

DDP Specialty Electronic Materials US, LLC (DDP/DuPont) Michigan Operations

CISWI Compliance Testing
1130 Building Specialty Monomer, EU95 Tar Incinerator

MI-ROP-P1027-2020a
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1. Introduction

1.1 Summary of Test Program

AECOM Technical Services, Inc. (AECOM) was contracted by DDP Specialty Electronic Materials US, LLC (DDP/DuPont) to conduct emissions performance testing on their site Tar Incinerator (EU95) at their Specialty Monomers (Spec Mono) Plant in Midland, Michigan during the week of June 20th, 2022. The Commercial and Industrial Solid Waste Incineration Units (CISWI) compliance performance testing consisted of measurements for nitrogen oxides (NO_x), carbon monoxide (CO), sulfur dioxide (SO₂), filterable particulate matter (PM), visible emissions (VE), polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), hydrogen chloride (HCl), and metals [specifically: lead (Pb), cadmium (Cd), and mercury (Hg)].

The results of testing are presented in Table 1-1. Details supporting these data are presented in the balance of this report.

Table 1-1 Emission Testing Results

Sample Type	Test Method	Sampling Time (min/run)	Allowable Emission Rate	Actual Emission Rate ¹
PM	EPA Method 5	96 min	110 mg/dscm @ 7% O ₂	5.63 mg/dscm @ 7% O ₂
*SO ₂	EPA Method 6C	60 min	720 ppmv @ 7% O ₂	0.2 ppmv @ 7% O ₂
*NO _x	EPA Method 7E	60 min	76 ppmv @ 7% O ₂	63.1 ppmv @ 7% O ₂
CO	EPA Method 10	60 min	35 ppmv @ 7% O ₂	<0.1 ppmv @ 7% O ₂
D/F	EPA Method 23	240 min	2.9 ng/dscm @ 7% O ₂ (total) - or - 0.32 ng/dscm @ 7% O ₂ (TEQ)	<0.140 ng/dscm @ 7% O ₂ (total) - or - 0.0229 ng/dscm @ 7% O ₂ (TEQ)
HCl	EPA Method 26A	96 min	14 ppmv @ 7% O ₂	0.215 ppmv @ 7% O ₂
Cd	EPA Method 29	120 min	0.023 mg/dscm @ 7% O ₂	<0.00025 mg/dscm @ 7% O ₂
Pb	EPA Method 29	120 min	0.096 mg/dscm @ 7% O ₂	<0.0021 mg/dscm @ 7% O ₂
Hg	EPA Method 29	120 min	0.0024 mg/dscm @ 7% O ₂	<0.00036 mg/dscm @ 7% O ₂
VE	EPA Method 9	60 min	20%	0%

¹Results shown with a "<" refer to results below the lab reporting limit (RDL).

*Compliance with the non-CISWI emission limit was not calculated since flow wasn't measured during this portion of the test.

1.2 Regulatory Background

On March 21, 2011, in parallel with publication of the Boiler National Emission Standard for Hazardous Air Pollutants (NESHAP) rules and the Non-Hazardous Secondary Material (NHSM) rule, EPA promulgated the final updates to the New Source Performance Standards (NSPS) and Emission Guidelines (EG) for Existing CISWI Units, collectively referred to as the “2011 CISWI Rules”. The 2011 CISWI Rules impact any facility that owns an emission unit that “combusts, or has combusted in the preceding six months, any solid waste as that term is defined in 40 CFR Part 241.2.” The CISWI rules were then reconsidered and amended in 2013. The final version of the CISWI Rules/Guidelines were published in the Federal Register on February 7, 2013. The final rule is titled: Subpart DDDD—Emissions Guidelines and Compliance Times for Commercial and Industrial Solid Waste Incineration Units.

Per Section 60.2720(a)(3) of the Federal CISWI Rule, as referenced by the Michigan Rule R 336.1974(9)(g), DDP reduced the frequency of testing for certain constituents to a triennial frequency following successful completion of the two tests in July 2018 and June 2019.

In accordance with the requirements of 40 CFR 60, Subpart DDDD, each affected unit must conduct an annual performance test. The requirements of that testing are outlined in 40 CFR 60.2690 and in Tables 2 or 6-9, depending on the specific mechanism by which the unit is affected.

The following table summarizes the pertinent data for this compliance test:

Responsible Groups	<ul style="list-style-type: none"> • DDP Specialty Electronic Materials US, LLC (DDP/DuPont) • Michigan Department of Environment, Great Lakes, and Energy (EGLE) • United States Environmental Protection Agency (US EPA)
Applicable Regulations	<ul style="list-style-type: none"> • MI-ROP-P1027-2020a • 40 CFR 60, Subpart DDDD: Commercial and Industrial Solid Waste Incineration Units (CISWI MACT) • “EGLE Air Quality Division Part 9, Rule 336.1974”
Industry/Plant	<ul style="list-style-type: none"> • Specialty Monomers, 1130 Building
Plant Location	<ul style="list-style-type: none"> • Midland, Michigan I-Park Facilities 48640
Unit Initial Start-up	<ul style="list-style-type: none"> • 1990
Air Pollution Control Equipment	<ul style="list-style-type: none"> • Low NOx burner technology, low excess air firing
Emission Points	<ul style="list-style-type: none"> • EU95 Tar Incinerator (EU95)
Pollutants/Diluent Measure	<ul style="list-style-type: none"> • Particulate Matter (PM) • Visible Emissions (VE) • Sulfur Dioxide (SO₂) • Nitrogen Oxides (NO_x) • Carbon Monoxide (CO) • Polychlorinated Dibenzodioxins (PCDDs) • Polychlorinated Dibenzofurans (PCDFs) • Hydrogen Chloride (HCl) • Metals: Lead/Cadmium/Mercury (Pb/Cd/Hg) • Oxygen/Carbon Dioxide (O₂/CO₂)
Test Dates	<ul style="list-style-type: none"> • June 22, 2022 • June 27-29, 2022

1.3 Key Personnel

The key personnel coordinating this test program were:

- Matt Lloyd will provide support as the Process Focal Point. The Process Focal Point is responsible for coordinating the plant operation during the test and ensuring the unit is operating at the agreed-upon conditions in the test plan. This person also serves as the key contact for collecting any process data required and providing all technical support related to process operations.
- Jenny Kraut will provide support as the Environmental Focal Point for this test. The Environmental Focal Point is responsible for ensuring that all regulatory requirements and citations are reviewed and considered for the testing. All agency communication will be completed through this role. Contact information is jennifer.kraut@dupont.com.
- James Edmister will serve as the Test Plan Coordinator. The Test Plan Coordinator is responsible for the overall leadership of the sampling program. This person also develops the overall testing plan and determines the correct sample methods.
- Wayne Washburn will provide support as the Technical Reviewer of the test QA/QC procedures, measurements data, and emissions results.
- Randy Reinke will serve as the Sample Team Leader. The Sample Team Leader is responsible for ensuring the data generated meets the quality assurance objectives of the plan. Quincy Crawford, Cheyanne Laux, and Fred Sanguedolce assisted as the sampling technicians.

2. Plant and Sampling Location Descriptions

2.1 Facility Description

DuPont operates a tar incinerator (EU95) at its Midland, Michigan chemical manufacturing facility. EU95 is a boiler that produces steam from the heat input of natural gas and process tars. The process tars contain distillation heavies from the 1130 building process and process aids from the distillation process. The boiler is rated for 48 MMBtu/hr while the burner is rated for 15 MMBtu/hr. EU95 must meet the requirements of the Commercial and Industrial Solid Waste Incineration (CISWI) rule promulgated under 40 CFR Part 60, Subpart DDDD, as referenced by EGLE Rule R 336.1974, and is regulated as an Energy Recovery Unit (ERU) under the rule.

2.2 Performance Test Operations

The Performance Test was conducted at one operating condition to demonstrate the system performance with respect to the emission standards listed in Table 1-1. During each test run, continuous monitoring system (CMS) parameters were recorded, and stack gas emissions were measured. The following sections briefly summarize these activities associated with the Performance test.

2.2.1 Unit Process Data

Process monitoring information pertinent to establishing that the unit was operating at normal conditions were recorded during the test by the EU95 Tars Incinerator data acquisition system. One-minute average data for each test run were obtained from the process control system including each operating parameter specified in the test plan. For each operating parameter, a test run overall average value was calculated for each test run.

Figure 1 EU95 Tar Incinerator Process Schematic

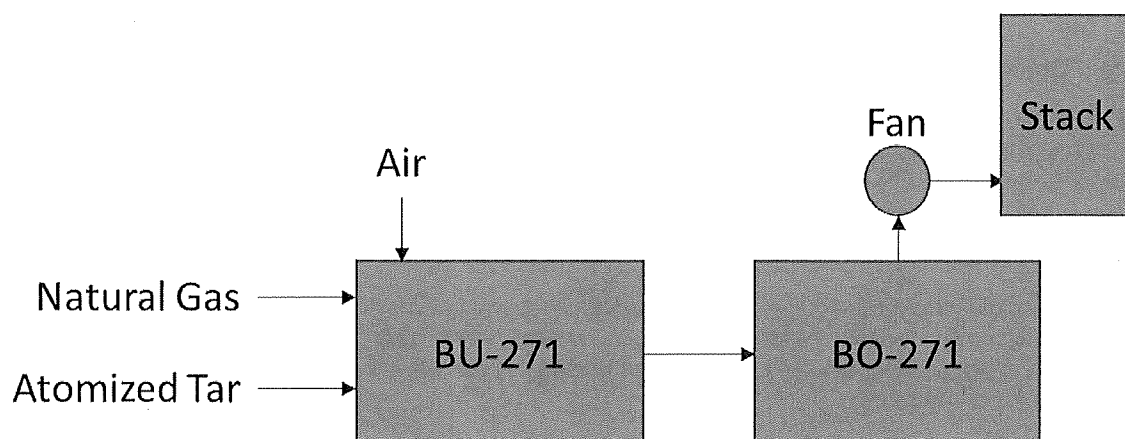


Table 2-1 Manufacturer's Name and Model Number

Equipment	Manufacturer	Model Number
BU-271	Bloom	S-1610-022
BO-271	Johnston	509 Series

3. Summary and Discussion of Test Plan

3.1 Objectives and Test Matrix

The primary objective of this testing was to demonstrate compliance with the requirements of 40 CFR 60 Subpart DDDD. The Performance Testing of the incinerator stack NO_x, CO, SO₂, PM, D/F, HCl and metals emissions was performed in strict accordance with the procedures specified in 40 CFR 60, Appendix A. This test protocol describes the instrumental and manual procedures that were performed on the incinerator stack located within the DuPont Specialty Monomers Plant.

Parameters measured during the June Performance testing include NO_x, CO, SO₂, PM, D/F, HCl and metals. O₂ and CO₂ concentrations were also be measured for molecular weight and excess air correction. The concentration of pollutants in the exhaust gas were measured using the following methods and procedures:

Table 3-1 Test Matrix and Objectives

Parameter	Test Method	Regulation	Emission Limit
O ₂ /CO ₂	EPA Method 3A	40 CFR 60, Subpart DDDD	N/A
PM	EPA Method 5	40 CFR 60, Subpart DDDD	110 mg/dscm @ 7% O ₂
SO ₂	EPA Method 6C	40 CFR 60, Subpart DDDD	720 ppmv @ 7% O ₂
NO _x	EPA Method 7E	40 CFR 60, Subpart DDDD	76 ppmv @ 7% O ₂
CO	EPA Method 10	40 CFR 60, Subpart DDDD	35 ppmv @ 7% O ₂
D/F	EPA Method 23	40 CFR 60, Subpart DDDD	2.9 ng/dscm @ 7% O ₂ (total) - or - 0.32 ng/dscm @ 7% O ₂ (TEQ)
HCl	EPA Method 26A	40 CFR 60, Subpart DDDD	14 ppmv @ 7% O ₂
Cd	EPA Method 29	40 CFR 60, Subpart DDDD	0.023 mg/dscm @ 7% O ₂
Pb	EPA Method 29	40 CFR 60, Subpart DDDD	0.096 mg/dscm @ 7% O ₂
Hg	EPA Method 29	40 CFR 60, Subpart DDDD	0.0024 mg/dscm @ 7% O ₂

The compliance test was conducted on June 22 and June 27-29, 2022, under normal process operating conditions. The emission testing of the incinerator stack consisted of three (3) test runs each for NO_x, CO, SO₂, PM, D/F, HCl and metals.

3.2 Process Operating Rates

As required by the regulation and EGLE guidance, all sampling was completed at normal operating conditions.

The normal operating rates were determined by reviewing the process data from the previous six months of operation and deciding the typical operating range of the unit. The average values do not include calibration data, startup data, shutdown data, malfunction data, and data obtained not burning waste.

Parameter	Normal Operating Rate	Average Operating Rate During Testing
Heat input (MMBtu/hr)	4-13	7.45
Tars Feed Rate (lb/hr)	180-420	360
Natural Gas Feed Rate (scfh)	1450-9000	1490
O ₂ in Vent Stack (%)	9-15	11
*Waste to Fuel Rate Ratio Tar / NG	2.5 -7	5.9

*Tar/NG ratio was calculated on a mass basis using IP21 data captured by the plant control system. Average tar rates were directly calculated using data outputs from IP21 (unit of measure is pounds). Natural gas inputs were calculated using data from IP21 (displayed in SCFMs) that needed to be converted into a mass flow rate in order to match the tar units of measure. This was done by taking density data from the natural gas CoA (certificate of analysis) Consumers Energy annually supplies DuPont. Then, dimensional conversions were done to get the natural gas flow rate into pounds. Since the majority component in the natural gas feed is methane (information on CoA confirms this), density data for methane was used.

Table 3-2 Testing Run Data (PM/HCl)

	Run 1	Run 2	Run 3	Average
Date	27-Jun-22	27-Jun-22	27-Jun-22	-
Time	12:55-14:21	15:20-16:40	17:28-18:55	-
Volume Collected (dscf)	44,884	43,747	45,372	-
Flow Rate (dscfm)	5,057	4,901	5,057	-
Oxygen Concentration (%)	12.47	12.47	12.48	-
Particulate Matter Found (mg)	-	-	-	-
Filter	0.50	0.50	0.95	-
Probe and Nozzle Rinse	4.41	2.93	3.68	-
Front Half Total	4.91	3.43	4.63	-
Full Train Total	4.91	3.43	4.63	-
Stack Gas Loading - Front Half Only				
Particulate Matter (mg/dscf)	0.109	0.0784	0.102	0.0953
Particulate Matter (mg/dscm)	3.86	2.77	3.60	3.36
Particulate Matter (mg/dscm, corrected to 7% O ₂)	6.37	4.57	5.94	5.63
Stack Gas Loading - Full Train				
Particulate Matter (mg/dscf)	0.106	0.0784	0.102	0.0953
Particulate Matter (mg/dscm)	3.73	2.77	3.60	3.36
Particulate Matter (mg/dscm @ 7% O ₂)	6.14	4.57	5.94	5.55
Emission Standard (mg/dscm @ 7% O₂)				110
Mass Emission Rate (lb/hr)				
Front Half Only	0.0732	0.0508	0.0682	0.0632
Full Train	0.0732	0.0508	0.0682	0.0632
Mass Found (ug)				
Hydrogen chloride	468	143	143	
Concentration (mg/dscf)				
Hydrogen chloride	0.0104	0.00327	0.00315	0.00562
Concentration (chloride equivalents ppmvd)				
Hydrogen chloride	0.243	0.0761	0.0734	0.131
Concentration (Chloride equivalents, ppmvd, corrected to 7% O₂)				
Total	0.399	0.125	0.121	0.215
Emission Standard (chloride equivalents, ppmvd, corrected to 7% O₂)				14
Mass Emission Rate (lb/hr)				
HCl Emissions Rate (lbs/hr)	0.00697	0.00212	0.00211	0.00373

Table 3-3 Testing Run Data (Cd/Pb/Hg)

	Run 1	Run 2	Run 3	Average
Date	6/28/2022	6/28/2022	6/29/2022	-
Time	11:55-15:06	15:44-18:26	09:24-12:22	-
Volume Collected (dscf)	79.718	81.670	80.312	-
Stack Gas Flow Rate (dscfm)	4,752	4,838	4,743	-
Oxygen Concentration (%)	12.4	12.4	12.4	-
Mass Found (µg)				-
Cadmium	<0.46	<0.30	<0.30	-
Lead	<5.1	<1.9	<1.9	-
Mercury	<0.49	<0.50	<0.50	-
Stack Gas Concentration (µg/dscf)				-
Cadmium	<0.0058	<0.0036	<0.0037	<0.0044
Lead	<0.063	<0.023	<0.024	<0.037
Mercury	<0.0062	<0.0061	<0.0062	<0.0061
Stack Gas Concentration (µg/dscm)				
Cadmium	<0.20	<0.13	<0.13	<0.15
Lead	<2.2	<0.82	<0.83	<1.3
Mercury	<0.22	<0.22	<0.22	<0.22
Stack Gas Concentration (µg/dscm, 7% O2)				
Cadmium	<0.33	<0.21	<0.21	<0.25
Lead	<3.7	<1.3	<1.4	<2.1
Mercury	<0.36	<0.35	<0.36	<0.36
Stack Gas Concentration (mg/dscm, 7% O2)				
Cadmium	<0.00033	<0.00021	<0.00021	<0.00025
Lead	<0.0037	<0.0013	<0.0014	<0.0021
Mercury	<0.00036	<0.00035	<0.00036	<0.00036

Table 3-4 Testing Run Data (D/F)

		Run 1	Run 2	Run 3
Date		28-Jun-22	28-Jun-22	29-Jun-22
Time		09:05-13:25	14:35-19:15	08:50-13:10
Volume (dscf)		140.146	139.441	140.193
Flow Rate (dscfm)		4,907	4,827	4,895
Oxygen Concentration (%)		12.49	12.45	12.40
Analyte	Toxicity Equivalent Factor	Mass Found (pg)		
2,3,7,8-TCDD	1	<2.13	<1.37	<1.16
1,2,3,7,8-PeCDD	0.5	<50	<50	<50
1,2,3,4,7,8-HxCDD	0.1	<0.752	<50	<0.633
1,2,3,6,7,8-HxCDD	0.1	<0.921	<0.706	<0.623
1,2,3,7,8,9-HxCDD	0.1	<1.22	<50	<1.11
1,2,3,4,6,7,8-HpCDD	0.01	<6.62	<3.72	<3.98
OCDD	0.001	<23.7	<15.2	<9.71
2,3,7,8-TCDF	0.1	<2.16	<1.06	<1.83
1,2,3,7,8-PeCDF	0.05	<1.14	<0.536	<50
2,3,4,7,8-PeCDF	0.5	<0.880	<0.624	<50
1,2,3,4,7,8-HxCDF	0.1	<1.98	<50	<50
1,2,3,6,7,8-HxCDF	0.1	<1.43	<50	<50
1,2,3,7,8,9-HxCDF	0.1	<50	<50	<50
2,3,4,6,7,8-HxCDF	0.1	<1.33	<50	<50
1,2,3,4,6,7,8-HpCDF	0.01	<4.35	<1.83	<1.64
1,2,3,4,7,8,9-HpCDF	0.01	<50	<1.36	<50
OCDF	0.001	<6.93	<5.46	<3.39
Total Mass PCDD/PCDF (pg)		206	382	424
Concentration (ng/dscf)		0.00147	0.00274	0.00302
Concentration (ng/dscm)		0.0518	0.0967	0.107
Concentration (ng/dscm @ 7% O ₂)		0.0856	0.159	0.175
Average Concentration (ng/dscm @ 7% O ₂)		0.140		
Emission Standard (ng/dscm @ 7% O ₂)		2.9		
Total Toxicity Equivalents (pg TEQ)		34.2	57.0	74.6
Concentration (ng TEQ/dscf)		0.000244	0.000409	0.000532
Concentration (ng TEQ/dscm)		0.00863	0.0144	0.0188
Concentration (ng TEQ/dscm @ 7% O ₂)		0.0143	0.0237	0.0308
Average Concentration (ng TEQ/dscm @ 7% O ₂)		0.0229		
Emission Standard (ng TEQ/dscm @ 7% O ₂)		0.32		

Table 3-5 Testing Run Data (NO_x, CO and SO₂)

	Run 1	Run 2	Run 3	Average
Run Date	6/22/2022	6/22/2022	6/22/2022	-
Run Times	0933-1033	1100-1200	1227-1327	-
Stack Gas O ₂ (%)	12.57	12.58	12.55	-
Nitrogen Oxides	-			
ppmvd	38.0	37.5	37.9	37.8
ppmvd @7% O ₂	63.38	62.72	63.19	63.10
lb/MMBtu	0.09	0.09	0.09	0.09
Carbon Monoxides	-			
ppmvd	0.0	0.0	0.0	0.0
ppmvd @7% O ₂	0.0	0.0	0.0	0.0
Sulfur Dioxide	-			
ppmvd	0.2	0.4	0.1	0.2
ppmvd @7% O ₂	0.28	0.65	0.22	0.38

4. Sampling and Analytical Procedures

4.1 Sample Time

The duration of each test run for instrumental methods (NO_x, CO and SO₂) test runs was sixty (60) minutes in duration. For "wet-method" isokinetic methods (PM, D/F, HCl and metals) test runs times are shown below:

- PM/HCl: 72 minutes
- D/F: 240 minutes
- Pb/Cd/Hg: 144 minutes

4.2 Sample Test Runs

Three (3) sample test runs were performed for each method.

4.3 Sample Port Location

The stack is approximately 40-ft high with an inside diameter of 35 inches at the cross-sectional plane of the sampling ports. The sampling ports are approximately 82-in downstream from the closest disturbance (i.e., the stack breach) and 93-in upstream from the next nearest disturbance (i.e., the stack exit to atmosphere). The number of sampling points at this port location will be determined in accordance with EPA Method 1. The diagrams in Figure 2 and Figure 3 present schematics of the sampling points and location relative to the cross-sectional plane of the sample ports. Figure 2 and Figure 3 present schematics of the sampling points and location. It was determined that the previous stack testing locations did not meet the minimum upstream duct diameters for sampling. Preliminary flow measurements were conducted at the original sample points and a 3D pitot was used to determine laminar flow. The results from the 3D pitot indicated the presence of cyclonic flow. The sample ports were moved to meet the minimum requirements for isokinetic sampling, and after a Method 2 cyclonic check, the results indicated less than 20% angle of velocity indicating laminar flow suitable for sampling. The sampling ports were moved 18 inches up toward the exit of the stack. Inside Diameter and stack height remained the same.

Figure 3 present schematics of the sampling points and location. It was determined that the previous stack testing locations did not meet the minimum upstream duct diameters for sampling. Preliminary flow measurements were conducted at the original sample points and a 3D pitot was used to determine laminar flow. The results from the 3D pitot indicated the presence of cyclonic flow. The sample ports were moved to meet the minimum requirements for isokinetic sampling, and after a Method 2 cyclonic check, the results indicated less than 20% angle of velocity indicating laminar flow suitable for sampling. The sampling ports were moved 18 inches up toward the exit of the stack. Inside Diameter and stack height remained the same.

4.4 Isokinetic Sampling Methods

4.4.1 EPA Methods 2, 3A and 4 (Flow Rate, Gas Composition, and Moisture)

Concurrent with the performance of all isokinetic sampling trains, measurements were made to determine stack gas flow rate by EPA Method 2, gas composition by EPA Method 3A, and moisture by EPA Method 4.

4.4.2 EPA Methods 5/26A (Particulate Matter and Hydrogen Chloride)

For the purpose of logistical ease and efficiency, methods 5 and 26A were combined for the PM/HCl determination.

The stack gas was sampled isokinetically for determination of particulate matter and hydrogen chloride using a sampling train meeting the requirements of both EPA Method 5 and EPA Method 26A. Gas is withdrawn from the duct isokinetically, utilizing a gooseneck nozzle of proper size to allow isokinetic sample collection. S-type pitot differential pressure is monitored to determine the isokinetic sampling rate. The particulate matter is filtered from the gas sample. The particulate matter is determined in the rinse of the probe and nozzle, and on the filter, gravimetrically for determination of front-half particulate matter. Back-half particulate matter will not be collected as only filterable PM is regulated in the rule.

From the heated filter, sample gas enters the series of impingers which are charged with absorbing solutions in accordance with EPA Method 26A. The first two impingers will contain a solution of 1N H₂SO₄. The third and fourth impingers will contain a solution of 1N NaOH. The fifth and final impinger will contain a desiccant to dry the sample gas before metering. A pump and dry gas meter are used to control and monitor the sample gas flow rate. The impingers are recovered and rinsed into separate containers and analyzed in accordance with the requirements of Method 26A.

An example of the sampling train is shown in Figure 5

4.4.3 EPA Methods 23 (PCDDs/PCDFs)

The stack gas was sampled for determination of dioxins and furans using a sampling train meeting the requirements of EPA Method 23. According to this method, gas is withdrawn from the duct isokinetically, utilizing a gooseneck nozzle of proper size. S-type pitot differential pressure is monitored to determine the isokinetic sampling rate.

Particulate matter is filtered from the gas sample, which then enters a sorbent module (water-cooled condenser and jacketed XAD-2 resin trap). Following the resin trap, the sample gas passes through a series of impingers to dry the gas before it enters the control console. Sample fractions were recovered in separate containers, to simplify shipping logistics, and later combined in the analytical laboratory and extracted to provide a single sample for analysis in accordance with the requirements of Method 23.

An example of the sampling train is shown in Figure 6

4.4.4 EPA Methods 29 (Metals)

The stack gas was sampled isokinetically for determination of metals (Pb/Cd/Hg) using a sampling train meeting the requirements of EPA Method 29. Gas was withdrawn from the duct isokinetically, utilizing a gooseneck nozzle of proper size to allow isokinetic sample collection. S-type pitot differential pressure is monitored to determine the isokinetic sampling rate. Particulate matter is filtered from the gas sample.

From the heated filter, sample gas enters the series of impingers which are charged with absorbing solutions in accordance with EPA Method 29. The first two impingers will contain a solution of 5% HNO₃ and 10% H₂O₂. The third impinger will be empty. The fourth and fifth impingers will contain a solution of 4% KMnO₄ and 10% H₂SO₄. The sixth and final impinger will contain a desiccant to dry the sample gas before metering. A pump and dry gas meter are used to control and monitor the sample gas flow rate. The impingers are recovered and rinsed into separate containers and analyzed in accordance with the requirements of Method 29.

An example of the sampling train is shown in Figure 7

4.5 Visible Emissions Observations

The observer was qualified in accordance with Section 3 of Method 9 and used the following procedures for visually determining the opacity of emissions.

Position. The qualified observer shall stand at a distance sufficient to provide a clear view of the emissions with the sun oriented in the 140-degree sector to his back. Consistent with maintaining the above requirement, the observer shall, as much as possible, make his observations from a position such that his line of vision is approximately perpendicular to the plume direction and, when observing opacity of emissions from rectangular outlets (e.g., roof monitors, open baghouses, noncircular stacks), approximately perpendicular to the longer axis of the outlet. The observer's line of sight should not include more than one plume at a time when multiple stacks are involved, and in any case the observer should make his observations with his line of sight perpendicular to the longer axis of such a set of multiple stacks (e.g., stub stacks on baghouses).

Field Records. The observer shall record the name of the plant, emission location, facility type, observer's name and affiliation, and the date on a field data sheet. The estimated distance to the emission location, approximate wind direction, estimated wind speed, description of the sky condition (presence and color of clouds), and plume background are recorded on a field data sheet along with the time opacity readings are initiated and completed.

Note: The latitude and longitude on the data sheet refer to the location of the source of visible emissions.

Observations. Method 9 readings were made at the point of greatest opacity in that portion of the plume where condensed water vapor is not present. The observer did not look continuously at the plume but instead observed the plume momentarily at 15-second intervals.

Attached Steam Plumes. When condensed water vapor is present within the plume as it emerges from the emission outlet, opacity observations shall be made beyond the point in the plume at which condensed water vapor is no longer visible. The observer shall record the approximate distance from the emission outlet to the point in the plume at which the observations are made.

Detached Steam Plume. When water vapor in the plume condenses and becomes visible at a distinct distance from the emission outlet, the opacity of emissions should be evaluated at the emission outlet prior to the condensation of water vapor and the formation of the steam plume.

Recording Observations

Stack Emissions. Opacity observations for Method 9 were recorded to the nearest 5 percent at 15-second intervals on the observational record sheet. A minimum of 24 observations were recorded. The duration of this measurement must be at least 6 minutes. Each momentary observation recorded shall be deemed to represent the average opacity of emissions for a 15-second period.

Data Reduction (Method 9 only). Opacity was determined as an average of 24 consecutive observations recorded at 15-second intervals. Divide the observations recorded on the record sheet into sets of 24 consecutive observations. A set is composed of any 24 consecutive observations. Sets need not be consecutive in time and in no case shall two sets overlap. For each set of 24 observations, AECOM calculated the average by summing the opacity of the 24 observations and dividing this sum by 24. If an applicable standard specifies an averaging time requiring more than 24 observations, AECOM calculated the average for all observations made during the specified time period or whatever statistical basis is specified in the permit. AECOM recorded the average opacity on the observational record sheet.

4.6 Instrumental Methods

Emission gas was withdrawn from the incinerator stack and transported to the AECOM mobile instrumental measurements laboratory located at ground level. A stainless-steel sampling probe will be inserted into the stack and used to collect sample gas. Traverse points across each stack were selected according to the procedure outlined in EPA Method 7E, Section 8.1, and marked clearly on the sampling probe. A heated Teflon sample line transported the sample gas from the sampling probe to the mobile laboratory. The instrumental analyzers were kept at a stable temperature inside the AECOM mobile laboratory. At the mobile laboratory, stack exhaust gas was routed to a condenser and then transported to each individual analyzer for analysis on a dry basis (i.e., for O₂/CO₂, NO_x, CO, and SO₂).

The analyzers' electronic output signals were converted to a digital format and stored by AECOM's computerized data acquisition system. The system translates this digital signal into the proper units of measurement (e.g. ppmv NO_x, dry basis) and stores them on a hard drive. The system stores the data as ten-second averages.

The analyzers were calibrated prior to initiating testing using appropriately certified standards as specified by EPA Methods 7E. EPA Protocol gases or certified pure zero nitrogen and air gases were used for calibration.

A three-point analyzer calibration error test was performed on each instrumental analyzer prior to testing. Zero and span gases were introduced directly to the instruments to establish calibration set points. Then, the mid-range gas was introduced as a QC check of instrument linearity. The calibration error of the response to each of these gases was no more than ±2% of span from the calibration gas value.

The AECOM sampling system bias was then checked. The total system, which includes the probe, heated filter, sample line, sample pump, and moisture condenser, was incorporated into the system bias check.

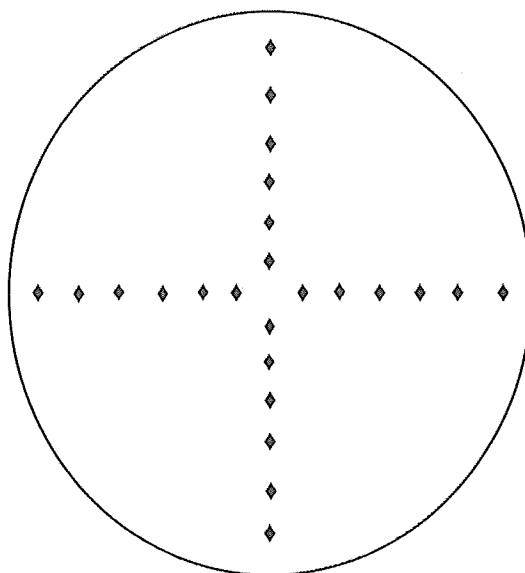
A system response time test for each parameter was performed and documented during the initial system bias check. A stratification test was performed including the required traverse points determined according to EPA Method 7E, Section 8.1.2.

A schematic of the instrumental sampling system is shown in Figure 4

The following instruments were used:

- EPA Method 3A (O₂/CO₂) - Teledyne model 300M; paramagnetic
 - EPA Method 6C (SO₂) - Western Research Series 921; non-dispersive ultraviolet light analyzer.
 - EPA Method 7E (NO_x) - TECO Model 42; chemiluminescent NO detector.
- EPA Method 10 (CO) - Teledyne Model 300M; gas filter correlation (GFC) infrared.

Figure 2 Sample Points



Stack Diameter 2.9 feet

Traverse Point ¹	Percent of Diameter	Distance from Wall ² (in)	Marking Location (in)
1	2.1	1.000	9.375
2	6.7	2.345	10.72
3	11.8	4.135	12.51
4	17.7	6.195	14.57
5	25.0	8.755	17.13
6	35.6	12.465	20.84
7	64.4	22.545	30.92
8	75.0	26.255	34.63
9	82.3	28.805	37.18
10	88.2	30.875	39.25
11	93.7	32.655	41.03
12	97.9	34.000	42.375

Figure 3 Sample Location

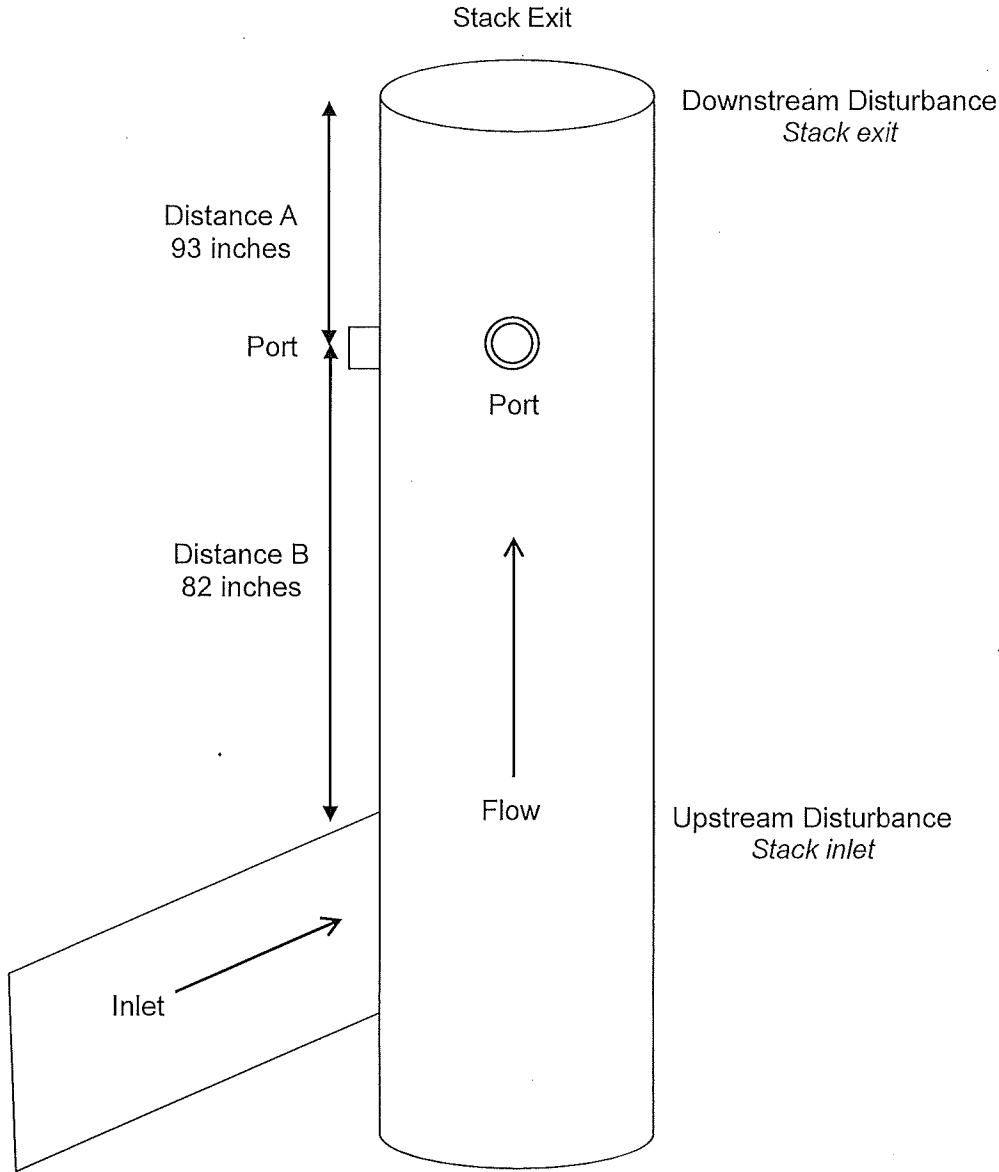
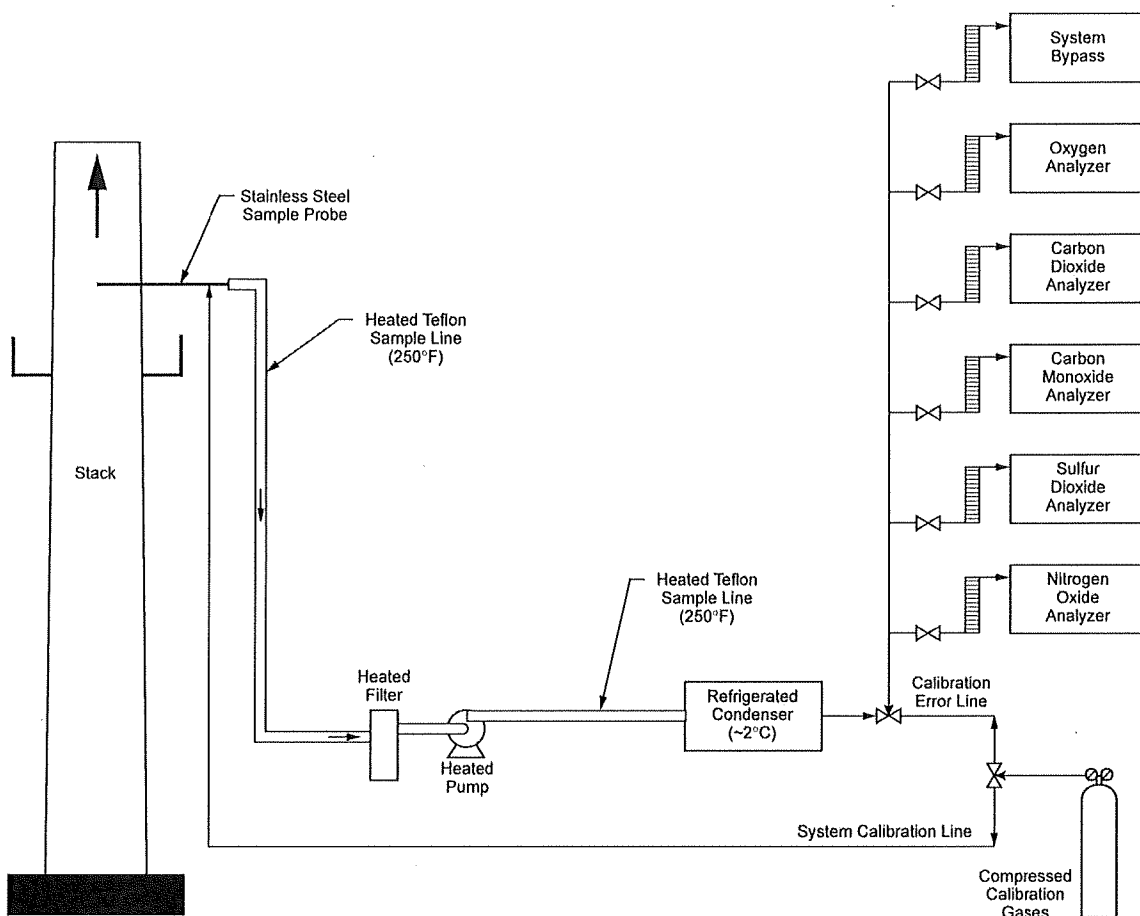
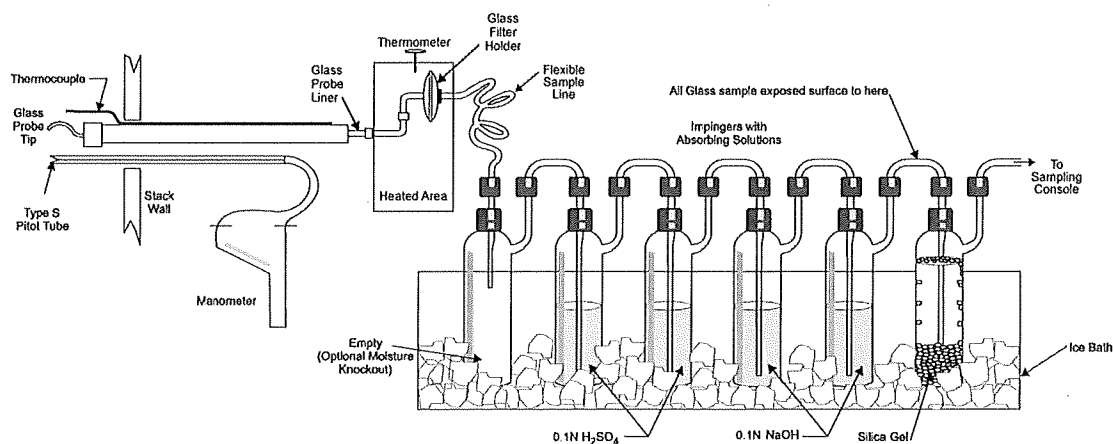


Figure 4 Schematic of AECOM CEM System



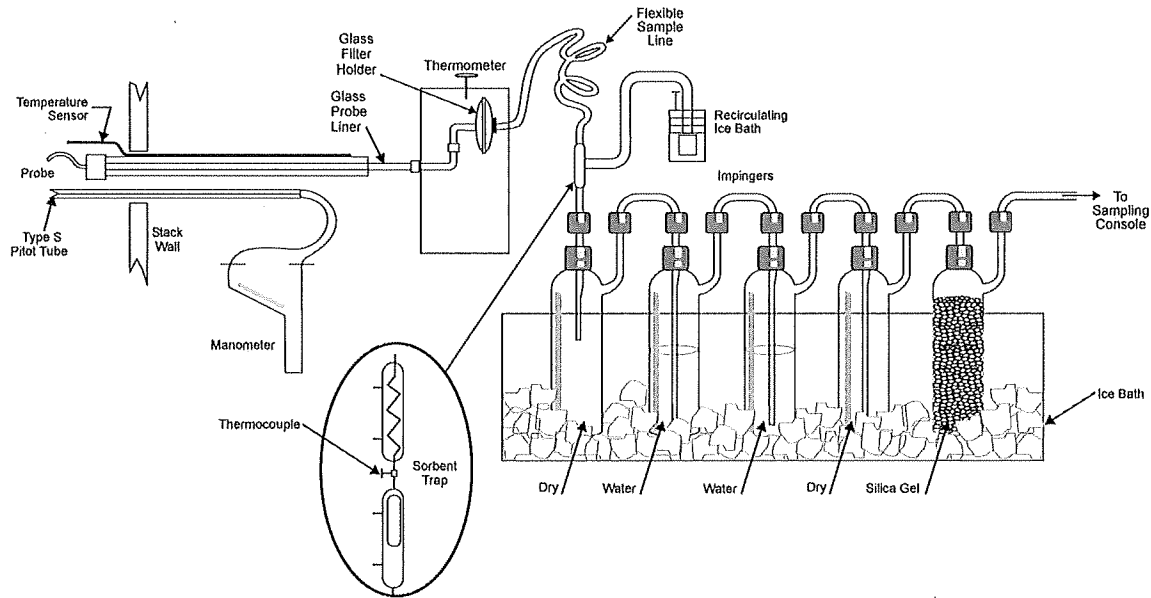
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Figure 5 Schematic of Method 5/26A Sample Train



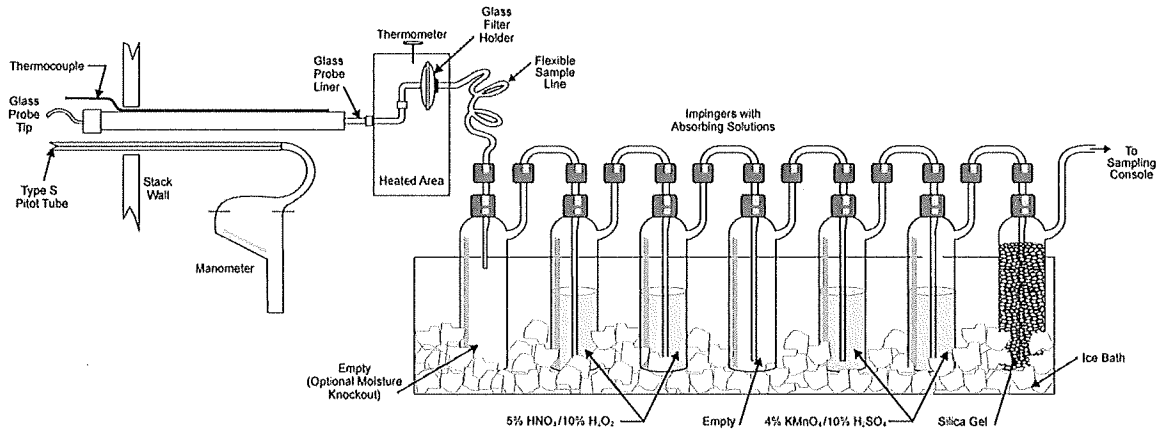
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Figure 6 Schematic of Method 23 Sample Train



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Figure 7 Schematic of Method 29 Sample Train



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5. Calculation Examples

Stack Gas Velocity & Volumetric Rates (EPA M2)

The velocity and volumetric flow rate of the stack gas are calculated using the following equations:

$$V_S = K_P C_P (\sqrt{\Delta p})_{AVG} \sqrt{\frac{T_{S(AVG)}}{P_S M_S}}$$

$$Q_W = V_S A_S (60 \text{ sec/min})$$

$$Q_{SW} = Q_W \left(\frac{528^\circ R}{T_S} \right) \left(\frac{P_S}{29.92 \text{ "Hg}} \right)$$

$$Q_{SD} = Q_{SW} (DGF)$$

Where: V_S	= Stack gas velocity (ft/sec)
K_P	= Pitot Tube Constant, $85.49 \frac{ft}{sec} \sqrt{\frac{(lb/lb \text{ mol})(^\circ Hg)}{(^\circ R)(^\circ H_2O)}}$
C_P	= Pitot Tube Coefficient, 0.84 (dimensionless)
Δp	= Velocity Head of Stack Gas, ("H ₂ O)
T_S	= Stack Temperature (°R)
P_S	= Absolute Stack Pressure ("Hg)
M_S	= Molecular weight of stack gas, wet basis (lb/lb-mole)
Q_W	= Stack Gas Wet Volumetric Flow at Stack Conditions (ft ³ /min)
Q_{SW}	= Stack Gas Wet Volumetric Flow at Standard Conditions (ft ³ /min)
A_S	= Stack Area (ft ²)
Q_{SD}	= Stack Gas Flow @ Std. Conditions, dry basis (dscf/min)
DGF	= Dry Gas Fraction

VOLUMETRIC FLOW EXAMPLE CALCULATION (M5/26A)

$$V_S = \left(85.49 \frac{ft}{sec} \sqrt{\frac{(lb/lb \text{ mol})(^\circ Hg)}{(^\circ R)(^\circ H_2O)}} \right) (0.84) (0.33 \text{ "H}_2\text{O}) \sqrt{\frac{834^\circ R}{(29.43 \text{ "Hg})(28.4 \text{ lb/lb mol})}} = 23.37 \text{ ft/sec}$$

$$Q_W = \left(\frac{23.37 \text{ ft}}{sec} \right) \left(\frac{6.61 \text{ ft}^2}{1} \right) \left(\frac{60 \text{ sec}}{min} \right) \left(\frac{60 \text{ min}}{1 \text{ hr}} \right) = 5.56 \times 10^5 \text{ acfh}$$

$$Q_{WS} = \left(\frac{5.56 \times 10^5 \text{ acf}}{hr} \right) \left(\frac{528^\circ R}{834^\circ R} \right) \left(\frac{29.43 \text{ "Hg}}{29.92 \text{ "Hg}} \right) = 3.46 \times 10^5 \text{ scfh}$$

$$Q_{SD} = (3.46 \times 10^5 \text{ scfh})(0.92) = 3.18 \times 10^5 \text{ dscfh}$$

Analyzer Calibration Error Calculations

The calibration error test consisted of challenging each reference monitor at three measurement points against known calibration gas values. Calibration error for the reference is calculated using the following equation:

Calibration Error - Equation 7E-1									
$ACE = \frac{C_{Dir} - C_v}{CS} \times 100\%$									
C _{dir} = Measured concentration of a calibration gas (low, mid, or high) when introduced in direct calibration mode									
C _v = Manufacturer certified concentration of a calibration gas (low, mid, or high)									
CS = Calibration span									
For oxygen, mid cal gas									
			C _{dir} =	10.00	%				
			C _v =	9.93	%				
			CS =	20.06	%				
$ACE = \frac{(10.00 - 9.93)}{20.06} \times 100 \%$									
ACE = 0.4 %									
For carbon monoxide, mid cal gas									
			C _{dir} =	14.92	ppmv				
			C _v =	14.85	ppmv				
			CS =	29.89	ppmv				
$ACE = \frac{(14.92 - 14.85)}{29.89} \times 100 \%$									
ACE = 0.2 %									

Calibration Drift Calculations

The calibration drift tests were conducted at the beginning and end of each run. Analyzer maintenance, repair or adjustment could not be completed until the system calibration response was recorded. Calibration drift for the reference is calculated using the following equation:

System Drift - Equation 7E-4																								
$D = SB_{final} - SB_i $																								
D = Drift assessment, percent of calibration span																								
SB_{final} = Post-run system bias, percent of calibration span																								
SB_i = Pre-run system bias, percent of calibration span																								
For oxygen, mid cal gas																								
$SB_{Final} = -0.5\%$																								
$SB_i = -0.4\%$																								
$D = -0.5 - (-0.4) $																								
$D = 0.1\%$																								

System Calibration Drift Correction

The gas concentrations are corrected for the system calibration bias. The concentrations are calculated using the following equations:

$$C_{Gas} = (\bar{C} - C_0) \left(\frac{C_{MA}}{C_M - C_0} \right)$$

where: C_{Gas} = Effluent Concentration, dry ppm or %
 \bar{C} = Average Analyzer Concentration, ppm or %
 C_0 = Average Initial and Final System Calibration Responses for Zero Gas, ppm or %
 C_M = Average Initial and Final System Calibration Responses for Upscale Calibration Gas, ppm or %
 C_{MA} = Actual Concentration of Upscale Calibration Gas, ppm or %

O₂ System Calibration Drift Correction for Run #1 Example

Effluent Concentration - Equation 7E-5b									
$C_{Gas} = (\bar{C}_{avg} - C_0) \left(\frac{C_{MA}}{C_M - C_0} \right)$									
C_{Gas} = Average effluent gas concentration adjusted for bias									
\bar{C}_{avg} = Average unadjusted gas concentration indicated by data recorder for the test run									
C_0 = Average of the initial and final system calibration bias check responses from the zero calibration gas									
C_{MA} = Actual concentration of the upscale calibration gas									
C_M = Average of initial and final system calibration bias check responses for the upscale calibration gas									
For oxygen, Compliance Run 1									
	\bar{C}_{avg}	=	12.54	%					
	C_0	=	0.02	%					
	C_{MA}	=	9.93	%					
	C_M	=	9.91	%					
	C_{gas}	=	$\left(12.54 - 0.02 \right) \left(\frac{9.93}{9.91 - 0.02} \right)$						
	C_{gas}	=	12.57	%					

PCDD/PCDF Total Toxicity Equivalents Rate Example Calculation

Toxic Equivalents, or TEQs, are used to report the toxicity-weighted masses of mixtures of dioxins. The TEQ method of dioxin reporting is more meaningful than simply reporting the total number of grams of a mixture of variously toxic compounds because the TEQ method offers toxicity information about the mixture.

Within the TEQ method, each dioxin compound is assigned a Toxic Equivalency Factor, or TEF (see the table below). This factor denotes a given dioxin compound's toxicity relative to 2,3,7,8-TCDD, which is assigned the maximum toxicity designation of one. Other dioxin compounds are given equal or lower numbers, with each number roughly proportional to its toxicity relative to that of 2,3,7,8-TCDD. Developed by the World Health Organization, TEFs are used extensively by scientists and governments around the world. The EPA uses units of grams-TEQ to report emissions of dioxins from known sources to the open environment in its Inventory of Sources of Dioxin in the United States.

To obtain the number of grams-TEQ of a dioxin mixture, one simply multiplies the mass of each compound in the mixture by its TEF and then totals them.

Analyte	Toxicity Equivalent Factor
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	0.5
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.001
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.05
2,3,4,7,8-PeCDF	0.5
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.001

2,3,7,8-TCDD Correction for Example

$$2,3,7,8-TCDD_{TEQCor} = (< 3.42 \text{ pg})(1_{TEQFactor}) = < 3.42 \text{ pg}$$

Total Toxicity Equivalents Conversion

All PCDD/PCDF are summed to provide a "Total Toxicity Equivalent". This total "TEQ" is converted from picograms to nanograms. The emission value in nanograms is then adjusted based on a sample flow rate at 7% oxygen.

$$Total\ TEQ = \left(\frac{concentration\ pg}{1} \right) \left(\frac{1\ ng}{1000\ pg} \right) \left(\frac{1}{sample\ volume\ dscm} \right)$$

$$TEQ_{corr} = TEQ \times \left(\frac{13.9\ \%}{20.9\% - Corrected\ Raw\ O_2\ Value} \right)$$

Emission Concentration Example

$$Total\ TEQ = \left(\frac{< 12.3\ pg}{1} \right) \left(\frac{1\ ng}{1000\ pg} \right) \left(\frac{1}{119.630\ dscf} \right) \left(\frac{1\ dscf}{0.028317\ dscm} \right) = < 0.0036\ ng/dscm$$

$$TEQ_{corr} = < 0.0036\ ng/dscm \times \left(\frac{13.9\ \%}{20.9\% - 13.8\%} \right) = < 0.0071\ ng/dscm$$

6. Field test Data