EMISSION TEST REPORT FOR VOLATILE ORGANIC COMPOUNDS (VOC), ACETALDEHYDE AND FORMALDEHYDE ON THE YEAST RAISED BREAD BAKING LINE AT THE ROSKAM BAKING COMPANY FACILITY LOCATED IN KENTWOOD, MICHIGAN

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1.0 EXECUTIVE SUMMARY

On April 24, 2019, the Stack Test Group, Inc. performed volatile organic compound (VOC), acetaldehyde and formaldehyde emission testing at the Roskam Baking Company facility located in Kentwood, Michigan. Testing was conducted on the Yeast Raised Bread Baking Line. Three tests were conducted on the oven exhaust stack. Presented below are the average results of these tests.

Yeast Raised Bread Baking Line:

VOC Emission Factor:	0.54 Pounds per Ton of Baked Bread
VOC Emission Rate:	2.44 Pounds per Hour as Propane
Acetaldehyde Emission Factor:	0.09 Pounds per Ton of Baked Bread
Acetaldehyde Emission Rate:	0.42 Pounds per Hour
Formaldehyde Emission Factor:	0.02 Pounds per Ton of Baked Bread
Formaldehyde Emission Rate:	0.09 Pounds per Hour

2.0 INTRODUCTION

On April 24, 2019, the Stack Test Group, Inc. performed volatile organic compound (VOC), acetaldehyde and formaldehyde emission testing at the Roskam Baking Company facility located in Kentwood, Michigan.

Testing for total VOC's, acetaldehyde and formaldehyde was conducted on the oven exhaust stack associated with the Yeast Raised Bread Baking Line. The purpose of this testing was to determine the concentrations and emissions rates of the above-mentioned parameters in order to develop an emission factor.

Testing was conducted while Roskam Baking Company personnel were baking Rothbury Bread on the Yeast Raised Bread Baking Line at the maximum routine production rate of 66 cuts per minute and the corresponding oven at normal conditions. Rothbury Bread is the main product baked on the Bread Line, and it has the highest yeast content, and the second highest yeast action time of the breads baked on the Bread Line.

Testing was supervised by Mr. Bill J. Byczynski, of the Stack Test Group, Inc. and coordinated by Mr. David Sikkenga of Roskam, and Mr. Mark Horne, P.E. of Environmental Partners, Inc. Testing was witnessed by Mr. Tom Gasloli and Mr. Christopher Robinson of the Michigan Department of Environmental Quality (MDEQ). FTIR testing was conducted by Mr. Phil Kauppi of Prism Analytical.

All testing followed the guidelines of U.S. EPA Reference Methods 1 through 4, 25A, and 320. This report contains a summary of results for the above-mentioned tests and all the supporting field, process, and computer-generated data.

3.0 SAMPLING AND ANALYTICAL PROCEDURES

3.1 Exhaust Gas Parameters

3.1.1 Traverse and Sampling Points

The number of velocity traverse and sample measurement points for each stack was determined using EPA Method 1.

Velocity and sample measurements were taken at each of 16 points, 8 points across each of the two ports set at 90° to each other on the oven exhaust stack. The test ports were located greater than 2.0 diameters downstream and greater than 0.5 diameters upstream of the nearest flow disturbances.

3.1.2 Velocity Traverse

Velocity measurements were performed during each emission test in accordance with EPA Method 2. An "S" type Pitot Tube with an attached type "K" thermocouple was used to conduct the velocity traverse.

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3.1.3 Gas Composition
Gas composition for oxygen, carbon dioxide, and nitrogen was determined employing EPA Method 3. An integrated gas sample was collected during each emission test. Gas analysis was conducted using a calibrated Servomex Model 1440C oxygen/carbon dioxide analyzer.

3.1.4 Moisture Content
The Exhaust stack gas moisture content was determined by using EPA Method 320. The procedure for EPA Method 320 can be found in sec 3.5

3.2 Volatile Organic Compound (Total VOC/Destruction Efficiency)
3.2.1 Sample Collection
Testing for total VOC on the oven exhaust stack was performed using U.S. EPA Reference Method 25A. A J.U.M. Model 3-300 Flame Ionization Detectors (FID) was used to determine the emission concentrations. A sample was transported through a heated Teflon line from the exhaust stack to the FID which analyzed the sample continuously. The output signal from the FID was then recorded at one-minute averages throughout the test. Copies of this data may be found in Appendix H.

At the beginning of the test series, the analyzer was calibrated and then checked for calibration error by introducing zero, low-range, mid-range and high-range calibration gases through the sampling system. Before and after each individual test run, a system drift was performed by introducing a zero and mid-range propane calibration gas to the outlet of the probe. Calibration gases used were U.S. EPA Protocol 1 certified.

3.2.2 Sample Duration and Frequency
The Method 25A train sample was collected in triplicate with each test lasting 60 minutes in duration.

3.2.3 Calibrations
All sampling equipment was calibrated per the procedures outlined in EPA Reference Method 25A. Copies of the FID calibrations are included in Appendix E.

3.3 Volatile Organic Compound by FTIR (Speciated VOC)
3.3.1 Sample Collection
Acetaldehyde and formaldehyde emissions were determined using U.S. EPA Method 320. The complete FTIR report is included in Appendix D. Mr. Phil Kauppi of Prism Analytical was on site to perform the 320 testing.

3.3.2 Sample Duration and Frequency
The samples were collected in triplicate with each test lasting approximately sixty minutes in duration and conducted simultaneously with the total VOC testing.

3.3.3 Calibration
The FTIR was calibrated according to the procedures outlined in Method 320. The calibrations along with the calibration gas certifications are included in Appendix D.

4.0 <u>TEST RESULTS</u>
Presented in this section are the results of this test series. Test results are reported in Table 4.1. Table 4.1 reports the stack gas conditions for the oven exhaust associated with the yeast raised

bread baking line including stack gas temperature, percent carbon dioxide and oxygen, percent moisture, molecular weight of the stack gas dry and wet, velocity in feet per second (fps), and flow rate in actual cubic feet per minute (acfm), standard cubic feet per minute (scfm), and dry standard cubic feet per minute (dscfm).

Table 4.1 also presents the total VOC, acetaldehyde and formaldehyde results for the oven exhaust. Total VOC, acetaldehyde and formaldehyde results are present in terms of parts per million (ppm), pounds per standard cubic feet (lb/scf), pounds per hour (lb/hr) and pounds per ton of baked bread.

Copies of the calculations used to determine these emission rates may be found in Appendix A. Copies of the field data sheets are presented in Appendix B. The Method 320 FTIR test report is included in Appendix D. Copies of equipment calibrations are presented in Appendix E.

Table 4.1

VOC Test Results
Roskam Baking Company
Kentwood, Michigan
04/24/19

Yeast Raised Bread Baking Line
Exhaust Stack

Test No:	T1	T2	T3	Avg.
Start Time:	08:55 AM	10:50 AM	12:25 PM	
Finish Time:	09:55 AM	11:57 AM	01:25 PM	
Stack Gas Temperature, degrees F:	360.3	362.1	363.3	361.9
% Carbon Dioxide:	5.4	5.0	5.5	5.3
% Oxygen:	15.4	16.0	15.4	15.6
% Moisture:	21.60	19.20	22.40	21.07
Molecular Weight dry, lb/lb-Mole:	29.49	29.44	29.49	29.47
Molecular Weight wet, lb/lb-Mole:	27.01	27.24	26.92	27.06
Velocity and Flow Results:				
Average Stack Gas Velocity FPS:	10.66	12.08	12.59	11.78
Stack Gas Flow Rate, ACFM:	838	949	990	926
Stack Gas Flow Rate, SCFM:	525	594	618	579
Stack Gas Flow Rate, DSCF/HR:	24,709	28,795	28,780	27,428
Stack Gas Flow Rate, DSCFM:	412	480	480	457
VOC Results:				
PPMvw as Propane:	762.0	630.2	653.0	681.7
LBS/SCF:	7.67E-05	6.42E-05	7.01E-05	7.04E-05
LBS/HR:	2.42	2.29	2.60	2.44
Pounds per Ton of Bread Baked:	0.54	0.53	0.56	0.54
Acetaldehyde Results:				
PPMvw as Acetaldehyde:	97.3	106.9	115.2	106.5
LBS/SCF:	1.11E-05	1.22E-05	1.32E-05	1.22E-05
LBS/HR:	0.35	0.43	0.49	0.42
Pounds per Ton of Bread Baked:	0.08	0.10	0.10	0.09
Formaldehyde Results:				
PPMvw as Formaldehyde:	34.5	31.8	33.3	33.2
LBS/SCF:	2.69E-06	2.48E-06	2.60E-06	2.59E-06
LBS/HR:	0.08	0.09	0.10	0.09
Pounds per Ton of Bread Baked:	0.02	0.02	0.02	0.02

APPENDIX A

SAMPLE CALCULATIONS

SAMPLE CALCULATIONS

The tables presenting the results are generated electronically from raw data. It may not be possible to exactly duplicate these results using a calculator. The reference method data, results and all calculations are carried to sixteen decimal places throughout. The final table is formatted to an appropriate number of significant figures.

1. Volume of water collected (wscf)

$$V_{wstd} = (0.04707)(V_{lc})$$

Where:

V_{lc}	total volume of liquid collected in impingers and silica gel (ml)
V_{wstd}	volume of water collected at standard conditions (ft^3)
0.04707	conversion factor (ft^3/ml)

2. Volume of gas metered, standard conditions (dscf)

$$V_{mstd} = \frac{(17.64)(V_m)\left(P_{bar} + \frac{\Delta H}{13.6}\right)(Y_d)}{(460 + T_m)}$$

Where:

P_{bar}	barometric pressure (in. Hg)
T_m	average dry gas meter temperature (°F)
V_m	volume of gas sample through the dry gas meter at meter conditions (ft^3)
V_{mstd}	volume of gas sample through the dry gas meter at standard conditions (ft^3)
Y_d	gas meter correction factor (dimensionless)
ΔH	average pressure drop across meter box orifice (in. H_2O)
17.64	conversion factor (°R/in. Hg)
13.6	conversion factor (in. H_2O/in. Hg)
460	°F to °R conversion constant

SAMPLE CALCULATIONS (CONTINUED)

3. Volume of gas metered, standard conditions (dscm)

$$V_{mstd(m)} = \frac{\left(V_{mstd(ft)}\right)}{35.35}$$

Where:

$V_{mstd(ft)}$	volume of gas sample through the dry gas meter at standard conditions (ft^3)
$V_{mstd(m)}$	volume of gas sample through the dry gas meter at standard conditions (m^3)
35.35	conversion factor (ft^3 to m^3)
13.6	conversion factor (in. H_2O/in. Hg)

4. Sample gas pressure (in. Hg)

$$P_s = P_{bar} + \left(\frac{P_g}{13.6}\right)$$

Where:

P_{bar}	barometric pressure (in. Hg)
P_g	sample gas static pressure (in. H_2O)
P_s	absolute sample gas pressure (in. Hg)
13.6	conversion factor (in. H_2O/in. Hg)

5. Actual vapor pressure (in. Hg)[1]

$$P_v = P_s$$

Where:

P_v	vapor pressure, actual (in. Hg)
P_s	absolute sample gas pressure (in. Hg)

6. Moisture content (%)

$$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$$

Where:

B_{wo}	proportion of water vapor in the gas stream by volume (%)
V_{mstd}	volume of gas sample through the dry gas meter at standard conditions (ft^3)
V_{wstd}	volume of water collected at standard conditions (ft^3)

[1] For effluent gas temperatures over 212°F, P_v is assumed to be equal to P_s.

SAMPLE CALCULATIONS (CONTINUED)

7. Saturated moisture content (%)

$$B_{ws} = \frac{(P_v)}{(P_s)}$$

Where:

B_{ws}	proportion of water vapor in the gas stream by volume at saturated conditions (%)
P_s	absolute sample gas pressure (in. Hg)
P_v	vapor pressure, actual (in. Hg)

Whichever moisture value is smaller is used for B_{wo} in the following calculations.

8. Molecular weight of dry gas stream (lb/lb·mole)

$$M_d = M_{CO_2}\frac{(CO_2)}{(100)} + M_{O_2}\frac{(O_2)}{(100)} + M_{CO+N_2}\frac{(CO+N_2)}{(100)}$$

Where:

Md	dry molecular weight of sample gas (lb/lb·mole)
M_{CO_2}	molecular weight of carbon dioxide (lb/lb·mole)
M_{O_2}	molecular weight of oxygen (lb/lb·mole)
$M_{CO}+N_2$	molecular weight of carbon monoxide and nitrogen (lb/lb·mole)
CO_2	proportion of carbon dioxide in the gas stream by volume (%)
O_2	proportion of oxygen in the gas stream by volume (%)
$CO+N_2$	proportion of carbon monoxide and nitrogen in the gas stream by volume (%)
100	conversion factor (%)

9. Molecular weight of sample gas (lb/lb·mole)

$$M_s = (M_d)(1 - B_{wo}) + (M_{H_2O})(B_{wo})$$

Where:

B_{wo}	proportion of water vapor in the gas stream by volume
M_d	dry molecular weight of sample gas (lb/lb·mole)
M_{H_2O}	molecular weight of water (lb/lb·mole)
M_s	molecular weight of sample gas, wet basis (lb/lb·mole)

SAMPLE CALCULATIONS (CONTINUED)

10. Velocity of sample gas (ft/sec)

$$V_s = (K_p)(C_P)(\overline{\sqrt{\Delta P}})\left(\sqrt{\frac{(\overline{T_s}+460)}{(M_s)(P_s)}}\right)$$

Where:

K_p	velocity pressure coefficient (dimensionless)
C_p	pitot tube constant
M_s	molecular weight of sample gas, wet basis (lb/lb·mole)
P_s	absolute sample gas pressure (in. Hg)
T_s	average sample gas temperature (°F)
V_s	sample gas velocity (ft/sec)
$\sqrt{\Delta P}$	average square roots of velocity heads of sample gas (in. H_2O)
460	°F to °R conversion constant

11. Total flow of sample gas (acfm)

$$Q_a = (60)(A_s)(V_s)$$

Where:

A_s	cross sectional area of sampling location (ft^2)
Q_a	volumetric flow rate at actual conditions (acfm)
V_s	sample gas velocity (ft/sec)
60	conversion factor (sec/min)

12. Total flow of sample gas (dscfm)

$$Q_{std} = \frac{(Q_a)(P_s)(17.64)(1-B_{wo})}{(\overline{T_s}+460)}$$

Where:

B_{wo}	proportion of water vapor in the gas stream by volume
P_s	absolute sample gas pressure (in. Hg)
Q_a	volumetric flow rate at actual conditions (acfm)
Q_{std}	volumetric flow rate at standard conditions, dry basis (dscfm)
T_s	average sample gas temperature (°F)
17.64	conversion factor (°R/in. Hg)
460	°F to °R conversion constant

SAMPLE CALCULATIONS (CONTINUED)

13. VOC concentration (lb/scf)

$$E_{lb/scf} = \frac{(ppm)(MW)}{(385.3 \times 10^6)}$$

Where:

$E_{lb/scf}$	emission rate
C_{ppm}	measured concentration in the gas stream (ppm_v)
MW	molecular weight of NMP (99.13)
385.3	conversion factor

14. VOC emission (lb/hr)

$$E_{lb/hr} = (lb/scf)(60)(scfm)$$

Where:

$E_{lb/hr}$	emission rate
$E_{lb/scf}$	concentration
SCFM	flow rate
$60_{min/hr}$	conversion factor