Derenzo and Associates, Inc.
Environmental Consultants

EMISSION TEST REPORT

Report Title	RESULTS OF THERMAL OXIDIZER AND BUILDING ENCLOSURE VOC CONTROL EFFICIENCY DETERMINATION
Report Date	June 4, 2015
Test Dates	May 5 – 6, 2015

Facility Information	
Name	Fitzgerald Finishing, L.L.C.
Street Address	17450 Filer Ave.
City, County	Detroit, Wayne
Phone	(313) 368-3630

Facility Permit Information			
State Registration No.	B3037	Permit to Install	403-99C

Testing Contractor	
Company	Derenzo and Associates, Inc.
Mailing Address	4990 Northwind Drive, Suite 120 East Lansing, MI 48823
Phone	(517) 324-1880
Project No.	1503009

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RESULTS OF THERMAL OXIDIZER AND BUILDING ENCLOSURE VOC CONTROL EFFICIENCY DETERMINATION

FITZGERALD FINISHING, L.L.C.
DETROIT, MICHIGAN

1.0 INTRODUCTION

Fitzgerald Finishing, L.L.C. (Fitzgerald) operates miscellaneous metal parts coating processes at its facility located at 17450 Filer Ave., Detroit, Wayne County, Michigan. Coating is transferred to the parts using dip-spin application and dried or cured in coating ovens. Volatilized solvents from the dip-spin parts coating processes are captured using a process ventilation system and directed to a regenerative thermal oxidizer (RTO) for the reduction of volatile organic compounds (VOC).

Fitzgerald recently installed a new regenerative thermal oxidizer (RTO) and was issued Permit to Install (PTI) No. 403-99C (dated February 18, 2014) by the Michigan Department of Environmental Quality, Air Quality Division (MDEQ-AQD). Condition V.2 for the emission group FG-DIPSPINS requires Fitzgerald to verify the capture efficiency of the air collection system and destruction efficiency of the RTO within 180 days of installation of RTO2. Installation of RTO2 was completed on December 29, 2014.

The VOC control efficiency determination testing was performed May 5 – 6, 2015 by Derenzo and Associates, Inc. representatives Robert Harvey, Andrew Rusnak, Jason Logan, Kalan Briggs, Jeff Schlaff and Blake Beddow. The project was coordinated by Fitzgerald representatives Mr. Larry Gutowsky and Ms. Amanda Davidson.

Mr. Tom Maza and Mr. Jorge Acevedo of the Michigan Department of Environmental Quality, Air Quality Division (MDEQ-AQD) were on-site to observe the compliance testing. The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan submitted to MDEQ-AQD dated March 27, 2015 and approved by the regulatory agency.

Appendix 1 provides a copy of the test plan approval letter issued by the MDEQ-AQD.

1.1 Project Contact Information

Questions regarding this emission test report should be directed to:

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1.2 Report Certification

This test report was prepared by Derenzo, Associates, Inc. based on field sampling data collected by Derenzo and Associates, Inc. Facility process data were collected and provided by Fitzgerald employees or representatives. This test report has been reviewed by Fitzgerald representatives and approved for submittal to the MDEQ-AQD.

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

Report Prepared By:

Andy Rusnak, QSTI
Technical Manager
Derenzo and Associates, Inc.

I certify that the facility and emission units were operated at maximum routine operating conditions for the test event. Based on information and belief formed after reasonable inquiry, the statements and information in this report are true, accurate and complete.

LARRY Gutowsky

Larry Gutowsky
General Manager
Fitzgerald Finishing, L.L.C.

2.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

2.1 Metal Parts Coating Line

Fitzgerald operates eight (8) dip-spin coating lines to apply high performance corrosion-resistant coatings to miscellaneous metal parts (e.g., fasteners, nuts, bolts).

In each coating line parts are loaded into a feed bin and conveyed into the dip-spin coating section. In the dip-spin coating section, a steel basket containing the miscellaneous metal parts is submerged in a coating reservoir. The coating reservoir is then lowered and the basket is spun to remove excess coating from the surface of the coated parts. The excess coating is collected on the interior freeboard surface of the coating reservoir and gravity drains to the liquid level within the reservoir. The coated parts are then dropped to a conveyor that transports them through a two-zone curing oven and a cool down zone. At the exit of the cool down zone the parts are dropped to a final product collection bin.

2.2 Type and Typical Quantity of Raw and Finished Materials Used in each Process

The high performance coatings are primarily solvent based, though some waterborne formulations are used. Coatings are received from the manufacturer and diluted (reduced) with either organic solvents or distilled water as appropriate prior to their application. For the compliance test demonstration only solvent based coatings were applied.

2.3 Emission Control System Description

Each coating line exhausts process air from the:

1. Dip-spin coating booth,
2. Capture hood or tunnel installed over the conveyor, where the coated parts are dropped from the basket;
3. Two-zone curing oven; and
4. Cool down zone.

Solvent laden process air exhausted from the dip-spin coating booths, conveyor hoods, and the coating ovens are combined and exhausted to a Tellkamp Roxidizer Model 40 VOC emissions control system (RTO). Process air exhausted from the cool down zones contain low concentrations of VOC (typically less than 20 ppm measured as propane) and are exhausted directly to the ambient atmosphere.

The RTO system consists of a variable frequency drive (VFD) fan, two (2) energy recovery chambers and a high-temperature combustion chamber containing natural gas-fired burners.

Fan speed is controlled to maintain an appropriate vacuum within the process air collection system and direct the collected air to the RTO unit. The solvent laden air enters the RTO unit through the inlet manifold into the base of the energy recovery chamber 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.

The energy recovery chambers periodically switch so 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 has a nominal design capacity of 40,000 standard cubic feet per minute (scfm). The combustion chamber is designed to maintain an adequate operating temperature that results in a VOC destruction efficiency of greater than 98%.

2.4 Sampling Locations and Velocity Measurements

The sampling location for the:

- RTO inlet (captured gas stream) was in the 45-inch diameter duct (common header) exterior to the facility, prior to RTO system fan.
- RTO outlet was in the 47.5-inch diameter vertical exhaust stack.
- Coating line cooldown zone exhausts were in the vertical exhaust stack for each line.
- Phosphating line was in the 39.5-inch diameter vertical exhaust stack.

Velocity traverse locations for each sampling point were determined in accordance with USEPA Method 1. A cyclonic flow check was performed for each measurement location to verify acceptability of the flow profile. Exhaust gas velocity pressure and temperature were measured at each sampling location in accordance with USEPA Method 2 using an S-type Pitot tube connected to a red-oil manometer. A K-type thermocouple mounted to the Pitot tube was used for temperature measurements. The Pitot tube and connective tubing were periodically leak-checked to verify the integrity of the measurement system.

Appendix 2 provides diagrams of the test sampling locations.

3.0 SUMMARY OF RESULTS

3.1 Purpose and Objectives of the Tests

Condition No. V.2. for FG-DIPSPINS (PTI No. 403-99C) states:

> *Within 180 days after commencement of trial operation, the permittee shall verify the VOC capture and destruction efficiency for both RTO1 and RTO2, from FG-DIPSPINS by testing at owner's expense, in accordance with Department requirements. No less than 60 days prior to testing, the permittee shall submit a complete test plan to the AQD Technical Programs Unit and District Office. The AQD must approve the final plan prior to testing. Verification of emission rates includes the submittal of a complete report of the test results to the AQD Technical Programs Unit and District Office within 60 days following the last date of the test.*

Installation of RTO2 was completed on December 29, 2014. After trial operation of RTO2 was complete RTO1 was removed from service and physically disconnected from the facility's RTO inlet common header.

For the RTO destruction efficiency (DE) determination the RTO inlet and exhaust gas streams were simultaneously monitored for three (3) one-hour test periods during which the VOC, oxygen (O_2) and carbon dioxide (CO_2) concentrations were measured using instrumental analyzers. Moisture content for the both gas streams was determined by gravimetric weight gain in chilled impingers.

For the RTO capture efficiency (CE) determination the RTO inlet, cooldown oven and phosphating line exhaust gas streams were simultaneously monitored for four (4) test periods during which the VOC concentrations were measured using instrumental analyzers. Moisture content for the RTO inlet gas stream was determined by gravimetric weight gain in chilled impingers. Moisture content in the cooldown oven and phosphating line exhaust gas streams was determined using the wet bulb/dry bulb approximation technique.

3.2 Variations from Normal Sampling Procedures or Operating Conditions

The testing was performed in accordance with the Test Protocol dated March 27, 2015 and specified USEPA test methods.

All instrument calibrations and sampling period results satisfied the quality assurance verifications required by USEPA Methods 3A and 25A, with the exception of the post CE Test No. 1 instrument calibrations for the rack mounted instruments (Cooldown Oven Exhaust Nos. 1 – 8 and phosphating line measurements). The post test calibrations drifted outside of the acceptable range compared to the initial calibrations (drifted low). This was discussed with Tom

Maza of the MDEQ and determined acceptable as long as the measured test concentrations were drift corrected using the post-test calibration readings and the instruments were recalibrated prior to the second test.

The third CE test period was run with the oven exhaust duct dampers fully open, in order to determine if that would increase the measured capture efficiency. The CE was slightly lower for the third test (when compared to the second test) so a fourth run was performed with the oven exhaust duct dampers in their original position. The four CE test period results had a Data Quality Objective indicator statistic of 2.70%, therefore, for the purposes of the overall CE determination all four (4) runs were considered. No other variations from the normal operating conditions of the coating lines or RTO occurred during the testing program.

3.3 Process Operating Conditions During the Compliance Testing

All eight (8) coating lines were operated during the compliance test periods and applied only solvent-based coatings. Individual line operation is interrupted periodically for paint checks, viscosity adjustments, paint changes, basket changes, and lot separation, which is typical of normal operations. These process interruptions were kept to a minimum during the compliance test periods. Process information was recorded on production log sheets with other critical operating data (start time, number of parts containers, coating applied, etc.). None of the coating lines experienced excessive or unusual downtime during the test periods.

Table 3.1 presents a summary of the production data for the test day.

The RTO maintained a minimum combustion chamber temperature of 1,536°F throughout the destruction efficiency test periods. The average recorded combustion chamber temperature was 1,560°F. The fan damper was set at 55% and the average pressure drop across the filter was 0.56 in. H_2O.

Appendix 3 provides RTO temperature records and production log sheets for each coating line.

During the capture efficiency testing, the oven cooldown exhausts and the phosphating tank exhaust system were in operation. The phosphating tank exhaust system, located within the building enclosure, has the potential to capture fugitive VOC emissions from within the facility and was included in the test program as an uncontrolled building enclosure exhaust.

Appendix 2 provides a building drawing depicting the process air collection and control system.

3.4 Summary of Air Pollutant Sampling Results

The RTO inlet and exhaust gas streams were monitored simultaneously during three (3) one-hour test periods to determine the VOC mass flowrate entering and exiting the RTO for VOC destruction efficiency (DE) determination. The calculated VOC DE for the RTO averaged 99.1% by weight. The oxidizer operated at a minimum chamber temperature of 1,536 °F.

In a separate demonstration, the captured process exhaust gas stream (combined dip-spin process exhaust to the RTO) and uncaptured facility exhausts were monitored simultaneously during four (4) test periods to determine the VOC capture efficiency (CE). The calculated VOC CE for the process air collection system averaged 86.3% by weight.

The average overall VOC reduction efficiency for the dip-spin coating process based on the test results (the product of the measured capture efficiency and destruction efficiency) is 85.5% by weight.

Table 3.2 presents a summary of the compliance test results.

Table 3.1 Summary of production data for May 6, 2015

Coating Unit	Number of Jobs Run	Number of Baskets Run	Total Run Weight (lb)	Weight per Basket
Line No. 1	19	409	186,912	457
Line No. 2	25	321	139,524	435
Line No. 3	21	483	228,156	472
Line No. 4	8	98	8,317	85
Line No. 7	29	858	167,038	195
Line No. 8	24	899	181,417	202
Line No. 9	16	753	171,455	228
Line No. 10	36	721	157,305	218

Table 3.2 Summary of VOC control efficiency test results

Operating Parameter / Test Measurement	Test No.1 Results	Test No.2 Results	Test No.3 Results	Test No. 4 Results	Average
Fan Damper Setting (%)	55	55	55	--	55
Filter Press. Drop (inH$_2$O)	0.56	0.58	0.55	--	0.56
RTO Temperature (°F)	1,558	1,561	1,561	--	1,560
Destruction Efficiency (%wt)	99.0	98.9	99.2	--	99.1
Capture Efficiency (%wt)	84.6	87.5	85.8	87.2	86.3
Overall Reduction (%wt)	--	--	--	--	85.5

4.0 SAMPLING AND ANALYTICAL PROCEDURES

The compliance testing consisted of the determination of total hydrocarbon (THC) concentration and air flowrate for the gas streams entering and exiting the RTO emission control system, and the captured and uncaptured gas streams exiting the building enclosure.

4.1 Summary of USEPA Test Methods

Derenzo and Associates, Inc. performed the exhaust gas and pollutant measurements in accordance with the following USEPA reference test methods:

Method 1	Velocity and sampling locations based on physical stack measurements.
Method 2	Gas flowrate determined using a type S Pitot tube.
Method 3A	RTO exhaust gas O_2 and CO_2 content determined using instrumental analyzers.
Method 3	RTO inlet and building enclosure exhaust O_2 and CO_2 content determined by Fyrite® combustion gas analyzers.
Method 4	Gas moisture based on the water weight gain in chilled impingers for the RTO inlet and exhaust gas streams. Moisture for all other sampling locations determined by wet bulb/dry bulb temperature measurements.
Method 25A	Total hydrocarbon concentration using a flame ionization analyzer (FIA) compared to a propane standard.
Method 204B	Determination of VOC emissions in captured vapor streams
Method 204E	Determination of VOC emissions from uncaptured vapor streams from a building enclosure (BE)

4.2 VOC Destruction Efficiency Determination

RTO VOC destruction efficiency was determined based on the simultaneous sampling of the RTO inlet and exhaust gas streams during three (3) one-hour sampling periods. THC concentration in the RTO inlet was measured by a Thermo Environment Instruments (TEI) Model 51 flame ionization detector (FID) according to USEPA Method 25A as described in Section 4.4 of this document. Nonmethane (NMHC) concentration in the RTO exhaust was measured by a TEI Model 55i methane/nonmethane flame ionization detector (FID) equipped with a gas chromatograph (GC) column, for methane separation, according to USEPA Method 25A as described in Section 4.4 of this document.

Gas properties for the RTO inlet were determined pursuant to USEPA Methods 3 and 4 using Fyrite® gas scrubbers to determine carbon dioxide and oxygen (CO_2/O_2) content and moisture by the chilled impinger method. Gas properties for the RTO exhaust were determined pursuant to USEPA Methods 3A and 4 using instrumental analyzers to determine CO_2/O_2 content and moisture by the chilled impinger method.

Air velocity measurements for each sampling location were performed near the beginning and end of each one-hour test period using a type-S Pitot tube in accordance to USEPA Method 2.

4.3 VOC Capture Efficiency Determination

The Fitzgerald Finishing structure operates as two (2) separate non-fugitive building enclosure (a permanent total enclosure with uncontrolled atmospheric exhausts). The first enclosure, located at the south end of the facility contains Line Nos. 9 and 10. The second enclosure located in the middle of the facility contains the phosphating tank and Line Nos. 1 – 4 and 7 – 8. The two (2) enclosures are separated by a material handling and paint storage area which are effectively separated and not considered part of either enclosure. Therefore, VOC capture efficiency across the eight (8) coating lines and phosphating line was determined by a gas/gas capture efficiency protocol using the facility as a building enclosure. A total of four (4) FID instruments were used simultaneously to measure the THC concentration in the captured and uncaptured gas streams. The:

- RTO inlet (captured gas stream) was monitored continuously using a TEI Model 51 FID analyzer and the captured VOC mass flowrate was determined using USEPA Method 204B.

- Phosphating tank exhaust was monitored continuously using a California Analytical Instruments (CAI) 600-Series heated FID analyzer.

- Eight (8) cooldown zone exhausts were monitored periodically during each test period using either a TEI Model 55i, CAI 300-Series heated FID analyzer or CAI 600 FID analyzer.

The total uncaptured VOC mass emission rate (sum of the nine uncaptured exhausts) was determined using USEPA Method 204E.

The CO_2/O_2 content for each gas stream was comparable to ambient air and verified using Fyrite® gas scrubbers. Moisture content of the RTO inlet gas stream (captured gas stream) was determined using the chilled impinger method; moisture content for all other gas streams was determined based on wet bulb-dry bulb temperature measurements. Air velocity measurements were performed for each gas stream at least once during each capture efficiency test period using a type S Pitot tube in accordance with USEPA Method 2.

During each capture efficiency test period, the direction of airflow into the building enclosure through all open natural draft openings (primarily manway doors or overhead doors) were verified using chemical airflow indicator tubes (smoke tubes).

4.4 Instrumental Analyzer Operating Procedures

THC concentration in the exhaust gas streams identified in the previous section was determined by USEPA Method 25A, *Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer*. Throughout each test period, a gas sample from each measurement location was delivered to the instrument rack using a heated Teflon sample line and extractive gas sampling system. Hydrocarbon concentrations were determined using a TEI Model 51, TEI Model 55i, CAI 300 or CAI600 FID instrument. The sampled gas stream was not dried prior to being introduced to the FID instruments; therefore, THC concentration measurements correspond to standard conditions with no moisture correction.

CO_2/O_2 content for the RTO exhaust was monitored continuously throughout the VOC DE test periods using a Servomex 1440D non-dispersion infrared (NDIR) analyzer for CO_2 and a paramagnetic sensor for O_2 in accordance with USEPA Method 3A. The sampled gas stream was dried prior to analysis using a refrigerant-based condenser equipped with a peristaltic pump to remove moisture from the sampled gas stream. Therefore, CO_2 and O_2 concentration measurements were performed on a dry gas basis.

At the conclusion of each test period, instrument calibration was verified against a mid-range (or representative up-scale) calibration gas and zero gas. The FID instruments were calibrated with certified concentrations of propane in air and zeroed using hydrocarbon-free air. The CO_2/O_2 analyzer was calibrated using certified concentrations of CO_2 and O_2 in nitrogen and zeroed using nitrogen. Concentrations measured with the instrumental analyzers were adjusted for calibration error and zero drift using the procedures in Method 7E.

The TEI Model 51 and 55i FID analyzers and Servomex 1440D CO_2/O_2 analyzer were rack-mounted in a mobile sampling trailer. 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. A STEC Model SGD-710C ten-step gas divider was used to obtain intermediate calibration gas concentrations as needed.

The CAI Model 300 and 600 THC FID analyzers were mounted in a mobile rack that was operated within the facility. Instrument response for each instrumental 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. A STEC Model SGD-SC-5L five-step gas divider was used to obtain intermediate calibration gas concentrations as needed.

4.5 Quality Assurance Procedures

Accuracy of the instrumental analyzers used to measure THC, NMHC, 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. Prior to the first test period of each day, appropriate high-range, mid-range and low-range span gases (USEPA protocol 1 certified calibration gases) followed by a zero gas (hydrocarbon free air or nitrogen) were introduced into each sampling system to verify instrument response and sampling system integrity. In addition, the analyzers used for the RTO outlet and cooldown exhausts were challenged with an additional low-level calibration gas (approximately 10 ppm propane) as requested by the MDEQ-AQD in the test plan approval letter. The calibration gas was delivered to the sampling system through a spring-loaded check valve and a stainless steel "Tee" installed at the base of the sample probe.

The gas dividers used to obtain intermediate calibration gas concentrations had each been NIST-certified within the previous year with a primary flow standard in accordance with USEPA Method 205 and were verified in the field according the procedures in Method 205, Section 3.2.

The Pitot tubes used for velocity pressure measurements were inspected for mechanical integrity and physical design prior to the field measurements. The gas velocity measurement trains (Pitot tube, connecting tubing and incline manometer) were leak-checked prior to the field measurements and periodically throughout the testing period. The absence of cyclonic flow was also verified for each measurement point.

The Nutech® Model 2010 sampling consoles and dry gas meters, which were used to extract a metered amount of exhaust gas from the RTO inlet and exhaust stack for moisture determination, were calibrated prior to and after the test event using the critical orifice calibration technique specified in USEPA Method 5. The digital pyrometer in the Nutech metering console was calibrated using a NIST traceable Omega® Model CL 23A temperature calibrator.

Appendix 4 provides information and quality assurance data for the equipment and instrumental analyzers used for the destruction and capture efficiency test periods (diagrams of the instrumental analyzer sample trains, calibration data, copies of calibration gas certificates, gas divider certification, Pitot tube integrity inspection sheets, and meter box critical orifice calibration records). The data quality objective (DQO) indicator calculations are also provided in Appendix 4.

5.0 TEST RESULTS AND DISCUSSION

5.1 RTO VOC Destruction Efficiency

The RTO inlet and exhaust gas streams were sampled May 5, 2015 for three (3) one-hour test periods to determine THC concentration and volumetric flowrate for each gas stream. Inlet and outlet THC concentration was monitored continuously using flame ionization analyzers. Air flowrate measurements were performed near the beginning and end of each test period.

VOC mass flowrate (THC as propane) into and out of the control device was calculated using the following equation:

$$M_{VOC} = Q\,[C_{THC}]\,MW\,(60\text{ min/hr}) / V_M / 1E{+}06$$

Where:

M_{VOC} = Mass flowrate VOC (lb/hr)
Q = Volumetric flowrate corrected to standard conditions (scfm)
C_{THC} = THC concentration (ppmv as propane)
MW = Molecular weight of propane (44.1 lb/lb-mol)
V_M = Molar volume of ideal gas at standard conditions (385 scf/lb-mol)

VOC destruction efficiency was determined based on the ratio of the inlet and outlet THC mass flowrate:

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

The average measured THC concentration for the combined coating line exhaust to the RTO was 375 parts per million by volume (ppmv) measured as propane. The average measured volumetric flowrate into the RTO was 22,812 standard cubic feet per minute (scfm), resulting in an average VOC mass flowrate of 58.7 pounds per hour (lb/hr) into the RTO.

The average measured THC concentration in the RTO exhaust was 2.72 ppmv as propane. Based on the measured flowrate of 29,228 scfm, the calculated exit VOC mass flowrate was 0.55 lb/hr, resulting in an average VOC DE of 99.1 percent by weight (% wt.)

Table 5.1 presents measured gas conditions and results for the VOC destruction efficiency test periods.

Appendix 5 provides calculations, instrument response data, and field data sheets used to determine VOC mass flow rate and destruction efficiency for each one-hour test period.

5.2 Building Enclosure VOC Capture Efficiency

A total of nine (9) uncaptured building exhausts (eight cooldown zone exhausts and phosphating line exhaust) and one captured gas stream (RTO inlet) were measured to determine VOC capture efficiency. Four (4) capture efficiency test periods were performed. The first test period was 95 minutes in length. Test Nos. 2 – 4 were 80 – 85 minutes in length.

The RTO inlet gas stream was monitored continuously throughout each capture efficiency test period. The cooldown zone exhausts and phosphating line exhaust were monitored periodically throughout each capture efficiency test period. The sample probe was moved from one exhaust to the next every 20 to 50 minutes, which resulted in 15 to 45 minutes of data collection for each exhaust during each test period. Concentration data collected while the sample probe was moved between measurement locations was discarded from the data set. The measured concentration data for each uncaptured exhaust were determined to be representative of the entire test period.

The captured VOC mass flowrate (M_{VOC}) was calculated using the equation presented in the previous section, which is consistent with procedures presented in USEPA Method 204B, *Volatile Organic Compound Emissions in Captured Stream.* The uncaptured VOC mass flowrate for each building exhaust was calculated using the same equation and the procedures presented in Method 204E, *Volatile Organic Compound Emissions in Uncaptured Stream from Building Enclosure.* VOC capture efficiency was determined by the ratio of the captured VOC mass flow to total measured VOC mass flow using the following equation:

$$CE_{VOC} = \frac{M_{VOC,\,Cap}}{M_{VOC,\,Cap} + \Sigma\, M_{VOC,Uncap}} \quad (100\ \%)$$

Where:

CE_{VOC} = VOC capture efficiency (% weight)
$M_{VOC,\,Cap}$ = VOC mass flowrate for captured stream (lb/hr)
$\Sigma\, M_{VOC,\,Uncap}$ = Total VOC mass flowrate in uncaptured building exhausts (lb/hr)

The average measured VOC mass flowrate for the captured gas stream was 58.8 lb/hr compared to an average measured uncaptured VOC mass emission rate of 9.32 lb/hr. This results in a calculated average capture efficiency of 86.3% by weight.

Table 5.2 presents measured captured and uncaptured building exhaust gas conditions and results for the VOC capture efficiency test periods.

Appendix 6 provides calculations and field data sheets used to determine exhaust gas conditions and volumetric flowrates, including records of instrumental analyzer response and calibrations for each test period.

5.3 Building Enclosure Verification

Several natural draft openings (NDOs) in the building enclosures were identified:

- Five (5) manway doors;
- Two (2) overhead doors; and
- Three (3) strip curtain covered openings into the enclosures.

All of these NDOs were open or partially open throughout each test period and the direction of airflow through the NDO was verified using chemical smoke tubes. Measurements were performed to determine the size of each NDO and its distance to the nearest VOC emitting point to demonstrate that the building enclosure and NDOs satisfy the USEPA Method 204 enclosure requirements for:

- Maximum NDO to enclosure area ratio (NEAR);
- Minimum NDO to emission point spacing; and
- Minimum NDO face velocity for inward flow.

Observations of airflow direction performed during the test periods verified that the direction of airflow at each facility NDO is inward relative to the building enclosure. Therefore, all fugitive emissions within the building are either captured within the process air collection system and directed to the RTO or exhausted to the atmosphere through the identified uncaptured exhausts, which were measured during the tests.

Table 5.3 presents the identified building enclosure NDOs and calculated average face velocity.

Appendix 7 provides measurements and observations for the building NDOs.

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

Date	5/5/2015	5/5/2015	5/5/2015	
Test Times	933 - 1033	1102 - 1202	1240 - 1340	
RTO Operating Data	Test 1	Test 2	Test 3	Avg
Fan Damper Setting (%)	55	55	55	55
Filter Pressure Drop (inH$_2$O)	0.56	0.58	0.55	0.56
Average Temperature (°F)	1558	1561	1561	1560
Minimum Temperature (°F)	1540	1536	1544	1536
RTO Inlet Gas				
Temperature (°F)	184	170	166	175
Flowrate (scfm)	22,134	22,961	23,341	22,812
Average THC Conc.[1] (ppmv C_3)	388	319	417	375
Calculated VOC Mass Flow[2] (lb/hr)	59.0	50.3	66.9	58.7
RTO Exhaust Gas				
Temperature (°F)	227	232	237	232
Flowrate (scfm)	28,539	29,398	29,747	29,228
Average THC Conc.[1] (ppmv C_3)	2.99	2.69	2.49	2.72
Calculated VOC Mass Flow[2] (lb/hr)	0.59	0.54	0.51	0.55
Calculated Destruction Efficiency[3]				
[1 – ($M_{VOC,out}$ / $M_{VOC,in}$)] x 100%	99.0%	98.9%	99.2%	99.1%

Table 5.1 Notes

1. Total hydrocarbon concentration as propane measured using a flame ionization analyzer in accordance with USEPA Method 25A.
2. THC mass flowrate calculated as propane:
   (Gas Flowrate, scfm) (Concentration, ppmv) (44.1 lb/lbmol) (60 min/hr) / (385 scf/lbmol) / 1E+06
3. Based on THC mass flowrate.

Table 5.2 Measured gas conditions and results for the VOC capture efficiency test

Date	5/6/2015	5/6/2015	5/6/2015	5/6/2015	
Test Times	945-1120	1230-1355	1450-1610	1650-1810	
RTO Inlet Gas (Captured)	Test 1	Test 2	Test 3	Test 4	Avg.
Flowrate (scfm)	24,296	24,972	24,694	24,890	24,713
Avg. THC Conc.[1] (ppmv C_3)	334	371	337	344	346
Calc. VOC Mass Flow[2] (lb/hr)	55.7	63.6	57.1	58.8	58.8
Cooldown #1					
Flowrate (scfm)	12,098	11,736	9,424	8,599	10,464
Avg. THC Conc.[1] (ppmv C_3)	21.1	18.1	22.6	16.7	19.6
Calc. VOC Mass Flow[2] (lb/hr)	1.76	1.46	1.46	0.99	1.42
Cooldown #2					
Flowrate (scfm)	13,832	12,706	9,442	11,320	11,825
Avg. THC Conc.[1] (ppmv C_3)	9.74	14.8	8.45	3.70	9.17
Calc. VOC Mass Flow[2] (lb/hr)	0.93	1.29	0.55	0.29	0.76
Cooldown #3					
Flowrate (scfm)	30,673	29,581	30,269	30,283	30,202
Avg. THC Conc.[1] (ppmv C_3)	3.95	9.38	10.1	10.4	8.46
Calc. VOC Mass Flow[2] (lb/hr)	0.83	1.91	2.10	2.17	1.75
Cooldown #4					
Flowrate (scfm)	6,499	6,088	6,449	6,239	6,319
Avg. THC Conc.[1] (ppmv C_3)	4.71	9.48	13.6	3.77	7.89
Calc. VOC Mass Flow[2] (lb/hr)	0.21	0.40	0.60	0.16	0.34
Cooldown #7					
Flowrate (scfm)	29,645	29,252	28,726	30,232	29,464
Avg. THC Conc.[1] (ppmv C_3)	8.52	2.95	4.19	5.49	5.29
Calc. VOC Mass Flow[2] (lb/hr)	1.73	0.59	0.83	1.14	1.07
Cooldown #8					
Flowrate (scfm)	29,023	28,032	28,343	28,981	28,595
Avg. THC Conc.[1] (ppmv C_3)	8.28	1.22	3.48	2.72	3.92
Calc. VOC Mass Flow[2] (lb/hr)	1.65	0.24	0.68	0.54	0.78

Table 5.2 Measured gas conditions and results for the VOC capture efficiency test (continued)

Date	5/6/2015	5/6/2015	5/6/2015	5/6/2015	
Test Times	945-1120	1230-1355	1450-1610	1650-1810	
Cooldown #9	Test 1	Test 2	Test 3	Test 4	Avg.
Flowrate (scfm)	29,459	28,766	28,007	28,243	28,619
Avg. THC Conc.[1] (ppmv C_3)	11.4	12.4	14.5	14.1	13.1
Calc. VOC Mass Flow[2] (lb/hr)	2.31	2.45	2.79	2.73	2.57
Cooldown #10					
Flowrate (scfm)	28,389	27,416	27,151	26,724	27,420
Avg. THC Conc.[1] (ppmv C_3)	0.78	0.68	0.56	1.50	0.88
Calc. VOC Mass Flow[2] (lb/hr)	0.15	0.13	0.10	0.28	0.17
Phosphating Line					
Flowrate (scfm)	18,057	15,191	19,358	19,740	18,087
Avg. THC Conc.[1] (ppmv C_3)	4.39	5.63	2.86	2.36	3.81
Calc. VOC Mass Flow[2] (lb/hr)	0.55	0.59	0.38	0.32	0.46
Calculated Capture Efficiency					
Total captured mass flow (lb/hr)	55.7	63.6	57.1	58.8	58.8
Total uncaptured mass flow (lb/hr)	10.1	9.05	9.49	8.61	9.32
Capture efficiency[3]	84.6	87.5	85.8	87.2	86.3

Table 5.2 Notes

1. Total hydrocarbon concentration as propane measured using a flame ionization analyzer in accordance with USEPA Method 25A.
2. THC mass flowrate calculated as propane:
   (Gas Flowrate, scfm) (Concentration, ppmv) (44.1 lb/lbmol) (60 min/hr) / (385 scf/lbmol) / 1E+06
3. Capture efficiency determined by the ratio of the captured VOC mass flow to total measured VOC mass flow:
   (VOC captured) / (VOC captured + VOC uncaptured).

Table 5.3 Building enclosure natural draft openings and calculated average face velocity

Natural draft opening	NDO Dimensions (ft.)	NDO Area (sq. ft.)	NDO Eq. Diameter (ft.)	Dist. to VOC Emitting Pt. (ft.)	Inward Flow at all Times
Mandoor A by Line #10	3 x 7	21	4.2	101	Yes
Mandoor B by Line #9	3 x 7	21	4.2	101	Yes
Strip Curtain A to Mat. Hand.	8 x 7	56	7.5	78	Yes
Strip Curtain B to Mat. Hand.	8 x 8	64	8.0	45	Yes
Mandoor C by Line #8	3 x 7	21	4.2	22	Yes
Mandoor D by Line #3	3 x 7	21	4.2	48	Yes
Garage Door A by Line #3[A]	12.5 x 4	50	6.1	48	Yes
Garage Door B by Line #7[A]	11 x 2	22	3.4	25	Yes
Mandoor E by Phos. Line	3 x 7	21	4.2	86	Yes
Strip Curtain C to Phos. Lines	6 x 7	42	6.5	111	Yes

Total NDO area (sq. ft)	339
Combined enclosure area (sq. ft.)[B]	161,170
NDO to enclosure area ratio	0.002
Total exhaust rate (scfm)[C]	42,800
Calculated face velocity (ft/min)[D]	183

Table 5.3 Notes

A. The garage door by Line No. 3 is normally closed but was opened 4 ft. to facilitate the testing (i.e., sample lines running to roof) and the garage door by Line No. 7 is normally closed but was opened 2 ft. on the testing day.

B. Sum of both enclosures.

C. Sum of enclosure exhausts (captured gas stream and phosphating line exhaust). The cooldown zone exhausts are assumed to be in balance with the cooldown zone supply air (i.e., push pull system).

D. Includes all NDOs that were open during the test periods (i.e., man doors are normally closed).

E. NDO to enclosure ratio is calculated using the formula: (NDO area)/(Enclosure area).

F. Equivalent diameter is calculated using the formula: (2LW)/(L+W).

G. NDO face velocity is calculated using the formula: (Total exhaust rate, scfm)/(NDO area); note, since the mandoors were closed during test periods they were excluded from the calculation (i.e., NDO area was 234 ft^2)