AIR EMISSION TEST REPORT
FOR THE
VERIFICATION OF AIR POLLUTANT EMISSIONS
FROM
WASTE INCINERATORS

Prepared for:

Michigan State University

East Lansing, MI

Test Dates: June 14, July 28-29, 2022

ICT Project No.: 2100199

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IMPACT
COMPLIANCE & TESTING

Report Certification

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The material and data in this document were prepared under the supervision and direction of the undersigned.

Impact Compliance & Testing, Inc.

Clay Gaffey
Project Manager

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1.0 Introduction

Michigan State University (MSU) operates pathological waste incinerators at two (2) facilities in East Lansing, Michigan.

EU-FLNRINC is a Consumat Pathological waste incinerator (Farm Lane/Incinerator Road) that burns 10% or less medical/infectious waste low-level nuclear waste, and low volumes of non-hazardous pharmaceutical waste.

EU-DCPAHINC is an ASC design Pathological Waste incinerator located at DCPAH facility on Bennet Rd that burns 5% or less medical/infectious waste. This unit is also called the Veterinary Diagnostic Lab (VDL) incinerator.

MSU contracted Impact Compliance & Testing, Inc. (ICT), a Michigan-based environmental consulting and testing company, to perform emissions testing for two (2) incinerators as required by State of Michigan Renewable Operating Permit (ROP) No. MI-ROP-K3429-2016a.

The field sampling and measurements presented in this report were performed by ICT representatives Clay Gaffey and Max Fierro on June 14, 2022, for EU-FLRINC and July 28-29, 2022, for EU-DCPAH. Dan McGeen and Trevor Drost from the State of Michigan Department of Environment, Great Lakes and Energy, Air Quality Division (EGLE-ADQ) were on-site and observed portions of the stack test program

The incinerator emission performance tests consisted of sampling periods for filterable particulate matter (PM). Exhaust gas velocity, moisture, oxygen (O_2) content, and carbon dioxide (CO_2) content were determined for each test period to calculate pollutant mass emission rates.

The exhaust gas sampling and analysis was performed using procedures described in United States Environmental Protection Agency (USEPA) reference test methods.

Questions regarding this air emission test report should be directed to:

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2.0 Summary of Test Results and Operating Conditions

2.1 Purpose and Objective of the Tests

The compliance test event was performed pursuant to conditions of ROP No. MI-ROP-K3429-2016a, which specifies for each unit (EU-FLRINC & EU-DCPAHINC) that:

> *The permittee shall verify PM emission rates, by testing at owner's expense, in accordance with department requirements … once every five years …. During performance testing, the permittee shall also determine and record the average operating temperature of the afterburner to control the emissions*

This test event was unable to be performed during the initially scheduled test dates due to the incinerators requiring major maintenance. This was openly discussed with EGLE-AQD to ensure testing was performed as soon as possible.

2.2 Summary of Operating Parameters

The incinerators operate as a batch process. Fuel meter readings, waste category, and chamber temperatures were recorded every 15 minutes for each test period.

For EU-FLRINC, a single charge, if heavy enough, can last a whole test period. If less heavy waste was used, charges were added during the test period to maintain appropriate burn rate.

The primary chamber temperature ranged from 1,500 to 1,626°F and the afterburner temperature ranged from 1,789 to 1,890°F during the test periods.

For EU-DCPAH, the charging system is automated. Once the operator charges the incinerator, the PLC will show the duration of the burn time remaining. This cannot be altered by operators. When possible, a new charge was added to the incinerator for each test period.

The primary chamber temperature ranged from 1,586 to 1,743°F and the afterburner temperature ranged from 1,682 to 2,041°F during the sampling periods. Each individual burner (P1-P6, S1-S2) temperature and operating percentage were recorded in 15-minute intervals during testing and is included in Appendix 3.

2.2 Summary of Air Pollutant Sampling Results

The gases exhausted from the incinerators were sampled during emissions testing performed June 14, 2022, for EU-FLRINC, and July 28-29, 2022, for EU-DCPAH.

Emissions testing was performed on each incinerator for particulate matter (PM) concentration, oxygen (O_2) content, and carbon dioxide (CO_2) content.

Table 2.1 presents the average measured PM emission rates for each incinerator compared to the applicable limits in ROP No. MI-ROP-K3429-2016a.

Test results for each sampling period are presented in Section 6.0 of this report.

Table 2.1 Average measured emission rates for the incinerators

Emission Unit Test Date	O2 (%)	CO2 (%)	PM	Emission Limit (PM)
EU-FLRINC				
June 14, 2022 Three-Test Average	18.1	2.01	0.06	0.20 lbs/1,000 lbs exhaust gas corrected to 50% excess air
EU-DCPAHINC				
July 28-29, 2022 Four-Test Average*	14.9	4.01	0.05	0.10 gr/dscf @7% oxygen
			1.32	1.71 lbs/hr

*Probe heater died on Run 3, Run 4 was performed with an Inconel probe

3.0 Source and Sampling Location Description

3.1 General Process Description

MSU operates two (2) pathological waste incinerators.

EU-FLRINC incinerator has a burn-rate capacity of 1,000lbs/hour at a burn temperature of 1,800°F.

EU-DCPAH has a burn-rate capacity of 1,200 lbs/hour at a burn temperature of 1,800°F.

3.2 Sampling Location

Exhaust gas is directed through a primary and secondary chamber during combustion and is released to the atmosphere through a dedicated vertical exhaust stack with a vertical release point.

The EU-FLRINC stack sampling ports are located in a vertical section of the exhaust duct, located after the muffler, with an inner diameter of 46 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location at approximately 10-feet upstream and approximately 25-feet downstream from any flow disturbance.

The EU-DCPAH stack sampling ports are located in a vertical section of the exhaust duct, located after the muffler, with an inner diameter of 37 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location at approximately 50-feet upstream and approximately 20-feet downstream from any flow disturbance.

Appendix 1 provides a diagram of the emission test sampling locations with actual stack dimension measurements.

4.0 Sampling and Analytical Procedures

A Stack Test Protocol for the air emission testing was reviewed and approved by the EGLE-AQD. This section provides a summary of the sampling and analytical procedures that were used during the testing periods.

4.1 Summary of Sampling Methods

USEPA Method 1	Exhaust gas velocity measurement locations were determined based on the physical stack arrangement and requirements in USEPA Method 1.
USEPA Method 2	Exhaust gas velocity pressure was determined using a Type-S Pitot tube connected to a red oil incline manometer; temperature was measured using a K-type thermocouple connected to the Pitot tube.
USEPA Method 3A	Exhaust gas O_2 and CO_2 content was determined using paramagnetic and infrared instrumental analyzers, respectively.
USEPA Method 4	Exhaust gas moisture was determined based on the water weight gain in chilled impingers or using the wet bulb/dry bulb temperature measurement technique.
USEPA Method 5	Exhaust gas filterable particulate matter was determined using an isokinetic sampling train.

4.2 Exhaust Gas Velocity Determination (USEPA Method 2)

The exhaust stack gas velocities and volumetric flow rates were determined using USEPA Method 2 throughout each sampling period for each incinerator. An S-type Pitot tube connected to a red-oil manometer was used to determine velocity pressure at each traverse point across the stack cross section. Gas temperature was measured using a K-type thermocouple mounted to the Pitot tube. The Pitot tube and connective tubing were leak-checked periodically throughout the test periods to verify the integrity of the measurement system.

The absence of significant cyclonic flow at the sampling location was verified using an S-type Pitot tube and oil manometer. The Pitot tube was positioned at each 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).

Appendix 3 provides exhaust gas flowrate calculations and field data sheets.

4.3 Exhaust Gas Molecular Weight Determination (USEPA Method 3A)

CO_2 and O_2 content in the exhaust gas stream was measured continuously throughout each test period in accordance with USEPA Method 3A. The CO_2 content of the exhaust was monitored using a Servomex infrared gas analyzer. The O_2 content of the exhaust was monitored using a Servomex gas analyzer that uses a paramagnetic sensor.

During each sampling period, a continuous sample of the exhaust gas stream was extracted from the stack using a stainless-steel probe connected to a Teflon® heated sample line. The sampled gas was conditioned by removing moisture prior to being introduced to the analyzers; therefore, measurement of O_2 and CO_2 concentrations correspond to standard dry gas conditions. Instrument response data were recorded using an ESC Model 8816 data acquisition system that monitored the analog output of the instrumental analyzers continuously and logged data as one-minute averages.

Prior to, and at the conclusion of each test, the instruments were calibrated using upscale calibration and zero gas to determine analyzer calibration error and system bias (described in Section 5.0 of this document). Sampling times were recorded on field data sheets.

Appendix 4 provides O_2 and CO_2 calculation sheets. Raw instrument response data are provided in Appendix 5.

4.4 Exhaust Gas Moisture Content (USEPA Method 4)

Moisture content of the exhaust gases were determined in accordance with USEPA Method 4 using a chilled impinger sampling train. Exhaust gas moisture content measurements were performed concurrently with the instrumental analyzer sampling periods as a part of the Method 5 isokinetic sampling train. At the conclusion of each sampling period the moisture gain in the impingers was determined gravimetrically by weighing each impinger to determine net weight gain.

4.5 Measurement of Particulate Matter (USEPA Method 5)

Testing was performed using a filterable particulate matter (PM) sampling train.

Filterable PM was determined using USEPA Method 5. Exhaust gas was withdrawn from each exhaust stack at an isokinetic sampling rate using an appropriately-sized stainless steel sample nozzle and heated probe. The collected exhaust gas was passed through a pre-tared glass fiber filter that was housed in an independent heated filter box.

At the conclusion of each one-hour test period, the sample train was leak-checked and disassembled. The sample nozzle, probe liner, and filter holder were brushed and rinsed with acetone. The recovered particulate filter and acetone rinses were stored in sealed containers and brought to Impact Compliance & Testing, Inc. (Holt, Michigan) for gravimetric measurements.

Diluent gas content (Method 3A O_2 and CO_2) measurements were performed with each of the PM isokinetic sampling periods.

Appendix 2 provides the PM laboratory report. Appendix 4 provides PM calculation sheets.

5.0QA/QC Activities

5.1 Flow Measurement Equipment

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

The absence of cyclonic flow for each sampling location was verified using an S-type Pitot tube and oil manometer. The Pitot tube was positioned at each of the velocity traverse points 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).

5.2 Gas Divider Certification (USEPA Method 205)

A STEC Model SGD-710C 10-step gas divider was used to obtain appropriate calibration span gases. The ten-step STEC gas divider was 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 ten-step STEC gas divider delivered calibration gas values ranging from 0% to 100% (in 10% step increments) 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 divider. The field evaluation yielded no errors greater than 2% of the triplicate measured average and no errors greater than 2% from the expected values.

5.3 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure O_2, and CO_2 have had an interference response test preformed prior to their use in the field, pursuant to the interference response test procedures specified in USEPA Method 7E. The appropriate interference test gases (i.e., gases that would be encountered in the exhaust gas stream) were introduced into each analyzer, separately and as a mixture with the analyte that each analyzer is designed to measure. All of analyzers exhibited a composite deviation of less than 2.5% of the span for all measured interferent gases. No major analytical components of the analyzers have been replaced since performing the original interference tests.

5.4 Instrument Calibration and System Bias Checks

At the beginning of each day of the testing program, initial three-point instrument calibrations were performed for the CO_2, and O_2 analyzers by injecting calibration gas directly into the inlet sample port for each instrument. System bias checks were performed prior to and at the conclusion of each sampling period by introducing the upscale calibration gas and zero gas into the sampling system (at the base of the stainless-steel sampling probe prior to the particulate filter and Teflon® heated sample line) and determining the instrument response against the initial instrument calibration readings.

The instruments were calibrated with USEPA Protocol 1 certified concentrations of CO_2 and O_2 in nitrogen and zeroed using hydrocarbon free nitrogen.

5.5 System Response Time

The response time of the sampling system was determined prior to the compliance test program 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.

Sampling periods did not commence until the sampling probe had been in place for at least twice the greatest system response time.

5.6 Meter Box Calibrations

The dry gas meter sampling console used for moisture testing 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.

Appendix 6 presents test equipment quality assurance data (instrument calibration and system bias check records, calibration gas certifications, interference test results, meter box calibration records, and field equipment calibration records).

5.7 Particulate Matter Recovery and Analysis

All recovered particulate matter samples were stored and shipped in certified trace clean amber glass sample bottles with Teflon® lined caps. The liquid level on each bottle was marked with a permanent marker prior to pick-up and the caps were secured closed with tape. Acetone with a residue after evaporation of ≤0.001% was used for the analysis. Based on the low amounts of particulates and no necessity for blank correction, a blank sample was not analyzed.

5.8 Laboratory QA/AC Procedures

The particulate matter analyses were conducted by Impact Compliance & Testing, Inc. according to the appropriate QA/QC procedures specified in the USEPA Method 5. Laboratory data sheets and calculations are presented in the Laboratory Report in Appendix 2.

6.0 Results

6.1 Test Results and Allowable Emission Limits

Air pollutant emission measurement results for each emission unit are presented in Tables 6.1 through 6.2.

The results indicate that both EU-FLRINC and EU-DCPAH are in compliance with the emission limits specified in ROP No. MI-ROP-K3249-2016a:

EU-FLRINC

- 0.20 lbs/1,000 lbs of exhaust gases corrected to 50% excess air

EU-DCPAHINC

- 0.10 gr/dscf corrected to 7% oxygen; and
- 1.71 lbs/hr

6.2 Variations from Normal Sampling Procedures or Operating Conditions

O_2 and CO_2 calibrations were performed once before Test 1 and again after Test 3 for EU-FLRINC.

Testing for EU-DCPAHINC was paused or delayed multiple times during the test periods due to low probe temperature readings. This was due to the stack temperature exceeding the anticipated temperature and slowly burning out the probe heater. The heater stopped working completely after the first half of Test 3, and the test was completed with a low probe temperature. ICT retrieved an Inconel probe to complete Test 4 the following day. All 4 test periods are included in this report.

During Test 1, the meter was started prior to the initial charge of the incinerator due to a charging malfunction of the incinerator. The charge entered the incinerator at 9:10 AM and the PM test commenced. The total sample volume pulled during the run (59.3 scf @STP) was used for moisture calculations, whereas the sample volume taken during actual PM sampling (43.1 scf @STP) was used for PM emission calculations.

All variations from normal sampling procedures were discussed with and approved by EGLE representatives on-site.

Table 6.1 Measured exhaust gas conditions and air pollutant emission rates for EU-FLRINC

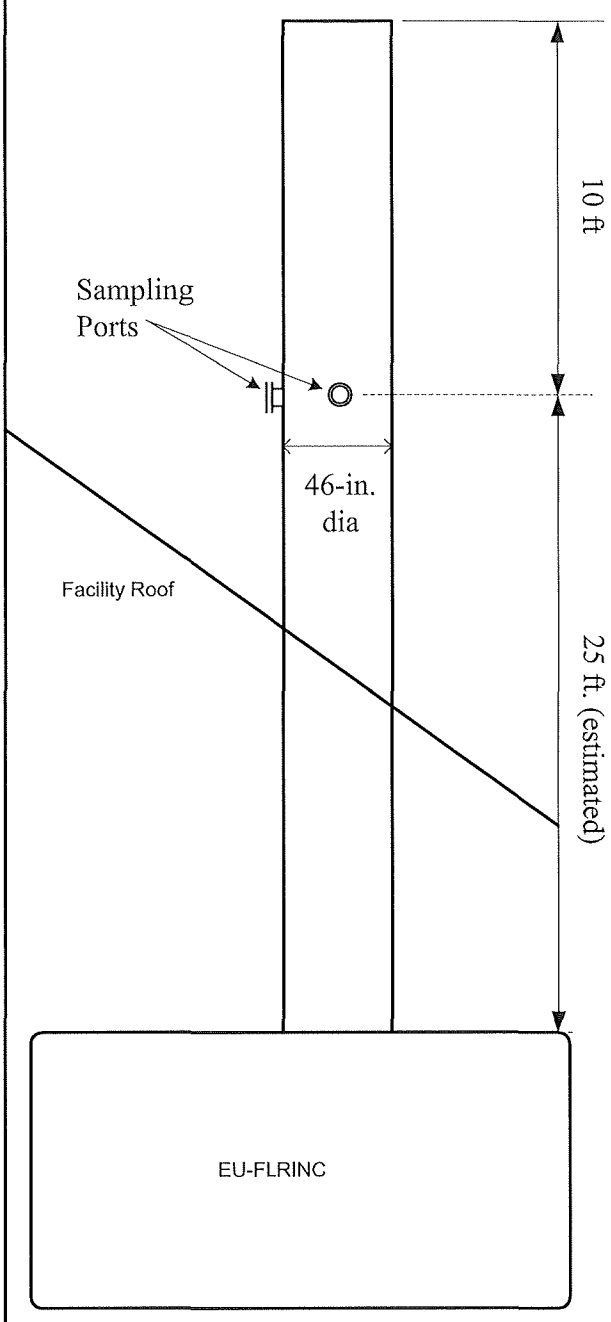
Test No. Test date Test period (24-hr clock)	Test 1 6/14/2022 0943-1013 1032-1102	Test 2 6/14/2022 1156-1226 1236-1306	Test 3 6/14/2022 1355-1425 1432-1502	Average
Exhaust Gas Composition				
CO_2 content (% vol)	2.01	2.11	1.93	2.01
O_2 content (% vol)	17.8	18.2	18.2	18.1
Moisture (% vol)	7.69	7.35	6.68	7.24
Exhaust gas temperature (°F)	724	736	714	725
Exhaust gas flowrate (dscfm)	3,861	3,643	4,251	3,918
Exhaust gas flowrate (scfm)	4,182	3,932	4,555	4,223
Particulate Matter				
Sampled volume (dscf, @ STP)	43.4	40.6	48.1	44.0
Filter catch (mg)	33.7	48.2	41.0	41.0
Acetone rinse catch (mg)	10.0	7.70	4.90	7.53
Total catch (mg)	43.7	55.9	45.9	48.5
Lb PM/1,000lb gas (dry)	0.03	0.04	0.03	0.03
Lb PM/1,000 lbs gas (dry, @ 50% excess air	0.05	0.07	0.05	0.06
Permit Limit	--	--	--	*0.20*

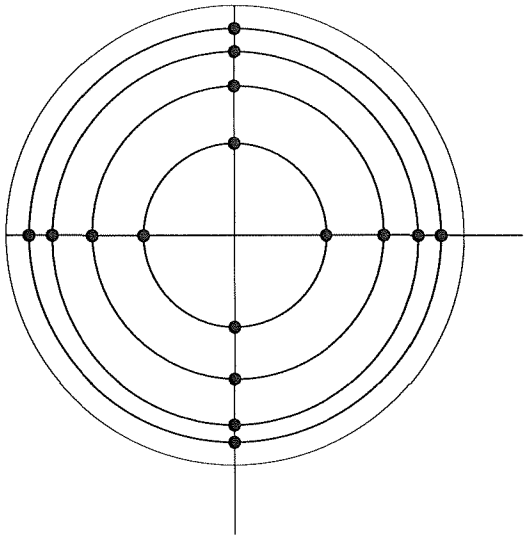
Table 6.2 Measured exhaust gas conditions and air pollutant emission rates for EU-DCPAHINC

Test No. Test date Test period (24-hr clock)	Test 1 7/28/22 0910- 1102	Test 2 7/28/22 1206- 1315	Test 3 7/28/22 1404- 1744	Test 4 7/29/22 0915- 1022	Average
Exhaust Gas Composition					
CO_2 content (% vol)	4.19	3.81	4.02	3.63	3.91
O_2 content (% vol)	14.5	15.3	14.9	15.6	15.1
Moisture (% vol)	10.5	10.1	9.65	7.80	9.53
Exhaust gas temperature (°F)	1,207	1,106	1,147	1,091	1,138
Exhaust gas flowrate (dscfm)	7,175	7,101	7,446	7,707	7,357
Exhaust gas flowrate (scfm)	8,019	7,902	8,241	8,359	8,130
Particulate Matter					
Sampled volume (dscf)	43.1	42.0	44.1	45.0	43.5
Filter catch (mg)	35.7	42.3	47.1	24.3	37.4
Acetone rinse catch (mg)	30.0	30.9	15.7	10.5	21.8
Total catch (mg)	65.7	73.2	62.8	34.8	59.1
PM conc. (gr/dscf)	0.02	0.03	0.02	0.01	0.02
PM conc. (gr/dscf @7%O_2)	0.05	0.07	0.05	0.03	0.05
Permit Limit (gr/dscf@7%O_2)	--	--	--	--	*0.10*
Total PM emissions (lb/hr)	1.45	1.64	1.40	0.79	1.32
Permit Limit (lb/hr)	--	--	--	--	*1.71*

APPENDIX 1

- Sample Port Diagram





Velocity locations
as measured from
stack wall

Pt	inch
1	1.47
2	4.83
3	8.92
4	14.9
5	31.1
6	37.1
7	41.2
8	44.5

Michigan State University
EU-FLRINC Stack Sampling Diagram

Scale	Sheet	Impact Compliance & Testing, Inc.
None	1 of 1	Project No. 2100199

APPENDIX 2

- PM Laboratory Report