EMISSIONS TEST REPORT

for

OXIDES OF NITROGEN (NO_X), CARBON MONOXIDE (CO), AND NON-METHANE NON-ETHANE ORGANIC COMPOUNDS (NMEOC)

EU017 & EU018

Z-330 - COMPRESSOR ENGINES 4 & 5

DTE GAS

BELLE RIVER MILLS COMPRESSOR STATION
East China, Michigan

August 13-14, 2024

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EXECUTIVE SUMMARY

DTE Energy's Environmental Management and Safety (EM&S) Field Services Group performed emissions testing at the DTE Gas Belle River Mills Compressor Station (SRN: B6478), located in East China, Michigan. The fieldwork was performed on August 13-14, 2024, to satisfy requirements of the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Renewable Operating Permit (ROP) No. B6478-2021 and 40CFR Part 60 Subpart JJJJ. Emissions tests were performed on EU017 and EU018 (Z-330 Compressor Engines 4 & 5) for oxides of nitrogen (NO_x), carbon monoxide (CO), and non-methane non-ethane organic compounds (NMEOC).

The results of the emissions testing are highlighted below:

Emissions Testing Summary – EU017 & EU018
Belle River Mills Compressor Station
East China, MI

	Oxides of Nitrogen (g/hp-hr)	Carbon Monoxide (g/hp-hr)	Non-Methane Organic Compounds (g/hp-hr)
EU017 (engine 4) August 13, 2024	2.07	1.80	0.2
EU018 (engine 5) August 14, 2024	1.66	2.05	0.3
Permit Limit	3.0	3.0	1.0

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1.0 INTRODUCTION

DTE Energy's Environmental Management and Safety (EM&S) Field Services Group performed emissions testing at the DTE Gas Belle River Mills Compressor Station (SRN: B6478), located in East China, Michigan. The fieldwork was performed on August 13-14, 2024, to satisfy requirements of the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Renewable Operating Permit (ROP) No. B6478-2021 and 40CFR Part 60 Subpart JJJJ. Emissions tests were performed on EU017 and EU018 (Z-330 Compressor Engines 4 & 5) for oxides of nitrogen (NO_x), carbon monoxide (CO), and non-methane non-ethane organic compounds (NMEOC).

Testing was performed pursuant to Title 40, *Code of Federal Regulations*, Part 60, Appendix A (40 CFR §60 App. A), Methods 3A, 19, and ASTM D6348.

The fieldwork was performed in accordance with EPA Reference Methods, ASTM Methods and EM&S's Intent to Test[1], test plan submittal which was approved in a letter by Mr. Andrew Riley from the Michigan Department of Environment, Great Lakes, and Energy (EGLE)[2] dated August 9th, 2024. The following EM&S personnel participated in the testing program: Mr. Mark Grigereit, Principal Engineer and Mr. Thomas Snyder, Principal Environmental Specialist. Mr. Snyder was the project leader. Mr. Michael Waters, DTE Gas, provided on-site support for the testing.

2.0 SOURCE DESCRIPTION

The Belle River Mills Compressor Station located at 5440 Puttygut Road, East China, Michigan, employs the use of two (#4 and #5) natural gas-fired Cooper Z-330 2-stroke lean burn 10,000 Horsepower reciprocating engines (derated to 9,000 Hp). The Z-330 compressor engines generate line pressure assisting the transmission of natural gas into and out of the gas storage field as well as to and from the pipeline transmission system in southeast Michigan.

The emissions from both Z-330 engines exhaust directly to the atmosphere through individual exhaust stacks. The compressor engines were operated at greater than 90% of the maximum load during the testing. The composition of the emissions from the engine depends on both the speed of the engine and the torque delivered to the compressor. Ambient atmospheric conditions, as it affects the density of air, may limit the speed and torque at which the engine can effectively operate.

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[1] EGLE, Test Plan, Submitted May 30, 2024. (Attached-Appendix A)

[2] EGLE, Acceptance Letter, August 9, 2024. (Attached-Appendix A)

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A schematic representation of the engine exhaust and sampling location is presented in Figure 1.

3.0 SAMPLING AND ANALYTICAL PROCEDURES

DTE Energy obtained emissions measurements in accordance with procedures specified in the USEPA *Standards of Performance for New Stationary Sources*. The sampling and analytical methods used in the testing program are indicated in the table below

Sampling Method	Parameter	Analysis
ASTM Method D6348	NO_x, CO, VOC, CO_2, Moisture Content	FTIR

3.1 MOISTURE (ASTM METHOD D6348)

3.1.1 Sampling Method

Moisture content in the exhaust was evaluated using ASTM Method D6348, "Measurement of Vapor Phase Organic Emissions by Extractive Fourier Transform Infrared (FTIR)".

3.2 OXIDES of NITROGEN, CARBON MONOXIDE, TOTAL VOC, CARBON DIOXIDE (ASTM METHOD D6348)

3.2.1 Sampling Method

Oxides of Nitrogen, Carbon Monoxide, VOC, and Carbon Dioxide emissions were evaluated using ASTM Method D6348, "Measurement of Vapor Phase Organic Emissions by Extractive Fourier Transform Infrared (FTIR)". Triplicate 60-minute test runs were performed on Unit 4. Two 60-minute tests, and one 50-minute test was performed on Unit 5. Post test calibrations were started prior to 60-minutes of data collection.

Stratification testing was performed during the first run at each location. The exhausts were not stratified as the diluent gas (CO_2) did not vary more than 0.1% for Unit 4 and 0.08% for Unit 5.

At 8:33am of Run 1 on Unit 5 the engine shut down due to a turbo overheating. Operations and maintenance were able to diagnose the issue and re-start the engine. The testing was resumed at 9:22am.

The ASTM D6348 sampling system (Figure 2) consisted of the following:

(1) Stainless steel sampling probe
(2) Heated Filter Box
(3) Flexible heated PTFE sampling line
(4) Air Dimensions Heated Head Diaphragm Pump
(5) MKS MultiGas 2030 FTIR spectrometer
(6) Appropriate Protocol 1 calibration gases
(7) Data Acquisition System

The FTIR was equipped with a temperature controlled, 5.11 meter multipass gas cell maintained at 191°C. Gas flows and sampling system pressures were monitored using a rotometer and pressure transducer. All data was collected at 0.5 cm^{-1}.

3.2.2 Sampling Train Calibration

The FTIR was calibrated per procedures outlined in ASTM Method D6348. Direct measurements of nitrogen, nitric oxide (NO), carbon monoxide (CO), propane (C_3H_8), and ethylene (C_2H_4) gas standards were made at the test location to confirm concentrations.

A calibration transfer standard (CTS) was analyzed before and after testing at each location. The concentration determined for all CTS runs were within ±5% of the certified value of the standard. Ethylene was passed through the entire system to determine the sampling system response time and to ensure that the entire sampling system was leak-free.

Nitrogen was purged through the sampling system at each test location to confirm the system was free of contaminants.

NO, CO, and C_3H_8 gas standards were passed through the sampling system at each test location to determine the response time and confirm recovery.

NO, CO, and C_3H_8 spiking was performed to verify the ability of the sampling system to quantitatively deliver a sample containing NO, CO, and C_3H_8 from the base of the probe to the FTIR. Analyte spiking assures the ability of the FTIR to quantify NO, CO, and C_3H_8 in the presence of effluent gas. 4 analyte spikes were performed on each engine.

As part of the spiking procedure, samples from each engine were measured to determine NO, CO, and C_3H_8 concentrations to be used in the spike recovery

calculations. The determined sulfur hexafluoride (SF_6) concentration in the spiked and unspiked samples was used to calculate the dilution factor of the spike and thus used to calculate the concentration of the spiked NO, CO, and C_3H_8. The following equation illustrates the percent recovery calculation.

$$DF = \frac{SF_{6(spike)}}{SF_{6(direct)}}$$ (Sec. 9.2.3 (3) ASTM Method D6348)

$$CS = DF * Spike_{dir} + Unspike (1 - DF)$$ (Sec. 9.2.3 (4) ASTM Method D6348)

DF = Dilution factor of the spike gas
$SF_{6(direct)}$ = SF6 concentration measured directly in undiluted spike gas
$SF_{6(spike)}$ = Diluted SF_6 concentration measured in a spiked sample
$Spike_{dir}$ = Concentration of the analyte in the spike standard measured by the FTIR directly
CS = Expected concentration of the spiked samples
Unspike = Native concentration of analytes in unspiked samples

All analyte spikes were introduced using an instrument grade stainless steel rotometer. The spike target dilution ratio was 1:10 or less. All NO, CO, and C_3H_8 spike recoveries were within the ASTM D6348 allowance of ±30%.

3.2.3 Quality Control and Assurance

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 ± 5% agreement. If there is a difference greater than ± 5%, the spectra are reviewed for possible spectral interferences or any other possible causes that might lead to inaccurately quantified data. PRISM Analytical Technologies, Inc. validated the FTIR data. The data validation reports are in Appendix D.

3.2.4 Data Reduction

Each spectrum was derived from the coaddition of 64 scans, with a new data point generated approximately every minute. The NO_x, CO, and VOC emissions were recorded in parts per million (ppm) dry volume basis. The moisture content was

recorded in percent (%). The CO_2 emissions were recorded in percent (%) dry volume basis. Diluent concentrations were corrected for analyzer calibration drift according to Method 3A. The moisture content was recorded in percent (%).

The FTIR manufacturer (MKS) software calculated total non-methane- non-ethane VOC by summing the hydrocarbons measured, multiplied by each compounds' molar ratio to propane. VOCs measured consist of Propane, Butane, Ethylene, Acetylene, Propylene, Acetaldehyde, and Methanol.

4.0 OPERATING PARAMETERS

The test program included the collection of engine torque (%), engine speed (RPM), Horsepower (BHp), exhaust manifold air temperature (°F), suction and discharge pressure (psig), fuel upper heating value (BTU), and fuel flow (100SCFH).

The operational data collection system (PI) for Unit 4 was under maintenance during the test period. Screen shots of the operator's engine overview screen are provided and contain all pertinent operational data.

One-minute operational data is provided and averaged for Unit 5. Operational data is in Appendix E.

5.0 DISCUSSION OF RESULTS

Table Nos. 1 & 2 presents the emission testing results from EU017 and EU018 while operating at greater than 90% of full load conditions. The NO_x, CO, and NMOC emissions are presented in grams per brake horsepower hour (g/bHP-Hr). Additional test data presented for each test includes the engine load in percentage (%), heat input (MMBtu/hr), and emissions (ppm). Compressor Engines 4 & 5 demonstrated compliance with NO_x, CO, and NMOC emission limits as stated in Michigan Renewable Operating Permit No. MI-ROP-B6478-2021 and 40 CFR60.4244 Subpart JJJJ.

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6.0 CERTIFICATION STATEMENT

"I certify that I believe the information provided in this document is true, accurate, and complete. Results of testing are based on the good faith application of sound professional judgment, using techniques, factors, or standards approved by the Local, State, or Federal Governing body, or generally accepted in the trade."

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RESULTS TABLES

Gaseous Emissions Testing Results
Compressor Engine No. 4 Z-330
DTE Energy, Belle River Mills Compressor Station
St. Clair, Michigan

Parameter	Run 1	Run 2	Run 3	Average
Sampling Date	08/13/24	08/13/24	08/13/24	
Sampling Start Time	8:08-8:38, 8:40-9:10	9:21-10:21	10:32-11:32	
Gross Dry BTU	1058	1058	1058	1058
Load (%)	91.7	91.2	92.5	91.8
RPM	285	285	286	285
Brake-HP	8,253	8,211	8,325	8,263
Fuel Flow (100 scf/hr)	631.8	633.2	637.1	634.0
Heat Input Rate (MMBtu/Hr)	66.8	67.0	67.4	67.1
Average Outlet CO_2 Content (% dry)	3.1	3.1	3.1	3.1
Average Outlet CO_2 Content (% dry, corrected)[1]	3.1	3.1	3.1	3.1
Average Outlet CO Concentration (ppmv) (dry)	203.3	200.7	198.3	200.8
Average Outlet CO Concentration (lb/MMBtu)	0.496	0.487	0.481	0.488
Average Outlet CO Emission Rate (lb/hr, dry)	33.15	32.66	32.40	32.74
Average Outlet CO Emission Rate (lb/MMscf fuel)	524.72	515.74	508.55	516.34
CO Emission Rate (gram/BHP-Hr, dry)	**1.82**	**1.80**	**1.77**	**1.80**
Average Outlet NO_x Concentration (ppmv) (dry)	138.4	139.5	144.7	140.9
Average Outlet NO_x Concentration (lb/MMBtu)	0.555	0.557	0.576	0.562
Average Outlet NO_x Emission Rate (lb/hr, dry)	37.07	37.29	38.84	37.74
Average Outlet NOx Emission Rate (lb/MMscf fuel)	586.83	588.91	609.63	595.12
NO_x Emission Rate (gram/BHP-Hr, dry)	**2.04**	**2.06**	**2.12**	**2.07**

[1]corrected for analyzer drift as per USEPA Method 6C

CO_2 : carbon dioxide
CO : carbon monoxide
NO_x : oxides of nitrogen

Gaseous Emissions Testing Results
Compressor Engine No. 4 Z-330
DTE Energy, Belle River Mills Compressor Station
St. Clair, Michigan

Parameter	Run 1	Run 2	Run 3	Average
Sampling Date	08/13/24	08/13/24	08/13/24	
Sampling Start Time	8:08-8:38, 8:40-9:10	9:21-10:21	10:32-11:32	
Gross Dry BTU	1058	1058	1058	1058
Load (%)	91.7	91.2	92.5	91.8
RPM	285	285	286	285
Brake-HP	8,253	8,211	8,325	8,263
Fuel Flow (100 scf/hr)	631.8	633.2	637.1	634.0
Heat Input Rate (MMBtu/Hr)	66.8	67.0	67.4	67.1
Average Outlet CO_2 Content (% dry, corrected)[1]	3.2	3.1	3.1	3.2
THC Concentration (ppmv, as propane corrected)[1]	17.4	17.2	17.1	17.2
THC Concentration (lb/MMBtu)	0.064	0.066	0.065	0.065
THC Emission Rate (lb/hr)	4.28	4.41	4.40	4.36
THC Emission Rate (gram/BHP-Hr)	**0.2**	**0.2**	**0.2**	**0.2**

Gaseous Emissions Testing Results
Compressor Engine No. 5 Z-330
DTE Energy, Belle River Mills Compressor Station
St. Clair, Michigan

Parameter	Run 1	Run 2	Run 3	Average
Sampling Date	08/14/24	08/14/24	08/14/24	
Sampling Start Time	07:48-08:33, 9:22-9:38	9:48-10:48	10:59-11:50	
Gross Dry BTU	1060	1060	1060	1060
Load (%)	97.5	96.6	96.5	96.9
RPM	280	280	280	280
Brake-HP	8,270	8,202	8,189	8,220
Fuel Flow (100 scf/hr)	645.2	642.1	639.0	642.1
Heat Input Rate (MMBtu/Hr)	68.4	68.0	67.7	68.0
Average Outlet CO_2 Content (% dry)	3.0	3.0	3.0	3.0
Average Outlet CO_2 Content (% dry, corrected)[1]	3.0	3.0	3.0	3.0
Average Outlet CO Concentration (ppmv) (dry)	215.1	219.8	223.9	219.6
Average Outlet CO Concentration (lb/MMBtu)	0.537	0.549	0.555	0.547
Average Outlet CO Emission Rate (lb/hr, dry)	36.74	37.33	37.59	37.22
Average Outlet CO Emission Rate (lb/MMscf fuel)	569.44	581.30	588.31	579.69
CO Emission Rate (gram/BHP-Hr, dry)	**2.01**	**2.06**	**2.08**	**2.05**
Average Outlet NO_x Concentration (ppmv) (dry)	110.3	107.1	106.1	107.8
Average Outlet NO_x Concentration (lb/MMBtu)	0.453	0.439	0.432	0.441
Average Outlet NO_x Emission Rate (lb/hr, dry)	30.95	29.88	29.26	30.03
Average Outlet NOx Emission Rate (lb/MMscf fuel)	479.71	465.32	457.99	467.67
NO_x Emission Rate (gram/BHP-Hr, dry)	**1.70**	**1.65**	**1.62**	**1.66**

[1]corrected for analyzer drift as per USEPA Method 6C

CO_2 : carbon dioxide
CO : carbon monoxide
NO_x : oxides of nitrogen

Gaseous Emissions Testing Results
Compressor Engine No. 5 Z-330
DTE Energy, Belle River Mills Compressor Station
St. Clair, Michigan

Parameter	Run 1	Run 2	Run 3	Average
Sampling Date	08/14/24	08/14/24	08/14/24	
Sampling Start Time	07:48-08:33, 9:22-9:38	9:48-10:48	10:59-11:50	
Gross Dry BTU	1060	1060	1060	1060
Load (%)	97.5	96.6	96.5	96.9
RPM	280	280	280	280
Brake-HP	8,270	8,202	8,189	8,220
Fuel Flow (100 scf/hr)	645.2	642.1	639.0	642.1
Heat Input Rate (MMBtu/Hr)	68.4	68.0	67.7	68.0
Average Outlet CO_2 Content (% dry, corrected)[1]	3.0	3.0	3.0	3.0
THC Concentration (ppmv, as propane corrected)[1]	22.3	21.6	21.3	21.7
THC Concentration (lb/MMBtu)	0.088	0.085	0.083	0.085
THC Emission Rate (lb/hr)	5.99	5.77	5.63	5.80
THC Emission Rate (gram/BHP-Hr)	**0.3**	**0.3**	**0.3**	**0.3**

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FIGURES

Figure 1 – Sampling Locations
Compressor Engines 4 & 5 - Z330
Belle River Mills Compressor Station

Point	Inches
1	2.90
2	9.64
3	19.54
4	46.46
5	56.36
6	63.10

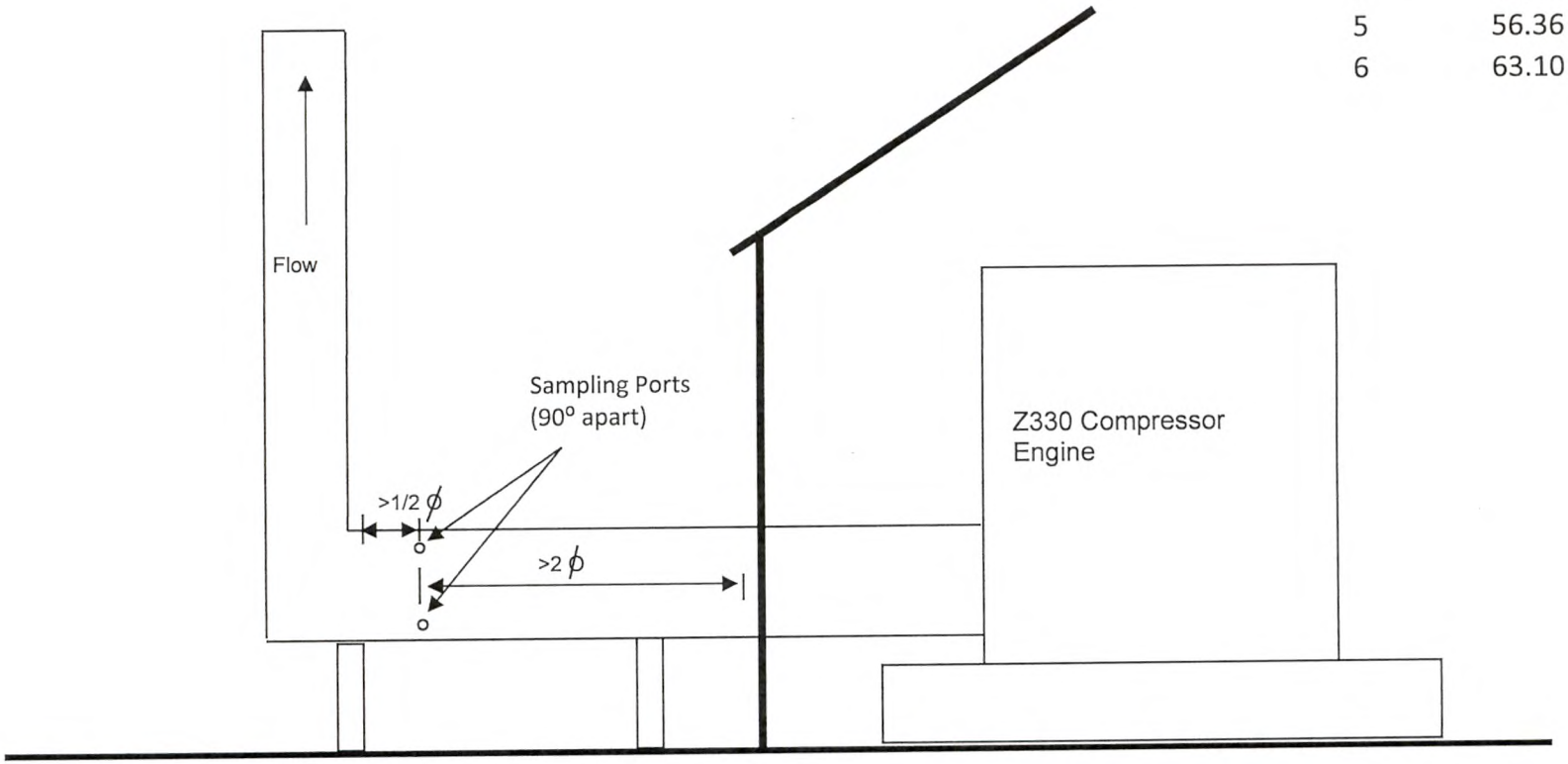

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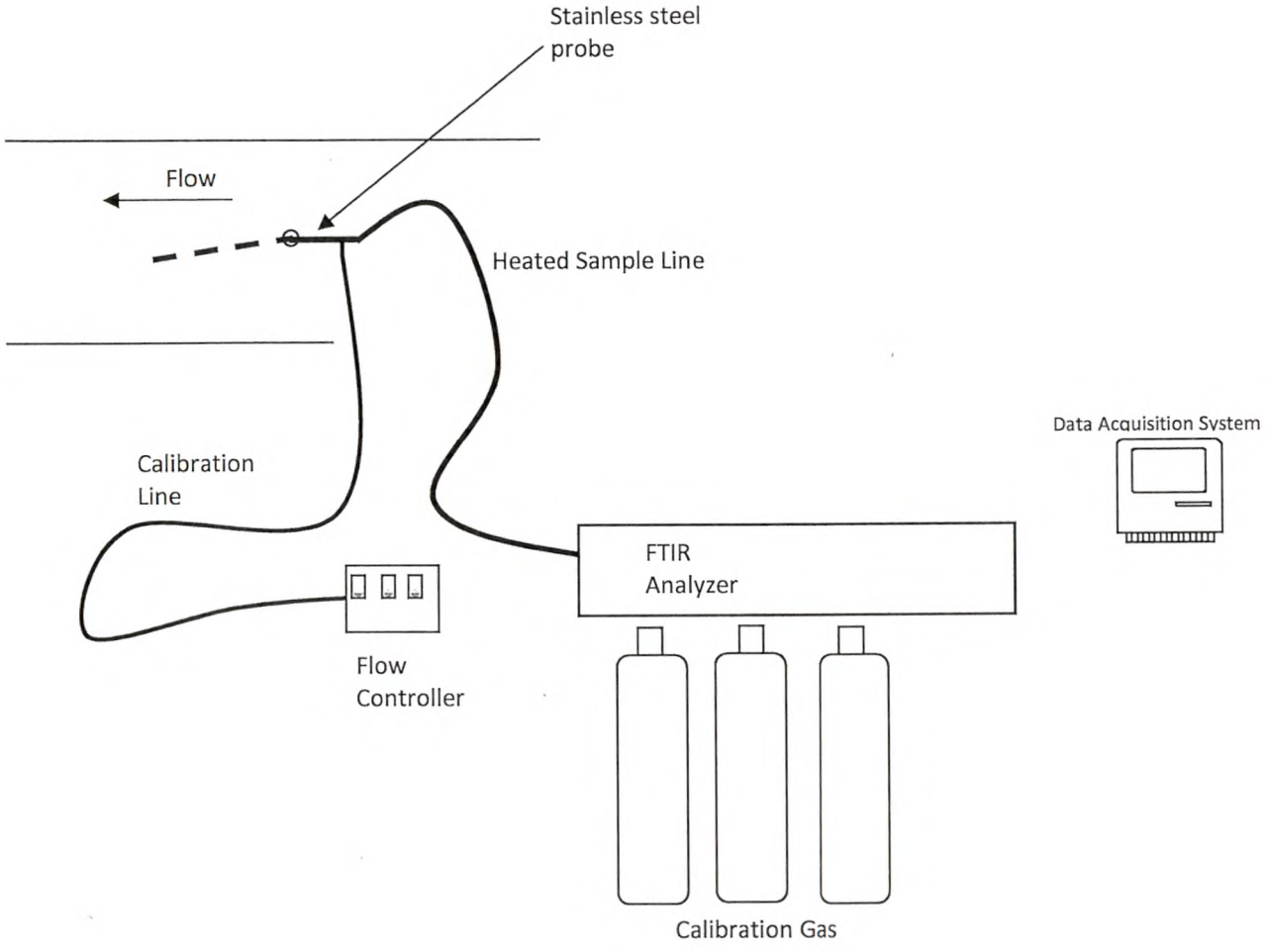
Figure 2 – ASTM D6348
Compressor Engines 4 & 5 - Z330
Belle River Mills Compressor Station



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