VOC CAPTURE & DESTRUCTION EFFICIENCY PERFORMANCE TEST

Prepared For
Automotive Lighting LLC

Performed At
Automotive Lighting
Hardcoat and Anti-Fog Lines and Associated Regenerative Thermal Oxidizer (FGRTO)
Clarkston, Michigan

Test Date(s)
July 11 and 12, 2018

Report No.
TRC Environmental Corporation Report 280992A

Report Submittal Date
August 21, 2018

TRC Environmental Corporation
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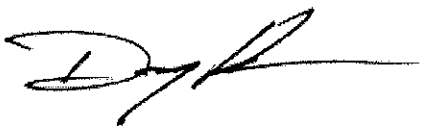
Report Certification

I certify that to the best of my knowledge:

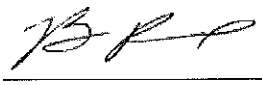
- Testing data and all corresponding information have been checked for accuracy and completeness.
- Sampling and analysis have been conducted in accordance with the approved protocol and applicable reference methods (as applicable).
- All deviations, method modifications, or sampling and analytical anomalies are summarized in the appropriate report narrative(s).



Douglas Ryan
AMS Group Manager

August 21, 2018
Date

TRC was operating in conformance with the requirements of ASTM D7036-04 during this test program.



Bruce Randall
TRC Emission Testing Technical Director

VOC CAPTURE AND DESTRUCTION EFFICIENCY PERFORMANCE TEST

1.0 INTRODUCTION

TRC Environmental Corporation (TRC) performed a volatile organic compound (VOC) test program on the Hardcoat and Anti-Fog Lines and assosciated Regenerative Thermal Oxidizer (FGRTO) at the Automotive Lighting facility in Clarkston, Michigan on July 11 and 12, 2018. The tests were authorized by and performed for Automotive Lighting LLC.

The purpose of this test program was to determine VOC capture and destruction efficiencies during normal operating conditions. The test program was conducted according to the TRC Test Protocol 280992, dated May 3, 2018.

1.1 Project Contact Information

Participants		
Test Facility	Automotive Lighting LLC 5600 Bow Point Drive Clarkston, Michigan 48346 Permit To Install 152-17	Matt Szczesiul EHS Coordinator (248) 238-2615 (phone) (248) 922-0909 (fax) matthew.szczesiul@al-lighting.com
Air Emissions Testing Body (AETB)	TRC Environmental Corporation 7521 Brush Hill Road Burr Ridge, Illinois 60527	Douglas Ryan AMS Group Manager (312) 533-2032 (phone) (312) 533-2070 (fax) dryan@trcsolutions.com

The tests were conducted by Gavin Lewis, Dave Wells, Ryan Novosel and Doug Ryan of TRC. Documentation of the on-site ASTM D7036-04 Qualified Individual(s) (QI) can be located in the appendix to this report.

David Patterson, Sebastian Kallumlak, Adam Bogner, Joe Forth and Lauren Magirl from the Michigan Department of Environmental Quality (MDEQ) observed the testing.

1.2 Facility and Process Description

Automotive Lighting operates an automotive lighting manufacturing facility that produces automotive lighting components for original equipment buyers. The manufacturing process includes injection molding, coating applications, metalizing of plastic parts, assembly and warehousing of components.

The facility has two emissions units which were tested; Anti-Fog (EUANTIFOG) and Hardcoat (EUHARDCOAT). Both processes are controlled by a single Regenerative Thermal Oxidizer (RTO). This group is collectively referred to as FGRTO. The processes each use an enclosure to capture VOC emissions and duct them to control.

The following process data was collected for each emissions test run and can be found in the appendix.

- Production Data
- Solvent usage (copies of usage logs kept at unit)
- Coating usage (copies of usage logs kept at unit)
- RTO combustion zone temperature
- RTO set point temperature
- Specific coating used

2.0 SUMMARY OF RESULTS

The results of this test program are summarized in the tables below. Detailed individual run results are presented in Section 6.0.

Regenerative Thermal Oxidizer (RTO) – Destruction Efficiency		
Parameter	**RTO Inlet (total)**	**RTO Outlet**
VOC, lb/hr as Propane	6.76	0.133
Destruction Efficiency, %	98.0	

FGRTO – Capture Efficiency		
Parameter	**Process Input**	**Mass to Control**
VOC, lb/hr as Propane	5.46	5.31
Capture Efficiency, %	97.3	

The table below summarizes the test methods used, as well as the number and duration of each at each test location:

FGRTO VOC Destruction Efficiency Testing				
Unit ID/ Sample Location	**Parameter Measured**	**Test Method**	**No. of Runs**	**Run Duration**
RTO Stack (SV-1)	Volumetric Flow Rate	USEPA 1 and 2	4	10 min
	O_2 and CO_2 Content	USEPA 3	4	---
	Moisture	USEPA ALT-008	3	60 min
	Total Hydrocarbons as Propane	USEPA 25A	3	60 min
Hardcoat Enclosure Exhaust (RTO Inlet 1) & Anti-Fog Enclosure Exhaust (RTO Inlet 2)	Volumetric Flow Rate	USEPA 1 and 2	4	5 min
	Moisture	ASTM E337-62	4	---
	Total Hydrocarbons As Propane	USEPA 25A	3	60 min

FGRTO VOC Capture Efficiency Testing					
Emissions Unit	**Sample Location**	**Parameter Measured**	**Test Method**	**No. of Runs**	**Run Duration**
Hardcoat (EUHARDCOAT)	Enclosure	PTE Evaluation	USEPA 204	N/A	N/A
	Hardcoat Enclosure Exhaust (RTO Inlet 1)	Volumetric Flow rate	USEPA 1 and 2	≥ 4	≥ 5 min
		Moisture	ASTM E337-62	3	---
Anti-Fog (EUANTIFOG)	Liquid Input Stream	Coating Usage by weight, % volatiles and FID response Factor	USEPA 24 & 204F	6 samples (single input)	N/A
	Anti-Fog Enclosure Exhaust (Captured Stream)	Volumetric Flow rate	USEPA 1 and 2	≥ 4	≥ 5 min
		Moisture	ASTM E337-62	3	---
		Total Hydrocarbons as Propane	USEPA 204B	3*	180 min

*Note: results from destruction efficiency tests 1-3 were used as the 1st 3-hr capture test.

3.0 DISCUSSION OF RESULTS

During testing on the July 11, (destruction efficiency and 1st capture test) both processes were running at conditions representative of normal operation/maximum throughput. On July 12th, the facility had only one (of two) mold machines in operation. As a result, process throughput during the 2nd and 3rd capture tests was reduced by approximately 50%.

During capture runs 2 and 3, process issues resulted in periods of downtime. Testing was stopped when the line was not in operation. Anti-Fog coating weights were recorded at the beginning and end of each distinct measurement period to ensure values remained representative of actual usage.

No problems were encountered with the testing equipment during the test program. Other than as noted above, source operation appeared normal during the entire test program. No changes or problems were encountered that required modification of any procedures presented in the test plan. No adverse test or environmental conditions were encountered during the conduct of this test program.

4.0 SAMPLING AND ANALYSIS PROCEDURES

All testing, sampling, analytical, and calibration procedures used for this test program were performed in accordance with the methods presented in the following sections. Where applicable, the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, Stationary Source Specific Methods, USEPA 600/R-94/038c, September 1994 was used to supplement procedures.

4.1 Determination of Sample Point Locations by USEPA Method 1

This method is applicable to gas streams flowing in ducts, stacks, and flues and is designed to aid in the representative measurement of pollutant emissions and/or total volumetric flow rates from stationary sources. In order to qualify as an acceptable sample location, it must be located at a position at least two stack or duct equivalent diameters downstream and a half equivalent diameter upstream from any flow disturbance.

The cross-section of the measurement sites were divided into a number of equal areas, and the traverse points were then located in the center of these areas. The minimum number of points were determined from Figure 1-2 (non-particulate) of USEPA Method 1. Site acceptability determinations were performed at each sampling location. The Anti-Fog RTO Inlet duct resultant angle was 2.5°, the Hardcoat RTO Inlet duct was 2.1°, and the RTO Stack was 1.5°.

4.2 Volumetric Flow Rate Determination by USEPA Method 2

This method is applicable for the determination of the average velocity and the volumetric flow rate of a gas stream.

The gas velocity head (ΔP) and temperature were measured at traverse points defined by USEPA Method 1. The velocity head was measured with a Type S (Stausscheibe or reverse type) pitot tube and oil-filled manometer; and the gas temperature was measured with a Type K thermocouple. The average gas velocity in the flue was calculated based on: the gas density (as determined by USEPA Methods 3 and 4); the flue gas pressure; the average of the square roots of the velocity heads at each traverse point, and the average flue gas temperature.

4.3 CO_2 and O_2 Determination by USEPA Method 3

This method is applicable for the determination of CO_2 and O_2 concentrations and dry molecular weight of a sample from an effluent gas stream of a fossil-fuel combustion process or other process.

Gas samples were extracted from the RTO outlet by single-point, grab sampling and was analyzed for percent CO_2 and percent O_2 using a fyrite.

Measurements were not performed at either RTO inlet location. Per USEPA Method 2 Section 8.6, for processes emitting essentially air, an analysis of O_2 and CO_2 need not be conducted and a dry molecular weight of 29.0 may be used.

4.4 Moisture Determination by USEPA Method ALT-008

This method is an approved alternative to USEPA Method 4 for the determination of stack gas moisture content using midget impingers. A gas sample was extracted at a constant rate from the RTO outlet. Moisture was removed from the sample stream by a series of pre-weighed impingers immersed in an ice bath.

4.5 Moisture Determination by ASTM Method E337-62

This method utilizes the flue gas wet bulb/dry bulb temperatures and absolute pressure to approximate the moisture content in the flue gas. Moisture content of the Hardcoat and Anti-Fog RTO inlets has been calculated as follows:

$$Bws = \left[\frac{e' - AP(t - t')}{P}\right]$$

where:

$e' = $ saturated vapor pressure of water, in. Hg, at the wet bulb temperature, t'

$A = 3.67 \times 10^{-4}\left[1 + 0.00064(t' - 32)\right]$

$P = $ absolute pressure, in. Hg, in the duct

$t = $ dry bulb temperature, °F

$t' = $ wet bulb temperature, °F

4.6 Total Organic Concentration Determination by USEPA Method 25A

This method is applicable for the determination of total gaseous organic concentration of vapors consisting primarily of alkanes, alkenes, and/or arenes (aromatic hydrocarbons). The concentration are expressed in terms of propane.

A gas sample was extracted from each source through a heated sample line and glass fiber filter to a flame ionization analyzer (FIA).

4.7 Verification of Enclosure Evaluation by USEPA Method 204

This procedure was used to determine whether the Hardcoat permanent enclosure meets the criteria for a total enclosure.

The enclosure was evaluated against the set of criteria described below. All of the criteria were met and Automotive Lighting confirmed that all exhaust gases from the enclosure are ducted to the RTO. Volatile organic compound (VOC) capture efficiency (CE) is assumed to be 100 percent, and CE was not measured.

The Permanent Total Enclosure (PTE) must meet five (5) specific engineering criteria. The criteria are described in USEPA Method 204, 40CFR51, Appendix M. A summary of these items and the evaluation technique used follows:

Natural Draft Openings (NDO) Distance to Emitting Point

Criteria: All NDOs such as open doorways, windows, etc. must be at least four equivalent NDO diameters from the nearest potential VOC emission point.

Technique: The dimensions of all NDOs and potential emission points are measured. The calculated NDO equivalent diameters are compared to the emission point distances measured.

Total NDO Area

Criteria: The area of all NDOs divided by the total area of all walls, floor and ceilings in the enclosure (called the "NEAR" ratio in the procedure) must not exceed 0.05.

Technique: Measurements are used to determine the surface area of the room and the NDOs and the NEAR ratio is determined.

Velocity of Air Flow through NDOs

Criteria: The calculated face velocity through the NDOs must be greater than 200 fpm. This is defined as the total exhaust volume (in scfm), less make up air, divided by the area of all NDOs (in square feet).

Technique: The alternative evaluation criteria was used to satisfy NDO face velocity. The static pressure of the enclosure was measured multiple times during the test program using a Dwyer 1439 Microtector. The average result was -0.014 inches of water (criteria is $\geq$ 0.007 inches H_2O).

Direction of Air Flow through the NDO

Criteria: The direction of air flow through all NDOs must be into the enclosure.

Technique: Smoke tubes or streamers were used at each NDO to measure the direction of the airflow. A record of this data will be included in the appendix.

4.8 Volatile Organic Compounds in Captured Stream by USEPA Method 204B

This method is applicable for the determination of volatile organic compounds content in captured gas streams. It is suitable for determining VOC mass to control for use in gas/gas or liquid/gas capture test protocols. The concentration is expressed in terms of propane.

A gas sample was extracted from the source through a heated sample line and glass fiber filter to a flame ionization analyzer (FIA). USEPA Methods 1-4 are incorporated by reference and are necessary to calculate an organic mass rate (lb/hr).

4.9 Volatile Organic Compounds from Liquid Input Stream by USEPA Method 204F

This procedure is used to determine the amount of VOC introduced to a process and is intended to be used in the development of liquid/gas capture test protocols.

A digital scale was used to measure the liquid input stream(s) at the beginning and end of each test run to determine the total weight of material used to within 0.2 lb. or 1.0 percent. Samples were collected from the single liquid input stream at the beginning and

end of each test run. Material samples were used to determine VOC content of the input and to develop FIA response factors for the material.

5.0 QUALITY ASSURANCE PROCEDURES

TRC integrates our Quality Management System (QMS) into every aspect of our testing service. We follow the procedures specified in current published versions of the test Method(s) referenced in this report. Any modifications or deviations are specifically identified in the body of the report. We routinely participate in independent, third party audits of our activities, and maintain:

- Accreditation from the Louisiana Environmental Laboratory Accreditation Program (LELAP);
- Accreditation from the Stack Testing Accreditation Council (STAC) and the American Association for Laboratory Accreditation (A2LA) that our operations conform with the requirements of ASTM D 7036 as an Air Emission Testing Body (AETB).

These accreditations demonstrate that our systems for training, equipment maintenance and calibration, document control and project management will fully ensure that project objectives are achieved in a timely and efficient manner with a strict commitment to quality.

All calibrations are performed in accordance with the test Method(s) identified in this report. If a Method allows for more than one calibration approach, or if approved alternatives are available, the calibration documentation in the appendices specifies which approach was used. All measurement devices are calibrated or verified at set intervals against standards traceable to the National Institute of Standards and Technology (NIST). NIST traceability information is available upon request.

ASTM D7036-04 specifies that: *"AETBs shall have and shall apply procedures for estimating the uncertainty of measurement. Conformance with this section may be demonstrated by the use of approved test protocols for all tests. When such protocols are used, reference shall be made to published literature, when available, where estimates of uncertainty for test methods may be found."* TRC conforms with this section by using approved test protocols for all tests.

6.0 TEST RESULTS SUMMARIES

VOC Destruction Efficiency Summary

Project Number:	280992	Test Date(s):	07/11/18
Customer:	Automotive Lighting LLC	Facility:	Clarkston, MI
Unit Identification:	Hardcoat & Antifog RTO	Recorded by:	Gavin Lewis

Location	Hard coat Inlet			
Test Run No.	1	2	3	Average
Test Date	7/11/2018	7/11/2018	7/11/2018	
Test Time - Start	12:20	14:05	15:45	
Test Time - End	13:19	15:04	16:44	
VOC (ppmvw as Propane)	383.17	382.89	388.51	384.86
Volumetric Flow Rate (scfm)	2437	2394	2403	2411
VOC (lb/hr as Propane)	6.412	6.294	6.410	6.372

Location	Anti-Fog Inlet			
Test Run No.	1	2	3	Average
Test Date	7/11/2018	7/11/2018	7/11/2018	
Test Time - Start	12:20	14:05	15:45	
Test Time - End	13:19	15:04	16:44	
VOC (ppmvw as Propane)	84.05	103.73	97.84	95.21
Volumetric Flow Rate (scfm)	588	603	602	598
VOC (lb/hr as Propane)	0.339	0.430	0.404	0.391

Location	Outlet (DE Only)			
Test Run No.	1	2	3	Average
Test Date	7/11/2018	7/11/2018	7/11/2018	
Test Time - Start	12:20	14:05	15:45	
Test Time - End	13:19	15:04	16:44	
VOC (ppmvw as Propane)	5.87	6.00	5.93	5.93
Volumetric Flow Rate (scfm)	3252	3237	3310	3266
VOC (lb/hr as Propane)	0.131	0.133	0.135	0.133

Destruction Efficiency				
Test Run No.	1	2	3	Average
Inlet VOC (lb/hr as Propane)	6.752	6.724	6.814	6.763
Outlet VOC (lb/hr as Propane)	0.131	0.133	0.135	0.133
Efficiency (%)	98.06	98.02	98.02	98.03

FGRTO Capture Efficiency Summary

Project No:	280992	Test Date(s):	7-11 & 7-12, 2018
Customer:	Automotive Lighting LLC	Facility:	Clarkston, MI
Unit ID:	FGRTO	Recorded by:	D. Ryan

Antifog Test Results					
Location	Test No.	Test Date(s)	Test Time		VOC Mass Rate (lb/hr as C_3H_8)
			Begin	End	
RTO Inlet (To Control)	1-A	07/11/18	12:20	13:19	0.341
	1-B	07/11/18	14:05	15:04	0.434
	1-C	07/11/18	15:45	16:44	0.411
	Run #1 Average				**0.395**
	2	07/12/18	9:45	13:20	0.198
	3	07/12/18	14:00	21:25	0.175
	Average				0.256
Process Input	1	07/11/18	12:20	16:44	0.592
	2	07/12/18	9:45	13:20	0.327
	3	07/12/18	14:00	21:25	0.300
	Average				0.406

Hardcoat Test Results					
Location	Test No.	Test Date(s)	Test Time		VOC Mass Rate (lb/hr as C_3H_8)
			Begin	End	
RTO Inlet (To Control)	1-A	07/11/18	12:20	13:19	6.41
	1-B	07/11/18	14:05	15:04	6.38
	1-C	07/11/18	15:45	16:44	6.52
	Run #1 Average				**6.44**
	2	07/12/18	9:45	13:20	4.45
	3	07/12/18	14:00	21:25	4.28
	Average				5.06

NOTE: Hard coat line satisfies PTE. Capture is assumed to be 100% (VOC input = VOC to control).

FGRTO Capture Efficiency Summary (Cont.)

Antifog Capture Efficiency Determination			
Test No.	VOC Mass Rate (lb/hr as C_3H_8)		Capture Efficiency %
	To Control	Process Input	
1	0.395	0.592	66.8
2	0.198	0.327	60.6
3	0.175	0.300	58.3
Average	0.256	0.406	61.9

FGRTO System Capture Efficiency Determination						
Test No.		VOC Mass Rate (lb/hr as C_3H_8)				Capture Efficiency %
		To Control		Process Input		
		Hardcoat	Antifog	Hardcoat	Antifog	
1		6.44	0.395	6.44	0.592	97.2
	Total	6.83		7.03		
2		4.45	0.198	4.45	0.327	97.3
	Total	4.65		4.78		
3		4.28	0.175	4.28	0.300	97.3
	Total	4.46		4.58		
Average		5.31		5.46		97.3