AIR EMISSION TEST REPORT
FOR THE VERIFICATION OF
EMISSION CONTROL DEVICE
CAPTURE AND DESTRUCTION EFFICIENCY
FOR A
PLASTIC PARTS COATING LINE

SPECTRUM INDUSTRIES, INC
GRAND RAPIDS, KENT COUNTY

1.0 INTRODUCTION

Spectrum Industries, Inc. (Spectrum) operates a plastic automotive parts coating line at is facility located in Grand Rapids, Kent County, Michigan (State Registration No. N6218). The coating line and associated emission control system has been issued Permit to Install (PTI) 277-97C by the Michigan Department of Environmental Quality, Air Quality Division (MDEQ-AQD).

The automotive parts are prepared and coated in a continuous, conveyorized coating line (emission unit EUMAINLINE) that consists of a parts washer, dryer, touch-up booth, two (2) coating spray booths, flash-off area and bake curing oven. Volatile organic compound (VOC) emissions from the spray booths, flash-off area, and bake curing oven are directed to a regenerative thermal oxidizer (RTO) for emission reduction prior to exhaust to the atmosphere.

Emission testing was performed at the request of the MDEQ-AQD to verify the capture and destruction efficiency of the RTO emission control system.

This test report presents the results of VOC control efficiency testing that was performed January 23, 2019 to determine the VOC:

- Destruction efficiency associated with the RTO,
- Capture efficiency associated with EUMAINLINE.

The control efficiency evaluation was performed using procedures specified in the test plan dated April 17, 2018 that was submitted to the Michigan Department of Environmental Quality, Air Quality Division (MDEQ-AQD) for review and approval.

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

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1.1 Contact Information

This test report was prepared by Impact Compliance & Testing, Inc. (ICT), formerly Derenzo Environmental Services (DES) based on field sampling data collected by ICT/DES representatives Robert Harvey, Andy Rusnak, and Jory VanEss. The project was coordinated by Mr. Charlie Adams, Spectrum Industries Plant Engineer. Facility process data were collected and provided by Spectrum Industries employees or representatives. Dave Patterson and April Lazzaro of the MDEQ-AQD were on-site to observe portions of the compliance testing. Questions regarding this emission test report should be directed to:

Testing Procedures

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1.2 Report Certification

This report has been reviewed by Spectrum Industries, Inc representatives and approved for submittal to the MDEQ-AQD.

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.

Robert L. Harvey, P.E.
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2.0 SUMMARY OF RESULTS

2.1 Results for RTO Destruction Efficiency

RTO VOC destruction efficiency was determined for three (3) one-hour test periods by simultaneously measuring the mass flowrate of total hydrocarbons (THC) entering and exiting the RTO emission control device. The average measured VOC destruction efficiency for the three test periods is 86.9% by weight.

The RTO combustion chamber temperature was recorded throughout each test period. The minimum recorded temperature was 1,552°F; the three-hour average combustion chamber for the test event was 1,553°F.

The RTO VOC destruction efficiency test results are summarized in Table 2.1. Data and information for each test period are presented in Section 5.0 and Table 5.1.

2.2 Results for EUMAINLINE Capture Efficiency

Operating parameters for EUMAINLINE were monitored to determine whether the VOC emission capture system satisfies the conditions of a permanent total enclosure (PTE).

Table 2.2 presents a summary of the monitored operating parameters; differential pressure (dP) between the spray booths and oven and surrounding area, and verification of inward flow at the natural draft openings (NDO). The monitored parameters satisfy the criteria for permanent total enclosure with one exception. The NDO at the PTE inlet is not accessible during normal coating operations and the direction of airflow could not be monitored. Preliminary observations indicated static flow at the NDO face with flow further downstream entering into the first spray booth (from a make-up air connection located between the NDO and the spray booth). This is discussed in more detail in Section 5.3 of this report.

2.3 Overall Control Efficiency

PTI No. 277-97C defines the required operating parameters for the RTO emission control system as follows:

> *Satisfactory operation of the RTO includes a minimum VOC capture efficiency of 95 percent (by weight), a minimum VOC destruction efficiency of 95 percent (by weight), and maintaining a minimum temperature of 1500°F and a minimum retention time of 0.5 seconds.*

The conditions of PTI 277-97C result in a minimum overall control efficiency of 90.25%. While there is one exception to the PTE design criteria, the enclosure is operating at a vacuum relative to the surrounding environment, which should be adequate to assume 100% capture efficiency. The test results presented above result in an overall control efficiency of 86.9% by weight.

Table 2.1 Summary of RTO VOC destruction efficiency test results

Control System Parameter	Test 1	Test 2	Test 3	Three-Hour Average
Avg. RTO Combustion Temperature (°F)	1,556	1,552	1,552	1,553
VOC Destruction Efficiency (%wt)	85.9%	87.4%	87.4%	86.9%
Permit Requirement	--	--	--	>95.0%

Table 2.2 Summary of EUMAINLINE permanent total enclosure criteria

Control System Parameter	Test 1	Test 2	Test 3
Min. dP within Booth 1 (in. H_2O)	-0.015	-0.015	-0.015
Inlet NDO is > 4ED from VOC emitting point	Yes	Yes	Yes
Verified inward direction of flow at inlet NDO	**	**	**
Min. dP within Booth 2 (in. H_2O)	-0.015	-0.010	-0.010
Min. dP within Oven (in. H_2O)	-0.010	-0.010	-0.015
Exit NDO is > 4ED from VOC emitting point	Yes	Yes	Yes
Verified inward direction of flow at exit NDO	Yes	Yes	Yes
NEAR < 0.05	Yes	Yes	Yes

** Not accessible during operation, see discussion in Section 5.3.
4ED is four equivalent diameters
NEAR is the NDO-to-enclosure area ratio

3.0 SOURCE DESCRIPTION

3.1 Coating Line

EUMAINLINE is a conveyorized plastic automotive parts coating line consisting of a parts washer and associated dryer, a touch-up booth, two (2) robotic spray booths, a flash-off area, and a steam-fired air dry bake curing oven.

The parts washer, associated dryer, and touch-up booth use a minimal amount of VOC and are exhausted to the atmosphere uncontrolled. The two (2) robotic spray booths, the flash-off area and the curing oven are connected to the RTO emission reduction system. Particulate matter from the two (2) robotic spray booths is controlled by water curtain overspray systems.

3.2 Type of Raw Materials Used

The coating line is designed to operate continuously as the conveyor transports the plastic parts through the various booths and processes. Coatings containing VOC are applied in the two robotic spray booths. Materials used in the parts washer and touch-up booth contain a minimal amount of VOC (or no VOC at all).

3.3 Emission Control System Description

3.3.1 EUMAINLINE VOC Capture

Fresh make-up air is introduced at various points in the coating line. The two (2) robotic spray booths, the flash-off area, and the curing oven have exhausts that capture process air and direct it to the RTO emission control device. The coating line from the inlet tunnel to the first robotic spray booth to the outlet of the curing bake oven was defined as the PTE.

Attachment 2 provides diagrams of the coating line enclosure.

3.3.2 Regenerative Thermal Oxidizer

Air collected air from the two (2) robotic spray booths, the flash-off area and the curing oven is directed to the RTO for VOC emission reduction. In the RTO, hydrocarbons (VOC) are oxidized (or destroyed) at high temperature to form carbon dioxide.

The RTO consists of a variable frequency drive (VFD) fan, energy recovery chambers, and a high-temperature combustion chamber containing natural gas-fired burners. Fan speed is controlled (by the VFD controller) to maintain an appropriate vacuum within the process air collection system and draw the collected air through the RTO unit. The collected solvent laden air enters the RTO unit through the inlet manifold into the base of one energy recovery column where it is preheated as it travels through the heat exchange media. The temperature of the preheated air is increased in the combustion chamber to complete the oxidation of hydrocarbons in the process air stream. The heated air flows through the outlet energy recovery chamber and is cooled (which raises the temperature of the heat exchange media) prior to being discharged to the ambient air through the vertical exhaust stack. At a predetermined interval, the air flow through the unit is reversed such that the heated heat exchange media (which was used to cool the exiting gas stream) becomes the preheating heat exchange media that is used to preheat the incoming solvent laden air.

The RTO is manufactured by Durr and has a nominal design capacity of 20,000 standard cubic feet per minute (scfm). The combustion chamber is designed to maintain an adequate operating temperature (1500°F) that should result in a VOC destruction efficiency of 95% or greater.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

A description of the sampling and analytical procedures is provided in the test plan dated April 17, 2018, 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 (RTO inlet)	Method 2	Dry molecular weight for ambient air (29.0)
Molecular Weight (RTO outlet)	Method 3A	Instrumental analyzers for CO_2 and O_2 content
Moisture (RTO inlet)	Method 4	Moisture determination by wet-bulb / dry-bulb temperature measurements
Moisture (RTO outlet)	Method 4	Moisture determination by chilled impinger method
THC Concentration	Method 25A	Determination of gaseous THC concentration using a flame ionization analyzer (FIA)
Capture Efficiency	Method 204	Physical measurements to verify design criteria for a permanent total enclosure (PTE)

4.2 RTO Destruction Efficiency Test Procedures

USEPA Method 25A, *Determination of Total Gaseous Organic Concentration Using A Flame Ionization Detector*, was used to measure the THC concentration, relative to a propane standard, for the RTO inlet and exhaust gas streams. Throughout each test period, a sample of the gas from the RTO inlet and exhaust measurement locations was delivered to the instrument trailer using independent heated Teflon® sample lines to maintain the temperature of the gas sample to 250 to 300°F.

The RTO inlet gas sample was introduced directly to a Thermo Environmental Instruments, Inc. (TEI) Model 51c THC flame ionization analyzer (FIA).

The RTO exhaust gas sample was divided between a:

1. TEI 51c THC FIA (direct injection with no moisture removal), and

2. Instrumental analyzer containing a Non-Dispersive Infrared (NDIR) cell to measure carbon dioxide (CO_2) and zirconia ion sensor to measure oxygen (O_2) content in accordance with USEPA Method 3A. The CO_2 / O_2 instrument was preceded by a refrigerant-based condenser that removes moisture prior to analysis (dry gas sample).

The instruments were calibrated as described in Section 6.0 of this report. Instrument response for each analyzer was recorded on an ESC Model 8816 data logging system that monitored the analog output of the instrumental analyzers continuously and logged data as one-minute averages.

Air flowrate measurements were performed during each one-hour test period in accordance with USEPA Method 2. An S-type Pitot tube connected to a red-oil manometer was used to determine velocity pressure and a K-type thermocouple mounted to the Pitot tube was used for temperature measurements. Velocity traverse locations were determined in accordance with USEPA Method 1 based on the stack diameter and distance to upstream and downstream flow disturbances.

The RTO exhaust volumetric flowrate was measured in the vertical 42-inch diameter exhaust stack. The RTO inlet volumetric flowrate was measured in the 38-inch diameter inlet duct.

Attachment 3 provides diagrams of the sampling locations.

Moisture content for the RTO exhaust gas was determined using a chilled impinger train and the procedures of USEPA Method 4; moisture for the RTO inlet gas streams (which is primarily building air captured by the coating line air collection systems) was determined by wet bulb / dry bulb temperature measurements.

The measured THC concentration was used with the measured volumetric air flowrate to calculate THC mass flow rate (pounds per hour as propane) for each gas stream using the following equation:

M_{THC} = Q [C_{THC}] (MW_{C3}) (60 min/hr) / V_M / 1E+06

Where: M_{THC} = Mass flowrate VOC (lb/hr)
Q = Volumetric flowrate (scfm)
C_{THC} = THC concentration (ppmv C_3)
MW_{C3} = Molecular weight of propane (44.1 lb/lb-mol)
V_M = Molar volume of ideal gas at standard condition (385 scf/lb-mol)

The THC destruction efficiency of the RTO emission control system was determined for each test period using the following equation:

DE = [1 – ($M_{VOC\ in}$ / $M_{VOC\ out}$)]* 100%

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

4.3 EUMAINLINE Capture Efficiency Test Procedures

VOC capture efficiency for the EUMAINLINE enclosure was verified during each test period by:

1. Measuring the differential pressure between the interior of the PTE and the surrounding area.
2. Observing the direction of airflow at the coating line inlet and exit natural draft openings.
3. Physical measurements to verify design criteria for a permanent total enclosure.

Differential pressure measurements were performed using a ¼-inch incline manometer between:

- Surrounding environment and the first spray booth
- Surrounding environment and the second spray booth
- Surrounding environment and the final bake curing oven

Streamers or chemical air current (smoke) tubes were used to visually determine the direction of airflow (e.g., into the enclosure) and recorded on a data sheet.

5.0 TEST RESULTS AND DISCUSSION

5.1 Control Device and Process Operating Data

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

- RTO combustion chamber temperature,
- RTO fan VFD controller output (Hz),
- RTO inlet vacuum (in. w.c.),
- Number and type of parts coated in each coating line,
- Coating(s) used in each coating line.

Attachment 4 provides RTO and coating process operating records for the test event.

5.2 RTO VOC Destruction Efficiency

Table 5.1 presents measured gas conditions and results for each destruction efficiency test period.

RTO VOC destruction efficiency was determined for three (3) one-hour test periods by simultaneously measuring the THC mass flowrate entering and exiting the RTO emission control device. The average measured VOC destruction efficiency for the three test periods is 86.9% by weight, which is less than the minimum destruction efficiency of 95% specified in PTI 277-97C.

The RTO combustion chamber temperature was recorded throughout each test period. The three-hour average combustion chamber for the test event is 1,553°F; the lowest recorded temperature during any of the test periods was 1,552°F. The conditions of PTI 277-97C specify that the RTO temperature must be maintained at a minimum of 1500°F.

Attachment 5 provides test data for the RTO VOC destruction efficiency testing performed January 23, 2019, including inlet/outlet concentration graphs, field data sheets, and calculations.

Table 5.1 Measured gas conditions and destruction efficiency test results for the RTO

	Test 1	Test 2	Test 3	3-Hour Avg
Date	1/23/19	1/23/19	1/23/19	
Test Times	1210-1310	1339-1439	1510-1610	
Avg. Combustion Temp (°F)	1,556	1,552	1,552	1,553
Fan speed (Hz)	46.8	50.0	51.6	49.5
RTO Inlet				
Inlet Flowrate (scfm)	13,319	14,605	14,926	14,284
Average THC Conc. (ppmv C_3)	225	132	145	167
THC Mass Flow (lb/hr)	20.6	13.2	14.8	16.2
RTO Exhaust				
Flowrate (scfm)	15,687	14,891	15,426	15,335
Average THC Conc. (ppmv C_3)	27.0	16.3	17.6	20.3
THC Mass Flow (lb/hr)	2.91	1.67	1.87	2.15
Destruction Efficiency[1] (%wt)	**85.9%**	**87.4%**	**87.4%**	**86.9%**

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

5.3 EUMAINLINE Permanent Total Enclosure

The criteria for a permanent total enclosure are presented in Table 2.2 at the beginning of this report. Each criterion of USEPA Method 204 is addressed individually below.

5.3.1 NDO Spacing to VOC Emitting Point

Any natural draft opening (NDO) shall be at least four equivalent opening diameters from each VOC emitting point.

The two NDO's for the enclosure were defined as the:

- 38-inch by 51-inch opening in the tunnel between the touch-up booth and spray booth 1. This NDO is approximately 17 feet from spray booth 1 where the paint is applied. The equivalent diameter of a 38-inch by 51-inch opening is 4.1 feet, resulting in a spacing equal to 4.1 equivalent diameters (ED).

  Inlet NDO spacing = 17 ft / 4.1 ft = 4.1 ED

- 3-foot by 4-foot opening at the end of the oven exit tunnel. This NDO is approximately 35 feet from the flash off area. The equivalent diameter of a 3-foot by 4-foot opening is 3.9 feet, resulting in a spacing equal to 9 equivalent diameters (ED).

  Exit NDO spacing = 35 ft / 3.9 ft = 9 ED

5.3.2 NDO-to-Enclosure Area Ratio (NEAR)

The total area of all NDO's shall not exceed 5 percent of the surface area of the enclosure's four walls, floor and ceiling.

The two NDO's identified in the previous section have a total opening area of 25.5 square feet.

The enclosure generally consists of two coating booths that measure 10-ft wide by 10-ft long by 8.5-ft tall and approximately 114 feet of 66-inch by 38-inch tunnel connecting the two booths and the flash-off area.

Area of each coating booth:

Four Walls = 4 x (10 ft) x (8.5 ft) = 340 sq. ft
Floor & Ceiling = 2 x (10 ft) x (10 ft) = 200 sq. ft

Area of tunnel:

Sides = 2 x (66 inches) x (114 ft) = 1,254 sq. ft
Floor & Ceiling = 2 x (38 inches) x (114 ft) = 722 sq. ft

The NDO-to-Enclosure Area (NEAR) ratio is less than 1%:

NEAR = (25.5 sq.ft) / [(2 x 540 sq. ft) + (1,976 sq. ft)] = 0.8%

5.3.3 NDO Face Velocity

The average facial velocity (FV) of air through all NDO's shall be at least 3,600 m/hr (200 fpm) and the direction of airflow through all NDO's shall be into the enclosure.

Alternatively, measure the pressure the differential across the enclosure. A pressure drop of 0.013 mm Hg (0.007 inches H_2O) corresponds to a FV of 3,600 m/hr (200 fpm).

Monitoring performed during the test periods verified that the:

- Differential pressure across the enclosure at the spray booth 1 inlet NDO was greater than 0.007 inches H_2O
- Differential pressure across the enclosure at the oven exit NDO was greater than 0.007 inches H_2O
- Observed airflow through the oven exit NDO was swift and into the enclosure.

The airflow through the booth 1 inlet NDO is relatively static. This is because there is a make-up air connection between the inlet NDO and booth 1. The tunnel between the touch-up booth and spray booth 1 is maintained at balanced airflow. Consequently, there is very little air being drawn through what was defined as the inlet NDO. There is however, strong airflow into booth 1 as all of the make-up air, which is introduced downstream of the NDO, is drawn into booth 1. Therefore, while there is not a strong face velocity through the NDO, there is significant flow from the inlet tunnel into booth 1.

5.3.4 Access Doors and Windows

All access doors and windows whose areas are not included in the NDO area and NDO FV determinations shall be closed during routine operation of the process.

All other openings into the coating line enclosure remain closed during normal operations. This is by design to avoid drawing contaminants (dust) into the coating areas.

5.3.5 Capture Efficiency

While there is one exception to the PTE design criteria (as explained in Section 5.3.3), it was verified that the enclosure is operating at a vacuum relative to the surrounding environment, which should be adequate to assume 100% capture efficiency.

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 April17, 2018, and the MDEQ-AQD test plan approval unless otherwise noted in this report. There are no test method deviations to report.

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, barometer, and pyrometers.

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 (barometer, 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 incline 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 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). 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 3A and 25A)

Accuracy of the instrumental analyzers used to measure THC, O_2, and CO_2 concentration was verified prior to and at the conclusion of each test period using the calibration procedures in Methods 25A, 3A and 7E.

At the beginning of each day, 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.

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

A STEC Model SGD-710C 10-step gas divider was used to obtain appropriate calibration span gases. The 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 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.