AIR EMISSION TEST REPORT FOR THE VERIFICATION OF PENTANE CAPTURE AND DESTRUCTION EFFICIENCY FOR PRE-EXPANSION SYSTEM

Prepared for:

DART CONTAINER OF MICHIGAN, LLC
SRN D8065

ICT Project No.: 2300150
September 26, 2023

IMPACT
COMPLIANCE & TESTING

Report Certification

AIR EMISSION TEST REPORT
FOR THE VERIFICATION OF
PENTANE CAPTURE AND DESTRUCTION EFFICIENCY
FOR PRE-EXPANSION SYSTEM

DART CONTAINER OF MICHIGAN, LLC
Mason, Michigan

This report has been reviewed by Dart Container of Michigan, LLC representatives and approved for submittal to the EGLE-AQD. A Renewable Operating Permit Report Certification form signed by the Dart Container of Michigan, LLC Responsible Official accompanies this report.

I certify that the testing was conducted in accordance with the reference test methods and submitted test plan unless otherwise specified in this report. I believe the information provided in this report and its attachments are true, accurate, and complete.

Prepared By:

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Technical Manager

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1.0 Introduction

Dart Container of Michigan, LLC (Dart) owns and operates a facility located in Mason, Ingham County, Michigan (State Registration No. D8065) that manufactures foam containers made from expandable polystyrene (EPS) beads. The facility has been issued Renewable Operating Permit (ROP) No. MI-ROP-D8065-2020 by the Michigan Department of Environment, Great Lakes and Energy, Air Quality Division (EGLE-AQD).

Pentane impregnated EPS beads are used to make foam containers using a steam chest molding process. The process (EU-CUP) consists of dumpers, blenders, hoppers, pre-expanders, graders/screeners, bead storage bags and molding machines. The blenders, hoppers and pre-expanders are collectively referred to as the Pre-Expansion System. Pentane emissions from the Pre-Expansion System are collected using the Pentane Control System and directed to three (3) boilers for emission reduction prior to exhaust to the atmosphere.

Dart is required to verify the pentane capture efficiency for EU-CUP Pre-Expansion System and pentane destruction efficiency for the boiler Pentane Control System every five years for EU-CUP as specified in MI-ROP-D8065-2020.

This test report presents the results of pentane control efficiency testing that was performed August 15 – 16, 2023 to determine the pentane:

- Destruction efficiency associated with the Boiler Nos. 7 and 8 operating under modulating and low fire conditions; and
- Capture efficiency associated with EU-CUP Pre-Expansion System.

The control efficiency evaluation was performed using procedures specified in the test plan dated July 5, 2023 that was submitted to the Michigan Department of Environment, Great Lakes and Energy (EGLE-AQD) for review and approval.

Attachment 1 provides a copy of the EGLE-AQD test plan approval letter.

Contact information for this project is presented below:

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2.0 Summary of Test Results and Operating Conditions

2.1 Results for Pentane Destruction Efficiency

Pentane destruction efficiency was determined for Boiler No. 7 and Boiler No. 8 while operating under normal modulating conditions and also low firing conditions. Three (3) one-hour test periods were performed on each boiler (two test periods in modulating mode and one test period in low fire mode). The pentane destruction efficiency was determined by simultaneously measuring the mass flowrate of total hydrocarbons (THC), measured as propane, entering and exiting the boiler and converting the concentration to pentane using a propane to pentane response factor that was generated for each THC analyzer.

The Boiler No. 7 average measured pentane destruction efficiency for the modulating operating mode is 93% by weight. The Boiler No. 7 average measured pentane destruction efficiency for the low fire operating mode is 92% by weight.

The Boiler No. 8 average measured pentane destruction efficiency for the modulating operating mode is 97% by weight. The Boiler No. 8 average measured pentane destruction efficiency for the low fire operating mode is 92% by weight.

The overall average DE during the operating scenario where both boilers were modulating was ≥95%, demonstrating compliance with the permitted pentane destruction efficiency requirement for that operating scenario.

The Boiler No. 7 average exhaust gas temperature for the modulating operating mode was 334 °F. The Boiler No. 7 average exhaust gas temperature for the low firing operating mode was 327 °F.

The Boiler No. 8 average exhaust gas temperature for the modulating operating mode was 338 °F. The Boiler No. 7 average exhaust gas temperature for the low firing operating mode was 333 °F.

The pentane destruction efficiency test results are summarized in Table No. 2.1. A matrix presenting the overall destruction efficiency for the combined operation of Boiler Nos. 7 and 8 is presented in Table 2.2. Data and information for each test period are presented in Section 5.0 and Table Nos. 5.1 – 5.2.

2.2 Results for EU-CUP Pre-Expansion System Pentane Capture Efficiency

Pentane capture efficiency was determined during six (6) one-hour test periods on August 15 – 16, 2023. The pentane capture efficiency was determined by measuring the mass flowrate of total hydrocarbons (THC), measured as propane, in the EU-CUP Pre-Expansion system captured duct and converting the concentration to pentane using a propane to pentane response factor that was generated for the THC analyzer. The mass of pentane emitted from the Pre-Expansion System was determined using Dart's records of material use and a factor that Dart developed to account for the amount of pentane released in the Pre-Expansion System.

The average pentane capture efficiency for the EU-CUP Pre-Expansion System is 45% by weight.

The pentane capture efficiency test results are summarized in Table No. 2.3. Data and information for each test period are presented in Section 5.0 and Table No. 5.3.

Table 2.1 Summary of Boiler Nos. 7 and 8 pentane destruction efficiency test results

Emission Unit / Operating Mode	Test 1	Test 2	Test 3	Average
Boiler No. 7 - Modulating	94%	93%	-	93%
Boiler No. 7 – Low Fire	-	-	92%	92%
Boiler No. 8 - Modulating	97%	97%	-	97%
Boiler No. 8 – Low Fire	-	-	92%	92%
Permit Requirement	--	--	--	**≥95%**

Table 2.2 Destruction efficiencies for combined operation of Boiler Nos. 7 and 8 at various operating modes

Emission Unit / Operating Mode	Boiler No. 8 - Modulating	Boiler No. 8 – Low Fire
Boiler No. 7 - Modulating	95%	93%
Boiler No. 7 – Low Fire	94%	92%

Table 2.2 Summary of EU-CUP pre-expansion system pentane capture efficiency test results

Test No.	Measured Pentane Capture Efficiency
Test Period No. 1	47%
Test Period No. 2	44%
Test Period No. 3	46%
Test Period No. 4	46%
Test Period No. 5	46%
Test Period No. 6	43%
Average Capture Efficiency	45%
Permitted Limit	**≥30%**

3.0 Source and Sampling Location Description

3.1 Foam Container Production Line

EU-CUP is a foam container production line. Pentane impregnated expandable polystyrene (EPS) beads are expanded into foam containers using a steam chest molding process. The process (EU-CUP) consists of dumpers, blenders, hoppers, pre-expanders, graders/screeners, bead storage bags and molding machines. The blenders, hoppers and pre-expanders are collectively referred to as the Pre-Expansion System.

Pentane emissions from the Pre-Expansion System are collected using the Pentane Control System and directed to three (3) boilers for emission reduction prior to exhaust to the atmosphere.

3.2 Type of Raw Materials Used

The raw materials used in the EU-CUP process are pentane impregnated EPS beads. The maximum EPS bead use rate is 5,000 lb/hr. Typical EPS bead use rate is 1,129 lb/hr. ROP No. MI-ROP-D8065-2020 limits the pentane concentration of the EPS beads to a maximum of 6.5% by weight.

During the emissions testing Dart processed EPS beads that ranged in pentane concentration from 5.14 – 5.27 % by wt. and the process bead use rate averaged 1,674 lb/hr.

3.3 Emission Control System Description

3.3.1 EU-CUP Pre-Expansion System Pentane Capture

The Pentane Control System is responsible for capturing the pentane emissions from the EPS bead Pre-Expansion System. The Pentane Control System consists of the ductwork, blower, pentane monitoring device, flow measurement device, safety valves, flame arrestor and three (3) boilers.

ROP No. MI-ROP-D8065-2020 specifies a minimum pentane capture efficiency of 30% by weight.

3.3.2 EU-CUP Boilers

Air collected from Pre-Expansion System is directed to one of three boilers for pentane emission reduction. In the boilers, pentane is oxidized (or destroyed) at high temperature to form carbon dioxide and water vapor.

The three boilers (EU-BOILER5, EU-BOILER7 and EU-BOILER8) are fueled with natural gas and two (EU-BOILER5 and EU-BOILIER7) have the capacity to use No. 2 fuel oil as a backup. EU-BOILER5 is a 600 hp boiler. EU-BOILER7 is a 700 hp boiler. EU-BOILER8 is an 800 hp boiler. The Pentane Control System main header duct branches off to individual dedicated ducts that feed each boiler.

Each boiler has an exhaust stack temperature monitoring system installed. The ROP and Compliance Assurance Monitoring (CAM) plan for the facility specifies a minimum exhaust gas temperature of 300 °F for proper operation. ROP No. MI-ROP-D8065-2020 specifies a minimum pentane destruction efficiency of 95% by weight.

During the emission testing program only two (2) boilers were operational, Boiler No. 7 and 8. Boiler No. 5 was taken offline for maintenance.

4.0 Sampling and Analytical Procedures

A description of the sampling and analytical procedures is provided in the test plan dated April 3, 2023, which was reviewed and approved by the MDEQ-AQD. This section provides a summary of those procedures.

4.1 Reference Test Methods

The following USEPA reference test methods were used as part of this project:

Property or Analyte Measured	Reference Test Method	Analytical Methodology
Velocity Traverses	Method 1	Selection of velocity traverse and sample locations based on physical measurements
Volumetric Flowrate	Method 2	Measurement of velocity head using a Type-S Pitot tube and inclined manometer
Molecular Weight[1] (Captured gas stream)	Method 2	Dry molecular weight for ambient air (29.0)
Molecular Weight (Boiler outlet)	Method 3	Exhaust gas O_2 and CO_2 content using Fyrite® gas analyzer or Method 3A instrumental anlayzer.
Moisture (Captured Gas Stream)	Method 4	Moisture determination by wet-bulb / dry-bulb temperature measurements
Moisture (Boiler outlet)	Method 4	Moisture determination by chilled impinger method
VOC Concentration (inlet and outlet)	Method 25A	Determination of gaseous VOC concentration using a flame ionization analyzer (FIA)

4.2 Pentane Control System Capture Efficiency Verification

The Pentane Control System capture efficiency was determined by comparing the:

- Calculated Pre-Expansion System pentane emission rate (lb/hr); vs.
- The measured pentane mass flow rate (lb/hr) in the Pre-Expansion System captured gas stream.

The combined duct for the Pentane Control System measurement location is shown in photographs contained in Attachment 2.

The total amount of pentane contained in the beads was calculated based on the manufacturer's specified pentane concentration for the EPS beads that were processed during the test period and the mass of EPS beads that were used during each test period. Not all of the pentane in the EPS beads is emitted in the Pre-Expansion System. Dart estimates that 53% of the available pentane is emitted in the Pre-Expansion System. The rest of the pentane is emitted after the Pre-Expansion System and while the final product is in storage. The following equation was used:

$$Q_{pentane} = \sum (M_{bead,i} * C_{pentane,i}) * 0.53$$

Where: $Q_{Pentane}$ = total mass flow of pentane emitted in the Pre-Expansion System ($lb_{pentane}$ / hr)
$M_{bead,i}$ = mass use rate of EPS beads ($lb_{bead\ used}$ / hr)
$C_{Pentane}$ = concentration of pentane in EPS bead (%by wt.)

The procedures of USEPA Method 204B were used to measure the captured pentane (as propane) mass flowrate using a single flame ionization analyzer positioned in the Pentane Control System duct. USEPA Methods 1 through 4 were used to measure air flowrate during each test period. Captured gas properties were determined pursuant to USEPA Methods 2 and 4 (ambient air dry molecular weight of 29.0 and wet bulb-dry bulb temperature measurements to determine moisture content).

The FIA, calibrated with a propane standard measured the amount of pentane in the exhaust duct (relative to propane). A propane to pentane response factor for the FIA was developed, for each FIA used, using the procedure specified in USEPA Method 204F, Section 8.2.4. A gas cylinder containing a certified concentration of pentane was used to develop the response factor. Equation 9.2.4 of USEPA Method 204F was used to calculate the propane to pentane response factor.

$$RF = C_{pentane} / C_{gas}$$

Where: RF = propane to pentane response factor
C_{gas} = certified concentration of pentane gas (ppmv)
$C_{Pentane}$ = FIA response to known concentration of pentane (ppmv, as propane)

The measured RF for the FIA used to measure the capture gas stream was 1.64 on 8/15/23 and 1.61 on 8/16/23. The measured RF for the FIA used to measure the boiler exhaust streams was 1.65.

The concentration of pentane (measured as propane) in the Pentane Control System captured duct was multiplied by the developed response factor in order to determine the concentration of pentane in the Pentane Control System captured duct.

The pentane mass flowrate in the captured Pentane Control System duct was calculated using the following equation based on the measured air flowrate, measured pentane concentration (average ppmv for test period), and molecular weight of pentane (72.15 lb/lb-mol).

$$M_{Pentane} = Q\,[C_{Pentane}]\,(MW_{C5})\,(60\text{ min/hr}) / VM / 1E{+}06$$

Where:

$M_{Pentane}$	= Mass flowrate pentane (lb/hr)
Q	= Volumetric flowrate (scfm)
$C_{Pentane}$	= Pentane concentration (ppmv, C5)
MW_{C5}	= Molecular weight of propane (72.15 lb/lb-mol)
VM	= Molar volume of ideal gas at standard condition (385 scf/lb-mol)

The pentane capture efficiency was determined using the following equation:

$$CE_{pentane} = \frac{M_{pentane}}{Q_{pentane}}\ (100\ \%)$$

Where:

$CE_{pentane}$	= Pentane capture efficiency (% weight)
$M_{pentane}$	= Pentane mass flowrate for captured stream (lb/hr)
$Q_{pentane}$	= total mass flow of pentane emitted in the Pre-Expansion System (lb/hr)

The Pre-Expansion System capture efficiency test periods were performed at the same time as the boiler destruction efficiency test periods.

4.3 Boiler Destruction Efficiency Determination

Boiler pentane destruction efficiency was determined based on the simultaneous sampling of the boiler inlet and exhaust gas streams. Pentane concentration in the boiler inlet and outlet were measured using FIAs to measure total hydrocarbons (THC) relative to a propane (C_3) standard according to USEPA Method 25A (Thermo Environmental Instruments model 51c or equivalent). The THC concentration in the boiler inlet was measured in the Pentane Control System duct. The THC concentration, measured as propane, was converted to an as pentane basis using the response factors for each analyzer, as described in Section 4.2.

The measurement locations are shown in photographs contained in Attachment 2.

Volumetric air flowrate into and out of the boiler were determined using the following methods and procedures:

- Air velocity measurements were performed at least once during each one-hour test period using USEPA Method 2.
- The boiler inlet gas is captured building air and a dry molecular weight of 29.0 was used as specified in Section 8.6 of Method 2. Moisture content was determined by wet-bulb / dry-bulb temperature measurements. The boiler inlet gas flowrate measurements were performed in the dedicated inlet duct to each boiler.
- Molecular weight for the boiler exhaust gas were based on measurements using a hand-held Fyrite® combustion gas analyzer as referenced in USEPA Method 3. The Method 4 chilled impinger method was used to determine boiler exhaust gas moisture.

The THC mass flowrate, as pentane, into and out of the boiler was calculated using the following equation based on the measured air flowrate, measured THC concentration (average ppmv for test period, as pentane), and molecular weight of pentane (72.15 lb/lb-mol).

$M_{pentane} = Q\ [C_{pentane}]\ (MW_{C5})\ (60\ \text{min/hr}) / VM / 1E{+}06$

Where:	$M_{pentane}$	= Mass flowrate pentane (lb/hr)
	Q	= Volumetric flowrate (scfm)
	$C_{pentane}$	= THC concentration (ppmv, C5)
	MW_{C5}	= Molecular weight of pentane (72.15 lb/lb-mol)
	VM	= Molar volume of ideal gas at standard condition (385 scf/lb-mol)

The pentane destruction efficiency of the boiler emission control device was determined for each test period using the following equation:

$DE = [1 - (M_{pentane\text{-}in} / M_{pentane\text{-}out})] \times 100\%$

Where:	DE	= pentane destruction efficiency (%wt)
	$M_{pentane\ in}$	= pentane mass flowrate into the boiler (lb/hr)
	$M_{pentane\ out}$	= pentane mass flowrate exhausted from the boiler (lb/hr)

4.4 Sampling Locations and Stack Gas Velocity (USEPA Method 1 and 2)

Prior to conducting the test program, stack gas sampling locations (i.e., pollutant concentration and velocity pressure measurement locations) were determined in accordance with the procedures specified in USEPA Method 1.

Exhaust gas velocity was measured using USEPA Method 2 during each test period. Gas velocity (pressure) measurements were performed at each gas traverse point using an S-type Pitot tube and red-oil manometer or a slack-tube manometer. Temperature measurements were conducted at each traverse point using a K-type thermocouple and a calibrated digital thermometer.

Prior to performing the initial velocity traverse, and periodically throughout the test program, the S-type Pitot tube and manometer lines were leak-checked at the test site.

4.5 Measurement of CO_2 and O_2 concentrations (USEPA Method 2/3)

CO_2 and O_2 content for the Pentane Control System duct and each dedicated boiler inlet duct were determined using a dry molecular weight of 29.00 per Section 8.6 in USEPA Method 2. Boiler exhaust gas CO_2 and O_2 content were determined using Fyrite® gas scrubbers.

4.6 Determination of Moisture Content (USEPA Method 4)

Moisture content of the boiler exhaust gas stream was determined in accordance with the USEPA Method 4 chilled impinger method. A gas sample was extracted at a constant rate (non-isokinetic) from a single point in the boiler exhaust stack where moisture was removed from the sample stream and determined gravimetrically (or volumetrically) from the impinger water gain.

Moisture measurements for each boiler inlet and the combined Pentane Control System duct were determined using the USEPA Method 4 wet-bulb/dry-bulb approximation technique. Wet bulb and dry bulb temperature measurements were obtained using a type-K thermocouple and calibrated digital pyrometer; the corresponding moisture content was determined using these measurements in conjunction with a psychometric chart.

4.7 THC Concentration Measurements (USEPA Method 25A)

THC concentration for each measured gas stream was determined using a flame ionization analyzer (FIA) in accordance with USEPA Method 25A, *Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer,* for direct measurement of THC concentrations in exhaust gases. A Thermo Environmental Instruments, Inc. (TEI), Model 51c THC analyzer was used to determine the THC inlet and exhaust concentration.

The sample gas was delivered to the instruments using an extractive gas sampling system that prevents condensation or contamination of the sample. The gas samples were not conditioned (i.e., dried) prior to being introduced to the FIA instruments.

The FIA instruments were calibrated using certified concentrations of propane in air. The calibration gases were diluted with hydrocarbon free air to obtain intermediate propane concentrations and to demonstration linearity of the instruments. A pentane response factor was developed for each Model 51c analyzer using a certified concentration of pentane.

5.0 Test Results and Discussion

5.1 Control Device and Process Operating Data

Control device and process operating data were recorded during each test period including:

- Mass of EPS beads process and pentane content of the beads;
- Hourly flow rate and pentane concentration as recorded by the Pentane Control System; and
- Boiler operating condition and boiler stack flue gas temperature.

Attachment 3 provides process operating records for the test event.

5.2 Boiler Pentane Destruction Efficiency

Table Nos. 5.1 and 5.2 present measured gas conditions and results for each destruction efficiency test period.

Pentane destruction efficiency was determined for three (3) one-hour test periods by simultaneously measuring the THC mass flowrate (as pentane) entering and exiting the Boiler No. 7 and Boiler No. 8 while operating in normal modulating mode and an alternate low fire mode. Test Period Nos. 1 and 2 for each boiler were conducted while the boiler operated in normal / modulating mode. Test Period No. 3 for each boiler was conducted while the boiler operated in low fire mode.

The Boiler No. 7 average measured pentane destruction efficiency for the modulating operating mode is 93% by weight. The Boiler No. 7 average measured pentane destruction efficiency for the low fire operating mode is 92% by weight. The Boiler No. 7 average exhaust gas temperature for the modulating operating mode was 334 °F. The Boiler No. 7 average exhaust gas temperature for the low firing operating mode was 327 °F.

The Boiler No. 8 average measured pentane destruction efficiency for the modulating operating mode is 97% by weight. The Boiler No. 8 average measured pentane destruction efficiency for the low fire operating mode is 92% by weight. The Boiler No. 8 average exhaust gas temperature for the modulating operating mode was 338 °F. The Boiler No. 7 average exhaust gas temperature for the low firing operating mode was 333 °F.

Special Condition No. IV.1 of MI-ROP-D8065-2020 specifies a minimum pentane destruction efficiency of 95% by weight for the pentane emissions captured from Pre-expansion System. The overall average DE during the operating scenario where both boilers were modulating was ≥95%, demonstrating compliance with this requirement for that operating scenario.

Further; samples of the boiler exhaust gas were analyzed for methane content following the emission testing program. The Boiler No. 7 modulating scenario had an elevated concentration of methane, such that, if it were subtracted from the measured pentane concentration the calculated destruction efficiency would have exceeded 95%. The

Pentane Control System captured gas stream is not expected to contain any methane (i.e., the only potential hydrocarbon in that gas stream is pentane).

Attachment 4 provides test data for the boiler pentane destruction efficiency testing performed August 15 – 16, 2023, field data sheets, and calculations.

Table 5.1 Measured Boiler No. 7 gas conditions and destruction efficiency test results Dart Container of Michigan, LLC

Test No. Test date	1 - Normal 8/15/23	2 - Normal 8/15/23	Normal Average	3 – Low Fire 8/15/23
Avg. Boiler Exhaust Temp (˚F)	334	335	334	327
Mass Type 601 Bead Used (lb)	311	318	315	323
Type 601 Bead C_5 Conc. (wt. %)	5.20	5.20	5.20	5.20
Mass Type 701 Bead Used (lb)	1,401	1,613	1,507	979
Type 701 Bead C_5 Conc. (wt. %)	5.14	5.14	5.14	5.14
PCS Recorded Flow (scfm)	762	759	761	760
PCS Recorded C_5 Mass Flow (lb/hr)	17.2	18.6	17.9	13.3
Boiler No. 7 Inlet				
Boiler 7 Inlet Flowrate (scfm)	891	913	902	884
Boiler 7 Inlet C_5 Conc. (ppmv)	978	1,049	1,013	788
Inlet Pentane Mass Flow (lb/hr)	9.80	10.8	10.3	7.83
Boiler No. 7 Exhaust				
Boiler 7 Exhaust Flowrate (scfm)	4,785	4,897	4,841	2,248
Boiler 7 Exhaust C_5 Conc. (ppmy)	11.3	13.4	12.3	25.9
Exhaust Pentane Mass Flow (lb/hr)	0.61	0.74	0.67	0.65
Destruction Efficiency[1](%wt)	94%	93%	93%	92%

1. Pentane Destruction Efficiency = 1 - [C5 out / C5 in] x 100%

Table 5.2 Measured Boiler No. 8 gas conditions and destruction efficiency test results Dart Container of Michigan, LLC

Test No. Test date	1 - Normal 8/16/23	2 - Normal 8/16/23	Normal Average	3 – Low Fire 8/16/23
Avg. Boiler Exhaust Temp (˚F)	336	340	338	333
Mass Type 601 Bead Used (lb)	349	461	405	517
Type 601 Bead C_5 Conc. (wt. %)	5.27	5.27	5.27	5.27
Mass Type 701 Bead Used (lb)	1,312	1,586	1,449	874
Type 701 Bead C_5 Conc. (wt. %)	5.22	5.22	5.22	5.15
PCS Recorded Flow (scfm)	761	756	758	766
PCS Recorded C_5 Mass Flow (lb/hr)	15.7	19.3	17.5	13.2
Boiler No. 8 Inlet				
Boiler 8 Inlet Flowrate (scfm)	957	984	970	898
Boiler 8 Inlet C_5 Conc. (ppmv)	929	1,128	1,029	739
Inlet Pentane Mass Flow (lb/hr)	9.99	12.5	11.2	7.46
Boiler No. 8 Exhaust				
Boiler 7 Exhaust Flowrate (scfm)	1,938	2,902	2,420	1,184
Boiler 7 Exhaust C_5 Conc. (ppmy)	14.9	12.1	13.5	44.3
Exhaust Pentane Mass Flow (lb/hr)	0.33	0.39	0.36	0.59
Destruction Efficiency[1](%wt)	97%	97%	97%	92%

1. Pentane Destruction Efficiency = 1 - [C5 out / C5 in] x 100%

5.3 PENTANE CONTROL SYSTEM CAPTURE EFFICIENCY

Table No. 5.3 present measured gas conditions and results for each capture efficiency test period.

Pentane capture efficiency was determined for six (6) one-hour test periods. The testing was conducted simultaneously with the boiler destruction efficiency testing. The testing was performed by measuring the THC mass flowrate (as pentane) in the combined Pre-Expansion System Pentane Control System duct and calculating the amount of pentane exhausted in the Pre-Expansion System while operating in normal modulating mode and an alternate low fire mode. Test Period Nos. 1, 2, 4 and 5 were conducted while the boilers operated in normal / modulating mode. Test Period Nos. 3 and 6 were conducted while one (1) boiler operated in low fire mode.

The average measured pentane capture efficiency for the Pentane Control System is 45% by weight. An average of 380 pounds of Type 601 beads, with a pentane concentration of 5.24% by weight were used during each test. An average of 1,294 pounds of Type 701 beads, with a pentane concentration of 5.16% by weight were used during each test.

Special Condition No. IV.2 of MI-ROP-D8065-2020 specifies a minimum pentane capture efficiency of 30% by weight for the Pre-expansion System Pentane Control System.

Attachment 5 provides test data for the boiler pentane capture efficiency testing performed August 15 – 16, 2023, field data sheets, and calculations.

Attachment 6 contains the instrument raw data.

Table 5.3 Capture efficiency test results for EUCUP

Test No. Test date	1 8/15/23	2 8/15/23	3 8/15/23	4 8/16/23	5 8/16/23	6 8/16/23	Six-Test Average
Pentane Use Rate							
Mass Type 601 Bead Used (lb)	311	318	323	349	461	517	380
Type 601 Bead C_5 Conc. (wt. %)	5.20	5.20	5.20	5.27	5.27	5.27	5.24
Mass Type 701 Bead Used (lb)	1,401	1,613	979	1,312	1,586	874	1,294
Type 701 Bead C_5 Conc. (wt. %)	5.14	5.14	5.14	5.22	5.22	5.15	5.16
Available Pentane (lb/hr)	88.2	99.4	67.1	86.9	107	72.3	86.8
Pentane Emitted in Pre-Expansion System (lb/hr)	46.7	52.7	35.6	46.0	56.8	38.3	46.0
Pentane Control System							
Captured Duct Flowrate (scfm)	2,005	1,943	1,848	2,046	2,070	1,967	1,980
Captured Duct C_5 Conc. (ppmv)	978	1,049	788	929	1,128	739	935
Captured Duct Pentane Mass Flow (lb/hr)	22.0	22.9	16.4	21.4	26.3	16.3	20.9
Capture Efficiency[1] (%wt)	47%	43%	46%	46%	46%	43%	45%

5.4 VARIATIONS FROM NORMAL SAMPLING PROCEDURES

The testing was performed as described in this report and in accordance with the reference test methods, test plan dated July 5, 2023, and the EGLE-AQD test plan approval unless otherwise noted in this report. There are no test method deviations to report.

5.5 TEST RESULT DISCUSSION

MI-ROP-D8065-2020 specifies a minimum pentane destruction efficiency of 95% for the boilers associated with the Pentane Control System. The ROP also specifies a minimum pentane capture efficiency of 30% for the pentane emissions from the Pre-Expansion System. This represents an overall pentane control efficiency of 29% for emissions of pentane from the Pre-Expansion System.

Overall Control Efficiency (29%) = Destruction Efficiency (95%) * Capture Efficiency (30%)

Boiler No. 7 had a tested destruction efficiency that was less than 95% during normal/modulating (93%) and low-fire operation (92%), however, the overall control efficiency of pentane emissions from the Pre-Expansion System (combined pentane capture and destruction efficiencies) was 42% during normal/modulating operation and 42% during low fire operation. The calculated pentane control efficiency for Boiler No. 7 exceeds what is required by the ROP in both normal/modulating and low-fire operating modes.

Boiler No. 8 had a tested destruction efficiency that was less than 95% during low-fire operation (92%), however, the overall control efficiency (combined pentane capture and destruction efficiencies) of pentane emissions from the Pre-Expansion System was 42% during low fire operation (it was 44% during normal/modulating operation). The calculated pentane control efficiency for Boiler No. 8 exceeds what is required by the ROP in both normal/modulating and low-fire operating modes.

6.0 Quality Assurance Procedures

Attachment 7 provides quality assurance and calibration records for the sampling equipment used during the test periods, including gas divider and instrumental analyzer calibration records, calibration gas certificates, and calibration information for the dry gas meter.

6.1 Exhaust Gas Flow Measurements (Methods 1 and 2)

Prior to arriving onsite, the instruments used during the source test to measure exhaust gas properties and velocity (pyrometer, and Pitot tube) were calibrated to specifications outlined in the sampling methods.

The physical design and condition of the Pitot tubes used for velocity pressure measurements satisfied USEPA Method 2 criteria. The gas velocity measurement train (Pitot tube, connecting tubing and manometer) was leak-checked prior to the field measurements and periodically throughout the test event.

The absence of cyclonic flow for each sampling location was verified using the gas velocity measurement train (S-type Pitot tube connected to an oil manometer). The Pitot tube was positioned at the velocity traverse point with the planes of the face openings of the Pitot tube perpendicular to the stack cross-sectional plane. The Pitot tube was then rotated to determine the null angle (rotational angle as measured from the perpendicular, or reference, position at which the differential pressure is equal to zero). The measured null angle for each traverse location was recorded on a data sheet. Cyclonic flow at each sampling location is minimal.

6.2 Instrument Calibration and System Bias Checks (Methods 25A)

Accuracy of the instrumental analyzers used to measure THC concentration was verified prior to and at the conclusion of each test period using the calibration procedures in Methods 25A and 7E.

At the beginning of each test day, appropriate high-range, mid-range, and low-range span gases followed by a zero gas were introduced to the THC analyzers, in series at a tee connection, which is installed between the sample probe and the particulate filter, through a poppet check valve. After each one-hour test period, mid-range and zero gases were re-introduced in series at the tee connection in the sampling system to check against the method's performance specifications for calibration drift and zero drift error.

The THC instruments were calibrated with USEPA Protocol 1 certified concentrations of propane in air and zeroed using hydrocarbon-free air. A STEC Model SGD-710C ten-step gas divider was used to obtain intermediate calibration gas concentrations as needed.

The response time of each sampling system was determined prior to beginning the first test period by introducing upscale gas and zero gas, in series, into the sampling system using a tee connection at the base of the sample probe. The elapsed time for the analyzer to display a reading of 95% of the expected concentration was determined using a stopwatch. Results of the response time determinations were recorded on field data sheets. For each test period, test data were collected once the sample probe was in position for at least twice the maximum system response time.

6.3 Dry Gas Meter Calibration (Method 4)

The dry gas metering console, which was used for exhaust gas moisture content sampling, was calibrated prior to and after the testing program. This calibration uses the critical orifice calibration technique presented in USEPA Method 5. The metering console calibration exhibited no data outside the acceptable ranges presented in USEPA Method 5.

The digital pyrometer in the metering console was calibrated using a NIST-traceable Omega® Model CL 23A temperature calibrator.

6.4 Gas Divider Certification (USEPA Method 205)

STEC Model SGD-710C 10-step gas dividers were used to obtain appropriate calibration span gases. The STEC gas dividers were NIST certified (within the last 12 months) with a primary flow standard in accordance with Method 205. When cut with an appropriate zero gas, the STEC gas dividers deliver calibration gas values ranging from 0% to 100% of the USEPA Protocol 1 calibration gas that was introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 were followed prior to use of gas dividers. The field evaluation yielded no errors greater than 2% of the triplicate measured average and no errors greater than 2% from the expected values.