Metal Emissions Test Protocol

PCC Structurals, Inc.
Large Parts Campus
Baghouse 8901
Baghouse 9256
Baghouse 9203
5001 SE Johnson Creek Blvd.
Milwaukie, Oregon 97222
Protocol No. P232604

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Protocol Submittal Date
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Submitted By

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1.0 INTRODUCTION

Mostardi Platt will be performing an emission test program on three (3) baghouses with HEPA after-filters (referred to as “baghouse systems”) at the PCC Structurals, Inc. (PCC) Large Parts Campus (LPC) facility in Milwaukie, Oregon. Testing is being performed to demonstrate removal efficiencies across each baghouse system as well as mass emission rates of several metals, including) hexavalent chrome ($Cr^{+}6$) [1], from the baghouse inlet and HEPA exhaust outlet of three integrated baghouse/HEPA control systems. All testing will be performed as described in the United States Environmental Protection Agency (USEPA) Title 40, *Code of Federal Regulations*, Part 60 (40CFR60), Appendix A, Methods 1, 2, 4, and 29; and The Resource Conservation and Recovery Act Test Methods for Evaluating Solid Waste: Physical/Chemical Methods (SW-846) Method 0061.

The identity of individuals associated with the test program is summarized below.

Location	Address	Contact
Test Consultant	Maul Foster & Alongi, Inc. 6 Centerpointe Drive, Suite 360 Lake Oswego, OR 97035	Mr. Brian Eagle Senior Consultant 971.713.3571 beagle@maulfoster.com
Test Facility	PCC Structurals, Inc. 5001 SE Johnson Creek Blvd. Milwaukie, OR 97222	Mr. Brandon Hadzinsky Division Environmental Affairs 503.724.3036 Brandon.hadzinsky@pccstructurals.com
Test Company Representative	Mostardi Platt 888 Industrial Drive Elmhurst, IL 60126	Mr. Eric Ehlers VP, Field Operations (630) 699-7690 eehlers@mp-mail.com

2.0 PROCESS DESCRIPTION

Baghouse/HEPA 8901 (BH8901) controls emissions from ingot finishing operations in the Alloy Service Center, which include cutting and grinding activities.

Baghouse/HEPA 9256 (BH9256) controls emissions from both the air casting process and the outfeed of the Master Caster furnace. Air casting emissions controlled include melting, pouring, cooling, and hot top application. Master Caster emissions controlled include cooling and hot top application. PCC expects both air casting and Master Caster activities to occur during each eight-hour baghouse/HEPA testing period.

Baghouse/HEPA 9203 (BH9203) controls emissions from cutting activities related to the cleaning process.

[1] List of metals to be tested included in Section 3.4

3.0 SPECIFIC TEST PROCEDURES

Detailed test procedures are appended, test runs will be performed following the below listed detailed test procedures during each of two test days, with one run performed on each test day. All testing will follow the methods listed in Section 1.0, however, for BH9203 outlet sampling, only two stacks will be sampled by M29 and 0061, the remaining stacks will be monitored for differential pressure and temperature during sampling in order to calculate total mass emission rates from the BH9203 system.

3.1 BH8901 and BH9256

1. $Cr^{+}6$ concentrations and emission rates will be determined simultaneously at the inlet and outlet of each of the baghouse/HEPA systems in accordance with USEPA Methods 1, 2, and SW-846 Method 0061. One, approximately eight-hour run will be performed each test day, with a minimum of 320 dry standard cubic feet sampled per run. Two total runs performed at each test location. Emissions will be reported in units of ug/dscf, lb/hr, lb/ton of metal processed, as well as percent removal efficiency on a mass basis across the baghouse/HEPA system. Impinger one solution will be checked after each port change for pH levels and refreshed when necessary. Moisture will not be determined using this sample train.

2. Metal concentrations and emission rates will be determined simultaneously at the inlet and outlet of each of the baghouse/HEPA systems in accordance with USEPA Methods 1, 2, 4, and 29. One, approximately eight-hour run will be performed each test day, with a minimum of 320 dry standard cubic feet sampled per run. Two total runs performed at each test location. Emissions will be reported in units of ug/dscf, lb/hr, lb/ton of metal processed, as well as percent removal efficiency on a mass basis across the baghouse/HEPA system.

3. Oxygen and carbon dioxide concentrations will be determined per section 8.6 of USEPA Method 2 – “for processes emitting essentially air, an analysis need not be conducted; use a dry molecular weight of 29.0.

4. BH9256 inlet sampling location test ports will not meet the required two minimum downstream diameters due to safety concerns with the inlet duct configuration. A site acceptability test will be performed prior to sampling this location, either in an earlier mobilization or on test setup day, in order to determine if the proposed site will meet Method 1, Section 11.5 requirements.

3.2 BH9203

1. $Cr^{+}6$ concentrations and emission rates will be determined simultaneously at each of three inlets and each of two outlets of the baghouse/HEPA system in accordance with USEPA Methods 1, 2, and SW-846 Method 0061. One, approximately eight-hour run will be performed each test day, with a minimum of 320 dry standard cubic feet sampled per run. Two total runs performed at each test location. Emissions will be reported in units of ug/dscf, lb/hr, lb/ton of metal processed, as well as percent removal efficiency on a mass basis across the baghouse/HEPA system. Impinger one solution will be checked after each port change for pH levels and refreshed when necessary. Moisture will not be determined using this sample train.

2. Metal concentrations and emission rates will be determined simultaneously at each of three inlets and each of two outlets of the baghouse/HEPA system in accordance with USEPA Methods 1, 2, 4, and 29. One, approximately eight-hour run will be performed each test day, with a minimum of 320 dry standard cubic feet sampled per run. Two total runs performed at each test location. Emissions will be reported in units of ug/dscf, lb/hr, lb/ton of metal processed, as well as percent removal efficiency on a mass basis across the baghouse/HEPA system.

3. Volumetric flow determinations will be performed in accordance with USEPA Method 2, at each of the four baghouse/HEPA system outlets that are not tested for $Cr^{+}6$ or metals. A preliminary manual traverse will be performed on each stack in order to determine a representative point in each stack of differential pressure and temperature. An automated single point for differential pressure and temperature will then be utilized for the remainder of testing.

4. Oxygen and carbon dioxide concentrations will be determined per section 8.6 of USEPA Method 2 – “for processes emitting essentially air, an analysis need not be conducted; use a dry molecular weight of 29.0.

3.3 Process Operating Data to Be Collected

<u>The following process operating data shall be collected during testing:</u>

8901 – Number of ingots processed, pounds of metal processed (pounds per ingot and total); baghouse differential pressure (recorded every 30 minutes throughout testing)

9256 – Air casting: number of pours (castings), pounds of metal poured (per casting and total); Master Caster: number of pours (castings), pounds of metal poured (per casting and total); Pounds of hot top applied (air casting and Master Caster); and baghouse differential pressure (recorded every 30 minutes throughout testing)

9203 – Number of castings processed, pounds of metal processed (pounds per casting and total); and baghouse differential pressure (recorded every 30 minutes throughout testing)

3.4 Method Detection Limit Summary

Cleaner Air Oregon Test Parameters and Estimated Detection Limits				
Measured Parameter	**Estimated Laboratory Method Detection Limits**	**Test location**	**Estimated in Stack Detection Limits, lb/hr**	**Test Method(s)**
$Cr^{+}6$	0.01 ug	BH8901	8.27E-09	SW-846 Method 0061
		BH9256	3.31E-07	
		BH9203	5.95E-07	
Aluminum (Al)	10.5 ug	BH8901	8.68E-06	USEPA Method 29
		BH9256	3.47E-04	
		BH9203	6.25E-04	
Arsenic (As)	2.45 ug	BH8901	2.03E-06	USEPA Method 29
		BH9256	8.10E-05	
		BH9203	1.46E-04	
Antimony (Sb)	1.75 ug	BH8901	1.45E-06	
		BH9256	5.79E-05	
		BH9203	1.04E-04	
Barium (Ba)	0.18 ug	BH8901	1.49E-07	
		BH9256	5.95E-06	
		BH9203	1.07E-05	
Beryllium (Be)	0.07 ug	BH8901	5.79E-08	
		BH9256	2.31E-06	
		BH9203	4.17E-06	
Cadmium (Cd)	0.14 ug	BH8901	1.16E-07	
		BH9256	4.63E-06	
		BH9203	8.33E-06	
Chromium (Cr)	0.28 ug	BH8901	2.31E-07	
		BH9256	9.26E-06	
		BH9203	1.67E-05	
Cobalt (Co)	0.18 ug	BH8901	1.49E-07	
		BH9256	5.95E-06	
		BH9203	1.07E-05	
Copper (Cu)	1.75 ug	BH8901	1.45E-06	
		BH9256	5.79E-05	
		BH9203	1.04E-04	
Lead (Pb)	1.75 ug	BH8901	1.45E-06	
		BH9256	5.79E-05	
		BH9203	1.04E-04	
Manganese (Mn)	0.11 ug	BH8901	9.09E-08	
		BH9256	3.64E-06	
		BH9203	6.55E-06	
Mercury (Hg)	0.047 ug	BH8901	3.89E-08	
		BH9256	1.55E-06	
		BH9203	2.80E-06	
Nickel (Ni)	1.05 ug	BH8901	8.68E-07	

Cleaner Air Oregon Test Parameters and Estimated Detection Limits				
Measured Parameter	**Estimated Laboratory Method Detection Limits**	**Test location**	**Estimated in Stack Detection Limits, lb/hr**	**Test Method(s)**
		BH9256	3.47E-05	
		BH9203	6.25E-05	
Phosphorus (P)	7.0 ug	BH8901	5.79E-06	
		BH9256	2.31E-04	
		BH9203	4.17E-04	
Selenium (Se)	5.25 ug	BH8901	4.34E-06	
		BH9256	1.74E-04	
		BH9203	3.13E-04	
Silver (Ag)	0.70 ug	BH8901	5.79E-07	USEPA Method 29
		BH9256	2.31E-05	
		BH9203	4.17E-05	
Thallium (Tl)	3.50 ug	BH8901	2.89E-06	
		BH9256	1.16E-04	
		BH9203	1.04E-04	
Vanadium (V)	0.35 ug	BH8901	2.89E-07	
		BH9256	1.16E-05	
		BH9203	2.08E-05	
Zinc (Zn)	1.05 ug	BH8901	8.68E-07	
		BH9256	3.47E-05	
		BH9203	6.25E-05	

4.0 PROJECT SCHEDULE

Mostardi Platt will provide the scope of services described above according to the following schedule:

Date	Activity	Manpower	On-Site Hours
Monday – 6/26/23	Mobilize to job site & set up test equipment.	12	8
Tuesday – 6/27/23	Perform 1st test run on BH8901 & BH9256. Setup BH9203.	12	12
Wednesday – 6/28/23	Perform 1st test run on BH9203. Setup BH8901 & BH9256.	12	12
Thursday – 6/29/23	Perform 2nd test run on BH8901 & BH9256. Setup BH9203.	12	12
Friday – 6/30/23	Perform 2nd test run on BH9203. Breakdown equipment.	12	12
Saturday – 7/1/23	Demobilize from site.	12	–

5.0 PROJECT PERSONNEL

Mostardi Platt will provide the following personnel to conduct the scope of services described above:

1 Senior Project Manager
2 Field Chemists
5 Test Engineers
4 Test Technicians

6.0 TEST METHODOLOGY

All testing will be performed as described in the Title 40, *Code of Federal Regulations*, Part 60 (40CFR60), Appendix A, Methods 1, 2, 4, and 29; and SW-846 Method 0061. The following provides description of the methodologies to be performed during the test program:

6.1 Method 1 Sample and Velocity Traverse Determination

Test measurement points are selected in accordance with Method 1, 40 CFR, Part 60, Appendix A. The characteristics of each measurement location is summarized in the table below. A null-point pitot traverse will be performed prior to testing to ensure the absence of cyclonic flow.

Sample Point Selection

Test Location	Stack Diameter	Upstream Distance	Downstream Distance	Test Parameters	Number of Sampling Points
BH8901 Inlet	12”	>0.5	>2.0	$CR^{+}6$ and Metals	24
BH8901 Outlet	12”	>0.5	>2.0	$CR^{+}6$ and Metals	24
BH9256 Inlet	60”	>0.5	~1.0	$CR^{+}6$ and Metals	40
BH9256 Outlet	60”	>0.5	>2.0	$CR^{+}6$ and Metals	24
BH9203 Inlets (3)	36”	>0.5	>2.0	$CR^{+}6$ and Metals	24
BH9203 Outlets (2)	34”	>0.5	>2.0	$CR^{+}6$ and Metals	24

6.2 Method 2 Volumetric Flow Rate Determination

Gas velocity is measured following Method 2, 40 CFR, Part 60, Appendix A, for purposes of calculating gas volumetric flow rate and emission rates on a lb/hr basis. An S-type pitot tube, as a component of the isokinetic sampling train, differential pressure gauge, thermocouple, and temperature readout are used to determine gas velocity at each sample point. All of the equipment used is calibrated in accordance with the specifications of the Method. Calibration data is presented in the Appendix of the final report.

6.3 Method 4 Moisture Determination

Stack gas moisture content is determined using a Method 4 sampling train as a component of the metals (M29) isokinetic sampling system. In this technique, stack gas is drawn through a series of four impingers following filterable particulate matter removal. The impingers are prepared according to the underlying method. The entire impinger train is measured or weighed before and after each test run to determine the mass of moisture condensed.

During testing, the Method 4 sample train will be incorporated in the manner specified in USEPA Method 5. All of the data specified in Method 4 (gas volume, delta H, impinger outlet well temperature, etc.) will be recorded on field data sheets.

All of the equipment used is calibrated in accordance with the specifications of the Method. Calibration data will be appended to the final report.

6.4 Method 29 Metals Determination

Metals concentrations and emission rates are determined in accordance with Method 29.

Impingers one and two are loaded with 100 mL each of 5% HNO_3/10% H_2O_2. The third impinger remains empty. The fourth and fifth impinger are loaded with 100mL of 10% H_2SO_4/5% $KMnO_4$. The sixth impinger is filled with silica gel. The impingers will be weighed prior to and after each test run in order to determine moisture content of the stack gas. Impingers are recovered as proscribed in the method, with 0.1N HNO3 utilized on impingers 1 and 2, 0.1N HNO3 also used on impinger three (in a separate sample container), and 10% H_2SO_4/5% $KMnO_4$, DI water, and 8N HCl for impingers four and five.

The filter media are Whatman quartz microfiber filters exhibiting a 99.97% efficiency on 0.3-micron DOP smoke particles in accordance with ASTM Standard Method D-2986-71.

Sample analysis is conducted by an approved laboratory for particle bound metals from the nozzle, probe, and filter catch, and analyzed for vapor phase metals from the impinger catch.

6.5 Method 0061 Cr^{+6} Determination

Stack gas hexavalent chromium (Cr^{+6}) concentrations are determined in accordance with SW-846 Method 0061. The sample is extracted isokinetically from the gas stream and passed through a 0.5N potassium hydroxide (KOH) solution, which is also recirculated through the first impinger to the sample nozzle. The sample train consists of a glass or teflon nozzle, and five impingers. The first three impingers contained the KOH solution (150 mL in impinger one, approximately 75mL each in impingers two and three, the fourth impinger remains empty, and the fifth impinger contains silica gel to absorb any remaining moisture). The pH of the first impinger is checked and verified to be greater than 8.5. A post-test nitrogen purge is performed on the impinger train for thirty minutes at 10 liters/minute. Once this purge is complete, samples are filtered and recovered utilizing deionized water and stored in Nalgene sample containers.

7.0 QUALITY ASSURANCE PROCEDURES

Mostardi Platt recognizes the previously described reference methods to be very technique oriented and attempts to minimize all factors that can increase error by implementing its Quality Assurance Program into every segment of its testing activities.

Copies of all pertinent calibration data (calibration gas certifications, Pitot tubes, dry gas meters, nozzles, etc.) will be given to the on-site observer from the observing agency prior to testing and included in the final test report.

Calculations are performed by computer. An explanation of the nomenclature and calculations along with the complete test results will be appended in the final report. Also, to be appended, are the calibration data and copies of the raw field data sheets. Analyzer interference data is kept on file at Mostardi Platt.

All the data necessary for the agency to reproduce the reported results will be included in the final test report. The data shall include, but not be limited to DAS printouts, unit operational data (e.g. steam flow, etc.) calibration data, uncorrected run averages, raw lab analysis (including chromatograms, spectra or other instrument output, and calibration and QA/QC data) with summary tables, and raw field data.

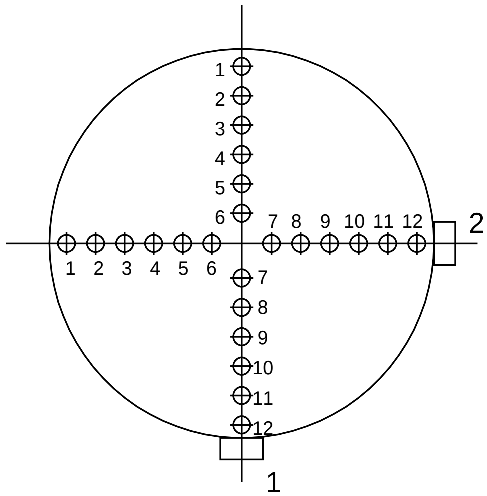
Dry gas meters are calibrated according to methods described in the Code of Federal Regulations. The dry test meters measure the test sample volumes to within 2 percent at the flowrate and conditions encountered during sampling.

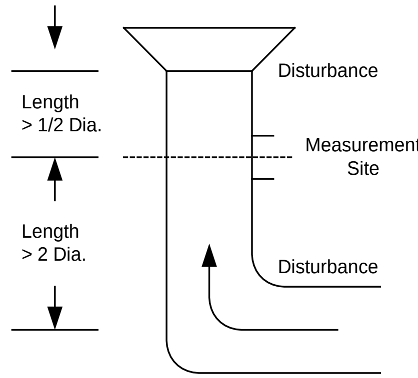
Mostardi Platt will incorporate the following additional QA/QC procedures for this test program to prevent any contamination as possible:

- A reagent blank for the 0.5N KOH will be prepared and analyzed prior to mobilization to confirm low background levels of $CR^{+}6$
- New probe brushes for Method 29 will be utilized for testing. Anytime during testing that a probe brush is found to be dirty, it will be replaced.
- Certified, pre-cleaned amber glass sample bottles will be used for all wash collection for M29. Pre-cleaned Nalgene will be used for 0061 samples.
- Stack/duct IDs will be verified on site.
- A pre-test null point traverse will be performed at each location.
- A pre-test 0.1N HNO_3 probe wash will be performed for Method 29. The probe will be heated to approximately 248°F, then a preliminary wash will be performed. This wash will not be analyzed. A 2nd wash will then be performed and this sample will be archived for potential analysis.
- Field reagent blanks will be collected from the remaining volume in the squeeze bottles used for this test program. These reagent blanks will be analyzed.

APPENDIX

EQUAL AREA TRAVERSE FOR ROUND DUCTS





Project: PCC Structurals, Inc.
Large Parts Campus
Milwaukie, Oregon

Unit: BH8901 Inlet

Stack Diameter: 1.0 Foot

Stack Area: 0.785 Square Feet

No. Points Across Diameter: 12

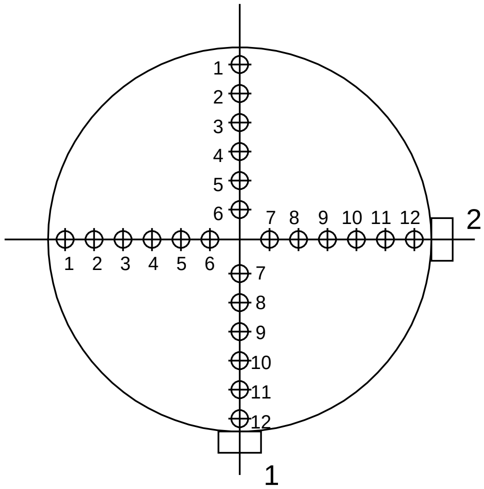
No. of Ports: 2

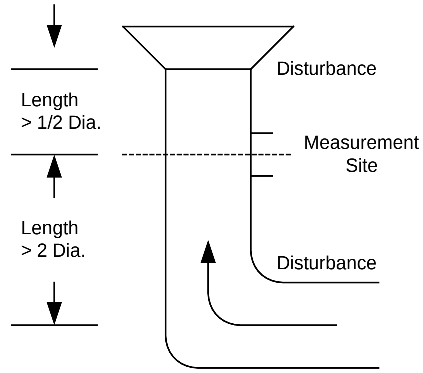
Port Length: TBD

Upstream Distance: >0.5

Downstream Distance: >2.0

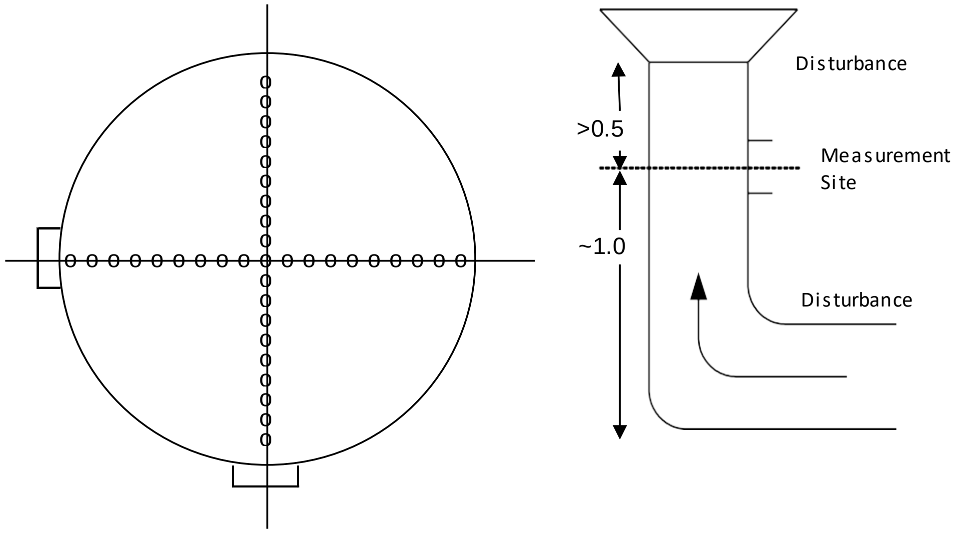
EQUAL AREA TRAVERSE FOR ROUND DUCTS





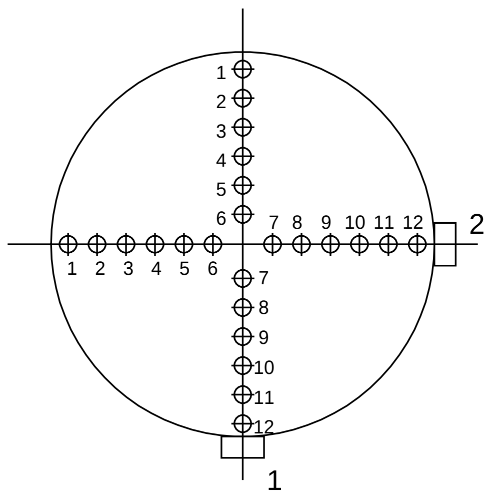
Project:	PCC Structurals, Inc. Large Parts Campus Milwaukie, Oregon
Unit:	BH8901 Outlet
Stack Diameter:	1.0 Foot
Stack Area:	0.785 Square Feet
No. Points Across Diameter:	12
No. of Ports:	2
Port Length:	TBD
Upstream Distance:	>0.5
Downstream Distance:	>2.0

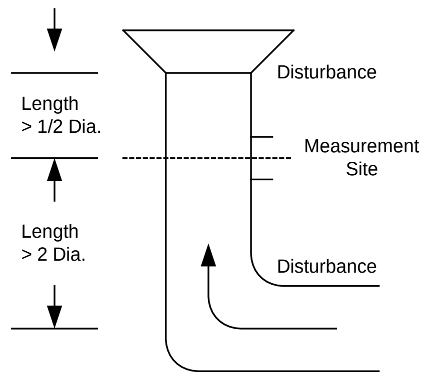
EQUAL AREA TRAVERSE FOR ROUND DUCTS



Project:	PCC Structurals, Inc. Large Parts Campus Milwaukie, Oregon
Unit:	BH9256 Inlet
Stack Diameter:	5.0 Feet
Stack Area:	19.635 Square Feet
No. Points Across Diameter:	20
No. of Ports:	2
Port Length:	TBD
Upstream Distance:	>0.5
Downstream Distance:	~1.0

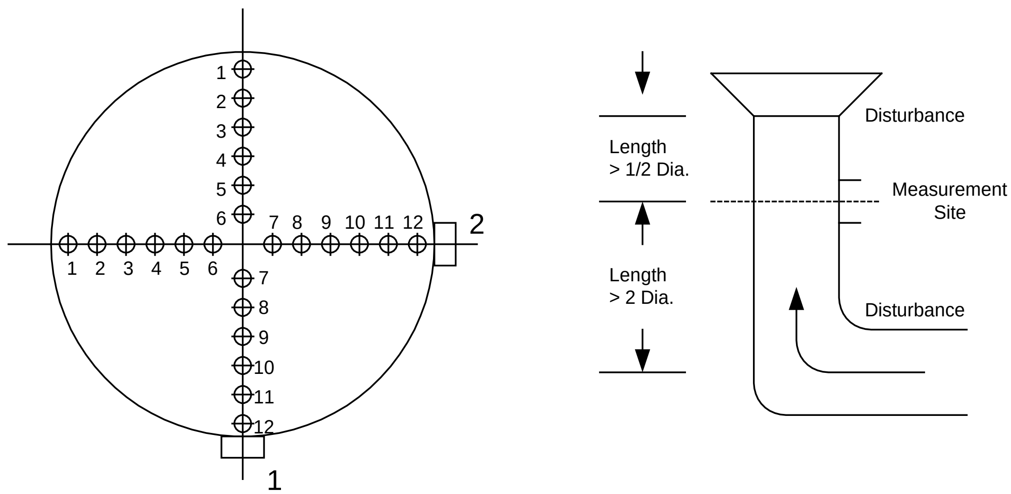
EQUAL AREA TRAVERSE FOR ROUND DUCTS





Project:	PCC Structurals, Inc.
	Large Parts Campus
	Milwaukie, Oregon
Unit:	BH9256 Outlet
Stack Diameter:	5.0 Feet
Stack Area:	19.635 Square Feet
No. Points Across Diameter:	12
No. of Ports:	2
Port Length:	TBD
Upstream Distance:	>0.5
Downstream Distance:	>2.0

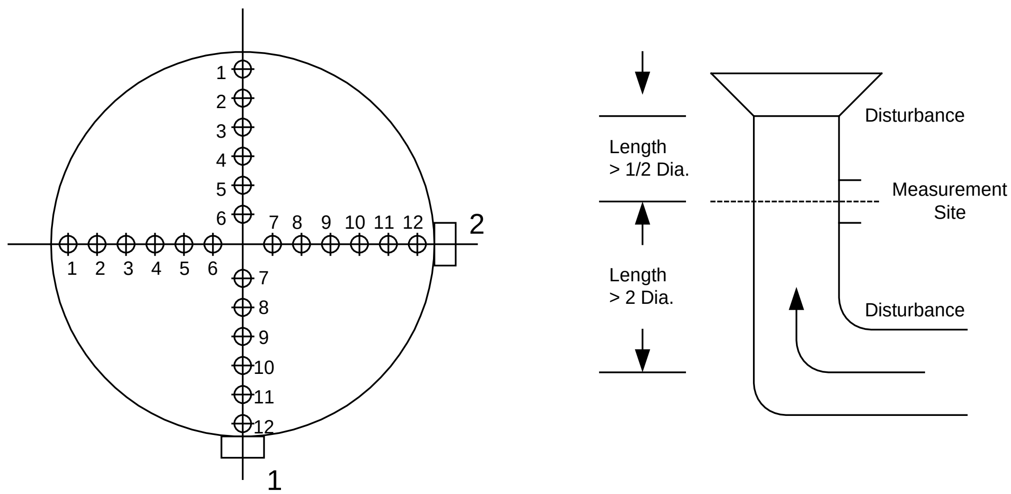
EQUAL AREA TRAVERSE FOR ROUND DUCTS



Project:	PCC Structurals, Inc. Large Parts Campus Milwaukie, Oregon
Unit:	BH9203 Inlets (3 total, identical dimensions)
Stack Diameter:	3.0 Feet
Stack Area:	7.069 Square Feet
No. Points Across Diameter:	12
No. of Ports:	2
Port Length:	TBD
Upstream Distance:	>0.5
Downstream Distance:	>2.0

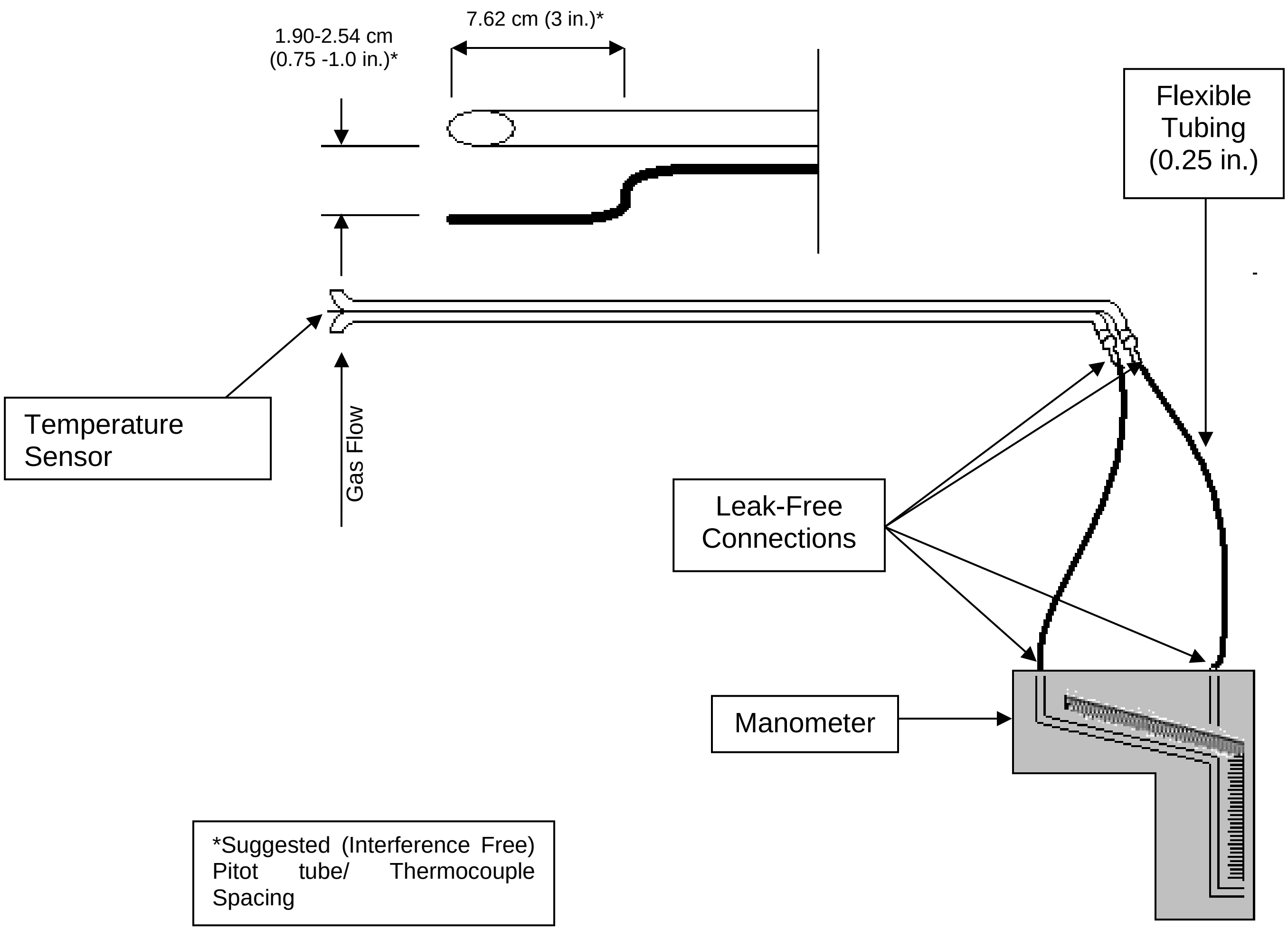
EQUAL AREA TRAVERSE FOR ROUND DUCTS

(PM and preliminary flows)



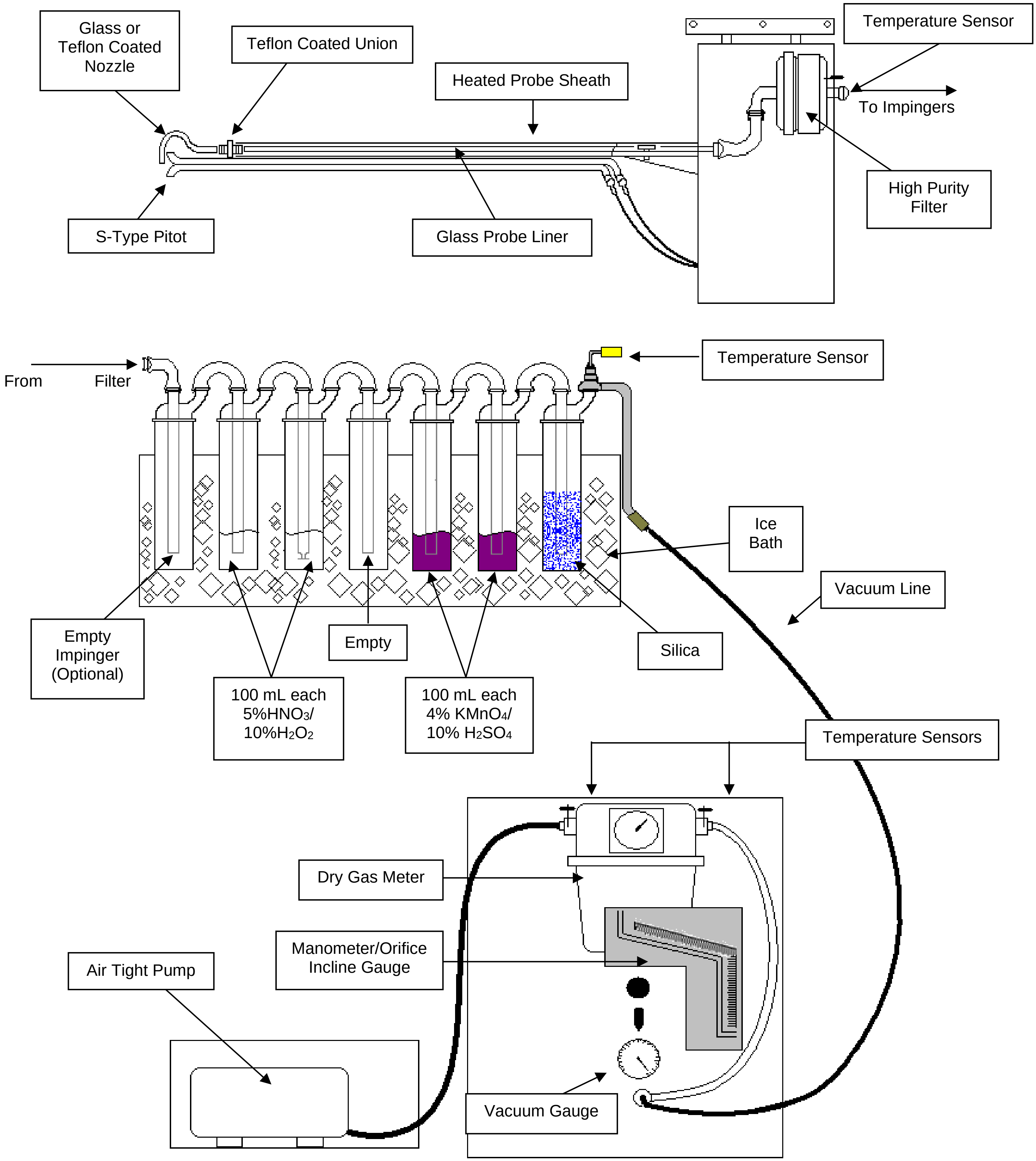
Project:	PCC Structurals, Inc.
	Large Parts Campus
	Milwaukie, Oregon
Unit:	BH9203 Outlets (6 total, identical dimensions)
Stack Diameter:	2.833 Feet
Stack Area:	6.305 Square Feet
No. Points Across Diameter:	12
No. of Ports:	2
Port Length:	TBD
Upstream Distance:	>0.5
Downstream Distance:	>2.0

USEPA Method 2- Type S Pitot Tube Manometer Assembly

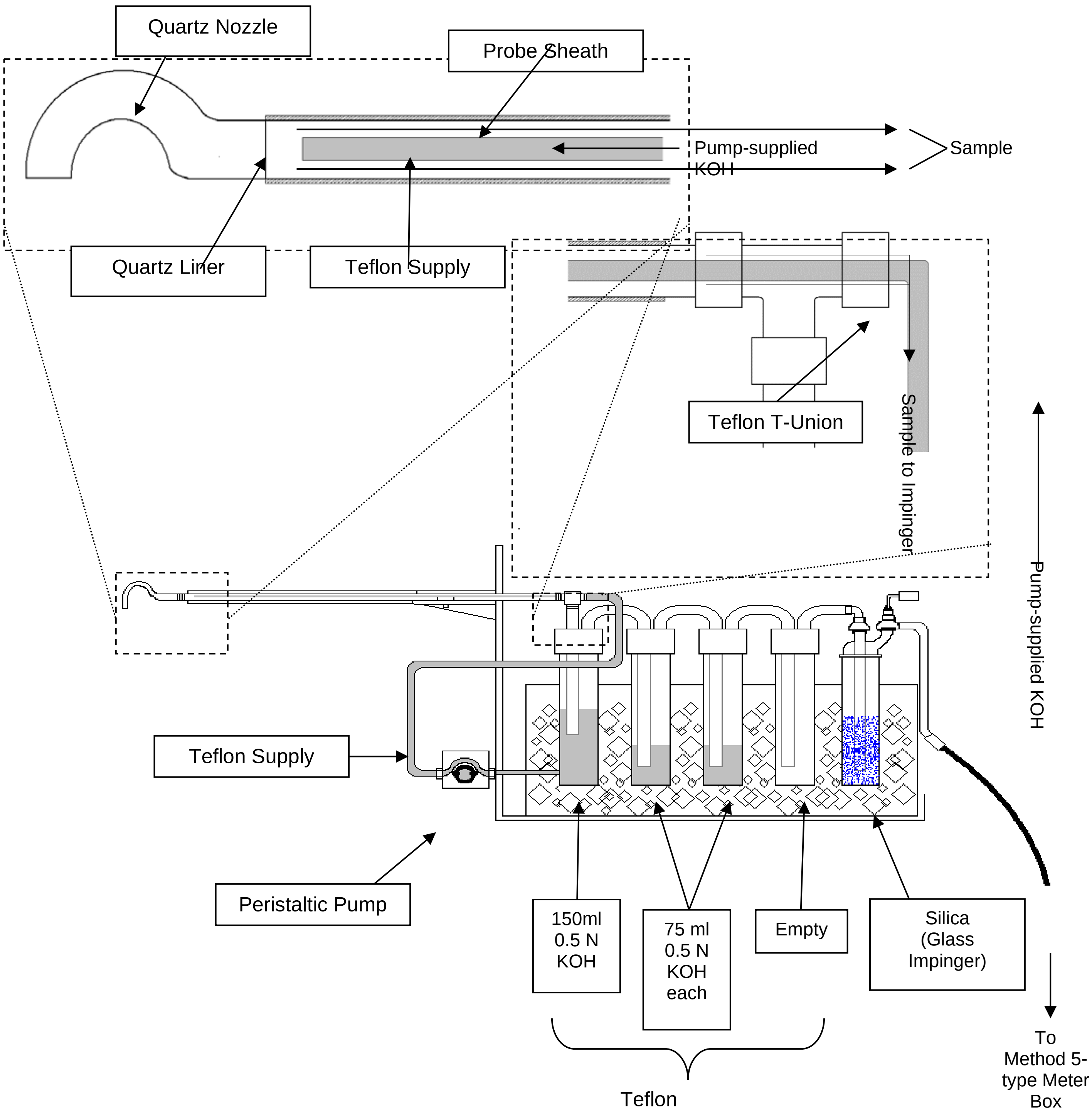


*Suggested (Interference Free) Pitot tube/ Thermocouple Spacing

USEPA Method 29- Metals Sample Train Diagram



Method 0061- Hexavalent Chromium Sampling Train



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Volumetric Flow Nomenclature

A =	Cross-sectional area of stack or duct, ft^2
B_{ws} =	Water vapor in gas stream, proportion by volume
C_p =	Pitot tube coefficient, dimensionless
M_d =	Dry molecular weight of gas, lb/lb-mole
M_s =	Molecular weight of gas, wet basis, lb/lb-mole
M_w =	Molecular weight of water, 18.0 lb/lb-mole
P_{bar} =	Barometric pressure at testing site, in. Hg
P_g =	Static pressure of gas, in. Hg (in. H_2O/13.6)
P_s =	Absolute pressure of gas, in. Hg = $P_{bar} + P_g$
P_{std} =	Standard absolute pressure, 29.92 in. Hg
Q_{acfm} =	Actual volumetric gas flow rate, acfm
Q_{sd} =	Dry volumetric gas flow rate corrected to standard conditions, dscf/hr
R =	Ideal gas constant, 21.85 in. Hg-ft^3/°R-lb-mole
T_s =	Absolute gas temperature, °R
T_{std} =	Standard absolute temperature, 528°R
v_s =	Gas velocity, ft/sec
$V_{w(std)}$ =	Volume of water vapor in gas sample, corrected to standard conditions, scf
Y =	Dry gas meter calibration factor
Δp =	Velocity head of gas, in. H_2O
K_1 =	17.647 °R/in. Hg
%EA =	Percent excess air
$\%CO_2$ =	Percent carbon dioxide by volume, dry basis
$\%O_2$ =	Percent oxygen by volume, dry basis
$\%N_2$ =	Percent nitrogen by volume, dry basis
0.264 =	Ratio of O_2 to N_2 in air, v/v
0.28 =	Molecular weight of N_2 or CO, divided by 100
0.32 =	Molecular weight of O_2 divided by 100
0.44 =	Molecular weight of CO_2 divided by 100
13.6 =	Specific gravity of mercury (Hg)

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Volumetric Air Flow Calculations

$$Vm\ (std) = 17.647 \times Vm \times \left[\frac{\left(P_{bar} + \left[\frac{DH}{13.6}\right]\right)}{(460 + Tm)}\right] \times Y$$

$$Vw\ (std) = 0.0471 \times Vlc$$

$$Bws = \left[\frac{Vw\ (std)}{Vw\ (std) + Vm\ (std)}\right]$$

$$Md = (0.44 \times \%CO_2) + (0.32 \times \%O_2) + [0.28 \times (100 - \%CO_2 - \%O_2)]$$

$$Ms = Md \times (1 - Bws) + (18 \times Bws)$$

$$Vs = \sqrt{\frac{(Ts + 460)}{Ms \times Ps}} \times \sqrt{DP} \times Cp \times 85.49$$

$$Acfm = Vs \times Area\ (of\ stack\ or\ duct) \times 60$$

$$Scfm = Acfm \times 17.647 \times \left[\frac{Ps}{(460 + Ts)}\right]$$

$$Scfh = Scfm \times 60 \frac{min}{hr}$$

$$Dscfm = Scfm \times (1 - Bws)$$

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Isokinetic Nomenclature

A = Cross-sectional area of stack or duct, square feet
A_n = Cross-sectional area of nozzle, square feet
B_{ws} = Water vapor in gas stream, by volume
C_a = Acetone blank residue concentration, g/g
C_{acf} = Concentration of particulate matter in gas stream at actual conditions, gr/acf
C_p = Pitot tube coefficient
C_s = Concentration of particulate matter in gas stream, dry basis, corrected to standard conditions, gr/dscf
IKV = Isokinetic sampling variance, must be $90.0\ \% \leq IKV \leq 110.0\%$
M_d = Dry molecular weight of gas, lb/lb-mole
M_s = Molecular weight of gas, wet basis, lb/lb-mole
M_w = Molecular weight of water, 18.0 lb/lb-mole
m_a = Mass of residue of acetone after evaporation, grams
P_{bar} = Barometric pressure at testing site, inches mercury
P_g = Static pressure of gas, inches mercury (inches water/13.6)
P_s = Absolute pressure of gas, inches mercury = $P_{bar} + P_g$
P_{std} = Standard absolute pressure, 29.92 inches mercury
Q_{acfm} = Actual volumetric gas flow rate, acfm
Q_{sd} = Dry volumetric gas flow rate corrected to standard conditions, dscfh
R = Ideal gas constant, 21.85 inches mercury cubic foot/°R-lb-mole
T_m = Dry gas meter temperature, °R
T_s = Gas temperature, °R
T_{std} = Absolute temperature, 528°R
V_a = Volume of acetone blank, ml
V_{aw} = Volume of acetone used in wash, ml
W_a = Weight of residue in acetone wash, grams
m_n = Total amount of particulate matter collected, grams
V_{1c} = Total volume of liquid collected in impingers and silica gel, ml
V_m = Volume of gas sample as measured by dry gas meter, dcf
$V_{m(std)}$ = Volume of gas sample measured by dry gas meter, corrected to standard conditions, dscf
v_s = Gas velocity, ft/sec
$V_{w(std)}$ = Volume of water vapor in gas sample, corrected to standard conditions, scf
Y = Dry gas meter calibration factor
ΔH = Average pressure differential across the orifice meter, inches water
Δp = Velocity head of gas, inches water
ρ_a = Density of acetone, 0.7855 g/ml (average)
ρ_w = Density of water, 0.002201 lb/ml
θ = Total sampling time, minutes
K_1 = 17.647 °R/in. Hg
K_2 = 0.04707 ft^3/ml
K_4 = 0.09450/100 = 0.000945
K_p = Pitot tube constant, $$85.49\,\frac{\text{ft}}{\text{sec}}\left[\frac{(\text{lb/lb}-\text{mole})(\text{in. Hg})}{({}^{\circ}\text{R})(\text{in. H}_2\text{O})}\right]^{1/2}$$
%EA = Percent excess air
$\%CO_2$ = Percent carbon dioxide by volume, dry basis

$\%O_2$ = Percent oxygen by volume, dry basis
%CO = Percent carbon monoxide by volume, dry basis
$\%N_2$ = Percent nitrogen by volume, dry basis
0.264 = Ratio of O_2 to N_2 in air, v/v
28 = Molecular weight of N_2 or CO
32 = Molecular weight of O_2
44 = Molecular weight of CO_2
13.6 = Specific gravity of mercury (Hg)

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Isokinetic Calculation Formulas

1. $$V_{w(std)} = V_{lc}\left(\frac{\rho_w}{M_w}\right)\left(\frac{RT_{std}}{P_{std}}\right) = K_2 V_{lc}$$

2. $$V_{m(std)} = V_m Y \left(\frac{T_{std}}{T_m}\right)\left(\frac{(P_{bar} + (\frac{\Delta H}{13.6}))}{P_{std}}\right) = K_1 V_m Y \frac{(P_{bar} + (\frac{\Delta H}{13.6}))}{T_m}$$

3. $$B_{ws} = \frac{V_{w(std)}}{(V_{m(std)} + V_{w(std)})}$$

4. $$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$$

5. $$M_s = M_d(1 - B_{ws}) + 18.0(B_{ws})$$

6. $$C_a = \frac{m_a}{V_a \rho_a}$$

7. $$W_a = C_a V_{aw} \rho_a$$

8. $$C_{acf} = 15.43 K_i \left(\frac{m_n P_s}{V_{w(std)} + V_{m(std)}\ T_s}\right)$$

9. $$C_S = (15.43 \text{ grains/gram})\ (m_n / V_{m(std)})$$

10. $$v_s = K_p C_p \sqrt{\frac{\Delta P\ T_s}{P_s M_s}}$$

11. $$Q_{acfm} = v_s A(60_{sec/min})$$

12. $$Q_{sd} = (3600_{sec/hr})(1 - B_{ws})\ v_s \left(\frac{T_{std} P_s}{T_s P_{std}}\right) A$$

13. $$E \text{ (emission rate, lbs/hr)} = Q_{std}\left(C_s / 7000 \text{ grains/lb}\right)$$

14. $$IKV = \frac{T_s V_{m(std)} P_{std}}{T_{std} v_s \theta A_n P_s 60(1 - B_{ws})} = K_4 \frac{T_s V_{m(std)}}{P_s v_s A_n \theta (1 - B_{ws})}$$

15. $$\%EA = \left(\frac{\%O_2 - (0.5\,\%CO)}{0.264\,\%N_2 - (\%O_2 - 0.5\,\%CO)}\right) \times 100$$

Procedures for Isokentic Calibration

Nozzles

The nozzles are measured according to Method 5, Section 10.1

Dry Gas Meters

The test meters are calibrated according to Method 5, Section 10.3 and 16.1. and “Procedures for Calibrating and Using Dry Gas Volume Meters as Calibration Standards” by P.R. Westlin and R.T. Shigehara, March 10, 1978.

Analytical Balance

The accuracy of the analytical balance is checked with Class S, Stainless Steel Type 303 weights manufactured by F. Hopken and Son, Jersey City, New Jersey.

Temperature Sensing Devices

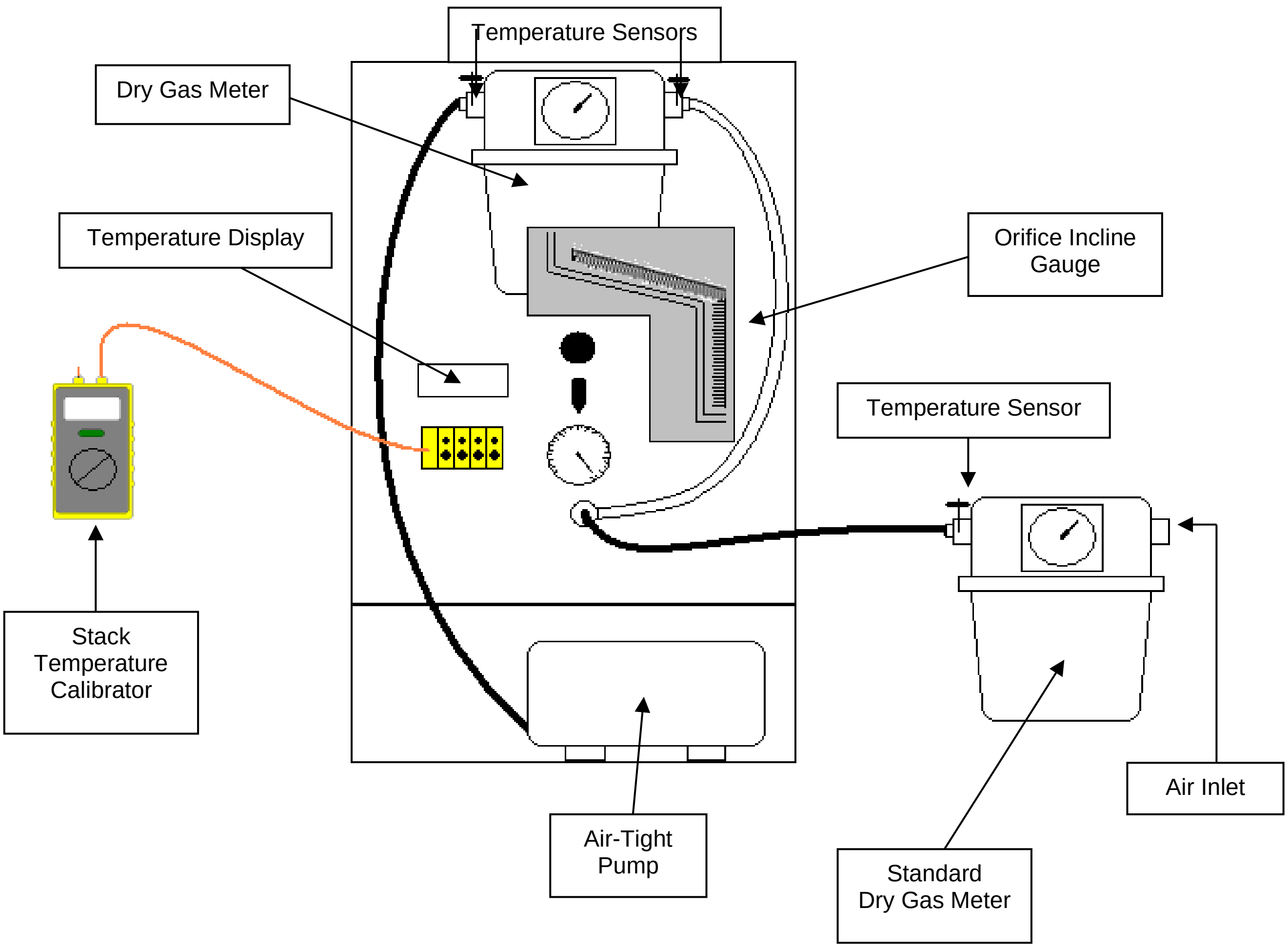
The potentiometer and thermocouples are calibrated utilizing a NIST traceable millivolt source.

Pitot Tubes

The “S” type pitot tubes utilized during this test program are manufactured according to the specification described and illustrated in the *Code of Federal Regulations*, Title 40, Part 60, Appendix A, Methods 1 and 2. The pitot tubes comply with the alignment specifications in Method 2, Section 10.1; and the pitot tube assemblies are in compliance with specifications in the same section.

These pitot tubes will have a wind tunnel calibrated CP calibrated as referenced to a standard type pitot.

Dry Gas Meter/Control Module Calibration Diagram



Dry Gas Meter No.	*CM-1*	*Date:*	
Standard Meter No.		*Calibrated By:*	
Standard Meter (Y)		*Barometric Pressure:*	

Run Number		*Orifice Setting in H_2O Chg (H)*	*Standard Meter Gas Volume vr*	*Dry Gas Meter Gas Volume vd*	*Standard Meter Temp. F° tr*	*Dry Gas Meter Inlet Temp. F° tdi*	*Dry Gas Meter Outlet Temp. F° tdo*	*Dry Gas Meter Avg. Temp. F° td*	*Time Min*	*Time Sec*	*Y*	*Chg (H)*
Final												
Initial												
Difference	*1*	*0.20*										
Final												
Initial												
Difference	*2*	*0.50*										
Final												
Initial												
Difference	*3*	*0.70*										
Final												
Initial												
Difference	*4*	*0.90*										
Final												
Initial												
Difference	*5*	*1.20*										
Final												
Initial												
Difference	*6*	*2.00*										

Average ____________________

Stack Temperature Sensor Calibration

Meter Box # : *CM-1*

Name : ____________________

Ambient Temperature : __________ ^{o}F

Date : ____________________

Calibrator Model # : __________

Serial # : __________

Date Of Certification : ____________________

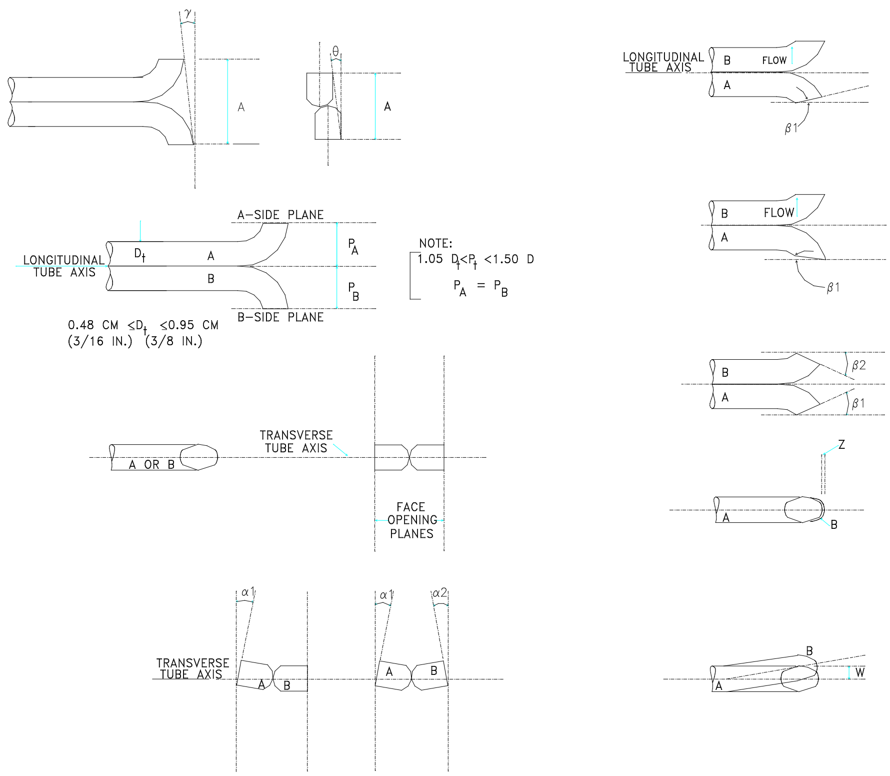
Primary Standards Directly Traceable National Institute of Standards and Technology (NIST)

Reference Source Temperature (^{o}F)	***Test Thermometer Temperature (^{o}F)***	***Temperature Difference %***
0		0.0
250		0.0
600		0.0
1200		0.0

$$\frac{(\text{Ref. Temp., }^{o}F + 460) - (\text{Test Therm. Temp., }^{o}F + 460)}{\text{Ref. Temp., }^{o}F + 460} * 100 <= 1.5\ \%$$

S TYPE PITOT TUBE INSPECTION FORM

Pitot Tube No: 1   Date: ____________   Inspectors Name: ____________



Pitot tube assembly level? x yes ______ no

Pitot tube openings damaged? ______ yes (explain below) x no

a_1 = 1 ^{o} ($<10^o$), a_2 = 1 ^{o} ($<10^o$) z = A sin g = 0.008 (in.); (<0.125 in.)

b_1 = 0 ^{o} ($<5^o$), b_2 = 2 ^{o} ($<5^o$) w = A sin q = 0.025 (in.); (<0.03125 in.)

γ = 0.5 ^{o}, θ = 1.5 ^{o}, A = 0.938 (in.) P_A = 0.477 (in.), P_B = 0.477 (in.), D_t = 0.375 (in.)

Calibration required? ______ yes x no

Note that wind tunnel calibrated pitot tubes will be used for measuring effluent volumetric flowrate during the liquifying test condition.

IMPINGER WEIGHT SHEET

PLANT:______________________________________

UNIT NO:____________________________________

LOCATION:___________________________________

DATE:_______________________________________

TEST NO:____________________________________

METHOD:_____________________________________

WEIGHED/MEASURED BY:______________________

BALANCE ID:__________________________________

	FINAL WEIGHT		INITIAL WEIGHT		IMPINGER		IMPINGER
Circle One:	MLS / GRAMS		MLS / GRAMS		GAIN		CONTENTS
IMPINGER 1							
IMPINGER 2							
IMPINGER 3							
IMPINGER 4							
IMPINGER 5							
IMPINGER 6							
IMPINGER 7							
IMPINGER 8							

IMPINGERS ______________ ______________ ______________

FINAL TOTAL INITIAL TOTAL TOTAL IMPINGER GAIN

SILICA ______________ ______________ ______________

FINAL TOTAL INITIAL TOTAL TOTAL SILICA GAIN

Isokinetic Sampling Cover Sheet

Test Engineer: ____________________

Test Technician: ____________________

Plant Information

Run Number: ________________________ Date: ______________________ Project Number: _____________________

Test Location: ________________________ Client Name: __________________ Plant Name: _________________________

Duct Shape: Circular or Rectangular Length: _________ Width: ________ or Diameter: ________________________

Flue Area: ________________________ Upstream Diameters:_____________ Downstream Diameters:________________

Port Type: ________________________ Port Length: ____________________ Port Diameter: _____________________

Test Method: _____________________ Source Condition: ________________

Meter and Probe Data

Meter ID: ____________________________ Meter Y Value: ___________________ ΔH Value:______________________________

Pitot ID:______________________________ Pitot Coefficient: _________________ Train Type: _________________________

Nozzle ID #__________________________ Nozzle Diameter: _________________ Filter Number/Weight:____________________

Probe Length: ________________________ Probe Liner: ____________________ Thimble Number/Weight:_________________

Pre-Test Nozzle Leak Check:______________@__________”Hg Post-Test Nozzle Leak Check: ______________@__________”Hg

Pre-Test Pitot Leak Check:____________________________”H_2O Post-Test Pitot Leak Check:___________________________”H_2O

Traverse Data

Ports Sampled: ____________________ Points/Port: ______________________ Min/Point: _________________________

Total Points: ______________________ Total Test Time: __________________ Sample Plane: Horizontal or Vertical

Stack Parameters

Barometric Pressure: ____________________ Static Pressure: ___________________

CO_2 %: ______/_______/_______/ Avg.______ O_2 %: ______/________/_______/Avg.________ Determined by: Method 3 or Method 3A

Imp and/or silica balance Model and S/N: _____________________________ Servomex Serial #:__________________________

Initial Imp. Volume or Weight: _____________ Final Imp. Volume or Weight: ________ Imp. Volume or Weight Gain: _________

Initial Silica Weight: ______________________ Final Silica Weight: ________________ Silica Weight Gain:_________________

Comments:

Isokinetic Sampling Field Data Sheet

Project Number:		Date:		Test Number:	
Client:		Test Location:		Operator:	Test Tech:
Plant:		Test Method:		Page Number:	of

Port-Point #.	Time	(ΔP)	Orifice Setting (ΔH)	Meter Volume (V_m) ft^3, Actual	Square Root, ΔP	Meter Rate, Cubic Feet/ Min.	Theoretical Meter Volume, (V_m) ft^3, per point	Theoretical Meter Volume, (V_m) ft^3, total	Stack Temp, °F	Meter Temp Inlet, °F	Meter Temp Outlet, °F	Pump Vacuum, " Hg	Probe Temp. °F	Filter Temp. °F	Impinger Outlet Well Temp. °F