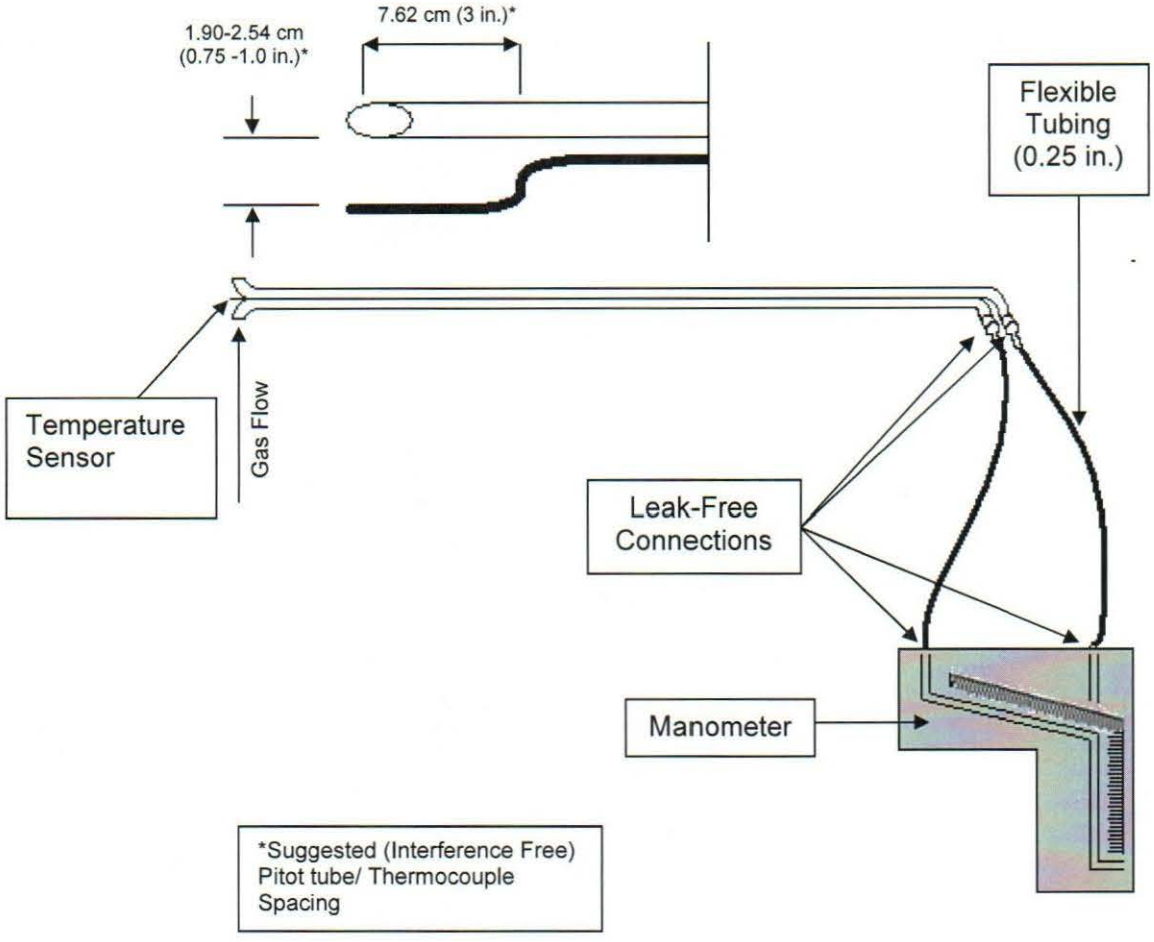
Job:	Upper Michigan Energy Resources Corporation F.D. Kuester Generating Station
Date:	October 24, 2023
Test Location:	EURICE4 Outlet Duct
Duct Diameter:	5.29 Feet
Duct Area:	21.979 Square Feet
No. Points Across Diameter:	1
No. of Ports:	1
Port Length:	8.0 Inches

Appendix C - Sample Train Diagrams

USEPA Methods 3A, 7E, 10, 25A, and 320 – Sample Train Diagram



USEPA Method 2 – Type S Pitot Tube Manometer Assembly



USEPA Method 5/202- Condensable Particulate Matter