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

EES Coke Battery, LLC contracted CleanAir Engineering (CleanAir) to complete compliance testing at the Zug Island EES Coke Battery, LLC facility located in River Rouge, MI.

The objective of the test program was to perform particulate and NO_x testing on the Pushing Emissions Control System (PECS) to demonstrate compliance with Michigan Permit to Install 51-08C (MI-PTI-51-08C).

The PECS Stack has a baghouse to control particulate emissions during each oven push. Process conditions provided by EES include the following:

- Oven number
- Push time
- Amount of coke pushed
- Coke volatile matter content
- Fan amps
- Baghouse pressure drop

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 / Permit Limits

Source Constituent	Sampling Method	Average Emission	Permit Limit[1]
PECS Stack			
PM (lb/Ton Coke)	EPA 201A	0.0065	0.02
PM (ton/yr)	EPA 201A	2.4	9.7
PM_{10} (lb/hr)[2]	EPA 201A/202	0.77	0.69
$PM_{2.5}$ (lb/hr)[2]	EPA 201A/202	0.68	0.69
Oxides of Nitrogen (lb/hr)[2]	EPA 7E	2.25	2.61

[1] Permit limits obtained from Michigan Permit to Install number: MI-PTI-51-08C.

[2] The source does not emit continuously; lb/hr values are operating hour of the PECS exhaust fan.

TEST PROGRAM DETAILS

PARAMETERS

The test program included the following measurements:

- particulate matter less than 10 microns in diameter (PM_{10})
- particulate matter less than 2.5 microns in diameter ($PM_{2.5}$)
- condensable particulate matter (CPM)
- nitrogen oxide (NO_x)
- flue gas composition (e.g., O_2, CO_2, H_2O)
- flue gas temperature
- flue gas flow rate

SCHEDULE

Testing was performed on September 20-23, 2022. 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	PECS Stack	USEPA Method 201A/202	PM, PM_{10}, $PM_{2.5}$	09/20/22	17:13	18:38
1	PECS Stack	USEPA Method 201A/202	PM, PM_{10}, $PM_{2.5}$	09/21/22	17:45	22:35
2	PECS Stack	USEPA Method 201A/202	PM, PM_{10}, $PM_{2.5}$	09/22/22	11:02	12:15
2	PECS Stack	USEPA Method 201A/202	PM, PM_{10}, $PM_{2.5}$	09/22/22	14:21	19:11
3	PECS Stack	USEPA Method 201A/202	PM, PM_{10}, $PM_{2.5}$	09/23/22	09:52	16:31
1	PECS Stack	USEPA 3A, 7E	O_2/CO_2, NO_x	09/21/22	20:49	23:40
2	PECS Stack	USEPA 3A, 7E	O_2/CO_2, NO_x	09/22/22	14:15	19:16
3	PECS Stack	USEPA 3A, 7E	O_2/CO_2, NO_x	09/23/22	09:27	14:45

DISCUSSION

Emission Calculation Explanation

Due to the intermittent operations of the facility, the approach to the emission calculations was adjusted. Each PM test run consisted of approximately 90 minutes of sampling time. However, 6 to 7 hours of time was required to obtain each sample since sampling can only occur while the PECS exhaust fan is operating. This is referred to as a push. A ratio of the metered sample time to elapsed test time was applied to the emission rate values to ensure representative results based on the process operations. Emission rates shown in pounds per hour are therefore corrected to be pound per hour (lb/hr) of clock time.

Test Program Summary

The test program was completed over the span of four test days. Due to the intermittent nature of the process at current operations, a minimum of 6 hours was required to complete one test run as the sampling can only occur during a push. A push occurred approximately every 13 minutes and during each push, roughly three minutes of sample was collected.

Each Method 201A/202 test run was completed so that 12 points were sampled. Each point was sampled for approximately eight minutes. Samples were collected isokinetically so that a minimum of 30 dry standard cubic feet (dscf) of sample was collected.

Due to scheduled outages and severe weather delays, the first 201A/202 run spanned two days. Sampling began at 17:13 on September 20 and was paused at 18:38 due to lightning in the area. Due to internal safety policies, CleanAir personnel are required to vacate the stack platform and seek shelter during thunderstorms when lightning is detected within 5 miles. 30 minutes without lightning within 5 miles is required for CleanAir to return to work. CleanAir remained on standby into the evening keeping an eye on lightning trackers, waiting for a gap in the storms to resume testing. Unfortunately, lightning strikes persisted within a 5-mile radius and the forecast showed a constant stormfront throughout the evening. At 21:45 the decision was made between CleanAir and EES to resume testing in the morning. CleanAir utilized a gap in the storms at 22:30 to head up to the stack to secure equipment for the night.

On the morning of September 21, EES notified CleanAir that equipment issues caused the plant to delay their scheduled outage from early morning until 12:19-17:19. CleanAir conducted a leak check on the sample train before resuming Run 1 at 17:45. Run 1 was completed at 22:35, well within the 36 hour start-to-finish window allowable by EGLE.

Failed PM_{10} Result

EES demonstrated compliance within their permit limits for all parameters except PM_{10}. There is reason to believe that the extended delay in testing during Run 1 played a factor in the higher reported PM results. Both filterable particulate matter (FPM) and condensable particulate matter (CPM) results were significantly higher during Run 1. If Run 1 PM_{10} numbers fell within the range of Runs 2 and 3, EES permit limits would have been met.

CEM QA/QC

Following a previous discussion with Tom Gasloli of MDEQ in September 2019, it was determined that ambient readings for all analytes would be eliminated. The O_2/CO_2 values were displayed only when pushing gas was being measured and this was the same for the NO_x values. All CEMS results were provided with the non-push readings omitted from the average results calculations.

The extended nature of the testing was a potential concern. Typically, bias checks are completed only before and after a test run. However, CleanAir performed bias checks during each test since test runs were upwards of 3 hours in duration. CleanAir attempted to perform all bias checks between pushes to maximize the sample collected. These checks were required to monitor analyzer bias and drift over the day of sampling.

PM_{10} / $PM_{2.5}$ – USEPA Method 201A/202

EPA Method 201A, "Determination of PM_{10} and $PM_{2.5}$ Emissions", was used for the particulate matter measurements along with EPA Method 202, "Dry Impinger Method for Determining Condensable Particulate Emissions from Stationary Sources". These methods are contained in Appendix M of 40 CFR 51.

Method 201A defines PM_{10} as particulate emissions equal to or less than an aerodynamic diameter of nominally 10 microns, and $PM_{2.5}$ as particulate emissions equal to or less than an aerodynamic diameter of nominally 2.5 microns.

The sampling apparatus utilized stainless steel in-stack cyclones followed by a Gelman filter holder. The cyclones are constructed according to the design specifications provided in Method 201A. When operated at a specified flow rate, the first cyclone is designed to collect particles greater than 10 microns while allowing particles less than or equal to 10 microns to pass through. The second cyclone is designed to collect particles greater than 2.5 microns while allowing particles less than or equal to 2.5 microns to pass through. The exit of the second cyclone connects directly to a 45-mm stainless steel filter holder that contains a high-efficiency quartz fiber filter to collect the $PM_{2.5}$ particles.

Sampling was performed at a constant flow rate that maintains the 10/2.5-micron cut-points of the cyclones. The sampling time (dwell time) at each traverse point varied proportionally with the velocity at each point, as determined from a pre-test velocity traverse. All particulate analyses were performed gravimetrically following EPA Method 5 procedures.

The condensable particulate matter was collected in dry impingers after the gas has traveled through the Method 201A cyclone. Total CPM was represented by the impinger fractions and the CPM filter.

The CPM fractions were used for the PM_{10} and $PM_{2.5}$ results.

Continuous Emissions Testing – USEPA Methods 3A and 7E

O_2, CO_2 and NO_x were continuously measured from a heated probe, filter, and sample line assembly run from the stack location to the test trailer. The heat remained enough to prevent condensation of the sample in the sample lines. The sample was extracted and conditioned prior to being sent to a flow panel. The flow panel diverts enough flow rate to the dry analyzers.

Test runs were conducted at a three-point traverse located at 15.75 in., 39.37 in and 78.74 in. In previous test mobilizations, the three points showed that the location met the requirements for single-point testing. However, during on-site discussions in December 2014 between Tom Gasloli (MDEQ, now EGLE) and Josh Childers (CleanAir), it was agreed that due to the process the CEMS sampling would continue to be performed at three points, not one. A total of three test runs were performed.

Modifications to the Test Methodology

Due to the extended nature of the test runs, CleanAir performed a mid-test bias calibration of the CEMS system. An attempt was made for this to occur only during non-push periods to avoid missing peaks during each push.

Michigan Department of Environment, Great Lakes, and Energy (EGLE) addressed bias/drift check procedures in an email dated September 9, 2016:

"The proposal to check the calibration of the analyzers mid run, during non-push periods is appropriate. To simplify calculations, the data may be corrected using the initial and final drift/bias checks, provided that all intermediate checks are within the acceptable range. (i.e. if the run is 6 hours long and drift bias checks were done every hour, and all are acceptable you may use the 1st and last calibration checks to correct all pushing data.) ".

End of Section

2. RESULTS

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

Table 2-1:
PECS Stack – Particulate Matter (PM)

Run No.		1	2	3	Average
Date (2022)		Sep 20 & Sep 21	Sep 22	Sep 23	
Start Time (approx.)		17:13	11:02	09:52	
Stop Time (approx.)		22:35	19:11	16:31	
Process Conditions					
R_p	Production rate (ton/hr)	72	97	99	90
P_1	Starting Oven Number	2	73	2	26
P_2	Elapsed pushing time (minutes)	375	363	399	379
P_3	Amount of coke pushed (tons)	451	590	662	567
F_c	Coke volatile matter content (%)	.64	.74	.49	1
F_t	Sample Time (minutes)	90	95	92	92
Cap	Capacity factor (hours/year)	8,760	8,760	8,760	8,760
Gas Conditions					
O_2	Oxygen (dry volume %)	21.0	20.9	20.8	**20.8**
CO_2	Carbon dioxide (dry volume %)	0.3	0.2	0.2	**0.2**
T_s	Stack temperature (°F)	125	117	123	**122**
B_w	Actual water vapor in gas (% by volume)	2.6	1.2	2.1	**2.0**
Gas Flow Rate					
Q_a	Volumetric flow rate, actual (acfm)	190,000	193,000	192,000	**191,000**
Q_s	Volumetric flow rate, standard (scfm)	167,000	172,000	171,000	**170,000**
Q_{sd}	Volumetric flow rate, dry standard (dscfm)	163,000	170,000	168,000	**167,000**
Sampling Data					
V_{mstd}	Volume metered, standard (dscf)	34.57	37.12	36.10	**35.93**
%I	Isokinetic sampling (%)	100.4	97.4	99.6	**99.1**
Laboratory Data					
m_n	Total FPM (g)	0.00446	0.00433	0.00218	
n_{NDL}	Number of non-detectable fractions	1 out of 4	1 out of 4	2 out of 4	
DLC	Detection level classification	DLL	DLL	DLL	
FPM Results					
$E_{lb/hr}$	Particulate Rate (lb/hr)	0.5672	0.6901	0.3084	**0.5553**
$E_{T/yr}$	Particulate Rate (Ton/yr)	2.9224	3.0227	1.3510	**2.4320**
$E_{R/t}$	Particulate Rate - Production-based (lb/ton)	0.0093	0.0071	0.0031	**0.0066**

Average includes 3 runs.

Detection level classifications are defined as follows:

ADL = Above Detection Level - all fractions are above detection limit

DLL = Detection Level Limited - some fractions are below detection limit

Table 2-2:
PECS Stack – $PM_{10}/PM_{2.5}$

Run No.		1	2	3	Average
Date (2022)		Sep 20 & Sep 21	Sep 22	Sep 23	
Start Time (approx.)		17:13	11:02	09:52	
Stop Time (approx.)		22:35	19:11	16:31	
Process Conditions					
R_p	Production rate (ton/hr)	72	97	99	90
P_1	Starting Oven Number	2	73	2	26
P_2	Elapsed pushing time (minutes)	375	363	399	379
P_3	Amount of coke pushed (tons)	451	590	662	567
P_4	Coke volatile matter content (%)	.64	.74	.49	1
θ	Sample Time (minutes)	90	95	92	92
Cap	Capacityfactor (hours/year)	8,760	8,760	8,760	8,760
Gas Conditions					
O_2	Oxygen (dry volume %)	21.0	20.9	20.8	20.9
CO_2	Carbon dioxide (dry volume %)	0.3	0.2	0.2	0.2
T_s	Stack temperature (°F)	125	117	123	122
B_w	Actual water vapor in gas (% by volume)	2.6	1.2	2.1	2.0
Gas Flow Rate					
Q_a	Volumetric flow rate, actual (acfm)	190,000	193,000	192,000	191,000
Q_s	Volumetric flow rate, standard (scfm)	167,000	172,000	171,000	170,000
Q_{sd}	Volumetric flow rate, dry standard (dscfm)	163,000	170,000	168,000	167,000
Sampling Data					
V_{mstd}	Volume metered, standard (dscf)	34.57	37.12	36.10	35.93
%I	Isokinetic sampling (%)	100.4	97.4	99.6	99.1
Total PM10 Laboratory Data					
$m_{fn\text{-}10}$	Total FPM < 10 µm (g)	0.00177	0.00135	0.00093	
m_{CPM}	Total CPM (g)	0.00513	0.00368	0.00237	
$m_{Part\text{-}10}$	Total PM < 10 µm (g)	0.00690	0.00503	0.00330	
n_{MDL}	Number of Non-Detectable Fractions	1 out of 5	1 out of 5	2 out of 5	
DLC	Detection Level Classification	DLL	DLL	DLL	
Total PM10 Results					
$E_{lb/hr}$	Particulate Rate (lb/hr)	1.0322	0.8005	0.4677	0.7668
Total PM2.5 Laboratory Data					
$m_{fn\text{-}2.5}$	Total FPM < 2.5 µm (g)	0.00113	0.00062	0.00061	
m_{CPM}	Total CPM (g)	0.00513	0.00368	0.00237	
$m_{Part\text{-}2.5}$	Total PM < 2.5 µm (g)	0.00626	0.00430	0.00298	
n_{MDL}	Number of Non-Detectable Fractions	1 out of 4	1 out of 4	2 out of 4	
DLC	Detection Level Classification	DLL	DLL	DLL	
Total PM2.5 Results					
$E_{lb/hr}$	Particulate Rate (lb/hr)	0.9358	0.6843	0.4224	0.6808

Table 2-3:
PECS Stack – NO_x

Run No.		1	2	3	Average
Date (2022)		Sep 21	Sep 22	Sep 23	
Start Time		20:49	14:15	09:27	
Stop Time		23:40	19:16	14:45	
Gas Conditions					
O_2	Oxygen (dry volume %)	20.96	20.86	20.81	**20.88**
CO_2	Carbon dioxide (dry volume %)	0.26	0.21	0.24	**0.24**
B_w	Actual water vapor in gas (% by volume)	2.62	1.23	2.12	**1.99**
Gas Flow Rate					
Q_a	Volumetric flow rate, actual (acfm)	190,000	193,000	192,000	**191,667**
Q_s	Volumetric flow rate, standard (scfm)	167,000	172,000	171,000	**170,000**
Q_{sd}	Volumetric flow rate, dry standard (dscfm)	163,000	170,000	168,000	**167,000**
Nitrogen Oxides (NOX)					
C_z	Concentration (ppmdv)	1.95	1.69	2.02	**1.89**
$E_{lb/hr}$	Mass Rate (lb/hr)	2.28	2.05	2.43	**2.25**

Average includes 3 runs.

Flow and moisture data obtained from USEPA Method 201A/202 testing.

End of Section

3. DESCRIPTION OF INSTALLATION

PROCESS DESCRIPTION

EES Coke Battery, LLC is a facility located on Zug Island in River Rouge, Michigan. The testing described in this document will be performed at the pushing PECS Stack location. The process includes the PECS Baghouse, Pushing Stack (PECS Stack) and a Combustion Stack.

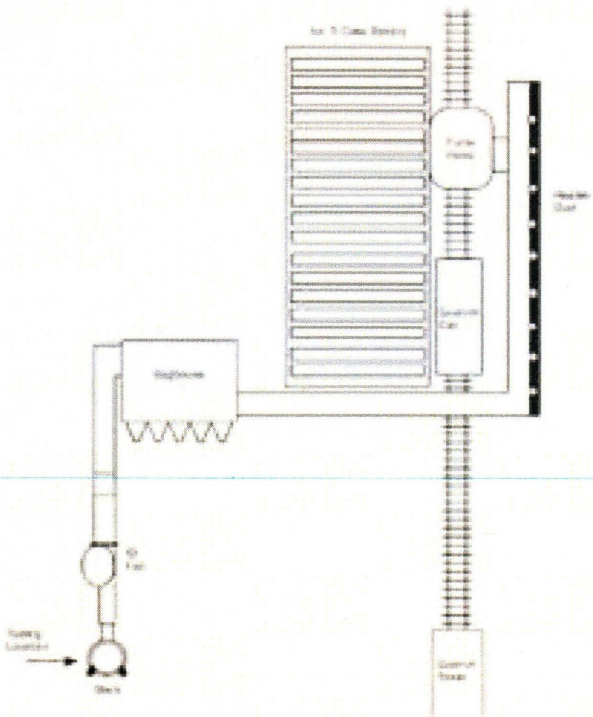
The No. 5 Coke Battery consists of 85, six-meter-high ovens producing furnace coke. A coal blend is used to charge each oven at timed intervals depending on the current production of the battery. Coking of the coal occurs in an oxygen free environment for 17 to 30 hours and the gases produced are collected, cleaned, and used to under fire the battery, supply fuel for other site sources, and sold to permitted off-site utilities.

The current permit limits allow for the charging of up to 1.420 million dry tons of coal per year. The design capacity heating requirement of the battery is approximately 375 MMBtu per hour. The heating requirements of the battery at the current production rate are approximately 325 MMBtu per hour.

Process source description information above was taken from written information provided by EES Coke.

A schematic of the process, indicating sampling locations, is shown in Figure 3-1.

Figure 3-1:
Process Schematic



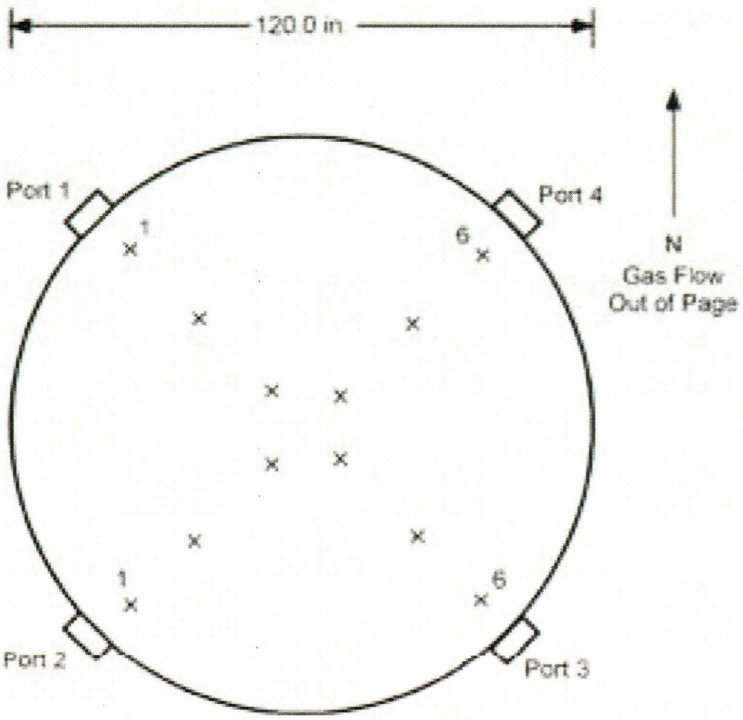
Test Location

The sample point placement was determined by EPA Method 1 specifications and EPA Method 7E. Table 3-1 presents the sampling information for the test location. The figures shown below represent 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
PECS Stack							
Total PM	EPA 201A/202	1-3	2	6	~8	~90	3-2
O_2, CO_2, NO_x	EPA 3A, 7E	1-3	1	3	20 (minimum)	60 (minimum)	3-3

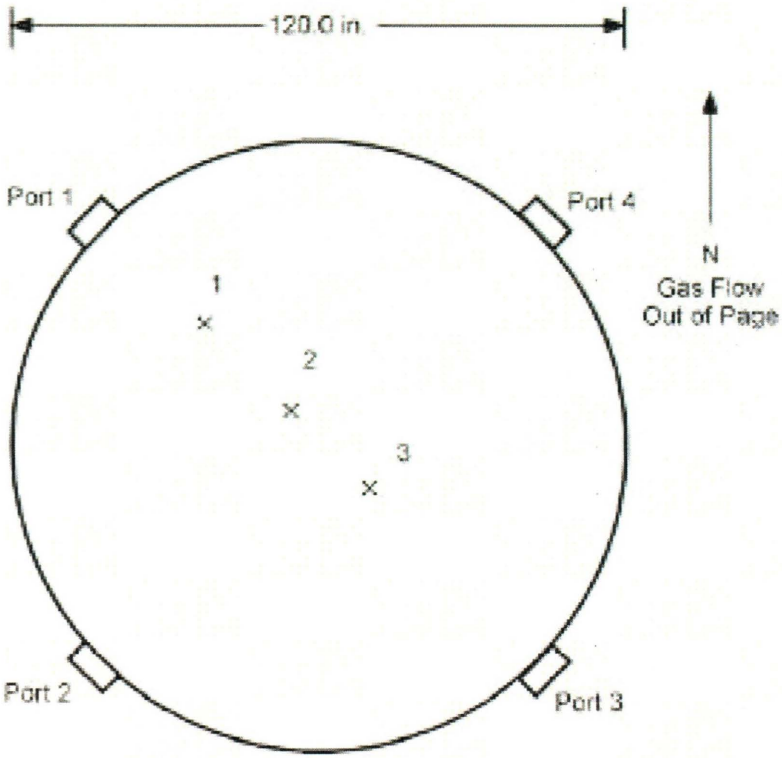
Figure 3-2:
PECS Stack Sample Point Layout (EPA Method 1)



Sampling Point	% of Stack Diameter	Port to Point Distance (inches)
1	95.6	114.7
2	85.4	102.5
3	70.4	84.5
4	29.6	35.5
5	14.6	17.5
6	4.4	5.3

Duct diameters upstream from flow disturbance (A): 2.0	Limit: 0.5
Duct diameters downstream from flow disturbance (B): 8.0	Limit: 2.0

Figure 3-3:
PECS Stack Sample Point Layout (EPA Method 7E)



Sampling Point	Method 7E Long Line Distance (m)	Port to Point Distance (inches)
1	0.4	15.7
2	1.0	39.4
3	2.0	76.7

Duct diameters upstream from flow disturbance (A): 2.0 Limit: 0.5
Duct diameters downstream from flow disturbance (B): 8.0 Limit: 2.0

End of Section

4. METHODOLOGY

PROCEDURES AND REGULATIONS

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 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"
Method 7E	"Determination of Nitrogen Oxide Emissions from Stationary Sources (Instrumental Analyzer Procedure)"

TITLE 40 CFR PART 51, APPENDIX M

Method 201A	"Determination of PM_{10} and $PM_{2.5}$ Emissions from Stationary Sources (Constant Sampling Rate Procedure)"
Method 202	"Dry Impinger Method for Determining Condensable Particulate Emissions from Stationary Sources"

End of Section

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: Monitor Data

Appendix H: Laboratory Data

Appendix I: Facility Operating Data

Appendix J: CleanAir Resumes and Certifications

APPENDIX A: TEST METHOD SPECIFICATIONS

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Specification Sheet for EPA Method 201A/202

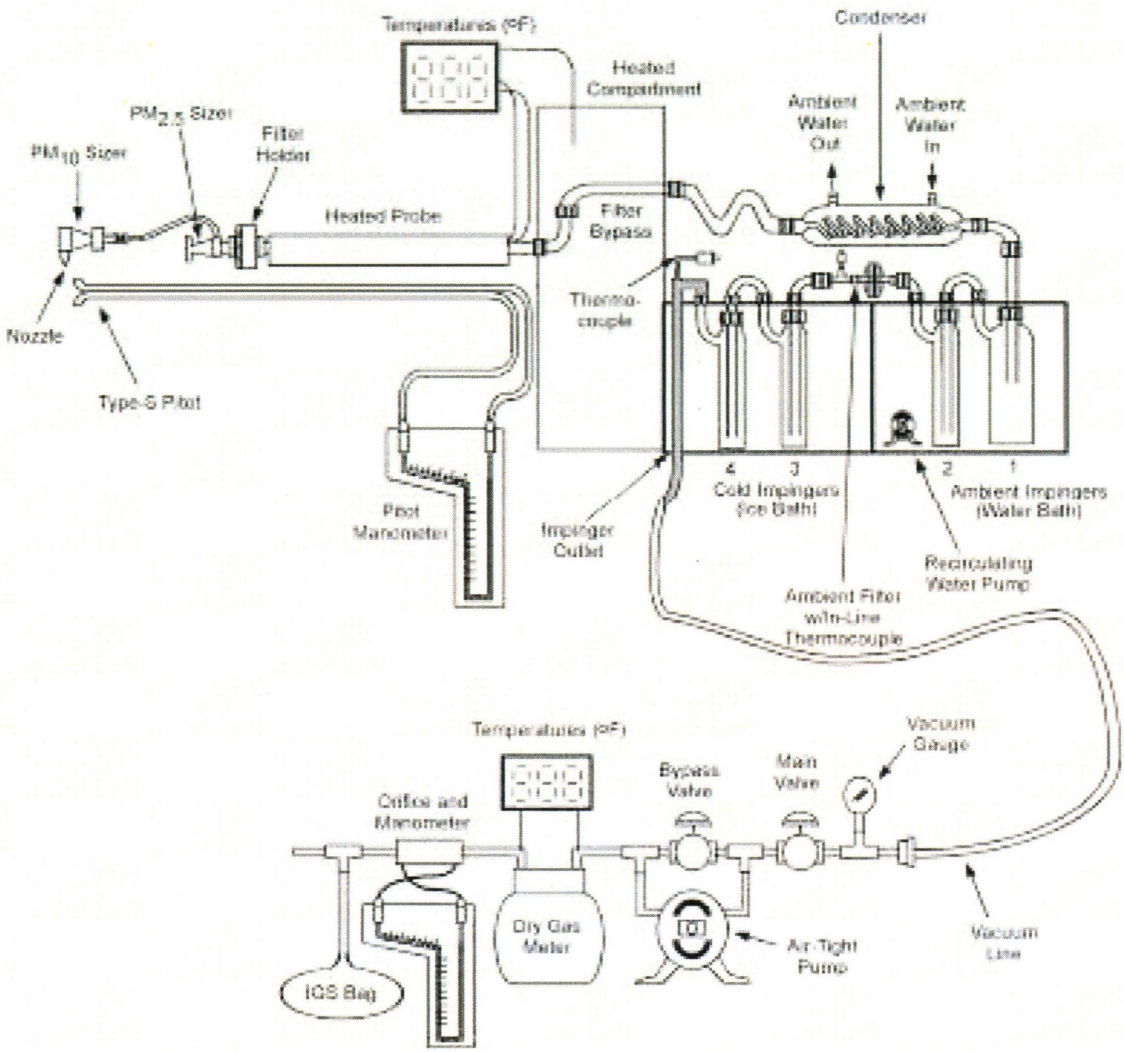
Source Location Name(s)	PECS Stack
Pollutant(s) to be Determined	$FPM_{2.5}$, FPM_{10}, Total FPM, CPM
Other Parameters to be Determined from Train	Gas Density, Moisture, Flow Rate

	Standard Method Specification	Actual Specification Used
Pollutant Sampling Information		
Duration of Run	N/A	90 minutes
No. of Sample Traverse Points	12	12
Sample Time per Point	N/A	7 minutes
Sampling Rate	Constant Rate (80-120% of Average Isokinetic Rate)	Constant Rate (80-120% of Average Isokinetic Rate)
Sampling Probe		
Nozzle Material	Stainless Steel	Stainless Steel
Nozzle Design	Straight	Straight
Probe Liner Material	Glass or Teflon	Teflon
Effective Probe Length	N/A	10 feet
Probe Temperature Set-Point	N/A	248°F±25°F
Velocity Measuring Equipment		
Pitot Tube Design	Type S	Type S
Pitot Tube Coefficient	N/A	0.84
Pitot Tube Calibration by	Geometric or Wind Tunnel	Geometric
Pitot Tube Attachment	Attached to Probe	Attached to Probe
Metering System Console		
Meter Type	Dry Gas Meter	Dry Gas Meter
Meter Accuracy	±2%	±1%
Meter Resolution	N/A	0.01 cubic feet
Meter Size	N/A	0.1 dcf/revolution
Meter Calibrated Against	Wet Test Meter or Standard DGM	Wet Test Meter
Pump Type	N/A	Rotary Vane
Temperature Measurements	N/A	Type K Thermocouple/Pyrometer
Temperature Resolution	5.4°F	1.0°F
ΔP Differential Pressure Gauge	Inclined Manometer or Equivalent	Inclined Manometer
ΔH Differential Pressure Gauge	Inclined Manometer or Equivalent	Inclined Manometer
Barometer	Mercury or Aneroid	Digital Barometer calibrated w/Mercury Aneroid
FPM Filter Description		
Filter Location	In Stack	In-Stack
Filter Holder Material	Stainless Steel	Stainless Steel
Filter Support Material	Stainless Steel	Stainless Steel
Cyclone Material	Stainless Steel	Stainless Steel
Filter Heater Set-Point	Stack Temp.	Stack Temp (±18°F)
Filter Material	Quartz Fiber	Quartz Fiber
Other Components		
Description	Condenser	Condenser
Location	Before Impinger 1	Before 1st Impinger
Operating Temperature	≤85°F	≤85°F

Specification Sheet for EPA Method 201A/202

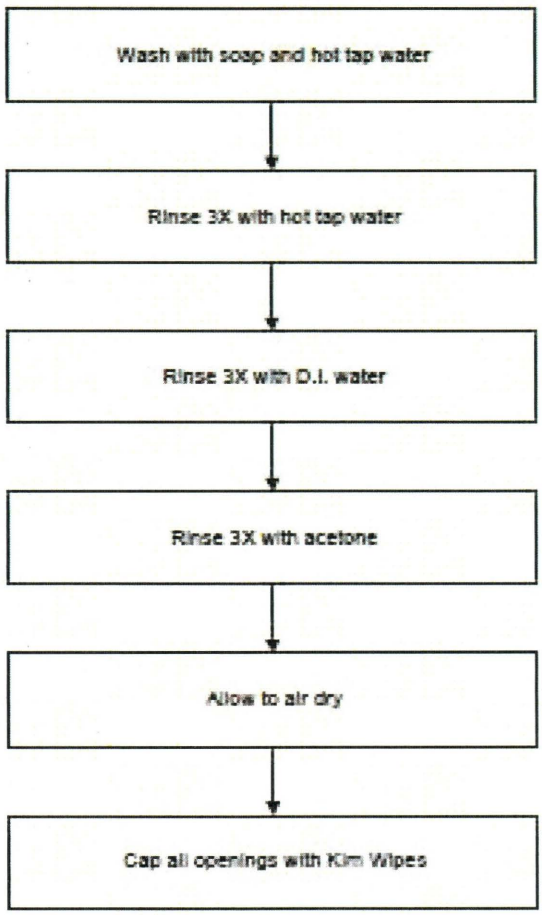
	Standard Method Specification	Actual Specification Used
Impinger Train Description		
Type of Glassware Connections	Leak-Free Glass Connectors	Ground Glass with Silicone O-Ring
Connection to Probe or Filter by	Direct or Flexible Connection	Direct Glass Connection
Number of Impingers	4	4
Impinger Stem Types		
Impinger 1	Shortened Stem (open tip)	Shortened Stem (open tip)
Impinger 2	Modified Greenburg-Smith	Modified Greenburg-Smith
Impinger 3	Modified Greenburg-Smith	Modified Greenburg-Smith
Impinger 4	Modified Greenburg-Smith	Modified Greenburg-Smith
Impinger 5		
Impinger 6		
Impinger 7		
Impinger 8		
CPM Filter Description		
Filter Location	Between 2nd and 3rd Impingers	Between 2nd and 3rd Impingers
Filter Holder Material	Glass, Stainless Steel or Teflon	Borosilicate Glass
Filter Support Material	Teflon	Teflon
Cyclone Material	None	None
Filter Heater Set-Point	>65°F but ≤85°F	>65°F but ≤85°F
Filter Material	Teflon Membrane	See Analytical Flow Chart
Gas Density Determination		
Sample Collection	Multi-point Integrated	Multi-Point Integrated
Sample Collection Medium	Flexible Gas Bag	Vinyl Bag
Sample Analysis	Orsat or CEM Analyzer	CEM
Sample Recovery Information		
Nozzle Brush Material	Nylon Bristle or Teflon	Nylon Bristle
Nozzle Rinse Reagent	Acetone	Acetone
Nozzle Rinse Wash Bottle Material	Glass or Polyethylene	Inorganic in polyethylene, organic in Teflon
Nozzle Rinse Storage Container	Glass or Polyethylene	Glass
Filter Recovered?	Yes	Yes
Filter Storage Container	FH filter in petri dish, CPM filter in petri dish	FH filter in petri dish, CPM filter in petri dish
Impinger Contents Recovered?	Yes	Yes
Impinger Rinse Reagent	DI Water/Acetone/Hexane	DI Water/Acetone/Hexane
Impinger Wash Bottle	Inorganic in polyethylene, organic in Teflon	Inorganic in polyethylene, organic in Teflon
Impinger Storage Container	Inorganic in polyethylene, organic in glass	Inorganic in amber glass, organic in amber glass
Analytical Information		
Method 4 H_2O Determination by	Volumetric or Gravimetric	Gravimetric
Filter Preparation Conditions	Dessicate 24 Hours or Filter Extraction	See Analytical Flow Chart
Front-Half Rinse Preparation	Evaporate at ambient temperature and pressure	Evaporate at ambient temperature and pressure
Back-Half Analysis	Sonication and Extraction	See Analytical Flow Chart
Additional Analysis	N/A	None

EPA Method 201A/202
Sampling Train Configuration



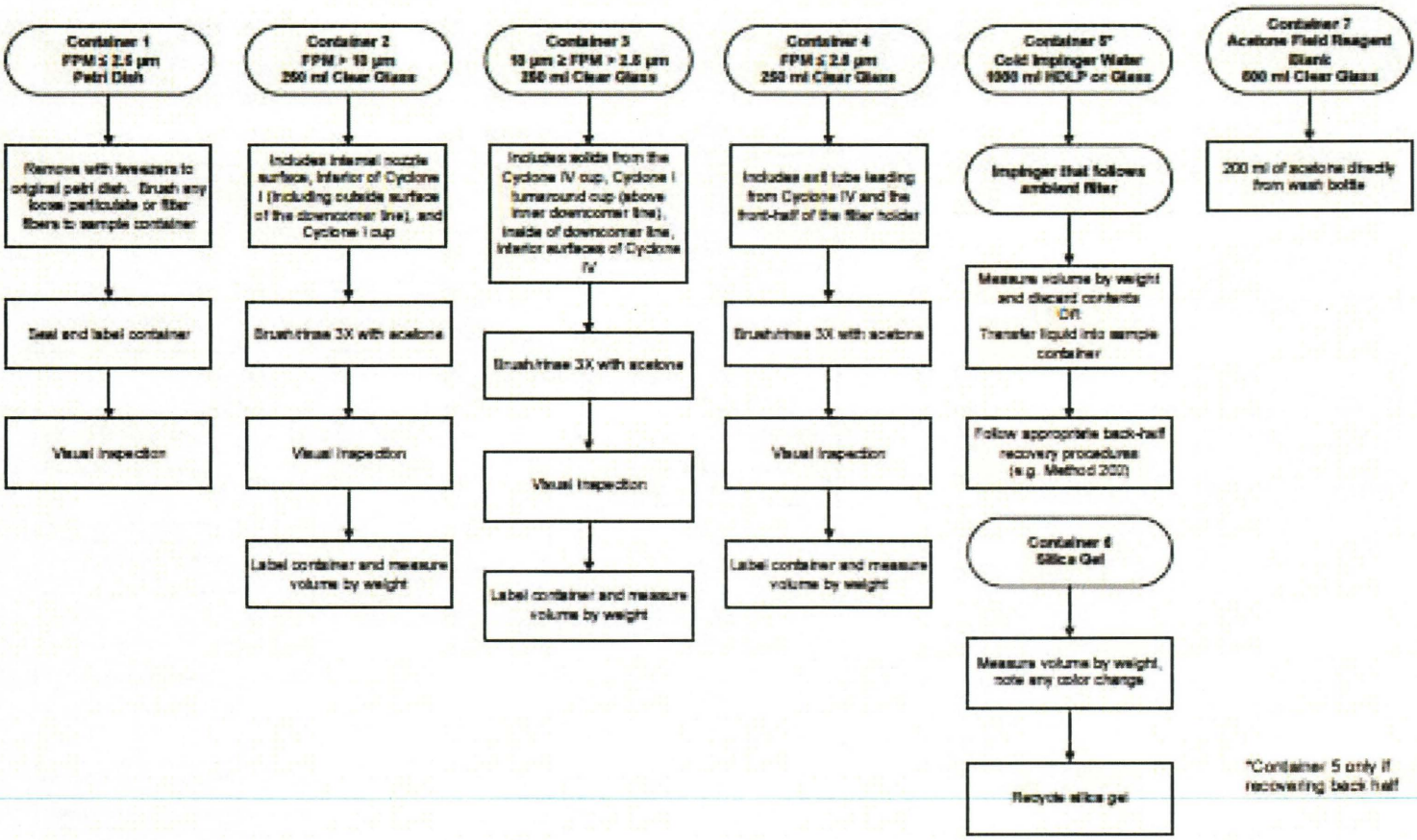
Impinger Contents	
Impinger 1	Empty
Impinger 2	Empty
Impinger 3	DI H_2O
Impinger 4	Silica Gel

EPA Method 201A
Glassware Preparation Procedures

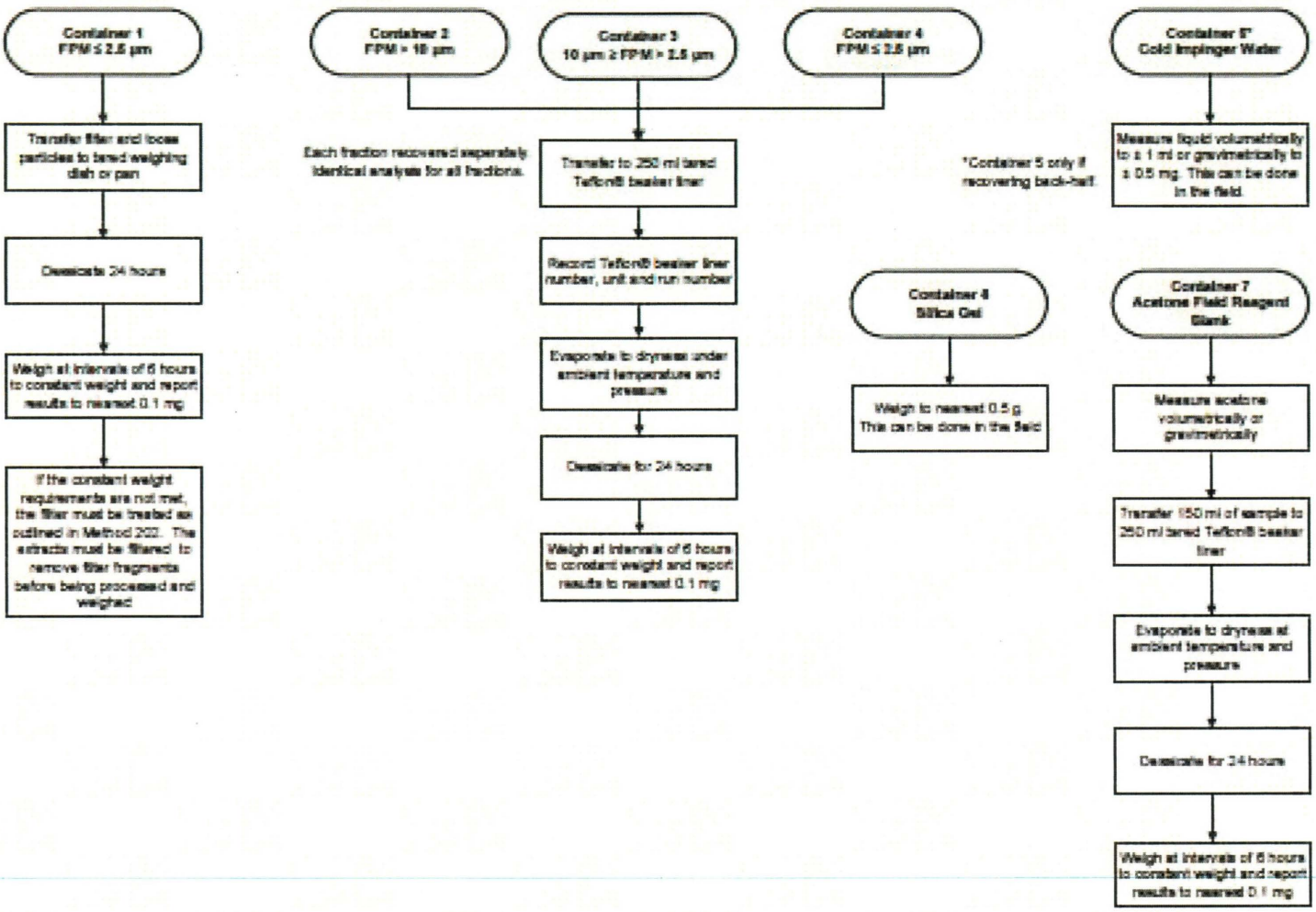


EPA Method 201A
Sample Recovery Flowchart

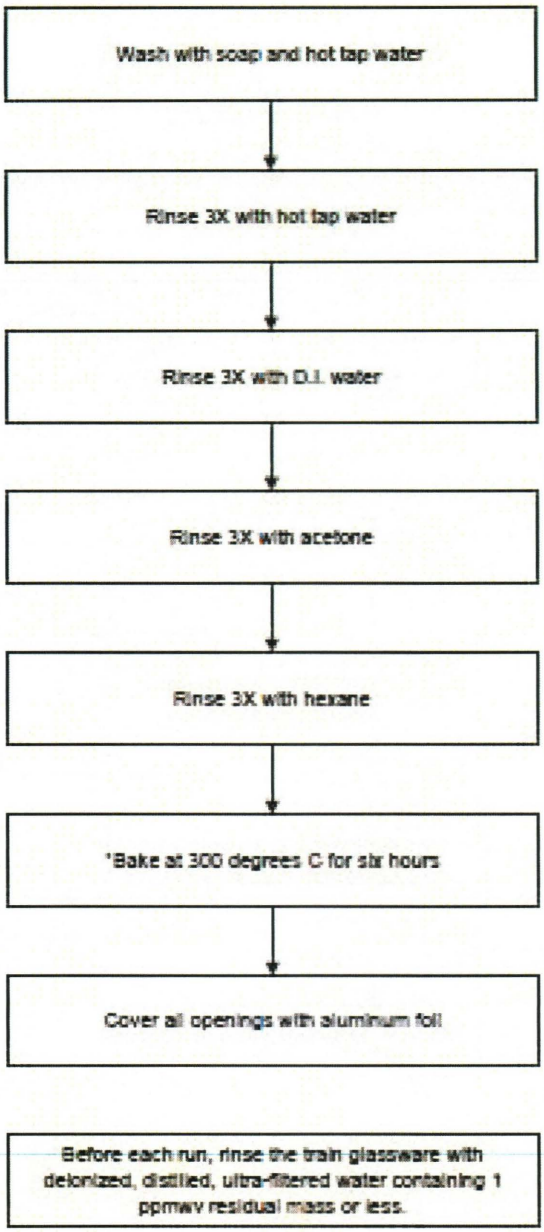
- Tare all sample containers before sample collection
- Mark all liquid levels and final weights on the outside of each sample container
- Seal all sample containers with Teflon tape
- If recycling, bake silica gel for two hours at 350 degrees F (175 degrees C)



EPA Method 201A
Analytical Flowchart



EPA Method 202
Glassware Preparation Procedures



*As an alternative to baking glassware, a field train proof blank can be performed on the sampling train glassware.

EPA Method 202
Sample Recovery Flowchart (1 of 2)

- Tare all sample containers before sample collection
- Mark all liquid levels and final weights on the outside of each sample container
- Seal all sample containers with Teflon tape
- If recycling, bake silica gel for two hours at 350 degrees F (175 degreesC)
- Samples must be maintained at or below 68 degrees F (20 degrees C) during shipping

Post-Test N2 Purge*

Transfer water collected in condenser and water dropout impinger to back-up impinger; measure and record volume or weight

Conduct purge on condenser, back-up impinger and CPM filter with N2 at 14 LPM for one hour

Purge Notes:

- *Continue operating condenser recirculation pump and maintain gas temperature at exit of CPM filter >65°F but ≤85°F*
- *If volume of water in moisture traps was not determined prior to purge, maintain trap temperature and keep gas temperature at exit of silica gel impinger below 68°F*
- *At conclusion of purge, simultaneously turn off delivery and pumping systems.*
- *For high moisture sampling, weigh and change out silica gel prior to purging*

CPM Container 1
Inorganic Rinse
500 ml Amber Glass

Back-half FPM filter holder, probe extension, condenser, dropout and back-up impingers, connecting glassware, front-half CPM filter holder

Measure and record impinger volume by weight

Empty contents into labeled container

Rinse 2X with deionized, distilled, ultra-filtered water and add to sample container

Visual inspection

Mark liquid level and label container

CPM Container 2
Organic Rinse
500 ml Amber Glass

Back-half FPM filter holder, probe extension, condenser, dropout and back-up impingers, connecting glassware, front-half CPM filter holder

Rinse 1X with acetone and add to sample container

Rinse 2X with hexane and add to sample container

Visual inspection

Mark liquid level and label container

CPM Container 3
Filter Sample
Petri Dish

CPM filter

Use tweezers and/or disposable surgical gloves to remove CPM filter and place in Petri dish

Visual inspection

Label container

CPM Container 4**
Cold Impinger Water
500 ml Plastic

Cold impinger that follows the CPM filter

Quantitatively transfer liquid into sample container

Visual inspection

Mark liquid level and label container

**If the water has been weighed in the field, it can be discarded.

CPM Container 5
Silica Gel

Measure volume by weight, note any color change

Recycle silica gel

EPA Method 202
Sample Recovery Flowchart (2 of 2)

- Tare all sample containers before sample collection
- Mark all liquid levels and final weights on the outside of each sample container
- Seal all sample containers with Teflon tape
- If recycling, bake silica gel for two hours at 350 degrees F (175 degrees C)
- Samples must be maintained at or below 85 degrees F (30 degrees C) during shipping

CPM Container 6 Acetone Field Reagent Blank

Collect 200 ml of acetone from wash bottle into amber glass container

Visual inspection

Mark liquid level and label container

Collect one acetone blank for each lot of solvent used

CPM Container 7 Water Field Reagent Blank

Collect 200 ml of water from wash bottle into amber glass container

Visual inspection

Mark liquid level and label container

Collect one water blank for each lot used

CPM Container 8 Hexane Field Reagent Blank

Collect 200 ml of hexane from wash bottle into amber glass container

Visual inspection

Mark liquid level and label container

Collect one hexane blank for each lot of solvent used

CPM Container 9 Field Train Proof Blank" Inorganic Rinses

Prior to testing, rinse probe extension, condenser, impingers, connecting glassware and front-half CPM filter housing 2X with water

Collect rinses in plastic sample container

Visual inspection

Mark liquid level and label container

If glass ware was not baked a field train proof blank must be performed to demonstrate the cleanliness of the glassware. Baking the glassware is a CleanAir SOP

CPM Container 10 Field Train Proof Blank" Organic Rinses

After rinsing with water, rinse probe extension, condenser, impingers, connecting glassware and front-half CPM filter housing with acetone

Repeat procedure by rinsing 2X with hexane

Collect both rinses in amber glass container

Visual inspection

Mark liquid level and label container

Field Train Blank (required)

A minimum of one field train blank for each source category tested at facility is required.

Recover field blank after first or second run

Assemble sampling train as it would be used for testing.

Prior to purge, add 100 ml water to first impinger and record data

Purge train and recover blank samples as described on Page 1 of 2

From field sample weight, subtract condensable particulate mass determined from blank train or 0.003 g whichever is less.

EPA Method 202
Analytical Flowchart (1 of 2)

- Log each sample in shipment and verify against chain-of-custody sheet
- Note liquid levels in the sample containers and confirm on the chain-of-custody sheet condition

CPM Container 1 Inorganic Rinse

Measure liquid volumetrically or gravimetrically

Transfer inorganic contents into separatory funnel and add 30 ml of hexane

Drain off lower inorganic phase into a clean sample container or beaker

Drain off organic phase into a separate clean sample container or beaker, leaving a small amount of hexane in funnel

Repeat procedure twice with 30 ml hexane, combining the organic phase with each extraction

Inorganic Extraction

Transfer inorganic fraction from extraction into 250 ml tared Teflon® beaker liner

Evaporate to no less than 10 ml on a hot plate or in 105 degree C oven

Allow to dry at room temperature (not to exceed 85 degrees F). Ensure the water and volatile acids have completely evaporated before neutralizing nonvolatile acids in sample

Desiccate for 24 hours

Weigh at intervals of 6 hours to constant weight and report results to nearest 0.1 mg

No constant weight

Redissolve residue in 100 ml of deionized, distilled ultra-filtered water

Titrate sample with 0.1 N NH_4OH to a pH of 7.0, record volume of titrant used

Evaporate to no less than 10 ml using hot plate or 105 degree C oven

Allow to dry at room temperature (not to exceed 85 degrees F)

Organic Extraction

The extraction should yield around 90 ml of organic extract

Combine the organic extract of Container 1 with the organic train rinse in Container 2

CPM Container 2 Organic Rinse

Measure liquid volumetrically or gravimetrically

Transfer contents into 250 ml tared Teflon® beaker liner

Evaporate to dryness at room temperature (not to exceed 85 degrees F)

Desiccate for 24 hours

Weigh at intervals of 6 hours to constant weight and report results to nearest 0.1 mg

CPM Container 3 Filter Sample

Was sample collected by Method 17 or 201A with a stack temp < 85°F? Can the filter be brought to constant weight?

Yes

Transfer filter and loose PM from sample container to tared glass weighing dish

Desiccate for 24 hours

Weigh to constant weight and report results to nearest 0.1 mg

No

Extract the filter

Inorganic Extraction

Fold filter into quarters and place in 50 ml extraction tube

Add 10 ml deionized, distilled ultra-filtered water to extraction tube (or sufficient to cover the filter)

Extract for at least 2 minutes in sonication bath; add to separate inorganic fraction Container 1

Repeat extraction twice more for a total of three extractions; add to Container 1

Organic Extraction

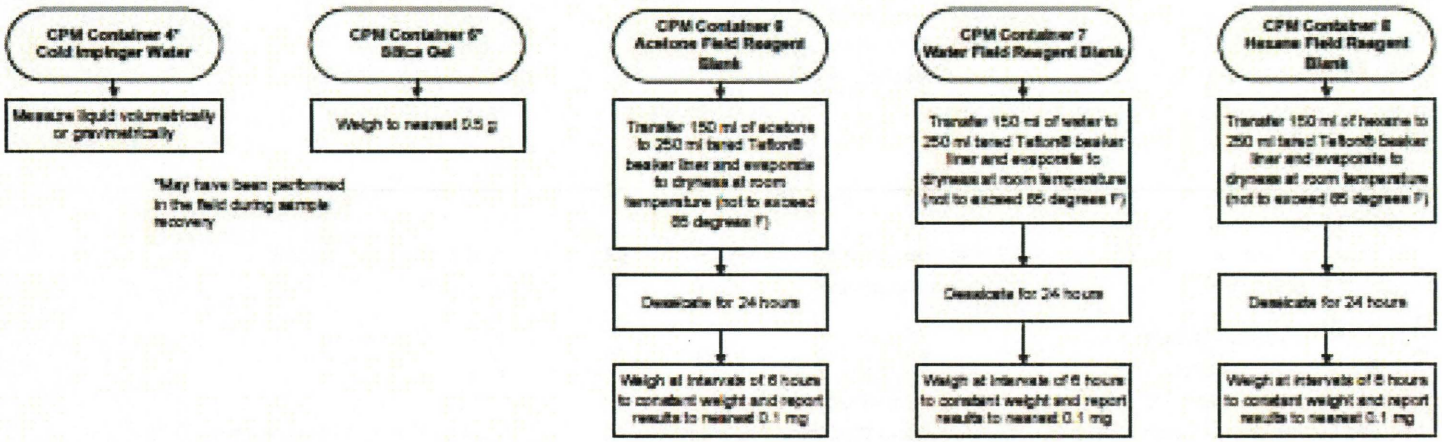
Add 10 ml hexane to extraction tube (or sufficient to cover the filter)

Extract for at least 2 minutes in sonication bath; add to separate organic fraction Container 2

Repeat extraction twice more for a total of three extractions; add to Container 2

EPA Method 202
Analytical Flowchart (2 of 2)

- Log each sample in shipment and verify against chain-of-custody sheet
- Note liquid levels in the sample containers and confirm on the chain-of-custody sheet condition



Specification Sheet for EPA Method 7E

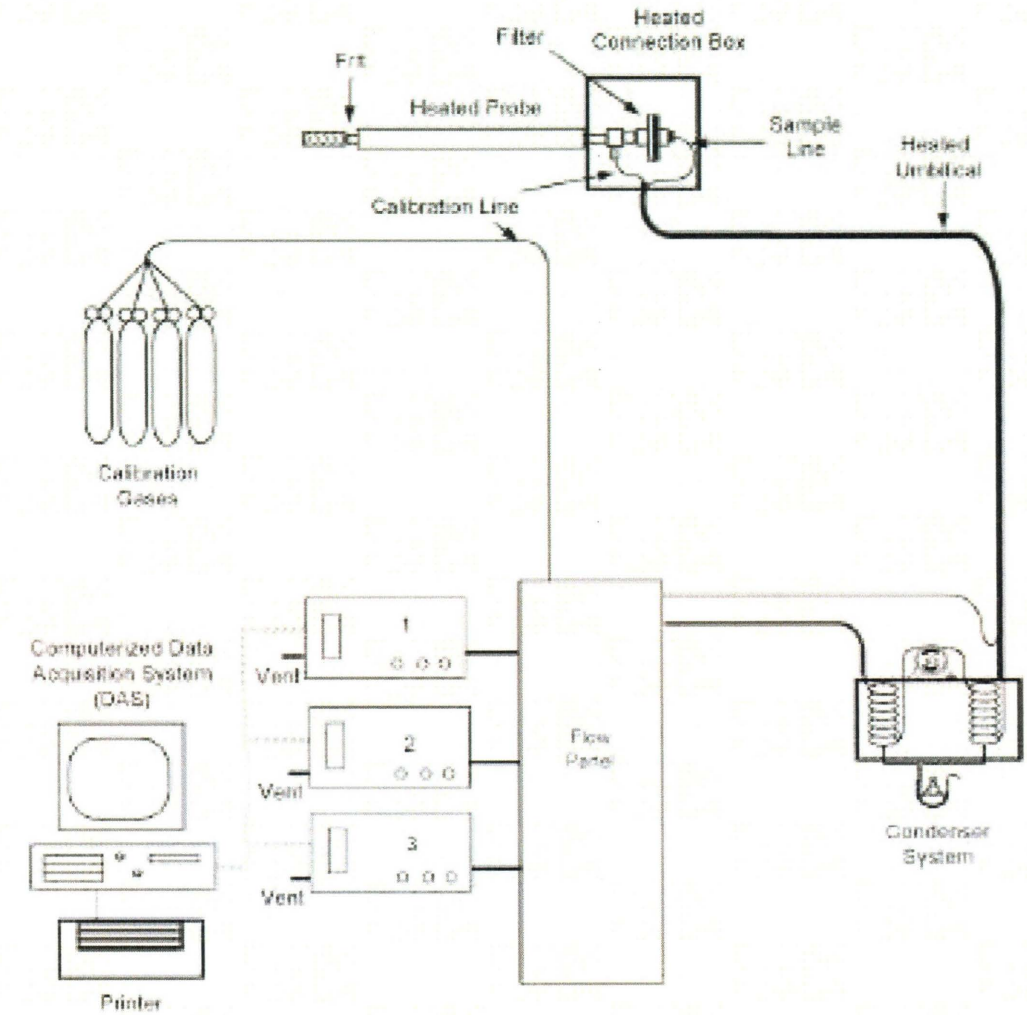
Source Location Name(s)	PECS Stack
Pollutant(s) to be Determined	Nitrogen Oxides
Other Parameters to be Determined from Train	O2 and CO2 (EPA Method 3A)

	Standard Method Specification	Actual Specification Used
Pollutant Sampling Information		
Duration of Run	N/A	minimum of 60 minutes
No. of Sample Traverse Points	N/A	3
Sample Time per Point	N/A	minimum of 20 minutes
Sampling Rate	Constant Rate	Constant Rate
Sampling Probe		
Nozzle Material	N/A	None
Nozzle Design	N/A	N/A
Probe Liner Material	Stainless Steel or Pyrex Glass	Stainless Steel
Effective Probe Length	Sufficient to Traverse Points	10 feet
Probe Temperature Set-Point	Prevent Condensation	248°F±25°F
Particulate Filter		
In-Stack Filter	Yes	Yes
In-Stack Filter Material	Non-reactive to gas	Fritted Stainless Steel
External Filter	Yes	Yes
External Filter Material	Borosilicate, Quartz Glass Wool or Fiber Mat	Borosilicate Glass Fiber Mat
External Filter Set-Point	Prevent Condensation	248°F±25°F
Sample Delivery System		
Heated Sample Line Material	Stainless Steel or Teflon	Teflon
Heated Sample Line Set-Point	Prevent Condensation	248°F±25°F
Heated Sample Line Connections	Probe Exit to Moisture Removal System	Probe to Moisture Removal System
Moisture Removal System	Refrigerator-type condenser or similar	Refrigerator-type condenser
Sample Pump Type	Leak-Free, minimal response time	Diaphragm
Sample Pump Material	Non-reactive to sample gases	Teflon
Sample Flow Control	Constant Rate	Constant Rate (±10%)
Non-Heated Sample Line Material	Stainless Steel or Teflon	Teflon
Non-Heated Sample Line Connections	Moisture Removal to Sample Gas Manifold	Moisture Removal to Sample Gas Manifold
Additional Filters	Optional	Yes
Additional Filter Type	N/A	Particulate Removal
Additional Filter Location	Optional	Entrance to Sample Manifold
Filter Material	Non-reactive to sample gases	Quartz Fiber
Analyzer Description		
Oxygen (O_2)	EPA Method 3A (Paramagnetic)	EPA Method 3A (Paramagnetic)
Carbon Dioxide (CO_2)	EPA Method 3A (NDIR)	EPA Method 3A (NDIR)
Sulfur Dioxide (SO_2)	N/A	N/A
Nitrogen Oxides (NO_x)	EPA Method 7E (Chemiluminescent)	EPA Method 7E (Chemiluminescent)
Carbon Monoxide (CO)	N/A	N/A
Total Hydrocarbon (THC)	N/A	
Hydrogen Chloride (HCl)	N/A	
Ammonia (NH_3)	N/A	

Specification Sheet for EPA Method 7E

	Standard Method Specification	Actual Specification Used
Instrument Span Range		
Oxygen (O_2)	≤ 1.33 x Expected Maximum	0-25%
Carbon Dioxide (CO_2)	≤ 1.33 x Expected Maximum	0-25%
Sulfur Dioxide (SO_2)		N/A
Nitrogen Oxides (NO_x)	≤ 1.33 x Expected Maximum	0-96.48 ppm
Carbon Moncalde (CO)	N/A	N/A
Total Hydrocarbon (THC)	N/A	N/A
Hydrogen Chloride (HCl)	N/A	N/A
Ammonia (NH_3)	N/A	N/A
Data Acquisition		
Data Recorder	Strip chart, Analog Computer or Digital Recorder	Analog Computer
Recorder Resolution	0.5 Percent of Span	0.1 Percent of Span
Data Storage	Manually or Automatic	Manually
Measurement Freq. <60 min. Sample Time	1-min. Intervals or 30 measurements (less restrictive)	One reading per second
Recording Freq. <60 min. Sample Time	1-min. Intervals or 30 measurements (less restrictive)	One Minute Average (60, 1 second readings)
Measurement Freq. >60 min. Sample Time	2-min. Intervals or 96 measurements (less restrictive)	N/A
Recording Freq. >60 min. Sample Time	2-min. Intervals or 96 measurements (less restrictive)	N/A
Calibration Gas Specifications		
Oxygen (O_2)	EPA Protocol 1	EPA Protocol 1
Carbon Dioxide (CO_2)	EPA Protocol 1	EPA Protocol 1
Sulfur Dioxide (SO_2)	N/A	
Nitrogen Oxides (NO_x)	EPA Protocol 1	EPA Protocol 1
Carbon Moncalde (CO)	N/A	
Total Hydrocarbon (THC)	N/A	
Hydrogen Chloride (HCl)	N/A	
Ammonia (NH_3)	N/A	

EPA Methods 3A and 7E
Sampling Train Configuration



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SPEC SHEET

Servomex 1420C O2 Analyzer

Rental and Application Notes

- Shipping Weight: 28 lbs.
- The analyzer measures the partial pressure of oxygen in the sample gas. Therefore, any change in sample pressure at the measuring cell will have an effect, which is proportional to the change in absolute pressure from the time of calibration.
- The Servomex 1420C/1415C can be plumbed together in a 19" rack mount. The combined weight is 44 lbs.
- These units are compatible with the older 1400B series

	Specifications
Weight	12 lbs
Dimensions	19" x 7" x 14"
Power	120VAC
Output	0-1v non-isolated or 4-20mA
Range	O2 0-25%, 0-100%
Response Time	<3 seconds
Accuracy	+/- 0.1%
Flow Rate	1 - 6 L/min
Inlet Pressure	1 - 10 psig
Vent Pressure	11.8-15.9 psia
Linearity	+/- 0.1%
Repeatability	+/- 0.1%
Zero Drift	< + 0.002% O2/hour
Span Drift	< + 0.002% O2/hour
Relative Humidity	0 - 90% non-condensing
Storage Temperature	-4° F to 158° F

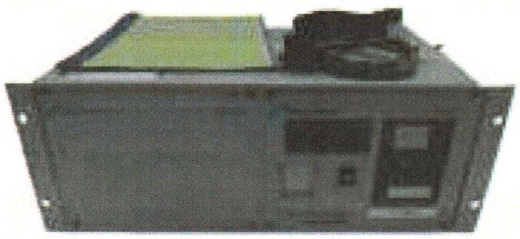
CleanAir.

SPEC SHEET

Servomex 1415 CO2 Analyzer

Rental and Application Notes

- Shipping Weight: 28 lbs.
- The Servomex 1420C/1415C can be plumbed together in a 19" rack mount. The combined weight is 44 lbs.
- These units are compatible with the older 1400B series



	Specifications
Weight	12 lbs
Dimensions	19" x 7" x 14"
Power	120VAC
Output	0-1v non-isolated or 4-20mA
Range	0-20 & 25% CO2
Response Time	<10 seconds
Accuracy	1% of selected range
Flow Rate	1 - 6 L/min
Inlet Pressure	1 - 10 psig
Vent Pressure	13.1 to 16.0 psia
Linearity	1% of selected range
Repeatability	1% of selected range
Zero Drift	2% of full scale/week
Span Drift	1% of reading/day
Relative Humidity	0% - 90% non-condensing
Storage Temperature	-4° F to 158° F

CleanAir.

SPEC SHEET

Thermo 42iHL NO_x, NO, NO_2 Analyzer

Rental and Application Notes

- Shipping Weight: 62 lbs. w/accessories (2 pumps= 36 lbs.) (1 pump= 30 lbs)
- Meets USEPA requirements for RFNA-1289-074
- User programmable software allows individual measurement range settings to be stored in memory for subsequent recall and NO, NO_2, NO_x hourly average storage for up to one month
- Dual range and autorange capability
- Can be remotely controlled with bi-directional RS-232 communication port, or ethernet port
- Rack mountable for integrated CEMS
- Independent calibration and outputs for NO, NO_2, and NO_x
- Calibration gases available for rent

	Specifications
Detection	Chemiluminescence
Unit Weight	47 lbs.
Dimensions	16.75"x 8.62"x 23"
Power Requirements	115 VAC @ 300W
Outputs	Analog: 6 voltages; 0-100mv, 1V, 5V, 10V Digital: 1 power fail, 10 digital relays, alarm output relay logic, 100mA @ 200VDC
Inputs	16 digital inputs (standard) 8 0-10VDS analog inputs (optional)
Ranges	CleanAir suggested range: 0-500ppm Manufacturer ranges: 0-10ppm to 5000ppm
Rise/Fall Times (0-90%)	NO mode: 2.5 seconds NO_x mode: 5.0 seconds
Operating Temperatures	0-45°C
Sample Temperature	Ambient
Flow Rate	25 ccm With bypass, 2 SCFH
Detection Limit	0.05ppm
Span Drift	±1% FS over 24 hours
Zero Drift	±0.050ppm over 24 hours
Linearity	±1% FS
Warm-up Time	90 minutes to stabilize

End of Appendix Section