CleanAir

CleanAir Engineering
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REPORT ON COMPLIANCE TESTING

Guardian Industries, LLC
14600 Romine Road
Carleton, Michigan 48117
Client Reference No. G000243910

CleanAir Project No. 14485
A2LA ISO 17025 Certificate No. 4342.01
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October 28, 2021

COMMITMENT TO QUALITY

To the best of our knowledge, the data presented in this report are accurate, complete, error free and representative of the actual emissions during the test program. Clean Air Engineering operates in conformance with the requirements of ASTM D7036-04 Standard Practice for Competence of Air Emission Testing Bodies.

October 28, 2021

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I hereby certify that the information contained within the final test report has been reviewed and, to the best of my ability, verified as accurate.

October 28, 2021

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REPORT REVISION HISTORY

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ACRONYMS & ABBREVIATIONS

AAS (atomic absorption spectrometry)
acfm (actual cubic feet per minute)
ACI (activated carbon injection)
ADL (above detection limit)
AIG (ammonia injection grid)
APC (air pollution control)
AQCS (air quality control system(s))
ASME (American Society of Mechanical Engineers)
ASTM (American Society for Testing and Materials)
BDL (below detection limit)
Btu (British thermal units)
CAM (compliance assurance monitoring)
CARB (California Air Resources Board)
CCM (Controlled Condensation Method)
CE (capture efficiency)
°C (degrees Celsius)
CEMS (continuous emissions monitoring system(s))
CFB (circulating fluidized bed)
CFR (Code of Federal Regulations)
cm (centimeter(s))
COMS (continuous opacity monitoring system(s))
CT (combustion turbine)
CTI (Cooling Technology Institute)
CTM (Conditional Test Method)
CVAAS (cold vapor atomic absorption spectroscopy)
CVAFS (cold vapor atomic fluorescence spectrometry)
DI H_2O (de-ionized water)
%dv (percent, dry volume)
DLL (detection level limited)
DE (destruction efficiency)
DCI (dry carbon injection)
DGM (dry gas meter)
dscf (dry standard cubic feet)
dscfm (dry standard cubic feet per minute)
dscm (dry standard cubic meter)
ESP (electrostatic precipitator)
FAMS (flue gas adsorbent mercury speciation)
°F (degrees Fahrenheit)
FB (field blank)
FCC (fluidized catalytic cracking)
FCCU (fluidized catalytic cracking unit)
FEGT (furnace exit gas temperatures)
FF (fabric filter)
FGD (flue gas desulfurization)
FIA (flame ionization analyzer)
FID (flame ionization detector)
FPD (flame photometric detection)
FRB (field reagent blank)
FSTM (flue gas sorbent total mercury)
ft (feet or foot)
ft^2 (square feet)
ft^3 (cubic feet)
ft/sec (feet per second)
FTIR (Fourier Transform Infrared Spectroscopy)
FTRB (field train reagent blank)
g (gram(s))
GC (gas chromatography)
GFAAS (graphite furnace atomic absorption spectroscopy)
GFC (gas filter correlation)
gr/dscf (grains per dry standard cubic feet)
> (greater than)/ ≥ (greater than or equal to)
g/s (grams per second)
H_2O (water)
HAP(s) (hazardous air pollutant(s))
HI (heat input)
hr (hour(s))
HR GC/MS (high-resolution gas chromatography and mass spectrometry)
HRVOC (highly reactive volatile organic compounds)
HSRG(s) (heat recovery steam generator(s))
HVT (high velocity thermocouple)
IC (ion chromatography)
IC/PCR (ion chromatography with post column reactor)
ICP/MS (inductively coupled argon plasma mass spectroscopy)
ID (induced draft)
in. (inch(es))
in. H_2O (inches water)
in. Hg (inches mercury)
IPA (isopropyl alcohol)
ISE (ion-specific electrode)
kg (kilogram(s))
kg/hr (kilogram(s) per hour)
< (less than)/ ≤ (less than or equal to)
L (liter(s))
lb (pound(s))
lb/hr (pound per hour)
lb/MMBtu (pound per million British thermal units)
lb/TBtu (pound per trillion British thermal units)
lb/lb-mole (pound per pound mole)
LR GC/MS (low-resolution gas chromatography and mass spectrometry)
m (meter)
m^3 (cubic meter)
MACT (maximum achievable control technology)
MASS® (Multi-Point Automated Sampling System)
MATS (Mercury and Air Toxics Standards)
MDL (method detection limit)
µg (microgram(s))
min. (minute(s))
mg (milligram(s))
ml (milliliter(s))
MMBtu (million British thermal units)
MW (megawatt(s))
NCASI (National Council for Air and Stream Improvement)
ND (non-detect)
NDIR (non-dispersive infrared)
NDO (natural draft opening)
NESHAP (National Emission Standards for Hazardous Air Pollutants)
ng (nanogram(s))
Nm^3 (Normal cubic meter)
% (percent)
PEMS (predictive emissions monitoring systems)
PFGC (pneumatic focusing gas chromatography)
pg (picogram(s))
PJFF (pulse jet fabric filter)
ppb (parts per billion)
PPE (personal protective equipment)
ppm (parts per million)
ppmdv (parts per million, dry volume)
ppmwv (parts per million, wet volume)
PSD (particle size distribution)
psi (pound(s) per square inch)
PTE (permanent total enclosure)
PTFE (polytetrafluoroethylene)
QA/QC (quality assurance/quality control)
QI (qualified individual)
QSTI (qualified source testing individual)
QSTO (qualified source testing observer)
RA (relative accuracy)
RATA (relative accuracy test audit)
RB (reagent blank)
RE (removal or reduction efficiency)
RM (reference method)
scf (standard cubic feet)
scfm (standard cubic feet per minute)
SCR (selective catalytic reduction)
SDA (spray dryer absorber)
SNCR (selective non-catalytic reduction)
STD (standard)
STMS (sorbent trap monitoring system)
TBtu (trillion British thermal units)
TEOM (Tapered Element Oscillating Microbalance)
TEQ (toxic equivalency quotient)
ton/hr (ton per hour)
ton/yr (ton per year)
TSS (third stage separator)
USEPA or EPA (United States Environmental Protection Agency)
UVA (ultraviolet absorption)
WFGD (wet flue gas desulfurization)
%wv (percent, wet volume)

1. PROJECT OVERVIEW

Test Program Summary

Guardian Industries, LLC (Guardian) contracted Clean Air Engineering (CleanAir) to complete testing on the stack of the flat gas manufacturing Line #1 (EU00079) at the Guardian facility located in Carleton, Michigan. The objective of the test program was to complete compliance measurements for sulfuric acid mist emissions per the facility's (State Registration Number: B1877) Renewable Operating Permit (ROP) Number: MI-ROP-B1877-2021b.

A summary of the test program results is presented below. Section 2 (Results) provides a more detailed account of the test conditions and data analysis.

Table 1-1:
Summary of Results

Source Constituent	Sampling Method	Average Emission	Permit Limit[1]
EU(00079) Stack			
H_2SO_4 (lb/hr)	CTM-013	0.4	1.6

[1] Permit limits obtained from Michigan ROP Number: MI-ROP-B1877-2021b.

Test Program Details

Parameters

The test program included the following measurements:

- sulfuric acid mist (H_2SO_4)
- flue gas composition (e.g., O_2, CO_2, H_2O)
- flue gas temperature and flow rate

SCHEDULE

Testing was performed on October 5, 2021. Table 1-2 outlines the on-site schedule followed during the test program.

Table 1-2:
Test Schedule

Run Number	Location	Method	Analyte	Date	Start Time	End Time
1	EU00079 Stack	CTM-013	H_2SO_4	10/05/21	08:40	09:40
2	EU00079 Stack	CTM-013	H_2SO_4	10/05/21	10:35	11:35
3	EU00079 Stack	CTM-013	H_2SO_4	10/05/21	12:26	13:26
3	EU00079 Stack	USEPA Method 2	Velocity & Flow Rate	10/05/21	09:45	10:00
4	EU00079 Stack	USEPA Method 2	Velocity & Flow Rate	10/05/21	11:37	11:54
5	EU00079 Stack	USEPA Method 2	Velocity & Flow Rate	10/05/21	13:30	13:50

DISCUSSION

CleanAir conducted three valid 1-hour CTM-013 tests for the determination of sulfuric acid mist only. During each CTM-013 test, CleanAir conducted a complete velocity traverse. The CTM-013 train pulled a minimum of 21 scf and the impingers were gravimetrically measured before and after each test to determine moisture content from each test. The dry gas meter collected an integrated sample containing slipstream of dry gas into a bag for analysis in the CleanAir test trailer for oxygen and carbon dioxide.

At the conclusion of each test, samples were appropriately recovered and sent to the on-site laboratory trailer for analysis. CleanAir analyzed the samples on-site by both barium-thorin titration procedures and ion chromatography (IC) for sulfate (SO_4^{2-}).

CleanAir performed a conditioning test run, Run 0, on Monday, October 4th as required by the methodology. The results are not included in the averages, but all data is contained within Appendix E of this test report.

EGLE required an audit sample for this test program. The audit sample results were reported from the barium-thorin titration procedure. Therefore, results in this report are reported based on the titration results as well.

The ERA audit sample report can be found in Appendix J. CleanAir reported a value of 55.169 mg/dscm versus the ERA assigned value of 55.2 mg/dscm. The acceptable range was between 49.7 – 60.7 mg/dscm.

CTM-013 did not contain impingers of hydrogen peroxide as sulfur dioxide determination is not required for reporting analysis.

2. RESULTS

This section summarizes the test program results. Additional results are available in the report appendices.

Table 2-1:
Stack (EU00079) – H_2SO_4

Run No.		1	2	3	Average
Date (2021)		Oct 5	Oct 5	Oct 5	
Start Time (approx.)		08:40	10:35	12:26	
Stop Time (approx.)		09:40	11:35	13:26	
Process Conditions					
R_P	Production rate - (tons produced/hr)	411	411	411	**411**
Gas Conditions					
O_2	Oxygen (dry volume %)	11.1	10.8	10.4	**10.8**
CO_2	Carbon dioxide (dry volume %)	7.9	8.5	8.9	**8.4**
T_s	Stack temperature (°F)	589	589	586	**588**
B_w	Actual water vapor in gas (% by volume)	14.60	13.23	14.66	**14.16**
Gas Flow Rate					
Q_a	Volumetric flow rate, actual (acfm)	87,200	86,400	87,100	**86,900**
Q_s	Volumetric flow rate, standard (scfm)	41,800	41,400	41,800	**41,700**
Q_{std}	Volumetric flow rate, dry standard (dscfm)	36,400	35,400	36,200	**36,000**
Sampling Data					
V_{mstd}	Volume metered, standard (dscf)	21.99	21.94	21.92	**21.95**
Laboratory Data (Ion Chromatography)					
m_n	Total H2SO4 collected (mg)	1.9093	1.1935	2.1788	
Sulfuric Acid (H2SO4) Results (Ion Chromatography)					
C_{sd}	H2SO4 Concentration (ppmdv)	0.752	0.471	0.861	**0.695**
$E_{lb/hr}$	H2SO4 Rate (lb/hr)	0.418	0.255	0.477	**0.383**
Laboratory Data (Titration)					
m_n	Total H2SO4 collected (mg)	1.83888	1.34851	2.02276	
Sulfuric Acid (H2SO4) Results (Titration)					
C_{sd}	H2SO4 Concentration (ppmdv)	0.725	0.533	0.800	**0.686**
$E_{lb/hr}$	H2SO4 Rate (lb/hr)	0.402	0.288	0.442	**0.377**

3. DESCRIPTION OF INSTALLATION

Guardian's flat gas manufacturing Line #1 consists of a raw material melting Furnace, glass forming and finishing, and glass cutting. Line #1 produces flat glass using the float method. Materials are weighed and mixed with water in the batch house before entering the natural gas-fired Furnace. Glass then enters the tin bath to be formed and drawn. Next, it enters a lehr to reduce its temperature. The natural gas-fired Furnace portion of the emission unit is controlled by a Control Device consisting of a Dry Scrubber (DS), Particulate Filter (PF), and Selective Catalytic Reduction (SCR).

The emission unit includes a 4,000 cubic foot Dry Scrubber reagent storage silo equipped with a passive bin vent and a 20,000-gallon pressurized aqueous ammonia storage tank.

The testing reported in this document was performed at the Stack location (EU00079) and the glass product ID was Ultra Clear during the test period.

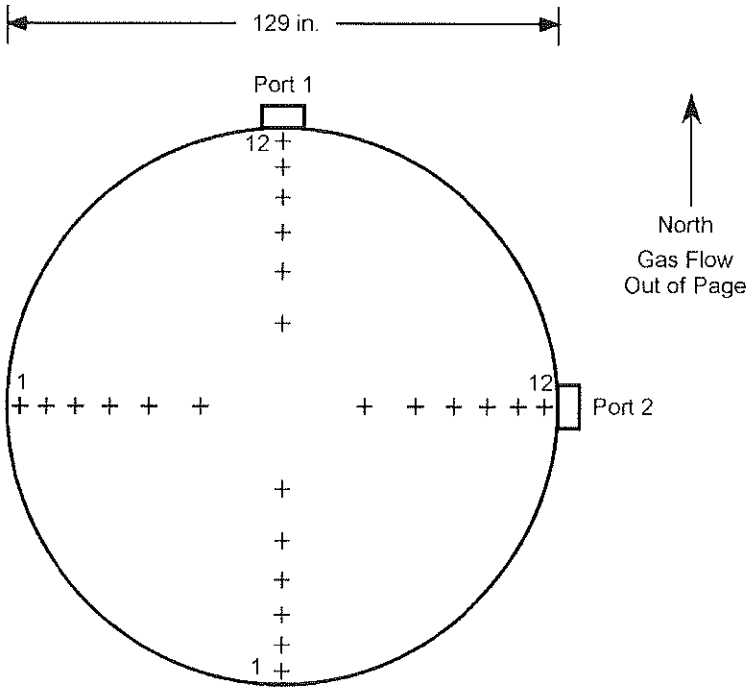
The sample point placement was determined by EPA Method 1 specifications. Table 3-1 presents the sampling information for the test location. The figure represents the layout of the test location.

Table 3-1:
Sampling Information

Source Constituent	Method	Run No.	Ports	Points per Port	Minutes per Point	Total Minutes	Figure
Stack							
Flow Rate	EPA M2	1-3	4	6	Varied	Varied	3-1
H_2SO_4	CTM-013	1-3	1	1	60	60	NA[1]

[1] H_2SO_4 was sampled at the approximate center of the duct. Readings were taken every 5 minutes.

Figure 3-1:
Stack (EU00079) Sample Point Layout (EPA Method 1)



Traverse Point	% of Stack Diameter	Port to Point Distance (inches)
1	97.9	126.3
2	93.3	120.4
3	88.2	113.8
4	82.3	106.2
5	75.0	96.8
6	64.4	83.1
7	35.6	45.9
8	25.0	32.3
9	17.7	22.8
10	11.8	15.2
11	6.7	8.6
12	2.1	2.7

Duct diameters upstream from flow disturbance (A): 11.2 Limit: 0.5
Duct diameters downstream from flow disturbance (B):7.0 Limit: 2.0

4. METHODOLOGY

The test program sampling measurements followed procedures and regulations outlined by the USEPA and Michigan Department of Environment, Great Lakes, and Energy (EGLE). These methods appear in detail in Title 40 of the CFR and at https://www.epa.gov/emc.

Appendix A includes diagrams of the sampling apparatus, as well as specifications for sampling, recovery, and analytical procedures. Any modifications to standard test methods are explicitly indicated in this appendix. In accordance with ASTM D7036 requirements, CleanAir included a description of any such modifications along with the full context of the objectives and requirements of the test program in the test protocol submitted prior to the measurement portion of this project. Modifications to standard methods are not covered by the ISO 17025 and TNI portions of CleanAir's A2LA accreditation.

CleanAir follows specific QA/QC procedures outlined in the individual methods and in USEPA "Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III Stationary Source-Specific Methods," EPA/600/R-94/038C. Appendix D contains additional QA/QC measures, as outlined in CleanAir's internal Quality Manual.

TITLE 40 CFR PART 60, APPENDIX A

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 the Determination of Dry Molecular Weight"
Method 3A	"Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)"
Method 4	"Determination of Moisture Content in Stack Gases"

CTM-013 (MOD.) CONTROLLED CONDENSATION METHOD (CCM)

"Determination of Sulfur Oxides Including Sulfur Dioxide, Sulfur Trioxide and Sulfuric Acid Vapor and Mist from Stationary Sources Using a Controlled Condensation Sampling Apparatus"

Methodology Discussion

Volumetric Flow Rate – Methods 1-4

EPA Methods 1, 2, 3 and 4 of 40 CFR 60, Appendix A, were followed to determine the average flue gas composition and volumetric flow rate. These methods determined several characteristics of the flue gas stream: velocity, moisture, flow rate, and the concentrations of oxygen (O_2) and carbon dioxide (CO_2).

Sulfuric Acid Mist – CTM-013

CleanAir followed EPA Conditional Test Method 013 (CTM-013). This method is applicable for the determination of sulfur trioxide (SO_3) and sulfuric acid vapor/mist (H_2SO_4) using a controlled condensation sampling system.

Key operating parameters include:

- Probe was maintained at a temperature of >350°F.
- Quartz fiber filter was maintained at a temperature of >500°F.
- H_2SO_4 condenser - Modified Graham condenser, filled with water and temperature maintained between 75 and 85°C (167 to 185°F).

A second filter referred to as the sulfuric acid mist (SAM) filter, was located at the condenser outlet for the collection of residual sulfuric acid aerosols not collected by the condenser. The condenser temperature was regulated by a water jacket and the SAM filter is regulated by a closed oven. Both the water jacket and oven were maintained between 167°F to 185°F. The condenser and SAM filter (glass frit) were maintained above the water dew point, which eliminates the problem of oxidation of dissolved SO_2.

The condenser collection media, including the coil condenser rinse and glass frit, were extracted with DI water.

5. APPENDIX

Appendix A: Test Method Specifications

Appendix B: Sample Calculations

Appendix C: Parameters

Appendix D: QA/QC Data

Appendix E: Field Data

Appendix F: Field Data Printouts

Appendix G: Laboratory Data

Appendix H: Facility Operating Data

Appendix I: Chromatograms

Appendix J: Audit Sample Report

Appendix K: CleanAir Resumes and Certifications