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REPORT OF CHROMIUM EMISSIONS TESTING ON THE BLUE LINE (FGBLUE1) AND GREEN LINE (FGGREEN1) AT THE ALLIED FINISHING INC. FACILITY LOCATED IN GRAND RAPIDS, MICHIGAN

Prepared for:

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STACK TEST GROUP, INC. PROJECT NO. 18-3108

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1.0 EXECUTIVE SUMMARY

On April 23 & 24, 2019 The Stack Test Group, Inc. performed chromium emission testing on the Blue Line (FGBLUE1) and the Green Line (FGGREEN1) exhausts at the Allied Finishing Inc., facility located in Grand Rapids, MI. Three chromium test runs were conducted on each unit. Presented below are the average results of these three tests.

Blue Line (FGBLUE1):

Chromium Concentration:	0.001 Mg/dscm
Chromium Emission Rate:	4.26E-05 Pounds per Hour

Green Line (FGGREEN1):

Chromium Concentration:	0.001 Mg/dscm
Chromium Emission Rate:	4.63E-05 Pounds per Hour

2.0 INTRODUCTION

The Stack Test Group, Inc. conducted chromium emissions testing on the Blue Line and Green Line exhaust stacks. Testing was performed at Allied Finishing Inc. facility located in Grand Rapids, Michigan on April 23 and 24, 2019. Three chromium test runs were conducted on each stack with each run lasting one hundred and twenty minutes in duration. The purpose of this testing was to determine the concentrations and emission rates of the above mentioned parameters exhausting from the processes and to prove compliance with existing permit limits. Permit # 349-01D.

Testing was conducted while Allied Finishing personnel operated the units at near maximum capacity and normal conditions. Process data can be found in appendix F.

Testing was supervised by Mr. Gary Kohnke of the Stack Test Group, Inc. and coordinated by Ms. Justine Lauri of Allied Finishing Inc. Testing was observed by a representative of the Michigan Department.of Environmental Quality. (MDEQ)

All testing was in accordance with U.S. EPA Reference Methods 1 through 4 and 306. 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

Testing was conducted on the exhaust stack of the Blue Line. The number of velocity traverse and sample measurement points for each stack was determined using EPA Method 1. The test ports were located 2.5 diameters downstream and 7.6 diameters upstream of the nearest flow disturbances. The stack diameter was 29 inches. Velocity measurements were taken at each of 24 points, 12 points in each of the two ports set at 90° to each other.

Testing was conducted on the exhaust stack of the Green Line. The number of velocity traverse and sample measurement points for each stack was determined using EPA Method 1. The test ports were located 5.2 diameters downstream and 2.3 diameters upstream of the nearest flow disturbances. The stack diameter measured 30 inhes. Velocity measurements were taken at each of 24 points, 12 points in each of the two ports set at 90° to each other.

3.1.2 Velocity Traverse

Velocity measurements were performed during each particulate/lead 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.

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 chromium emission test. Gas analysis was conducted using a fyrite combustion analyzer.

3.1.4 Moisture Content

The exhaust gas moisture content was determined using EPA Method 4 for all tests. Moisture content was determined by drawing the gas sample through four impingers in the sample train. Volumetric analysis was used to measure the condensed moisture in the first three impingers while gravimetric analysis of silica gel was used to measure moisture collected in the fourth impinger.

3.2 Chromium

3.2.1 Sample Collection

Chromium emissions were determined in accordance with USEPA Reference Methods 1,2,3,4 and 306. These Methods are titled:

Method 1	Sample and Velocity Traverses for Stationary Sources
Method 2	Determination of Stack Gas Velocity and Volumetric Flow Rate (Type "S" Pitot Tube)
Method 3	Gas Analysis for Carbon Dioxide, Oxygen, Excess Air and Dry Molecular Weight
Method 4	Determination of Moisture Content from Stationary Sources
Method 306	Determination of Chromium Emissions from Decorative and Hard Chromium Electroplating and Chromium Anodizing Operations-Isokinetic Method

These methods appear in detail in Title 40 of the Code of Federal Regulations (CFR), Part 60, Appendix A.

The Method 306 sampling train consisted of the following components.

1. Appropriately sized glass nozzle
2. Sample probe with glass liner
3. Glass filter bypass
4. Four impingers in an insulated ice water bath in the following sequence:
    - A. Greenburg-Smith design containing 0.1 N NaOH.
    - B. Greenburg-Smith design containing 0.1 N NaOH.
    - C. Modified Greenburg-Smith design empty.
    - D. Known amount of Silica Gel.
5. Sampling gas measuring system.

3.2.2 Sample Duration and Frequency

The Method 306 train samples were collected in triplicate with each test lasting at least 120 minutes in duration a minimum sample size of 60 dry standard cubic feet (dscf) was collected for each test.

3.2.3 Sample Recovery

Upon completion of each test the sampling train was removed from the stack. The probe, nozzle, and filter bypass were rinsed with .1N NaOH and placed into a labeled container. The impingers were weighed for moisture gain. The contents of the impingers were placed into a labeled sample container. The impingers, and all connecting glassware, were then rinsed three times with 0.1 N sodium hydroxide (NaOH). These rinses were placed into the same sample container.

3.2.4 Analytical Procedures

The chromium analysis was conducted by Enthalpy Analytical, LLC located in Durham, NC. The samples were analyzed by the procedures set forth in U.S. EPA Method 306.

3.2.5 Blanks
Blanks for the Method 306 train were prepared by recovering a 0.1N sodium hydroxide (NaOH) sample in the same manner listed above.

3.2.6 Calibrations
All sampling equipment was calibrated according to the procedures outlined in EPA Reference Method 5 and 306.

4.0 TEST RESULTS
Presented in this section are the results of this test series. Test results are reported in Tables 4.1 and 4.2. Table 4.1 reports the stack gas conditions for Blue Line 1 exhaust stack 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 chromium results in grains per dry standard cubic feet (grains/DSCF), pounds per dry standard cubic feet (lb. /dscf), pounds per hour (lb. /hr.) and milligrams per dry standard cubic meter (mg/dscm).

Table 4.2 presents the results for the Green Line 1 exhaust stack in the same manner and format as Table 4.1, respectively.

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. Copies of the analytical results are presented in Appendix C. Copies of equipment calibrations are presented in Appendix D.

Table 4.1

Chromium (Cr) Results
Allied Finishing Inc.
Grand Rapids, MI
04/23/19

Blue Line (FGBLUE1) Exhaust

Test No:	T1	T2	T3	Avg.
Start Time:	07:40 AM	10:00 AM	01:10 PM	
Finish Time:	09:43 AM	12:03 PM	03:13 PM	
Stack Gas Temperature, degrees F:	62.71	62.54	63.71	63.0
% Carbon Dioxide:	0.0	0.0	0.0	0.0
% Oxygen:	21.0	21.0	21.0	21.0
% Moisture:	1.30	1.12	1.21	1.21
Molecular Weight dry, lb/lb-Mole:	28.84	28.84	28.84	28.84
Molecular Weight wet, lb/lb-Mole:	28.70	28.72	28.71	28.71
Velocity and Flow Results:				
Average Stack Gas Velocity FPS:	48.49	48.02	47.84	48.12
Stack Gas Flow Rate, ACFM:	13,354	13,225	13,175	13,251
Stack Gas Flow Rate, SCFM:	13,075	12,952	12,870	12,966
Stack Gas Flow Rate, DSCF/HR:	774,273	768,416	762,867	768,519
Stack Gas Flow Rate, DSCFM:	12,905	12,807	12,714	12,809
Chromium (Cr) Results:				
Chromium, ug:	1.5	2.6	1.7	1.9
Grains Per DSCF:	3.00E-07	5.21E-07	3.42E-07	3.88E-07
LBS/DSCF:	4.29E-11	7.45E-11	4.89E-11	5.54E-11
LBS/HR:	3.32E-05	5.73E-05	3.73E-05	4.26E-05
mg/dscm:	0.001	0.001	0.001	0.001

Table 4.2

Chromium (Cr) Results
Allied Finishing Inc.
Grand Rapids, MI
04/24/19

Green Line (FGGREEN1) Exhaust

Test No:	T1	T2	T3	Avg.
Start Time:	07:45 AM	10:00 AM	01:05 PM	
Finish Time:	09:49 AM	12:05 PM	03:10 PM	
Stack Gas Temperature, degrees F:	79.96	69	74.54	74.5
% Carbon Dioxide:	0.0	0.0	0.0	0.0
% Oxygen:	21.0	21.0	21.0	21.0
% Moisture:	1.52	1.34	1.46	1.44
Molecular Weight dry, lb/lb-Mole:	28.84	28.84	28.84	28.84
Molecular Weight wet, lb/lb-Mole:	28.68	28.69	28.68	28.68
Velocity and Flow Results:				
Average Stack Gas Velocity FPS:	35.31	34.64	35.28	35.08
Stack Gas Flow Rate, ACFM:	10,402	10,205	10,393	10,334
Stack Gas Flow Rate, SCFM:	9,835	9,849	9,927	9,870
Stack Gas Flow Rate, DSCF/HR:	581,151	582,999	586,902	583,684
Stack Gas Flow Rate, DSCFM:	9,686	9,717	9,782	9,728
Chromium (Cr) Results:				
Chromium, ug:	2.2	3.1	2.2	2.5
Grains Per DSCF:	4.83E-07	6.90E-07	4.97E-07	5.57E-07
LBS/DSCF:	6.90E-11	9.87E-11	7.10E-11	7.96E-11
LBS/HR:	4.01E-05	5.75E-05	4.16E-05	4.64E-05
mg/dscm:	0.001	0.002	0.001	0.001

APPENDIX A

EXAMPLE CALCULATIONS

ALLIED FINISHING INC.
GRAND RAPIDS, MI

STG Project No: 18-3108

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

3. 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)

4. 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)

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

SAMPLE CALCULATIONS (CONTINUED)

5. 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)

6. 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.

7. 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 (%)

8. 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)

9. Velocity of sample gas (ft/sec)

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

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

10. 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)

11. 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)

12. Percent isokinetic (%)

$$I = \frac{(0.09450)(\overline{T_s} + 460)(V_{mstd})}{(P_s)(V_s)\left(\frac{(D_n)^2(\pi)}{(144)(4)}\right)(\Theta)(1 - B_{wo})}$$

Where:

D_n	diameter of nozzle (in)
B_{wo}	proportion of water vapor in the gas stream by volume
I	percent of isokinetic sampling (%)
P_s	absolute sample gas pressure (in. Hg)
T_s	average sample gas temperature (°F)
V_{mstd}	volume of gas sample through the dry gas meter at standard conditions (ft^3)
V_s	sample gas velocity (ft/sec)
Θ	total sampling time (min)
0.09450	constant
460	°F to °R conversion constant

13. Chromium concentration (gr/dscf)

$$C_{gr/dscf} = \frac{(15.43)(m_n)}{V_{mstd}}$$

Where:

$C_{gr/dscf}$	measured concentration in the gas stream (gr/dscf)
m_n	total amount of chromium collected, corrected for applicable reagent blank (g)
V_{mstd}	volume of gas sample through the dry gas meter at standard conditions (ft^3)
15.43	conversion factor (gr/g)

14. Chromium emission (lb/hr)

$$E_{lb/hr} = \frac{(C_{gr/dscf})(Q_{std})(60)}{7{,}000}$$

Where:

$C_{gr/dscf}$	measured concentration in the gas stream (gr/dscf)
$E_{lb/hr}$	emission rate (lb/hr)
Q_{std}	volumetric flow rate at standard conditions, dry basis (dscfm)
60	conversion factor (min/hr)
7,000	conversion factor (gr/lb)

APPENDIX B

FIELD DATA SHEETS