United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EMB REPORT 81-CBS-1
November & December 1981

Air

EPA

Coke Battery Stack Sulfate Emissions

Emission Test Report Republic Steel - Cleveland Works Cleveland, Ohio

VOLUME I

TEXT AND APPENDIX A

SUMMARY TEST REPORT
Method Development and Testing for the Coke Battery Stack Industry Republic Steel-Cleveland Works

Volume I
Text and Appendix A

by

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Contract No. 68-02-3546
Work Assignment No. 10
ESED No. 74/4i

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RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

December 1981

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SECTION 1

INTRODUCTION

During the weeks of October 26, 1981, and December 7, 1981, PEDCo Environmental personnel conducted emission sampling programs at Republic Steel Corporation's Cleveland, Ohio, facility.

The primary objective of the field tests was to obtain data on battery stack particulate emissions using several modifications of EPA Method 5. The modifications included front half sampling train temperatures of 177°C (350°F), 204°C (400°F), and 316°C (600°F), post-test heating of samples and wet chemistry analysis for sulfates. The data will be used, with other information, to formulate a test method to measure total non-sulfate particulate matter emissions from batteries underfiring non-desulfurized coke oven gas (NCOG) and desulfurized coke oven gas (DCOG); and, to determine the effect of underfiring NCOG and DCOG on particulate emissions. The secondary objective of the field tests was to measure the concentrations and types of reduced sulfur compounds in the fuel gas before and after the Sulfiban desulfurizer. Data on reduced sulfur compounds will be used, along with other information, to determine the impact of desulfurizers on sulfur compound emissions from coke ovens.

The purpose of this test report is to describe the measurement mode, document the results obtained, and discuss the possible relationships between the data and process or sampling conditions.

Republic's Cleveland plant was selected as the test site for the following reasons:

1. A pad up rebuilt of the battery was completed in 1977.
2. The plant uses no add-on pollution control devices at the coke battery exhaust.
3. Earlier test data indicate that it is representative of a well controlled facility.
4. The two test series could be conducted close enough in time so as to reduce the effects of changes in condition of the battery on emissions.

Comprehensive testing was conducted at two sources:

- The Coke Battery No. 1 exhaust
- The Sulfiban sulfur removal unit (SRU)

At the final exit stack serving Coke Battery No. 1, particulate, sulfur dioxide, and sulfuric acid mist concentrations were measured by EPA Methods 5 and 8* modified into a quad sampling train arrangement and two single sampling trains. A test run consisted of the operation of the quad train and two single sampling trains. Sampling and analytical parameters were varied between runs. Flue gas flow rates, temperature, moisture content, and composition [oxygen (O_2) and carbon dioxide (CO_2)] were measured in conjunction with the particulate test runs.

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*40 CFR 60, Appendix A, Reference Methods 1 through 5 and 8, July 1, 1981.

Flue gas samples were collected at the inlet and outlet (during DCOG testing only) of the Sulfiban desulfurization unit for determination of hydrogen sulfide (H_2S), carbonyl sulfide (COS), carbon disulfide (CS_2), and SO_2 concentrations. Gas chromatographic (GC) separation and flame photometric detection (FPD) by EPA Method 15* were used.

Visible emissions were observed at Coke Battery No. 1 exit stack during particulate tests according to EPA Method 9.**

Midwest Research Institute (MRI) monitored process operations during both test series. Mr. Yogesh Doshi monitored the NCOG test series, and Mr. Barry Gold monitored the DCOG test series. Mr. Frank Clay, EPA Task Manager, observed the NCOG test series, and Mr. Terry Harrison of EPA who represented Mr. Clay, observed the DCOG test series.

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*40 CFR 60, Appendix A, Reference Method 15, July 1, 1981.

**40 CFR 60, Appendix A, Reference Method 9, July 1, 1981.

SECTION 2

SUMMARY OF RESULTS

This section presents the results from the normal coke oven gas (NCOG) and desulfurized coke oven gas (DCOG) test series. The NCOG test series was conducted during the week of October 26, 1981, and the DCOG test series during the week of December 7, 1981. The delay between the two test series was necessary to allow the sulfur recovery unit (SRU) to stabilize after start-up.

2.1 PARTICULATE SAMPLING PROTOCOL

Tables 2-1 and 2-2 summarize sampling trains, configurations, metered volumes, and component temperatures for the NCOG and DCOG underfiring test series, respectively. Sampling Trains 1 through 4 comprised the quad train. Sampling Train 5 was the standard Method 5 train, and Sampling Train 6 was equipped for 316°C (600°F) probe and filter heat. Back-half train configurations and filter/probe temperatures varied between sample runs. The sample identifications listed in Tables 2-1 and 2-2 gives the sample train number (1 through 6), back-half configuration (Method 8 or Method 5), and front-half probe/filter temperature (°F).

Probe and filter temperatures were measured by thermocouples that contacted a well that had been blown into the glass probe

TABLE 2-1. SUMMARY OF SAMPLE TRAINS TEMPERATURE AND CONFIGURATION DURING NCOG UNDERFIRING TESTING

Run	Sample identification	Date (1981)	Metered[a] volume		Stack temperature		Average probe temperature		Average filter temperature	
			Nm^3	dscf	°C	°F	°C	°F	°C	°F
1	1-M8-250	10/27	1.76	62.21	280	537	126	258	122	252
	2-M8-250		1.67	58.98	281	538	126	259	125	257
	3-M8-350		1.68	59.28	280	536	211	411	170	338
	4-M8-350		1.64	57.95	281	538	239	462	169	336
	5-M5-250		1.44	50.97	288	550	123	253	128	263
	6-M8-600		1.42	49.99	288	550	334	634	320	608
2	1-M8-250	10/27	1.59	56.00	279	535	124	255	119	247
	2-M8-250		1.50	52.91	284	543	122	252	128	263
	3-M8-400		1.46	51.50	279	534	203	398	198	389
	4-M8-400		1.44	50.79	283	542	210	410	207	404
	5-M5-250		1.50	52.92	259	499	114	238	125	257
	6-M8-600		1.65	58.42	259	499	332	630	316	600
3	1-M8-250	10/28	1.75	61.88	279	535	125	258	113	236
	2-M8-250		1.66	58.55	282	540	129	263	127	260
	3-M8-350		1.63	57.66	280	536	186	366	178	353
	4-M8-350		1.58	55.81	282	540	191	376	169	336
	5-M5-250		1.72	60.90	270	518	109	229	109	229
	6-M8-600		1.84	64.99	270	518	334	633	293	560
4	1-M8-250	10/28	0.99	34.78	275	527	127	261	123	254
	2-M8-250		0.88	30.89	277	531	125	257	130	266
	3-M8-400		0.93	32.97	274	525	248	479	177	350
	4-M8-400		0.85	30.05	276	529	138	280	169	337
	5-M5-250		2.18	76.86	270	518	112	233	130	266
	6-M8-600		1.11	39.14	270	518	336	638	328	622

(continued)

TABLE 2-1 (continued)

Run	Sample identification	Date (1981)	Metered volume		Stack temperature		Average probe temperature		Average filter temperature	
			Nm^3	dscf	°C	°F	°C	°F	°C	°F
5	1-M8-250	10/29	1.64	58.03	274	524	124	255	124	255
	2-M5-250		1.50	52.83	276	529	127	260	123	254
	3-M8-350		1.53	53.84	276	529	184	363	176	349
	4-M5-350		1.43	50.61	275	527	178	353	186	366
	5-M5-250		1.61	56.68	271	520	129	265	116	240
	6-M8-600		1.54	54.48	271	520	325	617	324	616
6	1-M8-250	10/29	1.64	57.98	274	526	127	261	119	246
	2-M5-250		1.54	54.33	277	530	121	250	126	258
	3-M8-400		1.52	53.74	277	530	203	398	193	379
	4-M5-400		1.29	45.69	278	532	196	385	208	407
	5-M5-250		1.65	58.23	271	520	118	245	119	246
	6-M8-600		1.58	55.90	271	520	328	622	302	576
7	1-M8-250	10/30	1.73	60.90	277	530	122	251	122	252
	2-M5-250		1.66	58.55	280	537	130	266	126	258
	3-M8-350		1.48	52.35	277	530	131	269	181	358
	4-M5-350		1.57	55.56	280	536	169	336	178	353
	5-M5-400		1.66	58.63	271	520	208	407	196	385
	6-M8-600		1.60	56.60	271	520	329	624	308	587
8	1-M8-350	10/30	1.58	55.91	285	545	182	360	167	332
	2-M5-350		1.54	54.36	283	542	184	364	169	336
	3-M8-400		1.70	59.96	285	545	208	407	198	388
	4-M5-400		1.60	56.55	286	547	214	417	201	393
	5-M8-250		1.42	50.29	271	520	128	263	131	268
	6-M8-600		1.18	41.72	271	520	326	619	313	596

[a]Metered volume in dry normal cubic meters (dNm^3) and dry standard cubic feet (dscf). Standard conditions = 20°C and 760 mmHg (68°F and 29.92 in.Hg) and zero percent moisture.

TABLE 2-2. SUMMARY OF SAMPLE TRAINS TEMPERATURE AND CONFIGURATION DURING DCOG UNDERFIRING TESTING

Run	Sample identification	Date (1981)	Metered[a] volume		Stack temperature		Average probe temperature		Average filter temperature	
			Nm^3	dscf	°C	°F	°C	°F	°C	°F
D1	1-M8-250	12/8	1.25	44.11	242	468	129	264	119	246
	2-M8-250		1.23	39.67	242	468	124	255	133	272
	3-M8-350		1.16	40.99	242	468	178	352	190	374
	4-M8-350[b]		1.12	39.61	243	470	175	348	167	333
	5-M5-250[b]		-	-	-	-	-	-	-	-
	6-M8-600		0.96	34.02	252	485	265	508	268	515
D2	1-M8-250	12/10	1.40	49.40	253	487	238	460	118	244
	2-M8-250		1.78	62.68	252	486	237	458	109	229
	3-M8-350		1.71	60.47	252	486	186	366	184	363
	4-M8-350		1.79	63.26	252	486	173	343	197	387
	5-M5-250		1.84	64.79	252	486	129	263	126	258
	6-M8-600		1.68	59.35	252	486	320	608	298	569
D3	1-M8-250	12/11	1.48	52.29	252	486	127	261	120	248
	2-M8-250		1.62	57.25	252	486	125	258	132	270
	3-M8-400		1.40	49.32	252	486	214	417	211	411
	4-M8-400		1.44	51.01	249	480	218	425	204	400
	5-M5-250		1.79	63.10	252	486	124	255	123	254
	6-M8-600		1.72	60.82	252	486	325	616	280	536
D4	1-M8-250	12/12	1.69	59.82	254	490	113	236	148	299
	2-M8-250		1.69	59.79	254	490	123	253	126	259
	3-M8-400[b]		1.49	52.50	256	492	207	404	209	409
	4-M8-400[b]		-	-	-	-	-	-	-	-
	5-M5-250		1.75	61.80	254	490	134	273	128	263
	6-M8-600		1.67	58.85	254	490	302	576	325	617

(continued)

TABLE 2-2 (continued)

Run	Sample identification	Date (1981)	Metered volume		Stack temperature		Average probe temperature		Average filter temperature	
			Nm^3	scf	°C	°F	°C	°F	°C	°F
D5	1-M8-250	12/12	1.74	61.31	244	471	120	248	123	253
	2-M5-250		1.74	61.44	244	471	123	254	127	261
	3-M8-350		1.56	55.07	244	471	177	350	181	357
	4-M5-350		1.60	56.59	244	471	178	352	177	351
	5-M5-250		1.69	59.67	244	471	132	269	122	251
	6-M8-600		1.62	57.09	244	471	327	621	316	600
D6	1-M8-250	12/13	1.56	54.92	235	455	121	251	132	270
	2-M5-250		1.56	54.96	236	457	127	261	120	248
	3-M8-400		1.45	51.23	235	455	211	412	204	399
	4-M5-400		1.49	52.62	232	449	204	399	219	427
	5-M5-250		1.83	64.63	235	455	125	258	131	267
	6-M8-600		1.45	51.10	235	455	324	616	319	607

[a]Metered volume in dry normal cubic meters (dNm^3) and dry standard cubic feet (dscf). Standard conditions = 20°C and 760 mmHg (68°F and 29.92 in.Hg) and zero percent moisture.

[b]Test voided because of excessive post-test leak rate.

and the back-half of the glass filter holder. During a typical EPA Method 5 test*, the filter box temperature is the only parameter monitored to control front-half heat. Table 2-3 summarizes the sampling train component temperatures that were recorded during all tests for Sampling Train 5. In this case, the stack temperature was high 232° to 288°C (450° to 550°F), and the sample gas stream temperature was reduced to the desired filtering temperature. The filter box temperature and the actual filter temperature compared closely.

Sampling was conducted isokinetically by regulating the sample flow rate relative to the flue gas flow rate as measured by the pitot tube attached to the probe assembly. Except for Train 6 during NCOG underfiring, sampling trains were operated at 100 $\pm$10 percent isokinetic. An oversized quartz glass nozzle and a higher than expected grain loading prevented proper isokinetics from being maintained throughout the entire scheduled sample run on Train 6. During NCOG underfiring, Train 6 sampling rate averaged 47 percent isokinetic. The oversized nozzle problem was rectified for the DCOG underfiring test series.

Whatman Reeve Angel 934 AH glass fiber filters were used in all sampling trains except Train 6, in which a quartz glass filter was used. Filters were chosen for their proven tare weight stability when subjected to the heat treatments in the analytical procedures. Appendix H details a study conducted by PEDCo to assess the effect of heat treatment on various filter

*40 CFR 60, Appendix A, Reference Method 5, July 1, 1981.

TABLE 2-3. COMPARISON OF SAMPLE TRAIN 5 COMPONENT TEMPERATURES DURING STANDARD METHOD 5 SAMPLE COLLECTION

Test No.[a]	Average temperature, °C (°F)			
	Probe	Filter	Box	Stack
1.5	123 (253)	128 (263)	124 (256)	288 (550)
2.5	114 (238)	125 (257)	97 (207)	259 (499)
3.5	109 (229)	109 (229)	128 (263)	270 (518)
4.5	112 (233)	130 (266)	132 (270)	270 (518)
5.5	129 (265)	116 (240)	136 (277)	271 (520)
6.5	118 (245)	119 (246)	132 (270)	271 (520)
8.5	128 (263)	131 (268)	130 (267)	271 (520)
D2.5	129 (263)	126 (258)	132 (270)	252 (486)
D3.5	124 (255)	123 (254)	129 (264)	252 (486)
D4.5	134 (273)	128 (263)	133 (271)	254 (490)
D5.5	132 (269)	122 (251)	129 (264)	244 (471)
D6.5	125 (258)	131 (267)	135 (275)	235 (455)

[a]Train 7.5 operated at a higher temperature. Train D1.5 was a voided run.

Note: Probe, filter, and stack temperature measured by thermocouple indicator. Box temperature measured by dial thermometer.

tare weights. The Whatman Reeve Angel 934 AH proved to be one of the most stable. As a matter of routine, all filters used in this test program were heated at 316°C (600°F) prior to initial tare weighing.

2.2 SUMMARY OF PARTICULATE AND RELATED ANALYSES RESULTS

Tables 2-4 and 2-5 present the results obtained through analysis of samples collected during the NCOG and DCOG test series. All results are reported as milligrams (mg). The analytical scheme used is presented in Section 4 and is discussed in detail in Appendix D. Appendix C presents actual laboratory data.

In addition to the particulate analysis, acetone rinse residues and filters were analyzed for isopropanol soluble sulfate (acid sulfate) and water soluble sulfate (inorganic sulfate). Selected filters also were analyzed for total organic carbon (TOC). Because the quantity of TOC proved to be negligible, the data were not included on the summary tables (refer to Section 2.5.1 of this report for more information).

Back half solutions were analyzed for sulfuric acid mist and sulfur dioxide by EPA Method 8 or inorganic and organic content by ether/chloroform extraction and total organic carbon ampule techniques depending on the back-half configuration.

Tables 2-6 through 2-13 present the analytical results for each sampling train within a test run for NCOG underfiring, and Tables 2-14 through 2-19 for DCOG underfiring. Analytical results are reported in mg, milligrams per cubic meter (mg/m^3), and grains per dry standard cubic foot (gr/dscf). These tables also present details on desired front-half temperature, on average filter temperature, and on whether sequential heating of the front-half samples was performed prior to sulfate analysis.

TABLE 2-4. SUMMARY OF RESULTS FOR NCOG TEST SERIES (mg)

Run No.	Filterable particulates under various conditions (front-half results)																Back-half results				
	Ambient temperature		2-h at 350°F		4-h at 350°F		2-h at 400°F		4-h at 400°F		2-h at 600°F		IPA rinse (H_2SO_4)		H_2O rinse				Ether chloroform		
	Rinse	Filter	Rinse	Filter	Rinse	Filter	Rinse	Filter	Rinse	Filter	Rinse	Filter	Rinse	Filter	Rinse	Filter	SO_2	H_2SO_4	Inorganic	Organic	TOC
1.1	101.6	125.3											38.2	43.3	0	0	1960	8.89			
1.2	93.9	98.9	32.2	23.0									7.4	0.0	0	0	1850	9.43			
1.3	41.5	31.4											9.8	0.0	0	0	1870	65.4			
1.4	27.1	23.5											2.1	2.6	0	0	1810	56.0			
1.5	82.3	53.0	26.1	21.4	21.6	20.1	17.8	19.5	15.6	18.9	12.5	18.0	0.0	0.0	0	0	-	-	28.2	2.6	23.4
1.6	12.1	14.9											0.0	0.0	0	0	1120	606			
2.1	79.3	103.8											35.1	26.5	0	0	1370	741			
2.2	81.1	68.1					9.1	15.7					0.0	0.0	0	0	1720	16.0			
2.3	33.4	12.9											12.2	0.0	0	0	1700	53.0			
2.4	49.0	12.3											14.4	0.0	0	0	1610	19.6			
2.5	62.8	28.1	18.4	15.6	15.5	15.2	14.4	14.8	13.3	14.4	10.3	12.2	0.0	0.0	0	0	-	-	68.2	4.8	44.3
2.6	23.3	16.2											2.6	0.0	0	0	1940	15.7			
3.1	104.5	97.5											40.5	29.9	0	0	1790	8.3			
3.2	62.6	94.3	14.9	19.3									0.0	0.0	0	0	1540	8.6			
3.3	66.6	20.7											24.1	1.2	0	0	1680	67.2			
3.4	20.4	19.9											3.7	0.0	0	0	1620	89.2			
3.5	74.5	96.7	10.6	18.4	8.6	18.2	8.4	17.8	7.8	17.4	5.6	16.4	0.0	0.0	0	0	-	-	99.1	3.2	77.3
3.6	18.9	17.1											4.2	0.0	0	0	1720	164			
4.1	64.3	75.6											23.0	24.5	0	0	1300	11.5			
4.2	55.7	57.5					12.7	29.0					0.4	0.0	0	0	1170	11.9			
4.3	30.0	31.1											6.4	0.0	0	0	1250	29.8			
4.4	48.7	29.7											10.0	2.6	0	0	1160	10.4			
4.5	59.8	114.7	34.8	102.5	29.8	99.0	22.4	90.0	16.8	87.9	14.0	85.0	0.0	0.0	0	0	-	-	65.7	3.1	14.3
4.6	16.3	53.4											0.0	0.0	0	0	1550	73.7			
5.1	82.0	56.6											65.5	20.1	0	0	2070	34.4			
5.2	101.4	84.2	18.6	18.2									3.0	0.0	0	0	-	-	19.0	4.2	58.1
5.3	31.4	19.1											9.5	0.0	0	0	1970	81.5			
5.4	15.4	16.7											0.0	0.0	0	0	-	-	101.2	3.2	49.2
5.5	117.8	103.2	27.6	22.8	24.7	19.5	17.9	18.3	14.7	17.6	10.9	16.8	0.0	0.0	0	0	-	-	20.9	6.3	11.8
5.6	10.2	14.7											0.0	0.0	0	0	2050	129			
6.1	102.9	81.2											47.6	23.4	0	0	2000	24.0			
6.2	100.2	50.6					10.8	13.4					0.0	0.0	0	0	-	-	109.7	4.0	42.3
6.3	18.9	15.4											2.8	0.0	0	0	1900	97.6			
6.4	12.6	14.3											0.0	0.0	0	0	-	-	118.3	5.9	15.4
6.5	108.1	87.6	28.6	13.7	25.9	11.7	21.9	11.3	19.8	10.5	16.5	9.3	0.0	0.0	0	0	-	-	20.0	6.4	15.2
6.6	19.9	11.0											0.0	0.0	0	0	2010	115			
7.1	123.4	72.4																			
7.2	117.3	69.8																			
7.3	48.2	16.6																			
7.4	42.4	20.2																			
7.5	24.4	15.8																			
7.6	14.4	9.9																			
8.1	19.9	45.4																			
8.2	32.2	43.8																			
8.3	18.6	47.5																			
8.4	13.5	47.0																			
8.5[a]	85.4	98.5																			
8.6	11.0	34.1																			

[a]Special sequential analysis performed.

TABLE 2-5. SUMMARY OF RESULTS FOR DCOG TEST SERIES (mg)

Run No.	Filterable particulates under various conditions (front-half results)																Back-half results				
	Ambient temperature		2-h at 350°F		4-h at 350°F		2-h at 400°F		4-h at 400°F		2-h at 600°F		IPA rinse (H_2SO_4)		H_2O rinse				Ether chloroform		
	Rinse	Filter	Rinse	Filter	Rinse	Filter	Rinse	Filter	Rinse	Filter	Rinse	Filter	Rinse	Filter	Rinse	Filter	SO_2	H_2SO_4	Inorganic	Organic	TOC
D1.1	18.0	14.6	8.4	13.4	7.9	13.2	5.4	11.4	5.4	11.0	3.8	10.8	0.0	0.0	0.0	<0.3	69.7	115			
D1.2	22.2	15.2	7.5	14.5									1.0	1.0	2.1	Void	116.1	3.5			
D1.3	17.2	16.8											0.0	0.0	2.5	0.0	117.0	9.3			
D1.4	23.6	19.7											0.0	0.0	0.0	0.0	115.8	9.2			
D1.5[a]																			-	-	-
D1.6	15.2	12.1											0.0	0.0	1.6	0.0	97.9	6.3			
D2.1	242.8[b]	7.2											1.0	0.0	0.9	0.0	120.8	13.7			
D2.2	25.1	13.2	12.5	12.1									1.3	1.3	2.0	0.0	159.4	14.4			
D2.3	21.0	13.8											0.6	0.0	3.5	0.0	155.0	8.7			
D2.4	25.9	11.3											0.4	0.0	4.8	0.0	131.8	54.8			
D2.5	24.4	16.7	11.0	12.4	9.3	9.9	8.9	9.9	8.0	9.7	6.2	8.9	0.0	0.0	0.0	0.0	-	-	152.6	0.8	8.6
D2.6	14.7	15.6											0.0	<0.3	0.0	<0.3	152.8	10.7			
D3.1	26.8	11.8											0.3	0.0	6.0	0.0	90.1	84.0			
D3.2	19.4	15.1					6.3	11.8					0.1	1.7	0.0	0.0	152.8	7.0			
D3.3	18.3	12.6											0.0	0.0	4.1	0.0	130.8	12.0			
D3.4	27.4	11.3											1.9	0.0	0.8	0.0	143.4	8.2			
D3.5	18.9	16.1	7.3	14.9	6.0	13.9	5.3	10.4	5.3	10.4	4.2	9.2	0.0	0.0	0.9	0.0	-	-	28.9	2.0	3.4
D3.6	16.7	8.8											0.0	0.0	2.2	0.0	169.1	12.8			
D4.1	18.3	10.2											0.0	0.0	0.0	0.0	135.6	42.3			
D4.2	36.9	8.3					8.1	5.4					0.0	0.0	0.9	0.0	130.5	15.9			
D4.3	16.4	8.4											0.7	0.0	3.2	0.0	118.3	6.7			
D4.4[a]																			-	-	-
D4.5	19.6	11.6	13.4	8.3	13.1	7.1	7.6	7.5	7.6	7.3	6.0	6.3	0.0	0.0	0.0	0.0	-	-	84.5	2.9	8.5
D4.6	12.2	5.3											0.0	0.0	0.0	0.0	90.1	74.7			
D5.1	17.8	5.5											3.4	0.0	3.7	0.0	131.8	8.8			
D5.2	14.8	5.2	5.6	3.1									0.6	0.2	1.7	0.0	-	-	74.5	0.7	202
D5.3	11.0	5.3											2.2	0.0	1.6	0.0	123.6	7.8			
D5.4	15.1	4.0											0.6	0.0	3.8	0.0	-	-	158.1	4.0	572
D5.5	9.5	6.4	2.6	4.3	2.5	2.8	2.5	2.0	2.5	2.0	1.4	1.0	0.0	0.0	0.0	0.0	-	-	15.6	1.4	3.6
D5.6	7.9	5.0											0.3	0.0	1.4	0.0	129.0	8.2			
D6.1	7.2	5.0											0.0	0.0	0.0	0.0	118.3	13.2			
D6.2	14.2	6.9					1.7	3.7					0.0	0.0	0.0	0.0	-	-	55.2	2.4	403
D6.3	10.8	4.8											1.0	0.0	0.0	0.0	113.3	7.5			
D6.4	8.0	4.0											0.0	0.0	0.0	0.0	-	-	144.2	2.8	77
D6.5	12.6	7.3	8.4	5.2	7.8	5.0	6.5	5.0	6.5	4.8	1.0	3.4	0.0	0.0	0.0	0.0	-	-	10.0	2.4	8.0
D6.6	6.8	2.4											0.2	0.0	0.0	0.0	110.1	11.4			

[a]Test run voided.

[b]Contaminated with oil.

TABLE 2-6. NCOG UNDERFIRING CONDITION, RUN NO. 1
TEST RESULTS (10/27/81)

	Test No.					
	1.1	1.2	1.3	1.4	1.5	1.6
Desired front-half temperature, °C (°F)	121 (250)	121 (250	177 (350)	177 (350)	121 (250)	316 (600)
Actual average filter temperature, °C (°F)	122 (252)	125 (257)	170 (338)	169 (336)	128 (263)	320 (608)
Sequential heating, °C (°F)		177 (350)			316 (600)	
Front-half catch						
Particulate (ambient)						
mg	226.9	192.8	72.9	50.6	135.3	27.0
mg/m^3	128.9	115.4	43.4	30.8	94.0	19.0
gr/dscf	0.056	0.050	0.019	0.013	0.041	0.008
Acid soluble sulfate as $[H_2SO_4]$						
mg	81.5	7.4	9.8	4.7	0.0	0.0
mg/m^3	46.3	4.4	5.8	2.9	0.0	0.0
gr/dscf	0.020	0.002	0.002	0.001	0.000	0.000
as $[H_2SO_4(H_2O)_2]$						
mg	111.4	10.1	13.4	6.4	0.0	0.0
mg/m^3	63.3	6.1	8.0	3.9	0.0	0.0
gr/dscf	0.028	0.003	0.003	0.002	0.000	0.000
Back-half catch						
Sulfuric acid mist						
mg	8.9	9.4	65.4	56.0		606[a]
mg/m^3	5.0	5.6	38.9	34.1		426.8
gr/dscf	0.002	0.002	0.017	0.015		0.187
ppm	1	1	10	8		105
Sulfur dioxide						
mg	1960	1850	1870	1810		1120
mg/m^3	1114	1108	1113	1104		789
gr/dscf	0.486	0.484	0.487	0.482		0.346
ppm	419	416	418	415		296
Inorganic condensibles						
mg					28.2	
mg/m^3					19.6	
gr/dscf					0.008	
Organic condensibles						
mg					2.6	
mg/m^3					1.8	
gr/dscf					0.001	
Total organic carbon						
mg					23.4	
mg/m^3					16.2	
gr/dscf					0.007	

[a]Hydrogen peroxide contaminated.

TABLE 2-7. NCOG UNDERFIRING CONDITION, RUN NO. 2 TEST RESULTS (10/27/81)

	Test No.					
	2.1	2.2	2.3	2.4	2.5	2.6
Desired front-half temperature, °C (°F)	121 (250)	121 (250)	204 (400)	204 (400)	121 (250)	316 (600)
Actual average filter temperature, °C (°F)	119 (247)	128 (263)	198 (389)	207 (404)	125 (257)	316 (600)
Sequential heating, °C (°F)		204 (400)			316 (600)	
Front-half catch						
Particulate (ambient)						
mg	183.1	149.2	46.3	61.3	90.9	39.5
mg/m^3	115.2	99.5	31.7	42.6	60.6	23.9
gr/dscf	0.050	0.044	0.014	0.019	0.026	0.010
Acid soluble sulfate as $[H_2SO_4]$						
Mg	61.6	0.0	12.2	14.4	0.0	2.6
mg/m^3	38.7	0.0	8.3	10.0	0.0	1.6
gr/dscf	0.017	0.000	0.004	0.004	0.000	0.001
as $[H_2SO_4\ (H_2O)_2]$						
mg	84.2	0.0	16.7	19.7	0.0	3.5
mg/m^3	53.0	0.0	11.4	13.7	0.0	2.1
gr/dscf	0.023	0.000	0.005	0.006	0.000	0.001
Back-half catch						
Sulfuric acid mist						
mg	741[a]	16.0	53.0	19.6		157
mg/m^3	466	10.7	36.3	13.6		95.7
gr/dscf	0.204	0.005	0.016	0.006		0.041
ppm	114	3	9	3		23
Sulfur dioxide						
mg	1370	1720	1700	1610		1940
mg/m^3	862	1147	1164	1118		1176
gr/dscf	0.377	0.502	0.509	0.489		0.512
ppm	324	431	438	420		442
Inorganic condensibles						
mg					68.2	
mg/m^3					45.5	
gr/dscf					0.020	
Organic condensibles						
mg					4.8	
mg/m^3					3.2	
gr/dscf					0.001	
Total organic carbon						
mg					44.3	
mg/m^3					29.5	
gr/dscf					0.013	

[a]Hydrogen peroxide contaminated.

TABLE 2-8. NCOG UNDERFIRING CONDITION, RUN NO. 3
TEST RESULTS (10/28/81)

	Test No.					
	3.1	3.2	3.3	3.4	3.5	3.6
Desired front-half temperature, °C (°F)	121 (250)	121 (250)	177 (350)	177 (350)	121 (250)	316 (600)
Actual average filter temperature, °C (°F)	113 (236)	127 (260)	178 (353)	169 (336)	109 (229)	293 (560)
Sequential heating, °C (°F)		177 (350)			316 (600)	
Front-half catch						
Particulate (ambient)						
mg	202.0	156.9	87.3	40.3	171.2	36.0
mg/m^3	115.4	94.5	53.6	25.5	99.5	19.6
gr/dscf	0.050	0.041	0.023	0.011	0.043	0.008
Acid soluble sulfate as $[H_2SO_4]$						
mg	70.4	0.0	25.3	3.7	0.0	4.2
mg/m^3	40.2	0.0	15.5	2.3	0.0	2.3
gr/dscf	0.017	0.000	0.007	0.001	0.000	0.001
as $[H_2SO_4(H_2O)_2]$						
mg	96.2	0.0	34.6	5.0	0.0	5.7
mg/m^3	55.0	0.0	21.2	3.2	0.0	3.1
gr/dscf	0.024	0.000	0.009	0.001	0.000	0.001
Back-half catch						
Sulfuric acid mist						
mg	8.3	8.6	67.2	89.2		164
mg/m^3	4.7	5.2	41.2	56.4		89.1
gr/dscf	0.002	0.002	0.018	0.025		0.039
ppm	1	1	10	14		22
Sulfur dioxide						
mg	1790	1540	1680	1620		1720
mg/m^3	1023	928	1031	1025		935
gr/dscf	0.446	0.406	0.450	0.448		0.408
ppm	384	349	387	385		351
Inorganic condensibles						
mg					99.1	
mg/m^3					57.6	
gr/dscf					0.025	
Organic condensibles						
mg					3.2	
mg/m^3					1.9	
gr/dscf					0.001	
Total organic carbon						
mg					77.3	
mg/m^3					44.9	
gr/dscf					0.020	

TABLE 2-9. NCOG UNDERFIRING CONDITION, RUN NO. 4
TEST RESULTS (10/28/81)

	Test No.					
	4.1	4.2	4.3	4.4	4.5	4.6
Desired front-half temperature, °C (°F)	121 (250)	121 (250)	204 (400)	204 (400)	121 (250)	316 (600)
Actual average filter temperature, °C (°F)	123 (254)	130 (266)	177 (350)	169 (337)	130 (266)	328 (622)
Sequential heating, °C (°F)		204 (400)			316 (600)	
Front-half catch						
Particulate (ambient)						
mg	139.9	113.2	61.1	78.4	174.5	69.7
mg/m^3	141.3	128.6	65.7	92.2	80.0	62.8
gr/dscf	0.062	0.056	0.028	0.040	0.035	0.027
Acid soluble sulfate as $[H_2SO_4]$						
mg	47.5	0.4	6.4	12.6	0.0	0.0
mg/m^3	47.9	0.4	6.9	14.8	0.0	0.0
gr/dscf	0.021	0.0002	0.003	0.006	0.000	0.000
as $[H_2SO_4(H_2O)_2]$						
mg	64.9	0.5	8.7	17.2	0.0	0.0
mg/m^3	65.6	0.6	9.4	20.3	0.0	0.0
gr/dscf	0.029	0.0002	0.004	0.009	0.000	0.000
Back-half catch						
Sulfuric acid mist						
mg	11.5	11.9	29.8	10.4		73.7
mg/m^3	11.6	13.5	32.0	12.2		66.4
gr/dscf	0.005	0.006	0.014	0.005		0.029
ppm	3	3	8	3		16
Sulfur dioxide						
mg	1300	1170	1250	1160		1550
mg/m^3	1313	1329	1344	1365		1396
gr/dscf	0.577	0.584	0.585	0.596		0.611
ppm	494	500	505	513		525
Inorganic condensibles						
mg					65.7	
mg/m^3					30.1	
gr/dscf					0.013	
Organic condensibles						
mg					3.1	
mg/m^3					1.4	
gr/dscf					0.0001	
Total organic carbon						
mg					14.3	
mg/m^3					6.6	
gr/dscf					0.003	

TABLE 2-10. NCOG UNDERFIRING CONDITION, RUN NO. 5 TEST RESULTS (10/29/81)

	Test No.					
	5.1	5.2	5.3	5.4	5.5	5.6
Desired front-half temperature, °C (°F)	121 (250)	121 (250)	177 (350)	177 (350)	121 (250)	316 (600)
Actual average filter temperature, °C (°F)	124 (255)	123 (254)	176 (345)	186 (366)	116 (240)	324 (616)
Sequential heating, °C (°F)		177 (350)			316 (600)	
Front-half catch						
Particulate (ambient)						
mg	138.6	185.6	50.5	32.1	221.0	24.9
mg/m^3	84.5	123.7	33.0	22.4	137.3	16.2
gr/dscf	0.037	0.054	0.014	0.010	0.060	0.007
Acid soluble sulfate as [H_2SO_4]						
mg	85.6	3.0	9.5	0.0	0.0	0.0
mg/m^3	52.2	2.0	6.2	0.0	0.0	0.0
gr/dscf	0.023	0.0008	0.003	0.000	0.000	0.000
as [$H_2SO_4(H_2O)_2$]						
mg	117.0	4.1	13.0	0.0	0.0	0.0
mg/m^3	71.3	2.7	8.5	0.0	0.0	0.0
gr/dscf	0.031	0.001	0.004	0.000	0.000	0.000
Back-half catch						
Sulfuric acid mist						
mg	34.4		81.5			129
mg/m^3	21.0		53.3			83.8
gr/dscf	0.009		0.023			0.036
ppm	5		13			20
Sulfur dioxide						
mg	2070		1970			2050
mg/m^3	1262		1288			1331
gr/dscf	0.550		0.564			0.581
ppm	474		484			500
Inorganic condensibles						
mg		19.0		101.2	20.9	
mg/m^3		12.7		70.8	13.0	
gr/dscf		0.006		0.031	0.006	
Organic condensibles						
mg		4.2		3.2	6.3	
mg/m^3		2.8		2.2	3.9	
gr/dscf		0.001		0.001	0.002	
Total organic carbon						
mg		58.1		49.2	11.8	
mg/m^3		38.7		34.4	7.3	
gr/dscf		0.017		0.015	0.003	

TABLE 2-11. NCOG UNDERFIRING CONDITION, RUN NO. 6 TEST RESULTS (10/29/81)

	Test No.					
	6.1	6.2	6.3	6.4	6.5	6.6
Desired front-half temperature, °C (°F)	121 (250)	121 (250)	204 (400)	204 (400)	121 (250)	316 (600)
Actual average filter temperature, °C (°F)	119 (246)	126 (258)	193 (379)	208 (407)	119 (246)	302 (5760
Sequential heating,		204 (400)			316 (600)	
Front-half catch						
Particulate (ambient)						
mg	184.1	150.8	34.3	26.9	195.7	30.9
mg/m^3	112.2	97.9	22.6	20.8	118.6	19.6
gr/dscf	0.049	0.043	0.010	0.009	0.052	0.008
Acid soluble sulfate as $[H_2SO_4]$						
mg	71.0	0.0	2.8	0.0	0.0	0.0
mg/m^3	43.3	0.0	1.8	0.0	0.0	0.0
gr/dscf	0.019	0.000	0.0008	0.000	0.000	0.000
as $[H_2SO_4(H_2O)_2]$						
mg	97.0	0.0	3.8	0.0	0.0	0.0
mg/m^3	59.2	0.0	2.5	0.0	0.0	0.0
gr/dscf	0.026	0.000	0.001	0.000	0.000	0.000
Back-half catch						
Sulfuric acid mist						
mg	24.0		97.6			115
mg/m^3	14.6		64.2			72.8
gr/dscf	0.006		0.028			0.032
ppm	4		16			18
Sulfur dioxide						
mg	2000		1900			2010
mg/m^3	1219		1250			1272
gr/dscf	0.532		0.546			0.555
ppm	458		470			478
Inorganic condensibles						
mg		109.7		118.3	20.0	
mg/m^3		71.2		91.7	12.1	
gr/dscf		0.031		0.040	0.005	
Organic condensibles						
mg		4.0		5.9	6.4	
mg/m^3		2.6		4.6	3.9	
gr/dscf		0.001		0.002	0.002	
Total organic carbon						
mg		42.3		154[a]	15.2	
mg/m^3		27.5		119.4	9.2	
gr/dscf		0.012		0.052	0.004	

[a]Contaminated with isopropanol.

TABLE 2-12. NCOG UNDERFIRING CONDITION, RUN NO. 7 TEST RESULTS (10/30/81)

	Test No.					
	7.1	7.2	7.3	7.4	7.5	7.6
Desired front-half temperature, °C (°F)	121 (250)	121 (250)	177 (350)	177 (350)	204 (400)	316 (600)
Actual average filter temperature, °C (°F)	122 (252)	126 (258)	181 (358)	178 (353)	196 (385)	308 (587)
Front-half catch						
Particulate (ambient)						
mg	195.8	187.1	64.8	62.6	40.2	24.3
mg/m^3	113.2	112.7	43.8	39.9	24.2	15.2
gr/dscf	0.050	0.049	0.019	0.017	0.010	0.007

TABLE 2-13. NCOG UNDERFIRING CONDITION, RUN NO. 8 TEST RESULTS (10/30/81)

	Test No.					
	8.1	8.2	8.3	8.4	8.5	8.6
Desired front-half temperature, °C (°F)	177 (350)	177 (350)	204 (400)	204 (400)	121 (250)	316 (600)
Actual average filter, perature, °C (°F)	167 (332)	169 (336)	198 (388)	201 (393)	131 (268)	313 (596)
Front-half catch						
Particulate (ambient)						
mg	65.3	76.0	66.1	60.5	183.9	45.1
mg/m^3	41.3	49.4	38.9	37.8	129.5	38.2
gr/dscf	0.018	0.022	0.017	0.016	0.056	0.017

TABLE 2-14. DCOG UNDERFIRING CONDITION, RUN NO. D1 TEST RESULTS (12/8/81)

	Test No.					
	D1.1	D1.2	D1.3	D1.4	D1.5	D1.6
Desired front-half temperature, °C (°F)	121 (250)	121 (250)	177 (350)	177 (350)	Void	316 (600)
Actual average filter temperature, °C (°F)	119 (246)	133 (272)	190 (374)	167 (333)		268 (515)
Sequential heating, °C (°F)	316 (600)	177 (350)				
Front-half catch						
Particulate (ambient)						
mg	32.6	37.4	34.0	43.3		27.3
mg/m^3	26.1	33.4	29.3	38.7		28.4
gr/dscf	0.011	0.014	0.013	0.017		0.012
Acid soluble sulfate as $[H_2SO_4(H_2O)_2]$						
mg	0.0	2.7	0.0	0.0		0.0
mg/m^3	0.0	2.4	0.0	0.0		0.0
gr/dscf	0.000	0.001	0.000	0.000		0.000
Water soluble sulfate as $[SO_4^=]$						
mg	<0.3	2.1	2.5	0.0		1.6
mg/m^3	<0.2	1.9	2.1	0.0		1.7
gr/dscf	<0.0001	0.001	0.001	0.000		0.001
Back-half catch						
Sulfuric acid mist						
mg	115[a]	3.5	9.3	9.2		6.3
mg/m^3	92.0	3.1	8.0	8.2		6.6
gr/dscf	0.040	0.001	0.004	0.004		0.003
ppm	22	1	2	2		2
Sulfur dioxide						
mg	69.7	116.1	117.0	115.8		97.9
mg/m^3	55.8	103.7	100.9	103.4		102.0
gr/dscf	0.024	0.045	0.044	0.045		0.044
ppm	21	39	38	39		38

[a]Hydrogen peroxide contaminated.

TABLE 2-15. DCOG UNDERFIRING CONDITION, RUN NO. D2 TEST RESULTS (12/10/81)

	Test No.					
	D2.1	D2.2	D2.3	D2.4	D2.5	D2.6
Desired front-half temperature, °C (°F)	121 (250)	121 (250)	177 (350)	177 (350)	121 (250)	316 (600)
Actual average filter temperature, °C (°F)	118 (244)	109 (229)	184 (363)	197 (387)	126 (258)	298 (569)
Sequential heating, °C (°F)		177 (350)			316 (600)	
Front-half catch						
Particulate (ambient)						
mg	249.9[a]	38.3	34.8	37.2	41.1	30.3
mg/m^3	178.5	21.5	20.4	20.8	22.3	18.0
gr/dscf	0.078	0.009	0.009	0.009	0.010	0.008
Acid soluble sulfate as $[H_2SO_4(H_2O)_2]$						
mg	1.4	3.5	0.8	0.5	0.0	<0.4
mg/m^3	1.0	2.0	0.5	0.3	0.0	<0.2
gr/dscf	0.0004	0.001	0.0001	0.0001	0.000	<0.0001
Water soluble sulfate as $[SO_4^=]$						
mg	0.9	2.0	3.5	4.8	0.0	<0.3
mg/m^3	0.6	1.1	2.0	2.7	0.0	<0.2
gr/dscf	0.0003	0.001	0.001	0.002	0.000	<0.0001
Back-half catch						
Sulfuric acid mist						
mg	13.7	14.4	8.7	54.8[b]		10.7
mg/m^3	9.8	8.1	5.1	30.6		6.4
gr/dscf	0.004	0.004	0.002	0.013		0.003
ppm	2	2	1	8		2
Sulfur dioxide						
mg	120.8	159.4	155.0	131.8		152.8
mg/m^3	86.3	89.6	90.6	73.6		91.0
gr/dscf	0.038	0.039	0.040	0.032		0.040
ppm	32	34	34	28		34
Inorganic condensibles						
mg					152.6	
mg/m^3					82.9	
gr/dscf					0.036	
Organic condensibles						
mg					0.8	
mg/m^3					0.43	
gr/dscf					0.0002	
Total organic carbon						
mg					8.6	
mg/m^3					4.7	
gr/dscf					0.002	

[a]Acetone rinse contaminated with oil.

[b]Hydrogen peroxide contaminated.

TABLE 2-16. DCOG UNDERFIRING CONDITION, RUN NO. D3 TEST RESULTS (12/11/81)

	Test No.					
	D3.1	D3.2	D3.3	D3.4	D3.5	D3.6
Desired front-half temperature, °C (°F)	121 (250)	121 (250)	204 (400)	204 (400)	121 (250)	316 (600)
Actual average filter temperature, °C (°F)	120 (248)	132 (270)	211 (411)	204 (400)	123 (254)	280 (536)
Sequential heating, °C (°F)		204 (400)			316 (600)	
Front-half catch						
Particulate (ambient)						
mg	38.6	34.5	30.9	38.7	35.0	25.5
mg/m^3	26.1	21.3	22.1	26.9	19.6	14.8
gr/dscf	0.011	0.009	0.010	0.012	0.008	0.006
Acid soluble sulfate as $[H_2SO_4(H_2O)_2]$						
mg	0.4	2.5	0.0	2.6	0.0	0.0
mg/m^3	0.3	1.5	0.0	1.8	0.0	0.0
gr/dscf	0.0001	0.001	0.000	0.001	0.000	0.000
Water soluble sulfate as $[SO_4^=]$						
mg	6.0	0.0	4.1	0.8	0.9	2.2
mg/m^3	4.0	0.0	2.9	0.5	0.5	1.3
gr/dscf	0.002	0.000	0.002	0.0003	0.0002	0.001
Back-half catch						
Sulfuric acid mist						
mg	84.0[a]	7.0	12.0	8.2		12.8
mg/m^3	56.8	4.3	8.6	5.7		7.4
gr/dscf	0.025	0.002	0.004	0.002		0.003
ppm	14	1	2	1		2
Sulfur dioxide						
mg	90.1	152.8	130.8	143.4		169.1
mg/m^3	60.9	94.3	93.4	99.6		98.3
gr/dscf	0.026	0.041	0.041	0.043		0.043
ppm	23	35	35	37		37
Inorganic condensibles						
mg					28.9	
mg/m^3					16.1	
gr/dscf					0.007	
Organic condensibles						
mg					2.0	
mg/m^3					1.1	
gr/dscf					0.0005	
Total organic carbon						
mg					3.4	
mg/m^3					1.9	
gr/dscf					0.0008	

[a]Hydrogen peroxide contaminated.

TABLE 2-17. DCOG UNDERFIRING CONDITION, RUN NO. D4 TEST RESULTS (12/12/81)

	Test No.					
	D4.1	D4.2	D4.3	D4.4	D4.5	D4.6
Desired front-half temperature, °C (°F)	121 (250)	121 (250)	204 (400)	Void	121 (250)	316 (600)
Actual average filter temperature, °C (°F)	148 (299)	126 (259)	209 (409)		128 (263)	325 (617)
Sequential heating, °C (°F)		204 (400)			316 (600)	
Front-half catch						
Particulate (ambient)						
mg	28.5	45.2	24.8		31.2	17.5
mg/m^3	16.9	26.7	16.6		17.8	10.5
gr/dscf	0.007	0.012	0.007		0.008	0.004
Acid soluble sulfate as $[H_2SO_4(H_2O)_2]$						
mg	0.0	0.0	0.9		0.0	0.0
mg/m^3	0.0	0.0	0.6		0.0	0.0
gr/dscf	0.000	0.000	0.0003		0.000	0.000
Water soluble sulfate as $[SO_4^=]$						
mg	0.0	0.9	3.2		0.0	0.0
mg/m^3	0.0	0.5	2.1		0.0	0.0
gr/dscf	0.000	0.0002	0.001		0.000	0.000
Back-half catch						
Sulfuric acid mist						
mg	42.3[a]	15.9	6.7			74.7[a]
mg/m^3	25.0	9.4	4.5			44.7
gr/dscf	0.011	0.004	0.002			0.020
ppm	6	2	1			11
Sulfur dioxide						
mg	135.6	130.5	118.3			90.1
mg/m^3	80.2	77.2	79.4			54.0
gr/dscf	0.035	0.034	0.035			0.024
ppm	30	29	30			20
Inorganic condensibles						
mg					84.5	
mg/m^3					48.3	
gr/dscf					0.021	
Organic condensibles						
mg					2.9	
mg/m^3					1.6	
gr/dscf					0.0007	
Total organic carbon						
mg					8.5	
mg/m^3					4.8	
gr/dscf					0.002	

[a]Hydrogen peroxide contaminated.

TABLE 2-18. DCOG UNDERFIRING CONDITION, RUN NO. D5 TEST RESULTS (12/12/81)

	Test No.					
	D5.1	D5.2	D5.3	D5.4	D5.5	D5.6
Desired front-half temperature, °C (°F)	121 (250)	121 (250)	177 (350)	177 (350)	121 (250)	316 (600)
Actual average filter temperature, °C (°F)	123 (253)	127 (261)	181 (357)	177 (351)	122 (251)	316 (600)
Sequential heating, °C (°F)		177 (350)			316 (600)	
Front-half catch						
Particulate (ambient)						
mg	23.3	20.0	16.3	19.1	15.9	12.9
mg/m^3	13.4	11.5	10.4	11.9	9.4	8.0
gr/dscf	0.006	0.005	0.004	0.005	0.004	0.003
Acid soluble sulfate as $[H_2SO_4(H_2O)2]$						
mg	4.6	1.1	3.0	0.8	0.0	0.4
mg/m^3	2.6	0.6	1.9	0.5	0.0	0.2
gr/dscf	0.001	0.0003	0.001	0.0002	0.000	0.0001
Water soluble sulfate as $[SO_4^=]$						
mg	3.7	1.7	1.6	3.8	0.0	1.4
mg/m^3	2.1	1.0	1.0	2.4	0.0	0.9
gr/dscf	0.001	0.001	0.0004	0.001	0.000	0.0003
Back-half catch						
Sulfuric acid mist						
mg	8.8		7.8			8.2
mg/m^3	5.0		5.0			5.1
gr/dscf	0.002		0.002			0.002
ppm	1		1			1
Sulfur dioxide						
mg	131.8		123.6			129.0
mg/m^3	75.7		79.2			79.6
gr/dscf	0.033		0.035			0.035
ppm	28		30			30
Inorganic condensibles						
mg		74.5		158.1	15.6	
mg/m^3		42.8		98.8	9.2	
gr/dscf		0.019		0.043	0.004	
Organic condensibles						
mg		0.70		4.0	1.4	
mg/m^3		0.40		2.5	0.83	
gr/dscf		0.0002		0.001	0.0004	
Total organic carbon						
mg		202[a]		572[a]	3.6	
mg/m^3		116		357	2.1	
gr/dscf		0.050		0.156	0.0009	

[a]Contaminated with isopropanol.

TABLE 2-19. DCOG UNDERFIRING CONDITION, RUN NO. D6 TEST RESULTS (12/13/81)

	Test No.					
	D6.1	D6.2	D6.3	D6.4	D6.5	D6.6
Desired front-half temperature, °C (°F)	121 (250)	121 (250)	204 (400)	204 (400)	121 (250)	316 (600)
Actual average filter temperature, °C (°F)	132 (270)	120 (248)	204 (399)	219 (427)	131 (267)	319 (607)
Sequential heating, °C (°F)		204 (400)			316 (600)	
Front-half catch						
Particulate (ambient)						
mg	12.2	21.1	15.6	12.0	19.9	9.2
mg/m^3	7.8	13.5	10.8	8.0	10.9	6.3
gr/dscf	0.003	0.006	0.005	0.004	0.005	0.003
Acid soluble sulfate as $[H_2SO_4(H_2O)_2]$						
mg	0.0	0.0	1.4	0.0	0.0	0.3
mg/m^3	0.0	0.0	1.0	0.0	0.0	0.2
gr/dscf	0.000	0.000	0.0004	0.000	0.000	0.0001
Water soluble sulfate as $[SO_4^=]$						
mg	0.0	0.0	0.0	0.0	0.0	0.0
mg/m^3	0.0	0.0	0.0	0.0	0.0	0.0
gr/dscf	0.000	0.000	0.000	0.000	0.000	0.000
Back-half catch						
Sulfuric acid mist						
mg	13.2		7.5			11.4
mg/m^3	8.5		5.2			7.9
gr/dscf	0.004		0.002			0.003
ppm	2		1			2
Sulfur dioxide						
mg	118.3		113.3			110.1
mg/m^3	75.8		78.1			75.9
gr/dscf	0.033		0.034			0.033
ppm	28		29			28
Inorganic condensibles						
mg		55.2		144.2	10.0	
mg/m^3		35.4		96.8	5.5	
gr/dscf		0.015		0.042	0.002	
Organic condensibles						
mg		2.4		2.8	2.4	
mg/m^3		1.5		1.9	1.3	
gr/dscf		0.0007		0.0008	0.0006	
Total organic carbon						
mg		403[a]		77[a]	8.0	
mg/m^3		258		51.7	4.4	
gr/dscf		0.113		0.022	0.002	

[a]Contaminated with isopropanol.

No water soluble sulfates were found on NCOG filters and acetone rinse residues. Figures 2-1 and 2-2 present graphs plotting particulate concentration versus average filter temperature for NCOG and DCOG underfiring, respectively. A line of best fit was determined for each data set by a least-squares linear regression calculation. Performance of this calculation, showed that the NCOG data more accurately depicted a bimodal line of best fit. Figure 2-3 presents the NCOG and DCOG best fit lines for particulate concentration versus average filter temperature.

Analytical results obtained from Sampling Trains 1 and 2 [121°C (250°F) front-half temperature], Sampling Trains 3 and 4 [177°C (350°F) or 204°C (400°F) front-half temperature], Sampling Train 5 [121°C (250°F) front-half temperature], and Sampling Train 6 [316°C (600°F) front-half temperature] are presented in Tables 2-20, 2-21, 2-22, and 2-23 for the NCOG underfiring test series and Tables 2-24, 2-25, 2-26, and 2-27 for the DCOG underfiring test series, respectively.

Visible emissions observations and process data collected during particulate testing are presented in Sections 2.5 and 2-10 of this report.

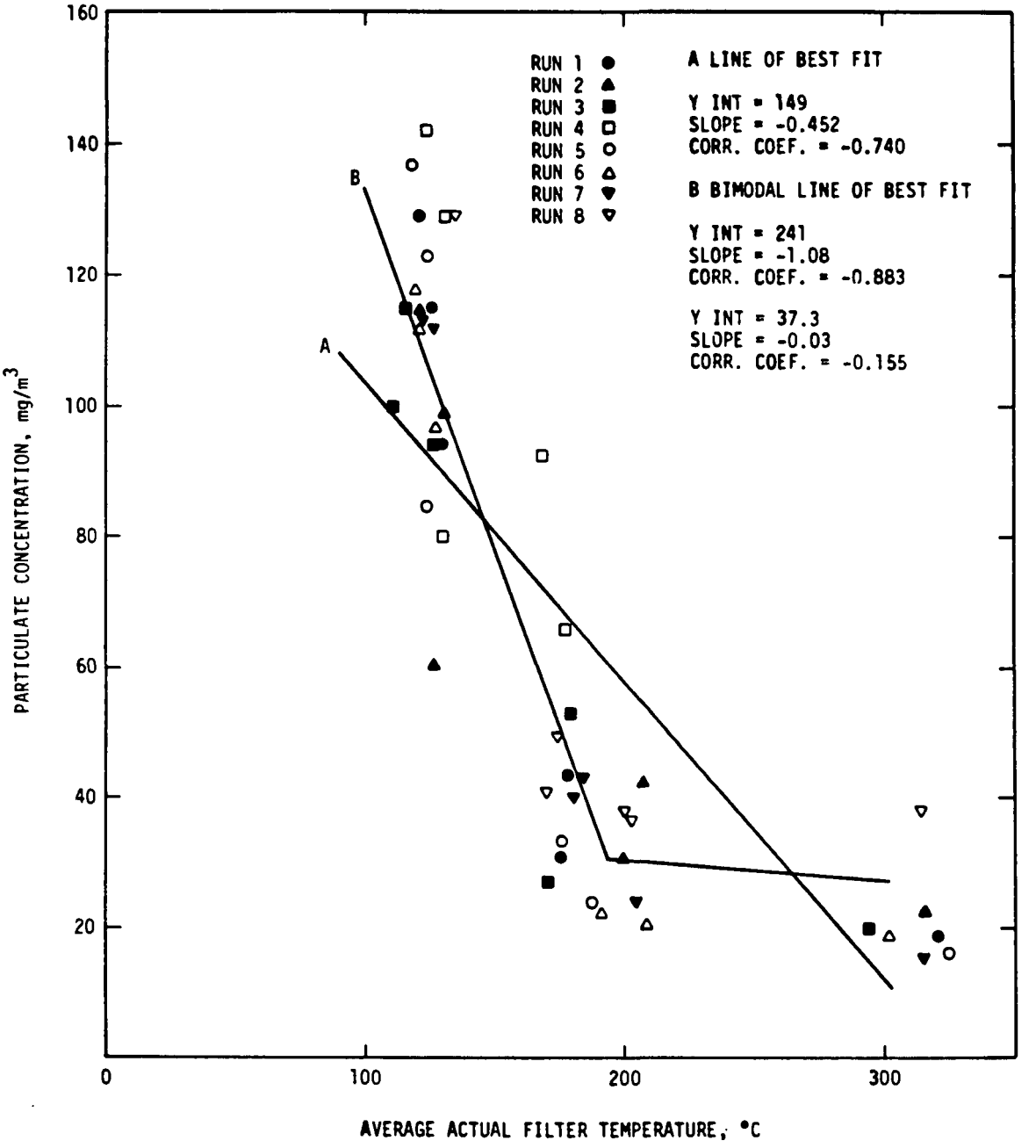


Figure 2-1. Particulate concentration vs. average actual filter temperature during NCOG underfiring.

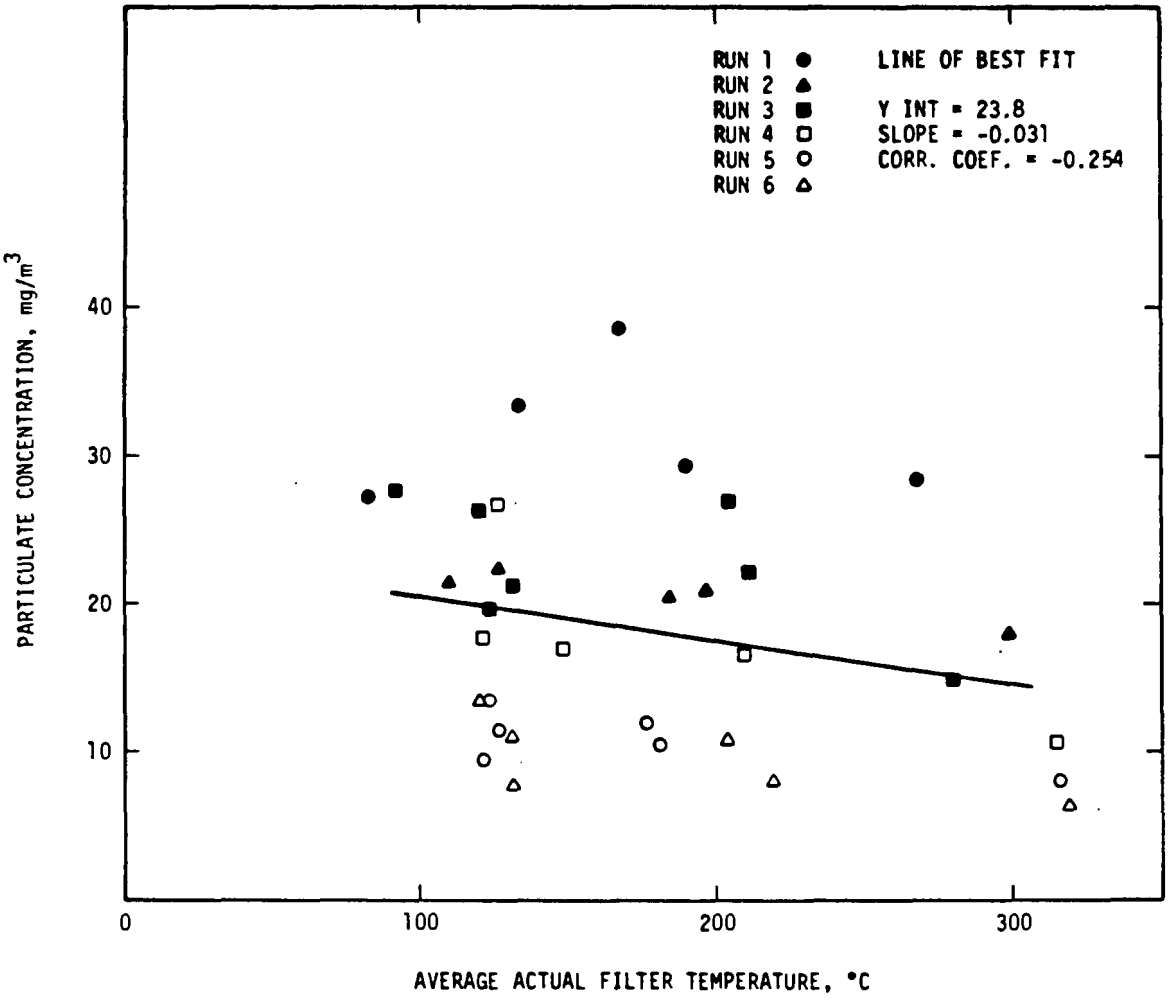


Figure 2-2. Particulate concentration vs. average actual filter temperature during DCOG underfiring.

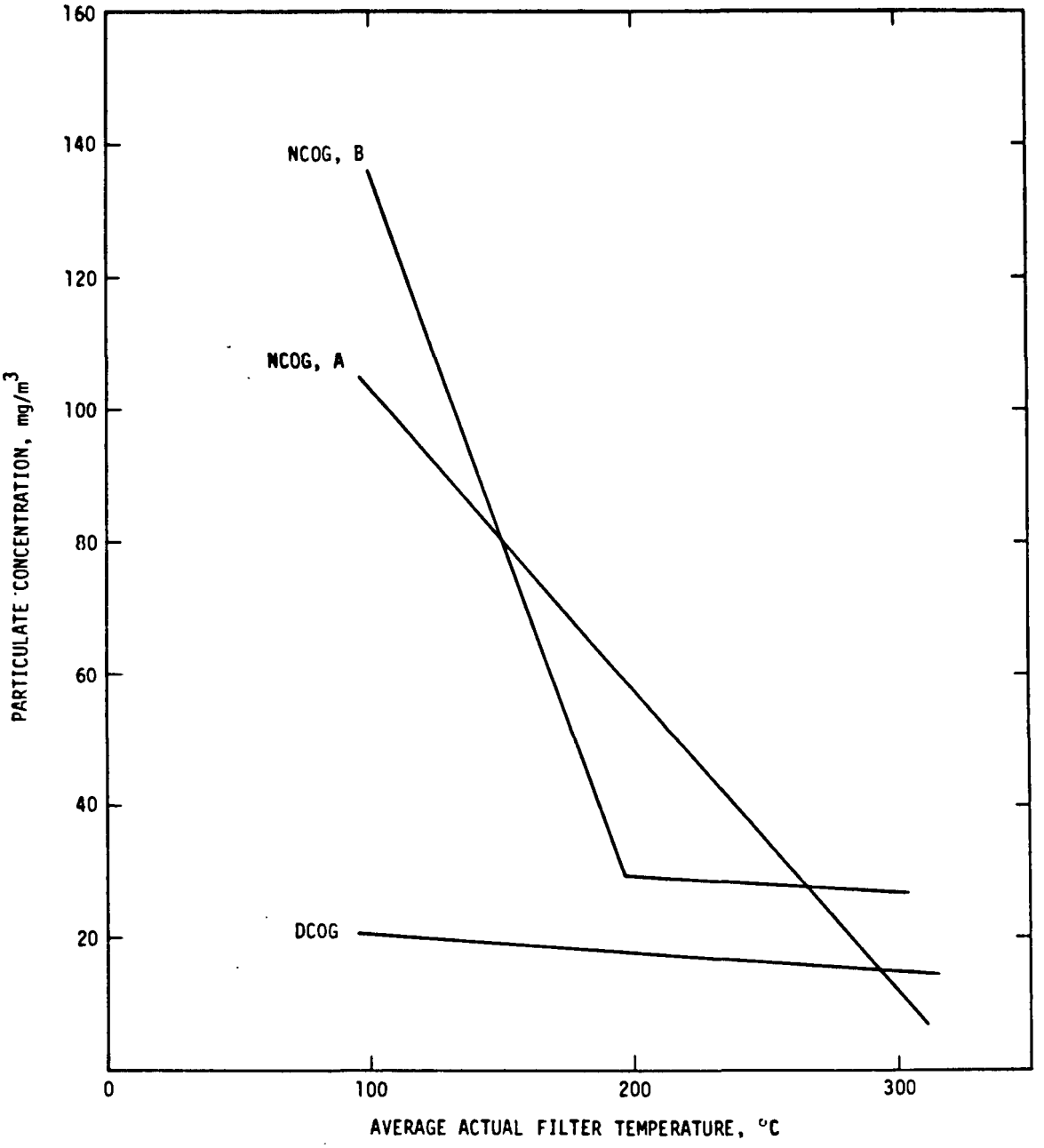


Figure 2-3. Summary of best-fit lines from particulate concentration vs. average actual filter temperature for NCOG and DCOG underfiring.

TABLE 2-20. NCOG UNDERFIRING CONDITION, TRAINS 1 AND 2 OF QUAD TRAIN [121°C (250°F) FRONT HALF]

	Test No.																	
	1.1	1.2		3.1	3.2		5.1	5.2		2.1	2.2		4.1	4.2		6.1	6.2	
Date (1981)	10/27	10/27		10/28	10/28		10/29	10/29		10/27	10/27		10/28	10/28		10/29	10/29	
Actual average filter temperature, °C (°F)	122 (252)	125 (257)		113 (236)	127 (260)		124 (255)	123 (254)		119 (247)	128 (263)		123 (254)	130 (266)		119 (246)	126 (258)	
Sequential heating (2 hours), °C (°F)		Amb.	177 (350)		Amb.	177 (350)		Amb.	177 (350)		Amb.	204 (400)		Amb.	204 (400)		Amb.	204 (400)
Front-half catch																		
Particulate (ambient)																		
mg	226.9	192.8	55.2	202.0	156.9	34.2	138.6	185.6	36.8	183.1	149.2	24.8	139.9	113.2	41.7	184.1	150.8	24.2
mg/m^3	128.9	115.4	33.0	115.4	94.5	20.6	84.5	123.7	24.5	115.2	99.5	16.5	141.3	128.6	47.4	112.2	97.9	15.7
gr/dscf	0.056	0.050	0.014	0.050	0.041	0.009	0.037	0.054	0.011	0.050	0.044	0.007	0.062	0.056	0.021	0.049	0.043	0.007
% loss	-	-	72	-	-	78	-	-	80	-	-	84	-	-	62	-	-	84
Acid soluble sulfate as [H_2SO_4]																		
mg	81.5	-	7.4	70.4	-	0.0	85.6	-	3.0	61.6	-	0.0	47.5	-	0.4	71.0	-	0.0
mg/m^3	46.3		4.4	40.2		0.0	52.2		2.0	38.7		0.0	47.9		0.4	43.3	-	0.0
gr/dscf	0.020		0.002	0.017		0.000	0.023		0.0008	0.017		0.000	0.021		0.0002	0.019		0.000
as [$H_2SO_4(H_2O)_2$]																		
mg	111.4	-	10.1	96.2	-	0.0	117.0	-	4.1	84.2	-	0.0	64.9	-	0.5	97.0	-	0.0
mg/m^3	63.3		6.1	55.0		0.0	71.3		2.7	53.0		0.0	65.6		0.6	59.6		0.0
gr/dscf	0.028		0.003	0.024		0.000	0.031		0.004	0.023		0.000	0.029		0.0002	0.026		0.000
Back-half catch																		
Sulfuric acid mist																		
mg	8.9	9.4		3.3	8.6		34.4	-		741[a]	16.0		11.5	11.9		24.0	-	
mg/m^3	5.0	5.6		4.7	5.2		21.0			466	10.7		11.6	13.5		14.6		
gr/dscf	0.002	0.002		0.002	0.002		0.009			0.204	0.005		0.005	0.006		0.006		
Sulfur dioxide																		
mg	1960	1850		1790	1540		2070	-		1370	1720		1300	1170		2000	-	
mg/m^3	1114	1108		1023	928		1262			862	1147		1313	1329		1219		
gr/dscf	0.486	0.484		0.446	0.406		0.550			0.377	0.502		0.577	0.584		0.532		
ppm	419	416		384	349		474			324	431		494	500		458		
Inorganic condensibles																		
mg	-	-		-	-		-	19.0		-	-		-	-		-	109.7	
mg/m^3								12.7									71.2	
gr/dscf								0.006									0.031	
Organic condensibles																		
mg	-	-		-	-		-	4.2		-	-		-	-		-	4.0	
mg/m^3								2.8									2.6	
gr/dscf								0.001									0.001	
Total organic carbon																		
mg	-	-		-	-		-	58.1		-	-		-	-		-	42.3	
mg/m^3								38.7									27.5	
gr/dscf								0.017									0.012	

[a]Hydrogen peroxide contaminated.

TABLE 2-21. NCOG UNDERFIRING CONDITION, TRAINS 3 AND 4 OF QUAD TRAIN [121°C (250°F) AND 204°C (400°F) FRONT HALF]

	177°C (350°F)						204°C (400°F)					
Test No.	1.3	1.4	3.3	3.4	5.3	5.4	2.3	2.4	4.3	4.4	6.3	6.4
Date (1981)	10/27	10/27	10/28	10/28	10/29	10/29	10/27	10/27	10/28	10/28	10/29	10/29
Actual average filter temperature, °C (°F)	170 (338)	169 (336)	178 (353)	169 (336)	176 (349)	186 (366)	198 (389)	207 (404)	177 (350)	169 (337)	193 (379)	208 (407)
Front-half catch												
Particulate (ambient)												
mg	72.9	50.6	87.3	40.3	50.5	32.1	46.3	61.3	61.1	78.4	34.3	26.9
mg/m^3	43.4	30.8	53.6	25.5	33.0	22.4	31.7	42.6	65.7	92.2	22.6	20.8
gr/dscf	0.019	0.013	0.023	0.011	0.014	0.010	0.014	0.019	0.028	0.040	0.010	0.009
Acid soluble sulfate as $[H_2SO_4]$												
mg	9.8	4.7	25.3	3.7	9.5	0.0	12.2	14.4	6.4	12.6	2.8	0.0
mg/m^3	5.8	2.9	15.5	2.3	6.2	0.0	3.3	10.0	6.9	14.8	1.8	0.0
gr/dscf	0.002	0.001	0.007	0.001	0.003	0.000	0.004	0.004	0.003	0.006	0.0008	0.000
as $[H_2SO_4(H_2O)_2]$												
mg	13.4	6.4	34.6	5.0	13.0	0.0	16.7	19.7	8.7	17.2	3.8	0.0
mg/m^3	8.0	3.9	21.2	3.2	8.5	0.0	11.4	13.7	9.4	20.3	2.5	0.0
gr/dscf	0.003	0.002	0.009	0.001	0.004	0.000	0.005	0.006	0.004	0.009	0.001	0.000
Back-half catch												
Sulfuric acid mist												
mg	65.4	56.0	67.2	89.2	81.5	-	53.0	19.6	29.8	10.4	97.6	-
mg/m^3	38.9	34.1	41.2	56.4	53.3		36.3	13.6	32.0	12.2	64.2	
gr/dscf	0.017	0.015	0.018	0.025	0.023		0.016	0.006	0.014	0.005	0.028	
Sulfur dioxide												
mg	1870	1810	1680	1620	1970	-	1700	1610	1250	1160	1900	-
mg/m^3	1113	1104	1031	1025	1288		1164	1118	1344	1365	1250	
gr/dscf	0.487	0.482	0.450	0.448	0.564		0.509	0.489	0.585	0.596	0.546	
ppm	418	415	387	385	484		438	420	505	513	470	
Inorganic condensibles												
mg	-	-	-	-	-	101.2	-	-	-	-	-	118.3
mg/m^3						70.8						91.7
gr/dscf						0.031						0.040
Organic condensibles												
mg	-	-	-	-	-	3.2	-	-	-	-	-	5.9
mg/m^3						2.2						4.6
gr/dscf						0.001						0.002
Total organic carbon												
mg carbon	-	-	-	-	-	49.2	-	-	-	-	-	154[a]
mg/m^3						34.4						119.4
gr/dscf						0.015						0.052

[a]Isopropanol contaminated.

TABLE 2-22. NCOG UNDERFIRING CONDITION, TRAIN 5 [121°C (250°F) FRONT HALF]

	Test No. 1.5 (10/27/81)							Test No. 2.5 (10/27/81)						
Actual average filter temperature, °C (°F)	128 (263)							125 (257)						
Front-half catch														
Filter half designation	A						B	A						B
Sequential heating, °C (°F)	Amb.	177 (350)	177 (350)	204 (400)	204 (400)	316 (600)		Amb.	177 (350)	177 (350)	204 (400)	204 (400)	316 (600)	
Heating time, h		2	4	2	4	2			2	4	2	4	2	
Particulate (ambient)														
mg	135.3	47.5	41.7	37.3	34.5	30.5		90.9	34.0	30.7	29.2	27.7	22.5	
mg/m^3	94.0	33.0	29.0	25.9	24.0	21.2		60.6	22.7	20.5	19.5	18.5	15.0	
gr/dscf	0.041	0.014	0.013	0.011	0.010	0.009		0.026	0.010	0.009	0.008	0.008	0.006	
% difference[b]	-	66	68	73	76	78		-	62	62	69	69	77	
Acid sulfates						ND[c]							ND	
Total organic carbon							ND							ND
Back-half catch														
Inorganic condensibles														
mg	28.2							68.2						
mg/m^3	19.6							45.5						
gr/dscf	0.008							0.020						
Organic condensibles														
mg	2.6							4.8						
mg/m^3	1.8							3.2						
gr/dscf	0.001							0.001						
Total organic carbon														
mg carbon	23.4							44.3						
mg/m^3	16.2							29.5						
gr/dscf	0.007							0.013						

TABLE 2-22 (continued)

	Test No. 3.5 (10/28/81)							Test No. 4.5 (10/28/81)						
Actual average filter temperature, °C (°F)	109 (229)							130 (266)						
Front-half catch														
Filter half designation	A						B	A						B
Sequential heating, °C (°F)	Amb.	177 (350)	177 (350)	204 (400)	204 (400)	316 (600)		Amb.	177 (350)	177 (350)	204 (400)	204 (400)	316 (600)	
Heating time, h		2	4	2	4	2			2	4	2	4	2	
Particulate (ambient)														
mg	171.2	29.0	26.8	26.2	25.2	22.0		174.5	137.3	128.8	112.4	104.7	99.0	
mg/m^3	99.5	16.9	15.6	15.2	14.6	12.8		80.0	63.0	59.1	51.6	48.0	45.4	
gr/dscf	0.043	0.007	0.007	0.007	0.006	0.006		0.035	0.028	0.026	0.022	0.021	0.020	
% differenceb	-	84	84	84	86	86		-	20	26	37	40	43	
Acid sulfates						ND							ND	
Total organic carbon							ND							ND
Back-half catch														
Inorganic condensibles														
mg	99.1							65.7						
mg/m^3	57.6							30.1						
gr/dscf	0.025							0.013						
Organic condensibles														
mg	3.2							3.1						
mg/m^3	1.9							1.4						
gr/dscf	0.001							0.001						
Total organic carbon														
mg carbon	77.3							14.3						
mg/m^3	44.9							6.6						
gr/dscf	0.020							0.003						

TABLE 2-22 (continued)

	Test No. 5.5 (10/29/81)							Test No. 6.5 (10/29/81)						
Actual average filter temperature, °C (°F)	116 (240)							119 (246)						
Front-half catch														
Filter half designation	A						B	A						B
Sequential heating, °C (°F)	Amb.	177 (350)	177 (350)	204 (400)	204 (400)	316 (600)		Amb.	177 (350)	177 (350)	204 (400)	204 (400)	316 (600)	
Heating time, h		2	4	2	4	2			2	4	2	4	2	
Particulate (ambient)														
mg	221.0	50.4	44.2	36.2	32.3	27.7		195.7	42.3	37.6	33.2	30.3	25.8	
mg/m^3	137.3	31.3	27.4	22.5	20.1	17.2		118.6	25.6	22.8	20.1	18.4	15.6	
gr/dscf	0.060	0.014	0.012	0.010	0.009	0.008		0.052	0.011	0.010	0.009	0.008	0.007	
% difference[b]	-	77	80	83	85	87		-	79	81	83	85	86	
Acid sulfates						ND							ND	
Total organic carbon							ND							ND
Back-half catch														
Inorganic condensibles														
mg	20.9							20.0						
mg/m^3	13.0							12.1						
gr/dscf	0.006							0.005						
Organic condensibles														
mg	6.3							6.4						
mg/m^3	3.9							3.9						
gr/dscf	0.002							0.002						
Total organic carbon														
mg carbon	11.8							15.2						
mg/m^3	7.3							9.2						
gr/dscf	0.003							0.004						

[a]All weights corrected to entire filter catch.

[b]Calculated from concentration.

[c]ND = Not detectable, sample response equaled blank response.

TABLE 2-23. NCOG UNDERFIRING CONDITION, TRAIN 6
[316°C (600°F) FRONT HALF]

	Test No.					
	1.6	2.6	3.6	4.6	5.6	6.6
Date (1981)	10/27	10/27	10/28	10/28	10/29	10/29
Actual average filter temperature, °C (°F)	320 (608)	316 (600)	293 (560)	328 (622)	324 (616)	302 (576)
Front-half catch						
Particulate (ambient)						
mg	27.0	39.5	36.0	69.7	24.9	30.9
mg/m^3	19.0	23.9	19.6	62.8	16.2	19.6
gr/dscf	0.008	0.010	0.008	0.027	0.007	0.008
Acid soluble sulfate as $[H_2SO_4]$						
mg	0.0	2.6	4.2	0.0	0.0	0.0
mg/m^3	0.0	1.6	2.3	0.0	0.0	0.0
gr/dscf	0.000	0.001	0.001	0.000	0.000	0.000
as $[H_2SO_4(H_2O)_2]$						
mg	0.0	3.5	5.7	0.0	0.0	0.0
mg/m^3	0.0	2.1	3.1	0.0	0.0	0.0
gr/dscf	0.000	0.001	0.001	0.000	0.000	0.000
Back-half catch						
Sulfuric acid mist						
mg	606[a]	157	164	73.7	129	115
mg/m^3	426.8	95.7	89.1	66.4	83.8	72.8
gr/dscf	0.187	0.041	0.039	0.029	0.036	0.032
Sulfur dioxide						
mg	1120	1940	1720	1550	2050	2010
mg/m^3	789	1176	935	1396	1331	1272
gr/dscf	0.346	0.512	0.408	0.611	0.581	0.555
ppm	296	442	351	525	500	478

[a]Hydrogen peroxide contaminated.

TABLE 2-24. DCOG UNDERFIRING CONDITION, TRAINS 1 AND 2 OF QUAD TRAIN [121°C (250°F) FRONT HALF]

	Test No.																			
	D1.1	D1.2		D2.1	D2.2		D5.1	D5.2		D3.1	D3.2		D4.1	D4.2		D6.1	D6.2			
Date (1981)	12/8	12/8		12/10	12/10		12/12	12/12		12/11	12/11		12/12	12/12		12/13	12/13			
Actual average filter temperature, °C (°F)	119 (246)	133 (272)		118 (244)	109 (229)		123 (253)	127 (261)		120 (248)	132 (270)		148 (299)	126 (259)		132 (270)	120 (248)			
Sequential heating (2 hours), °C (°F)	316 (600)	Amb.	177 (350)		Amb.	177 (350)		Amb.	177 (350)		Amb.	204 (400)		Amb.	204 (400)		Amb.	204 (400)		
Front-half catch																				
Particulate (ambient)																				
mg	32.6	37.4	22.0	249.9	38.3	24.6	23.3	20.0	8.7	38.6	34.5	18.1	28.5	45.2	13.5	12.2	21.1	5.4		
mg/m^3	26.1	33.4	19.6	178.5	21.5	13.8	13.4	11.5	5.0	26.1	21.3	11.2	16.9	26.7	8.0	7.8	13.5	3.5		
gr/dscf	0.011	0.014	0.008	0.078	0.009	0.006	0.006	0.005	0.002	0.011	0.009	0.005	0.007	0.012	0.003	0.003	0.006	0.001		
% loss	-	-	41	-	-	36	-	-	56	-	-	47	-	-	70	-	-	74		
Acid soluble sulfate as $[H_2SO_4(H_2O)_2]$																				
mg	0.0	-	2.7	1.4	-	3.5	4.6	-	1.1	0.4	-	2.5	0.0	-	0.0	0.0	-	0.0		
mg/m^3	0.0		2.4	1.0		2.0	2.6		0.6	0.3		1.5	0.0		0.0	0.0		0.0		
gr/dscf	0.000		0.001	0.0004		0.001	0.001		0.0003	0.0001		0.001	0.000		0.000	0.000		0.000		
Water soluble sulfate as $[SO_4^=]$																				
mg	<0.3	-	2.1	0.9	-	2.0	3.7	-	1.7	6.0	-	0.0	0.0	-	0.9	0.0	-	0.0		
mg/m3	<0.2		1.9	0.6		1.1	2.1		1.0	4.0		0.0	0.0		0.5	0.0		0.0		
gr/dscf	<0.004		0.001	0.0003		0.001	0.001		0.001	0.002		0.000	0.000		0.0002	0.000		0.000		
Back-half catch																				
Sulfuric acid mist																				
mg	115[b]	3.5		13.7	14.4		8.8	-		84.0[b]	7.0		42.3[b]	15.9		13.2	-			
mg/m^3	92	3.1		9.8	8.1		5.0			56.8	4.3		25.0	9.4		8.5				
gr/dscf	0.040	0.001		0.004	0.004		0.002			0.025	0.002		0.011	0.004		0.004				
Sulfur dioxide																				
mg	69.7	116.1		120.8	159.4		131.8	-		90.1	152.8		135.6	130.5		118.3	-			
mg/m^3	55.8	103.7		86.3	89.6		75.7			60.9	94.3		80.2	77.2		75.8				
gr/dscf	0.024	0.045		0.038	0.039		0.033			0.026	0.041		0.035	0.034		0.033				
ppm	21	39		32	34		28			23	35		30	30		28				
Inorganic condensibles																				
mg	-	-		-	-		-	74.5		-	-		-	-		-	55.2			
mg/m^3								42.8									35.4			
gr/dscf								0.019									0.015			
Organic condensibles																				
mg	-	-		-	-		-	0.70		-	-		-	-		-	2.4			
mg/m^3								0.40									1.5			
gr/dscf								0.0002									0.0007			
Total organic carbon																				
mg carbon	-	-		-	-		-	202[c]		-	-		-	-		-	403[c]			
mg/m^3								116									258			
gr/dscf								0.050									0.113			

[a]Acetone rinse contaminated with oil.

[b]Hydrogen peroxide contaminated.

[c]Isopropanol contaminated.

TABLE 2-25. DCOG UNDERFIRING CONDITION, TRAINS 3 AND 4 OF QUAD TRAIN [177°C (350°F) AND 204°C (400°F) FRONT HALF]

	177°C (350°F)						204°C (400°F)					
Test No.	01.3	D1.4	02.3	D2.4	D5.3	05.4	D3.3	03.4	D4.3	D4.4	D6.3	D6.4
Date (1981)	12/8	12/8	12/10	12/10	12/12	12/12	12/11	12/11	12/12	Void run	12/13	12/13
Actual average filter temperature, °C (°F)	190 (374)	167 (333)	184 (363)	197 (387)	181 (357)	177 (351)	211 (411)	204 (400)	209 (409)		204 (399)	219 (427)
Front-half catch												
Particulate (ambient)												
mg	34.0	43.3	34.8	37.2	16.3	19.1	30.9	38.7	24.8		15.6	12.0
mg/m^3	29.3	38.7	20.4	20.8	10.4	11.9	22.1	26.9	16.6		10.8	8.0
gr/dscf	0.013	0.017	0.009	0.009	0.004	0.005	0.010	0.012	0.007		0.005	0.004
Acid soluble sulfate as $[H_2SO_4(H_2O)_2]$												
mg	0.0	0.0	0.8	0.5	3.0	0.8	0.0	2.6	0.9		1.4	0.0
mg/m^3	0.0	0.0	0.5	0.3	1.9	0.5	0.0	1.8	0.6		1.0	0.0
gr/dscf	0.000	0.000	0.0001	0.0001	0.001	0.0002	0.000	0.001	0.0003		0.0004	0.000
Water soluble sulfate as $[SO_4^=]$												
mg	2.5	0.0	3.5	4.8	1.6	3.8	4.1	0.8	3.2		0.0	0.0
mg/m^3	2.1	0.0	2.0	2.7	1.0	2.4	2.9	0.5	2.1		0.0	0.0
gr/dscf	0.001	0.000	0.001	0.002	0.0004	0.001	0.002	0.0003	0.001		0.000	0.000
Back-half catch												
Sulfuric acid mist												
mg	9.3	9.2	8.7	54.8[a]	7.8	-	12.0	8.2	6.7		7.5	-
mg/m^3	8.0	8.2	5.1	30.6	5.0		8.6	5.7	4.5		5.2	
gr/dscf	0.004	0.004	0.002	0.013	0.002		0.004	0.002	0.002		0.002	
Sulfur dioxide												
mg	117.0	115.8	155.0	131.8	123.6	-	130.8	143.4	118.3		113.3	-
mg/m^3	100.9	113.4	90.6	73.6	79.2		93.4	99.6	79.4		78.1	
gr/dscf	0.044	0.045	0.040	0.032	0.035		0.041	0.043	0.035		0.034	
ppm	38	39	34	28	30		35	37	30		29	
Inorganic condensibles												
mg	-	-	-	-	-	158.1	-	-	-		-	144.2
mg/m^3						98.8						96.8
gr/dscf						0.043						0.042
Organic condensibles												
mg	-	-	-	-	-	4.0	-	-	-		-	2.8
mg/m^3						2.5						1.9
gr/dscf						0.001						0.0008
Total organic carbon												
mg carbon	-	-	-	-	-	572[b]	-	-	-		-	77[b]
mg/m^3						357						51.7
gr/dscf						0.156						0.022

[a] Hydrogen peroxide contaminated.

[b] Isopropanol contaminated.

TABLE 2-26. DCOG UNDERFIRING CONDITION, TRAIN 5 [121°C (250°F) FRONT HALF]

	Test No. D1.1 (12/8/81)							Test No. D2.5 (12/10/81)						
Actual average filter temperature, °C (°F)	119 (246)							126 (258)						
Front-half catch														
Filter half designation	A						B	A						B
Sequential heating, °C (°F)	Amb.	177 (350)	177 (350)	204 (400)	204 (400)	316 (600)		Amb.	177 (350)	177 (350)	204 (400)	204 (400)	316 (600)	
Heating time, h		2	4	2	4	2			2	4	2	4	2	
Particulate (ambient)														
mg	32.6	21.8	21.1	16.8	16.4	14.6		41.1	23.4	19.2	18.8	17.7	15.1	
mg/m^3	26.1	17.4	16.9	13.4	13.1	11.7		22.3	12.7	10.4	10.2	9.6	8.2	
gr/dscf	0.011	0.008	0.007	0.006	0.006	0.005		0.010	0.005	0.004	0.004	0.004	0.003	
% difference[b]	-	33	35	49	50	55		-	43	53	54	57	63	
Acid sulfates as $[H_2SO_4(H_2O)_2]$														
mg	0.0							0.0						
mg/m^3	0.0							0.0						
gr/dscf	0.000							0.000						
Water soluble sulfate as $[SO_4^=]$														
mg	<0.3							0.0						
mg/m^3	<0.2							0.0						
gr/dscf	<0.0001							0.000						
Total organic carbon							ND[c]							ND
Back-half catch														
Inorganic condensibles														
mg	N/A[d]							152.6						
mg/m^3								82.9						
gr/dscf								0.036						
Organic condensibles														
mg	N/A							0.8						
mg/m^3								0.4						
gr/dscf								0.0002						
Total organic carbon														
mg carbon	N/A							8.6						
mg/m^3								4.7						
gr/dscf								0.002						

TABLE 2-26 (continued)

	Test No. D3.5 (12/11/81)							Test No. D4.5 (12/12/81)						
Actual average filter temperature, °C (°F)	123 (254)							128 (263)						
Front-half catch														
Filter half designation	A						B	A						B
Sequential heating, °C (°F)	Amb.	177 (350)	177 (350)	204 (400)	204 (400)	316 (600)		Amb.	177 (350)	177 (350)	204 (400)	204 (400)	316 (600)	
Heating time, h		2	4	2	4	2			2	4	2	4	2	
Particulate (ambient)														
mg	35.0	22.2	19.9	15.7	15.7	13.4		31.2	21.7	20.2	15.1	14.9	12.3	
mg/m^3	19.6	12.4	11.1	8.8	8.8	7.5		17.8	12.4	11.5	8.6	8.5	7.0	
gr/dscf	0.008	0.005	0.005	0.004	0.004	0.003		0.008	0.005	0.005	0.004	0.004	0.005	
% difference[b]	-	37	43	55	55	62		-	34	35	52	52	61	
Acid suifates as $[H_2SO_4(H_2O)_2]$														
mg	0.0							0.0						
mg/m^3	0.0							0.0						
gr/dscf	0.000							0.000						
Water soluble sulfate as $[SO_4^=]$														
mg	0.9							0.0						
mg/m^3	0.5							0.0						
gr/dscf	0.0002							0.000						
Total organic carbon							ND							ND
Back-half catch														
Inorganic condensibles														
mg	28.9							84.5						
mg/m^3	16.1							48.3						
gr/dscf	0.007							0.021						
Organic condensibles														
mg	2.0							2.9						
mg/m^3	1.1							1.6						
gr/dscf	0.0005							0.0007						
Total organic carbon														
mg carbon	3.4							8.5						
mg/m^3	1.9							4.8						
gr/dscf	0.0008							0.002						

TABLE 2-26 (continued)

	Test No. D5.5 (12/12/81)							Test No. D6.5 (12/13/81)						
Actual average filter temperature, °C (°F)	122 (251)							131 (267)						
Front-half catch														
Filter half designation	A						B	A						B
Sequential heating, °C (°F)	Amb.	177 (350)	177 (350)	204 (400)	204 (400)	316 (600)		Amb.	177 (350)	177 (350)	204 (400)	204 (400)	316 (600)	
Heating time, h		2	4	2	4	2			2	4	2	4	2	
Particulate (ambient)														
mg	15.9	6.9	5.3	4.5	4.5	2.4		19.9	13.6	12.8	11.5	11.3	4.4	
mg/m^3	9.4	4.1	3.1	2.7	2.7	1.4		10.9	7.4	7.0	6.3	6.2	2.4	
gr/dscf	0.004	0.002	0.001	0.001	0.001	0.001		0.005	0.003	0.003	0.003	0.003	0.001	
% difference[b]	-	56	67	71	71	85		-	32	26	42	43	78	
Acid sulfates as $[H_2SO_4(H_2O)_2]$														
mg	0.0							0.0						
mg/m^3	0.0							0.0						
gr/dscf	0.000							0.000						
Water soluble sulfate as $[SO_4^=]$														
mg	0.0							0.0						
mg/m^3	0.0							0.0						
gr/dscf	0.0002							0.000						
Total organic carbon							ND							ND
Back-half catch														
Inorganic condensibles														
mg	15.6							10.0						
mg/m^3	9.2							5.5						
gr/dscf	0.004							0.002						
Organic condensibles														
mg	1.4							2.4						
mg/m^3	0.8							1.3						
gr/dscf	0.0004							0.0006						
Total organic carbon														
mg carbon	3.6							8.0						
mg/m^3	2.1							4.4						
gr/dscf	0.0009							0.002						

[a]All weights corrected to entire filter catch.

[b]Calculated from concentration.

[c]ND = Not detectable, sample response similar to blank response.

[d]N/A = Not analyzed.

TABLE 2-27. DCOG UNDERFIRING CONDITION, TRAIN 6
[316°C (600°F) FRONT HALF]

	Test No.					
	D1.6	D2.6	D3.6	D4.6	D5.6	D6.6
Date (1981)	12/8	12/10	12/11	12/12	12/12	12/13
Actual average filter temperature, °C (°F)	268 (515)	298 (569)	280 (536)	325 (617)	316 (600)	319 (607)
Front-half catch						
Particulate (ambient)						
mg	27.3	30.3	25.5	17.5	12.9	9.2
mg/m^3	28.4	18.0	14.8	10.5	8.0	6.3
gr/dscf	0.012	0.008	0.006	0.004	0.003	0.003
Acid soluble sulfate as $[H_2SO_4(H_2O)_2]$						
mg	0.0	< 0.4	0.0	0.0	0.4	0.3
mg/m^3	0.0	< 0.3	0.0	0.0	0.2	0.2
gr/dscf	0.000	< 0.0001	0.000	0.000	0.0001	0.0001
Water soluble sulfate as $[SO_4^=]$						
mg	1.6	< 0.3	2.2	0.0	1.4	0.0
mg/m^3	1.7	< 0.2	1.3	0.0	1.9	0.0
gr/dscf	0.001	< 0.0001	0.001	0.000	0.0005	0.000
Back-half catch						
Sulfuric acid mist						
mg	6.3	10.7	12.8	74.7[a]	8.2	11.4
mg/m^3	6.6	6.4	7.4	44.7	5.1	7.9
gr/dscf	0.003	0.003	0.003	0.020	0.002	0.003
Sulfur dioxide						
mg	97.9	152.8	169.1	90.1	129.0	110.1
mg/m^3	102.0	91.0	98.3	54.0	79.6	75.9
gr/dscf	0.044	0.040	0.043	0.024	0.035	0.033
ppm	38	34	37	20	30	28

[a]Hydrogen peroxide contaminated.

2.3 COMPARISON OF PARTICULATE RESULTS AT SELECTED TEMPERATURES

Selected particulate samples collected at a probe and filter temperature of approximately 121°C (250°F) were sequentially heated to determine weight loss at 177°C (350°F), 204°C (400°F), and 316°C (600°F). Tables 2-28 and 2-29 present the results from the sequential heating of the NCOG and DCOG samples, respectively. This data showed that more than half of the weight loss occurred when the sample was initially heated to 177°C (350°F). Therefore, a sample was sequentially heated in 14°C (25°F) increments to determine at what temperature the highest weight loss occurred. This data is presented in Table 2-30. Figures 2-4 and 2-5 present this data graphically.

Tables 2-31 through 2-33 present data comparing particulate concentrations determined from sampling at two different temperatures [177°C (350°F) versus 121°C (250°F), but analyzing after heat treatment at 177°C (350°F); 204°C (400°F) versus 121°C (250°F), but analyzed after heat treatment at 204°C (400°F); and 316°C (600°F) versus 121°C (250°F) but analyzing after treatment at 316°C (600°F)] for NCOG underfiring. Tables 2-34 through 2-36 present these data for DCOG underfiring.

TABLE 2-28. RESULTS OF SEQUENTIAL HEATING OF SELECTED NCOG UNDERFIRING TEST SERIES SAMPLES

Sequential heating		Particulate weight					
		Front-half rinse		Filter		Total	
Temperature, °C (°F)	Time, h	mg	% weight loss	mg	% weight loss	mg	% weight loss
Sampling Train 1.5							
Ambient	-	82.3	-	53.0	-	135.3	-
177 (350)	2	26.1	68	21.4	60	47.5	65
177 (350)	4	21.6	74	20.1	62	41.7	69
204 (400)	2	17.8	78	19.5	63	37.3	72
204 (400)	4	15.6	81	18.9	64	34.5	74
316 (600)	2	12.5	85	18.0	66	30.5	77
Sampling Train 2.5							
Ambient	-	62.8	-	28.1	-	90.9	-
177 (350)	2	18.4	71	15.6	44	34.0	63
177 (350)	4	15.5	75	15.2	46	30.7	66
204 (400)	2	14.4	77	14.8	47	29.2	68
204 (400)	4	13.3	79	14.4	49	27.7	69
316 (600)	2	10.3	83	12.2	56	22.5	75
Sampling Train 3.5							
Ambient	-	74.5	-	96.7	-	171.2	-
177 (350)	2	10.6	86	18.4	81	29.0	83
177 (350)	4	8.6	88	18.2	81	26.8	84
204 (400)	2	8.4	89	17.8	82	26.2	85
204 (400)	4	7.8	89	17.4	82	25.2	85
316 (600)	2	5.6	92	16.4	83	22.0	87
Sampling Train 4.5							
Ambient	-	59.8	-	114.7	-	174.5	-
177 (350)	2	34.8	42	102.5	11	137.3	21
177 (350)	4	29.8	50	99.0	14	128.8	26
204 (400)	2	22.4	62	90.0	21	112.4	35
204 (400)	4	16.8	72	87.9	23	104.7	40
316 (600)	2	14.0	77	85.0	26	99.0	43
Sampling Train 5.5							
Ambient	-	117.0	-	103.2	-	221.0	-
177 (350)	2	27.6	76	22.8	78	50.4	77
177 (350)	4	24.7	79	19.5	81	44.2	80
204 (400)	2	17.9	85	18.3	82	36.2	84
204 (400)	4	17.4	87	17.6	83	32.3	85
316 (600)	2	10.9	91	16.8	84	27.7	87
Sampling Train 6.5							
Ambient	-	108.1	-	87.6	-	195.7	-
177 (350)	2	28.6	73	13.7	84	42.3	78
177 (350)	4	25.9	76	11.7	87	37.6	81
204 (400)	2	21.9	80	11.3	87	33.2	83
204 (400)	4	19.8	82	10.5	88	30.3	84
316 (600)	2	16.5	85	9.3	89	25.8	87

TABLE 2-29. RESULTS OF SEQUENTIAL HEATING OF SELECTED DCOG UNDERFIRING TEST SERIES SAMPLES

Sequential heating		Particulate weight					
		Front-half rinse		Filter		Total	
Temperature, °C (°F)	Time, h	mg	% weight loss	mg	% weight loss	mg	% weight loss
Sampling Train D1.5							
Ambient	-	18.0	-	14.6	-	32.6	-
177 (350)	2	8.4	53	13.4	8	21.8	33
177 (350)	4	7.9	56	13.2	9	21.1	35
204 (400)	2	5.4	70	11.4	22	16.8	48
204 (400)	4	5.4	70	11.0	25	16.4	50
316 (600)	2	3.8	79	10.8	26	14.6	55
Sampling Train D2.5							
Ambient	-	24.4	-	16.7	-	41.1	-
177 (350)	2	11.0	55	12.4	26	23.4	43
177 (350)	4	9.3	62	9.9	41	19.2	53
204 (400)	2	8.9	63	9.9	41	18.8	54
204 (400)	4	8.0	67	9.7	42	17.7	57
316 (600)	2	6.2	74	8.9	47	15.1	63
Sampling Train D3.5							
Ambient	-	18.9	-	16.1	-	35.0	-
177 (350)	2	7.3	61	14.9	7	22.2	36
177 (350)	4	6.0	68	13.9	14	19.9	43
204 (400)	2	5.3	72	10.4	35	15.7	55
204 (400)	4	5.3	72	10.4	35	15.7	55
316 (600)	2	4.2	78	9.2	43	13.4	62
Sampling Train D4.5							
Ambient	-	19.6	-	11.6	-	31.2	-
177 (350)	2	13.4	32	8.3	28	21.7	30
177 (350)	4	13.1	33	7.1	39	20.2	35
204 (400)	2	7.6	61	7.5	35	15.1	52
204 (400)	4	7.6	61	7.3	37	14.9	52
316 (600)	2	6.0	69	6.3	46	12.3	60
Sampling Train D5.5							
Ambient	-	9.5	-	6.4	-	15.9	-
177 (350)	2	2.6	72	4.3	33	6.9	57
177 (350)	4	2.5	74	2.8	56	5.3	67
204 (400)	2	2.5	74	2.0	69	4.5	72
204 (400)	4	2.5	74	2.0	69	4.5	72
316 (600)	2	1.4	85	1.0	84	2.4	85
Sampling Train D6.5							
Ambient	-	12.6	-	7.3	-	19.9	-
177 (350)	2	8.4	33	5.2	29	13.6	32
177 (350)	4	7.8	38	5.0	31	12.8	36
204 (400)	2	6.5	48	5.0	31	11.5	42
204 (400)	4	6.5	48	4.8	34	11.3	43
316 (600)	2	1.0	92	3.4	53	4.4	78

TABLE 2-30. RESULTS OF SEQUENTIAL HEATING OF SELECTED NCOG UNDERFIRING TEST SERIES RUN 8.5, FRONT HALF

Sequential heating		Particulate weight						Source concentration	
		Front-half rinse		Filter		Total			
Temperature, °C (°F)	Time, h	mg	% weight loss	mg	% weight loss	mg	% weight loss	mg/m^3	gr/dscf
Ambient	-	85.4	-	98.5	-	183.9	-	129.5	0.056
135 (275)	2	32.3	62	43.2	56	75.5	59	53.2	0.023
	4	23.9	72	42.8	56	66.7	64	47.0	0.021
149 (300)	2	22.1	74	42.4	57	64.5	65	45.4	0.020
	4	20.1	76	42.3	57	62.4	66	43.9	0.019
163 (325)	2	18.7	78	42.3	57	61.0	67	43.0	0.019
	4	17.6	79	42.3	57	59.9	67	42.2	0.018
177 (350)	2	15.7	82	42.2	57	57.9	68	40.8	0.018
	4	15.3	82	42.1	57	57.4	69	40.4	0.017
204 (400)	2	11.3	87	41.6	58	52.9	71	37.2	0.016
	4	10.0	88	40.9	58	50.9	72	35.8	0.016
316 (600)	2	6.4	92	39.2	60	45.6	75	32.1	0.014

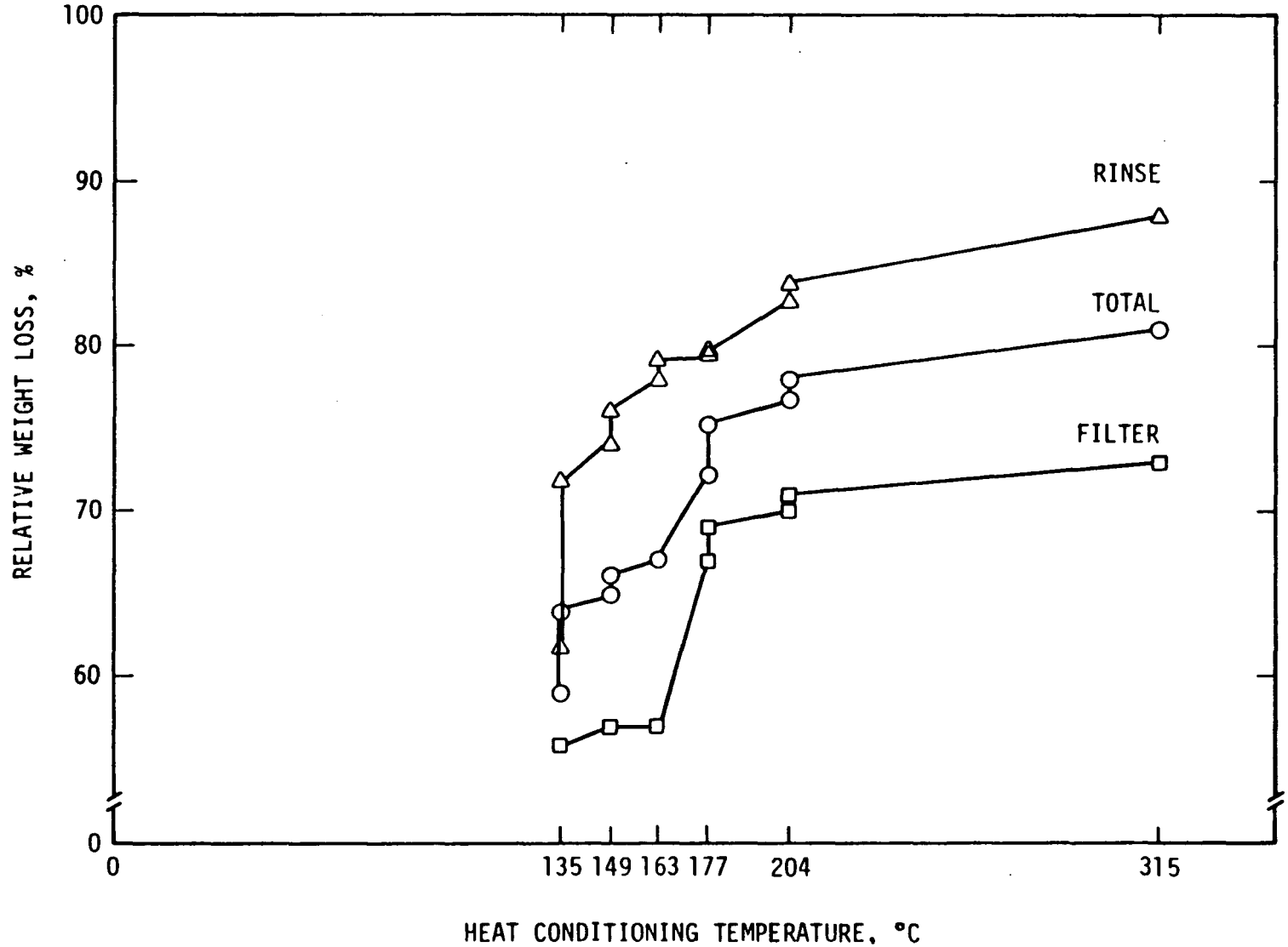


Figure 2-4. Average percent weight loss from Sampling Train 5, 121°C (250°F) front-half temperature, due to heat conditioning prior to weighing (NCOG underfiring).

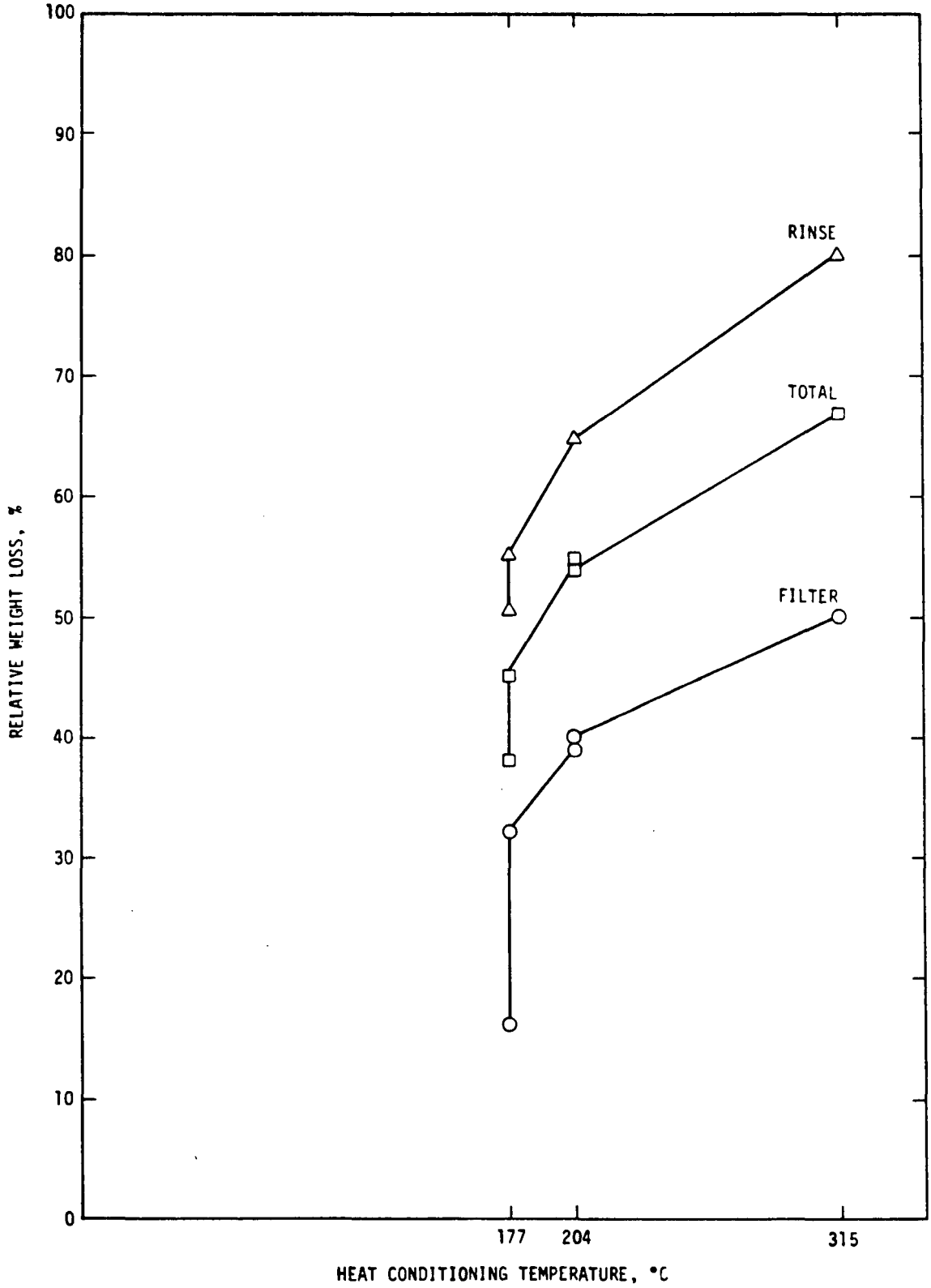


Figure 2-5. Average percent weight loss from Sampling Train 5, 121°C (250°F) front-half temperature, due to heat conditioning prior to weighing (DCOG underfiring).

TABLE 2-31. COMPARISON OF PARTICULATE CONCENTRATIONS DETERMINED FROM SAMPLING AT TWO DIFFERENT TEMPERATURES UNDER NCOG UNDERFIRING CONDITIONS: 177°C (350°F) VS. 121°C (250°F) BUT ANALYZING AFTER TREATMENT AT 177°C (350°F)

Test No.	Date (1981)	Actual filter temperature, °C (°F)	Sequential heating temperature, °C (°F)	Heating time, h	Front-half catch particulate		
					mg	mg/m^3	gr/dscf
1.2	10/27	125 (257)	177 (350)	2	55.2	33.0	0.014
1.3	10/27	170 (338)	No	-	72.9	43.4	0.019
1.4	10/27	169 (336)	No	-	50.6	30.8	0.013
1.5	10/27	128 (263)	177 (350)	2	47.5	33.0	0.014
			177 (350)	4	41.7	29.0	0.013
2.5	10/27	125 (257)	177 (350)	2	34.0	22.7	0.010
			177 (350)	4	30.7	20.5	0.009
3.2	10/28	127 (260)	177 (350)	2	34.2	20.6	0.009
3.3	10/28	178 (353)	No	-	87.3	53.6	0.023
3.4	10/28	169 (336)	No	-	40.3	25.5	0.011
3.5	10/28	109 (229)	177 (350)	2	29.0	16.9	0.007
			177 (350)	4	26.8	15.6	0.007
4.3	10/28	177 (350)	No	-	61.1	65.7	0.028
4.4	10/28	169 (337)	No	-	78.4	92.2	0.040
4.5	10/28	130 (266)	177 (350)	2	137.3	63.0	0.028
			177 (350)	4	128.8	59.1	0.026
5.2	10/29	123 (254)	177 (350)	2	36.8	24.5	0.011
5.3	10/29	176 (349)	No	-	50.5	33.0	0.014
5.4	10/29	186 (366)	No	-	32.1	22.4	0.010
5.5	10/29	116 (240)	177 (350)	2	50.4	31.3	0.014
			177 (350)	4	44.2	27.4	0.012
6.5	10/29	119 (246)	177 (350)	2	42.3	25.6	0.011
			177 (350)	4	37.6	22.8	0.010

TABLE 2-32. COMPARISON OF PARTICULATE CONCENTRATIONS DETERMINED FROM SAMPLING AT TWO DIFFERENT TEMPERATURES UNDER NCOG UNDERFIRING CONDITIONS: 204°C (400°F) VS. 121°C (250°F) BUT ANALYZING AFTER TREATMENT AT 204°C (400°F)

Test No.	Date (1981)	Actual filter temperature, °C (°F)	Sequential heating temperature, °C (°F)	Heating time, h	Front-half catch particulate		
					mg	mg/m^3	gr/dscf
1.5	10/27	128 (263)	204 (400) 204 (400)	2 4	37.3 34.5	25.9 24.0	0.011 0.010
2.2	10/27	128 (263)	204 (400)	2	24.8	16.5	0.007
2.3	10/27	198 (389)	No	-	46.3	31.7	0.014
2.4	10/27	207 (404)	No	-	61.3	42.6	0.019
2.5	10/27	125 (257)	204 (400) 204 (400)	2 4	29.2 27.7	19.5 18.5	0.008 0.008
3.5	10/28	109 (229)	204 (400) 204 (400)	2 4	26.2 25.2	15.2 14.6	0.007 0.006
4.2	10/28	130 (266)	204 (400)	2	41.7	47.4	0.021
4.5	10/28	130 (266)	204 (400) 204 (400)	2 4	112.4 104.7	51.6 48.0	0.022 0.021
5.5	10/29	116 (240)	204 (400) 204 (400)	2 4	36.2 32.3	22.5 20.1	0.010 0.009
6.2	10/29	126 (258)	204 (400)	2	24.2	15.7	0.007
6.3	10/29	193 (379)	No	-	34.3	22.6	0.010
6.4	10/29	208 (407)	No	-	26.9	20.8	0.009
6.5	10/29	119 (246)	204 (400) 204 (400)	2 4	33.2 30.3	20.1 18.4	0.009 0.008

TABLE 2-33. COMPARISON OF PARTICULATE CONCENTRATIONS DETERMINED FROM SAMPLING AT TWO DIFFERENT TEMPERATURES UNDER NCOG UNDERFIRING CONDITIONS: 316°C (600°F) VS. 121°C (250°F) BUT ANALYZING AFTER TREATMENT AT 315°C (600°F)

Test No.	Date (1981)	Actual filter temperature, °C (°F)	Sequential heating temperature, °C (°F)	Heating time, h	Front-half catch particulate		
					mg	mg/m^3	gr/dscf
1.5	10/27	128 (263)	316 (600)	2	30.5	21.2	0.009
1.6	10/27	320 (608)	No	-	27.0	19.0	0.008
2.5	10/27	125 (257)	316 (600)	2	22.5	15.0	0.006
2.6	10/27	316 (600)	No	-	39.5	23.9	0.010
3.5	10/28	109 (229)	316 (600)	2	22.0	12.8	0.006
3.6	10/28	293 (560)	No	-	36.0	19.6	0.008
4.5	10/28	130 (260)	316 (600)	2	99.0	45.4	0.020
4.6	10/28	328 (622)	No	-	69.7	62.8	0.027
5.5	10/29	116 (240)	316 (600)	2	27.7	17.2	0.008
5.6	10/29	324 (616)	No	-	24.9	16.2	0.007
6.5	10/29	119 (246)	316 (600)	2	25.8	15.6	0.007
6.6	10/29	302 (576)	No	-	30.9	19.6	0.008

TABLE 2-34. COMPARISON OF PARTICULATE CONCENTRATIONS DETERMINED FROM SAMPLING AT TWO DIFFERENT TEMPERATURES UNDER DCOG UNDERFIRING CONDITIONS: 177°C (350°F) VS. 121°C (250°F) BUT ANALYZING AFTER TREATMENT AT 177°C (350°F)

Test No.	Date (1981)	Actual filter temperature, °C (°F)	Sequential heating temperature, °C (°F)	Heating time, h	Front-half catch particulate		
					mg	mg/m^3	gr/dscf
D1.1	12/8	119 (246)	177 (350)	2	21.8	17.4	0.008
				4	21.1	16.9	0.007
D1.2	12/8	133 (272)	177 (350)	2	22.0	19.6	0.008
D1.3	12/8	190 (374)	-	-	34.0	29.3	0.013
D1.4	12/8	167 (333)	-	-	43.3	38.7	0.017
D2.2	12/10	109 (229)	177 (350)	2	24.6	13.8	0.006
D2.3	12/10	184 (363)	-	-	34.8	20.4	0.009
D2.4	12/10	197 (387)	-	-	37.2	20.8	0.009
D2.5	12/10	126 (258)	177 (350)	2	23.4	12.7	0.005
				4	19.2	10.4	0.004
D3.5	12/11	123 (254)	177 (350)	2	22.2	12.4	0.005
				4	19.9	11.1	0.005
D4.5	12/12	128 (263)	177 (350)	2	21.7	12.4	0.005
				4	20.2	11.5	0.005
D5.2	12/12	127 (261)	177 (350)	2	8.7	5.0	0.002
D5.3	12/12	181 (357)	-	-	16.3	10.4	0.004
D5.4	12/12	177 (351)	-	-	19.1	11.9	0.005
D5.5	12/12	122 (251)	177 (350)	2	6.9	4.1	0.002
				4	5.3	3.1	0.001
D6.5	12/13	131 (267)	177 (350)	2	13.6	7.4	0.003
				4	12.8	7.0	0.003

TABLE 2-35. COMPARISON OF PARTICULATE CONCENTRATIONS DETERMINED FROM SAMPLING AT TWO DIFFERENT TEMPERATURES UNDER DCOG UNDERFIRING CONDITIONS: 204°C (400°F) VS. 121°C (250°F) BUT ANALYZING AFTER TREATMENT AT 204°C (400°F)

Test No.	Date (1981)	Actual filter temperature, °C (°F)	Sequential heating temperature, °C (°F)	Heating time, h	Front-half catch particulate		
					mg	mg/m^3	gr/dscf
D1.1	12/8	119 (246)	204 (400)	2 4	16.8 16.4	13.4 13.1	0.006 0.006
D2.5	12/10	126 (258)	204 (400)	2 4	18.8 17.7	10.2 9.6	0.004 0.004
D3.2	12/11	132 (270)	204 (400)	2	18.1	11.2	0.005
D3.3	12/11	211 (411)	-	-	30.9	22.1	0.010
D3.4	12/11	204 (400)	-	-	38.7	26.9	0.012
D3.5	12/11	123 (254)	204 (400)	2 4	15.7 15.7	8.8 8.8	0.004 0.004
D4.2	12/12	126 (259)	204 (400)	2	13.5	8.0	0.003
D4.3	12/12	209 (409)	-	-	24.8	16.6	0.007
D4.5	12/12	128 (263)	204 (400)	2 4	15.1 14.9	8.6 8.5	0.004 0.004
D5.5	12/12	122 (251)	204 (400)	2 4	4.5 4.5	2.7 2.7	0.001 0.001
D6.2	12/13	120 (248)	204 (400)	2	5.4	3.5	0.001
D6.3	12/13	204 (399)	-	-	15.6	10.8	0.005
D6.4	12/13	219 (427)	-	-	12.0	8.0	0.004
D6.5	12/13	131 (267)	204 (400)	2 4	11.5 11.3	6.3 6.2	0.003 0.003

TABLE 2-36. COMPARISON OF PARTICULATE CONCENTRATIONS DETERMINED FROM SAMPLING AT TWO DIFFERENT TEMPERATURES UNDER DCOG UNDERFIRING CONDITIONS: 316°C (600°F) VS. 121°C (250°F) BUT ANALYZING AFTER TREATMENT AT 316°C (600°F)

Test No.	Date (1981)	Actual filter temperature, °C (°F)	Sequential heating temperature, °C (°F)	Heating time, h	Front-half catch particulate		
					mg	mg/m^3	gr/dscf
D1.1[a]	12/8	119 (246)	316 (600)	2	14.6	11.7	0.005
D1.6	12/8	268 (515)	-	-	27.3	28.4	0.012
D2.5	12/10	126 (258)	316 (600)	2	15.1	8.2	0.003
D2.6	12/10	298 (569)	-	-	30.3	18.0	0.008
D3.5	12/11	123 (254)	316 (600)	2	13.4	7.5	0.003
D3.6	12/11	280 (536)	-	-	25.5	14.8	0.006
D4.5	12/12	128 (263)	316 (600)	2	12.3	7.0	0.003
D4.6	12/12	325 (617)	-	-	17.5	10.5	0.004
D5.5	12/12	122 (251)	316 (600)	2	2.4	1.4	0.001
D5.6	12/12	316 (600)	-	-	12.9	8.0	0.003
D6.5	12/13	131 (267)	316 (600)	2	4.4	2.4	0.001
D6.6	12/13	319 (607)	-	-	9.2	6.3	0.003

[a]D1.5 was void run sequential heating procedure done on D1.1.

2.4 PARTICULATE SULFATE

Acetone rinse residues and filters were analyzed for isopropanol (IPA) soluble sulfate (acid sulfate) and water soluble sulfate (inorganic sulfate). Tables 2-37 and 2-38 summarize the acid sulfate concentrations determined for the NCOG and DCOG test series. The IPA extractable acid sulfate concentration is presented as H_2SO_4 in mg/m^3. Assuming that the acid sulfate is hydrated H_2SO_4, the resulting concentration is presented as $H_2SO_4(H_2O)_2$ in mg/m^3. Nonsulfate particulate concentration is determined by subtracting the $H_2SO_4(H_2O)_2$ concentration from the total particulate concentration.

No water soluble sulfates were found on particulate collected during NCOG underfiring. A few outliers were attributed to incomplete IPA extraction. Water soluble sulfate data for the NCOG test series is presented in Appendix C. The water soluble sulfate found on particulate collected during the DCOG tests are presented in Table 2-38 as $SO_4=$ in mg/m^3.

TABLE 2-37. SUMMARY OF PARTICULATE AND ACID SULFATE RESULTS FOR THE NCOG UNDERFIRING TEST SERIES

Test No.	Average filter temperature, °C (°F)	Conditioning temperature, °C (°F)	Concentration, mg/m³													
			Particulate			Acid sulfate H_2SO_4			Acid sulfate $H_2SO_4(H_2O)_2$			Nonsulfate particulate			H_2SO_4	
			Rinse	Filter	Total	Rinse	Filter	Total	Rinse	Filter	Total	Rinse	Filter	Total	Back-half	Total
1.1	122 (252)	Ambient	57.7	71.2	128.9	21.7	24.6	46.3	29.7	33.6	63.3	28.0	37.6	65.6	5.0	51.3
1.2	125 (257)	Ambient	56.2	59.2	115.4	-	-	-	-	-	-	-	-	-	5.6	-
		177 (350)	19.3	13.8	33.1	4.4	0.0	4.4	6.1	0.0	6.1	13.2	13.8	27.0	-	-
1.3	170 (338)	Ambient	24.7	18.7	43.4	5.8	0.0	5.8	8.0	0.0	8.0	16.7	18.7	35.4	38.9	44.7
1.4	169 (336)	Ambient	16.5	14.3	30.8	1.3	1.6	2.9	1.7	2.2	3.9	14.8	12.1	26.9	34.1	37.0
1.5	128 (263)	Ambient	57.2	36.8	94.0	-	-	-	-	-	-	-	-	-	-	-
		316 (600)	8.7	12.5	21.2	0.0	0.0	0.0	0.0	0.0	0.0	8.7	12.5	21.2	NA[a]	-
1.6	320 (608)	Ambient	8.5	10.5	19.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	10.5	19.0	426.8[b]	-
2.1	119 (247)	Ambient	49.9	65.3	115.2	22.1	16.6	38.7	30.2	22.8	53.0	19.7	12.3	32.0	466[a]	
2.2	128 (263)	Ambient	54.1	45.4	99.5	-	-	-	-	-	-	-	-	-	10.7	-
		204 (400)	6.0	10.5	16.5	0.0	0.0	0.0	0.0	0.0	0.0	6.0	10.5	16.5	-	-
2.3	198 (389)	Ambient	22.9	8.8	31.7	8.3	0.0	8.3	11.4	0.0	11.4	11.5	8.8	20.3	36.3	47.7
2.4	207 (404)	Ambient	34.0	8.6	42.6	10.0	0.0	10.0	13.7	0.0	13.7	20.3	8.6	28.9	13.6	23.6
2.5	125 (257)	Ambient	41.9	18.7	60.6	-	-	-	-	-	-	-	-	-	-	-
		316 (600)	6.9	8.1	15.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	8.1	15.0	NA	-
2.6	316 (600)	Ambient	14.1	9.8	23.9	1.6	0.0	1.6	2.1	0.0	2.1	12.0	9.8	21.8	95.2	96.8
3.1	113 (236)	Ambient	59.7	55.7	115.4	23.1	17.1	40.2	31.6	23.4	55.0	28.1	32.3	60.3	4.7	44.9
3.2	127 (260)	Ambient	37.7	56.8	94.5	-	-	-	-	-	-	-	-	-	5.2	-
		177 (350)	9.0	11.6	20.6	0.0	0.0	0.0	0.0	0.0	0.0	9.0	11.6	20.6	-	-
3.3	178 (353)	Ambient	40.8	12.8	53.6	14.8	0.7	15.5	20.2	1.0	21.2	20.6	11.8	32.4	41.2	56.7
3.4	169 (336)	Ambient	12.9	12.6	25.5	2.3	0.0	2.3	3.2	0.0	3.2	9.7	12.6	22.3	56.4	58.7
3.5	109 (229)	Ambient	43.3	56.2	99.5	-	-	-	-	-	-	-	-	-	NA	-
		316 (600)	3.3	9.5	12.8	0.0	0.0	0.0	0.0	0.0	0.0	3.3	9.5	12.8	-	-
3.6	293 (560)	Ambient	10.3	9.3	19.6	2.3	0.0	2.3	3.1	0.0	3.1	7.2	9.3	16.5	89.1	91.4
4.1	123 (254)	Ambient	64.9	76.4	141.3	23.2	24.7	47.9	31.8	33.8	65.6	33.1	42.6	75.7	11.6	59.5
4.2	130 (266)	Ambient	63.3	65.3	128.6	-	-	-	-	-	-	-	-	-	13.5	-
		204 (400)	14.5	32.9	47.4	0.4	0.0	0.4	0.6	0.0	0.6	13.9	32.9	46.8	-	-
4.3	177 (350)	Ambient	32.2	33.5	65.7	6.9	0.0	6.9	9.4	0.0	9.4	22.8	33.5	56.3	32.0	38.9
4.4	169 (337)	Ambient	57.9	34.9	92.2	11.8	3.0	14.8	16.1	4.2	20.3	41.8	30.7	72.5	12.2	27.0
4.5	130 (266)	Ambient	27.4	52.6	80.0	-	-	-	-	-	-	-	-	-	-	-
		316 (600)	6.4	39.0	45.4	0.0	0.0	0.0	0.0	0.0	0.0	6.4	39.0	45.4	NA	-
4.6	328 (622)	Ambient	14.7	48.1	62.8	0.0	0.0	0.0	0.0	0.0	0.0	14.7	48.1	62.8	66.4	66.4
5.1	124 (255)	Ambient	50.0	34.5	84.5	39.9	12.3	52.2	54.6[c]	16.7	71.3	-4.6	17.8	13.2	21.0	73.0
5.2	123 (254)	Ambient	67.6	56.1	123.7	-	-	-	-	-	-	-	-	-	NA	-
		177 (350)	12.4	12.1	24.5	2.0	0.0	2.0	2.7	0.0	2.7	9.7	12.1	21.8	-	-
5.3	176 (349)	Ambient	20.5	12.5	33.0	6.2	0.0	6.2	8.5	0.0	8.5	12.0	12.5	24.5	53.3	59.5
5.4	186 (366)	Ambient	10.8	11.6	22.4	0.0	0.0	0.0	0.0	0.0	0.0	10.8	11.6	22.4	NA	-
5.5	116 (240)	Ambient	73.2	64.1	137.3	-	-	-	-	-	-	-	-	-	-	-
		316 (600)	6.8	10.4	17.2	0.0	0.0	0.0	0.0	0.0	0.0	6.8	10.4	17.2	NA	-
5.6	324 (616)	Ambient	6.6	9.6	16.2	0.0	0.0	0.0	0.0	0.0	0.0	6.6	9.6	16.2	83.8	83.8
6.1	119 (246)	Ambient	62.7	49.5	112.2	29.0	14.3	43.3	39.7	19.5	59.2	23.0	30.0	53.0	14.6	57.9
6.2	126 (258)	Ambient	65.1	32.8	97.9	-	-	-	-	-	-	-	-	-	NA	-
		204 (400)	7.0	8.7	15.7	0.0	0.0	0.0	0.0	0.0	0.0	7.0	8.7	15.7	-	-
6.3	193 (379)	Ambient	12.4	10.2	22.6	1.8	0.0	1.8	2.5	0.0	2.5	9.9	10.2	20.1	64.2	66.0
6.4	208 (407)	Ambient	9.8	11.0	20.8	0.0	0.0	0.0	0.0	0.0	0.0	9.8	11.0	20.8	-	-
6.5	119 (246)	Ambient	65.5	53.1	118.6	-	-	-	-	-	-	-	-	-	-	-
		316 (600)	10.0	5.6	15.6	0.0	0.0	0.0	0.0	0.0	0.0	10.0	5.6	15.6	-	-
6.6	302 (576)	Ambient	12.6	7.0	19.6	0.0	0.0	0.0	0.0	0.0	0.0	12.6	7.0	19.6	72.8	72.8

[a] N/A = Not analyzed.

[b] Contaminated with hydrogen peroxide.

[c] Most likely hydrated with less than two H_2O per H_2SO_4 molecule.

TABLE 2-38. SUMMARY OF PARTICULATE AND ACID SULFATE RESULTS FOR THE DCOG UNDERFIRING TEST SERIES

Test No.	Average filter temperature, °C (°F)	Conditioning temperature, °C (°F)	Concentration, mg/m³															
			Particulate			Sulfate							Nonsulfate particulate			H_2SO_4		
						$H_2SO_4(H_2O)_2$			$SO_4^=$									
			Rinse	Filter	Total	Rinse	Filter	Total	Rinse	Filter	Total	Total	Rinse	Filter	Total	Front-half	Back-half	Total
D1.1	119 (246)	Ambient	14.4	11.7	26.1	-	-	-	-	-	-	-	-	-	-	-	92.0[a]	92.0[a]
		316 (600)	3.0	8.7	11.7	0.0	0.0	0.0	0.0	<0.2	<0.2	<0.2	3.0	8.5	11.5	0.0	-	-
D1.2	133 (272)	Ambient	19.8	13.8	33.4	-	-	-	-	-	-	-	-	-	-	-	-	-
		177 (350)	6.7	12.9	19.6	1.2	1.2	2.4	1.9	Void	1.9	4.3	3.6	11.7	15.3	1.7	3.1	4.8
D1.3	190 (374)	Ambient	14.8	14.5	29.3	0.0	0.0	0.0	2.1	0.0	2.1	2.1	12.7	14.5	27.2	0.0	8.0	8.0
D1.4	167 (333)	Ambient	21.1	17.6	38.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.1	17.6	38.7	0.0	8.2	8.2
D1.6	268 (515)	Ambient	15.8	12.6	28.4	0.0	0.0	0.0	1.7	0.0	1.7	1.7	15.8	10.9	26.7	0.0	6.6	6.6
D2.1	118 (244)	Ambient	173.4[b]	5.1	178.5[b]	1.0	0.0	1.0	0.6	0.0	0.6	1.6	171.8	5.1	176.9[b]	0.7	9.8	10.5
D2.2	109 (229)	Ambient	14.1	7.4	21.5	-	-	-	-	-	-	-	-	-	-	-	-	-
		177 (350)	7.0	6.8	13.8	1.0	1.0	2.0	1.1	0.0	1.1	3.1	4.9	5.8	10.7	1.5	8.1	9.6
D2.3	184 (363)	Ambient	12.3	8.1	20.4	0.5	0.0	0.5	2.0	0.0	2.0	2.5	9.8	8.1	17.9	0.3	5.1	5.4
D2.4	197 (387)	Ambient	14.5	6.3	20.8	0.3	0.0	0.3	2.7	0.0	2.7	3.0	11.5	6.3	17.8	0.2	30.6[a]	30.8[a]
D2.5	126 (258)	Ambient	13.3	9.0	22.3	-	-	-	-	-	-	-	-	-	-	-	-	-
		316 (600)	3.4	4.8	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	4.8	8.2	0.0	NA[c]	-
D2.6	298 (569)	Ambient	8.7	9.3	18.0	0.0	<0.3	<0.3	<0.0	<0.2	<0.2	<0.5	8.7	8.8	17.5	<0.2	6.4	6.6
D3.1	120 (248)	Ambient	18.1	8.0	26.1	0.3	0.0	0.3	4.0	0.0	4.0	4.3	17.8	4.0	21.8	0.2	56.8[a]	57.0[a]
D3.2	132 (270)	Ambient	12.0	9.3	21.3	-	-	-	-	-	-	-	-	-	-	-	-	-
		204 (400)	3.9	7.3	11.2	0.1	1.4	1.5	0.0	0.0	0.0	1.5	3.8	5.9	9.7	1.1	4.3	5.4
D3.3	211 (411)	Ambient	13.1	9.0	22.1	0.0	0.0	0.0	2.9	0.0	2.9	2.9	13.1	6.1	19.2	0.0	8.6	8.6
D3.4	204 (400)	Ambient	19.0	7.9	26.9	1.8	0.0	1.8	0.5	0.0	0.5	2.3	16.7	7.9	24.6	1.3	5.7	7.0
D3.5	123 (254)	Ambient	10.5	9.1	19.6	-	-	-	-	-	-	-	-	-	-	-	-	-
		316 (600)	2.3	5.2	7.5	0.0	0.0	0.0	0.5	0.0	0.5	0.5	2.3	4.7	7.0	0.0	NA	-
D3.6	280 (536)	Ambient	9.7	5.1	14.8	0.0	0.0	0.0	1.3	0.0	1.3	1.3	9.7	3.8	13.5	0.0	7.4	7.4
D4.1	148 (299)	Ambient	10.8	6.1	16.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8	6.1	16.9	0.0	25.0[a]	25.0[a]
D4.2	126 (259)	Ambient	21.8	4.9	26.7	-	-	-	-	-	-	-	-	-	-	-	-	-
		204 (400)	4.8	3.2	8.0	0.0	0.0	0.0	0.5	0.0	0.5	0.5	4.3	3.2	7.5	0.0	9.4	9.4
D4.3	209 (409)	Ambient	11.0	5.6	16.6	0.6	0.0	0.6	2.1	0.0	2.1	2.7	8.3	5.6	13.9	0.5	4.5	5.0
D4.5	128 (263)	Ambient	11.2	6.6	17.8	-	-	-	-	-	-	-	-	-	-	-	-	-
		316 (600)	3.4	3.6	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	3.6	7.0	0.0	NA[c]	-
D4.6	325 (617)	Ambient	7.3	3.2	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	3.2	10.5	0.0	74.7[a]	74.7[a]
D5.1	123 (253)	Ambient	10.2	3.2	13.4	2.6	0.0	2.6	2.1	0.0	2.1	4.7	5.5	3.2	8.7	1.9	5.0	6.9
D5.2	127 (261)	Ambient	8.5	3.0	11.5	-	-	-	-	-	-	-	-	-	-	-	-	-
		177 (350)	3.2	1.8	5.0	0.4	0.2	0.6	1.0	0.0	1.0	1.6	1.8	1.6	3.4	0.5	NA	
D5.3	181 (357)	Ambient	7.0	3.4	10.4	1.9	0.0	1.9	1.0	0.0	1.0	2.9	4.1	3.4	7.5	1.4	5.0	6.4
D5.4	177 (351)	Ambient	9.4	2.5	11.9	0.5	0.0	0.5	2.4	0.0	2.4	2.9	6.5	2.5	10.0	0.4	NA	-
		316 (600)	0.8	0.6	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.6	1.4	0.0	NA	
D5.6	316 (600)	Ambient	4.9	3.1	8.0	0.2	0.0	0.2	0.9	0.0	0.9	1.1	3.8	3.1	7.9	0.2	5.1	5.3
D6.1	132 (270)	Ambient	4.6	3.2	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	3.2	7.8	0.0	8.5	8.5
D6.2	120 (248)	Ambient	9.1	4.4	13.5	-	-	-	-	-	-	-	-	-	-	-	-	-
		204 (400)	1.1	2.4	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	2.4	3.5	0.0	NA	
D6.3	204 (399)	Ambient	7.4	3.4	10.8	1.0	0.0	1.0	0.0	0.0	0.0	1.0	6.4	3.4	9.8	0.7	5.2	5.9
D6.4	219 (427)	Ambient	5.3	2.7	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	2.7	8.0	0.0	NA	
D6.5	131 (267)	Ambient	6.9	4.0	10.9	-	-	-	-	-	-	-	-	-	-	-	-	-
		316 (600)	0.5	1.9	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.9	2.4	0.0	NA	
D6.6	219 (607)	Ambient	4.7	1.6	6.3	0.2	0.0	0.2	0.0	0.0	0.0	0.2	4.5	1.6	6.1	7.9	7.9	8.0

[a] Hydrogen peroxide contaminated.

[b] Contaminated with oil.

[c] NA = Not analyzed.

2.5 DISCUSSION OF PARTICULATE RESULTS

As shown in Figures 2-1 and 2-2 under similar front-half temperatures and COG underfiring conditions particulate concentrations were consistent between runs. During the NCOG test series the particulate concentration decreased as the front-half temperature increased. This decrease was not as marked during the DCOG test series. Overall, the particulate concentration was lower during DCOG underfiring than during NCOG underfiring, as shown in Figure 2-3.

Heat treatment of a particulate catch prior to gravimetric analysis caused a loss of from 21 to 87 percent, depending on heating temperature and time, sampling temperature, and type of COG underfired. As shown in Tables 2-28 through 2-30, more than half of the total loss caused by a sequential heating takes place at the first heating.

The results presented in Tables 2-31 through 2-36 are graphically depicted in Figures 2-6 and 2-7. The data shows a consistent difference between samples collected at a specified temperature and samples collected at a lower temperature and heated to the specified temperature prior to analysis. The sequentially heated results are always lower than the actual filter temperature results.

As shown in Tables 2-37 and 2-38 acid sulfate is a major constituents of the particulate caught on a 121°C (250°F) heated

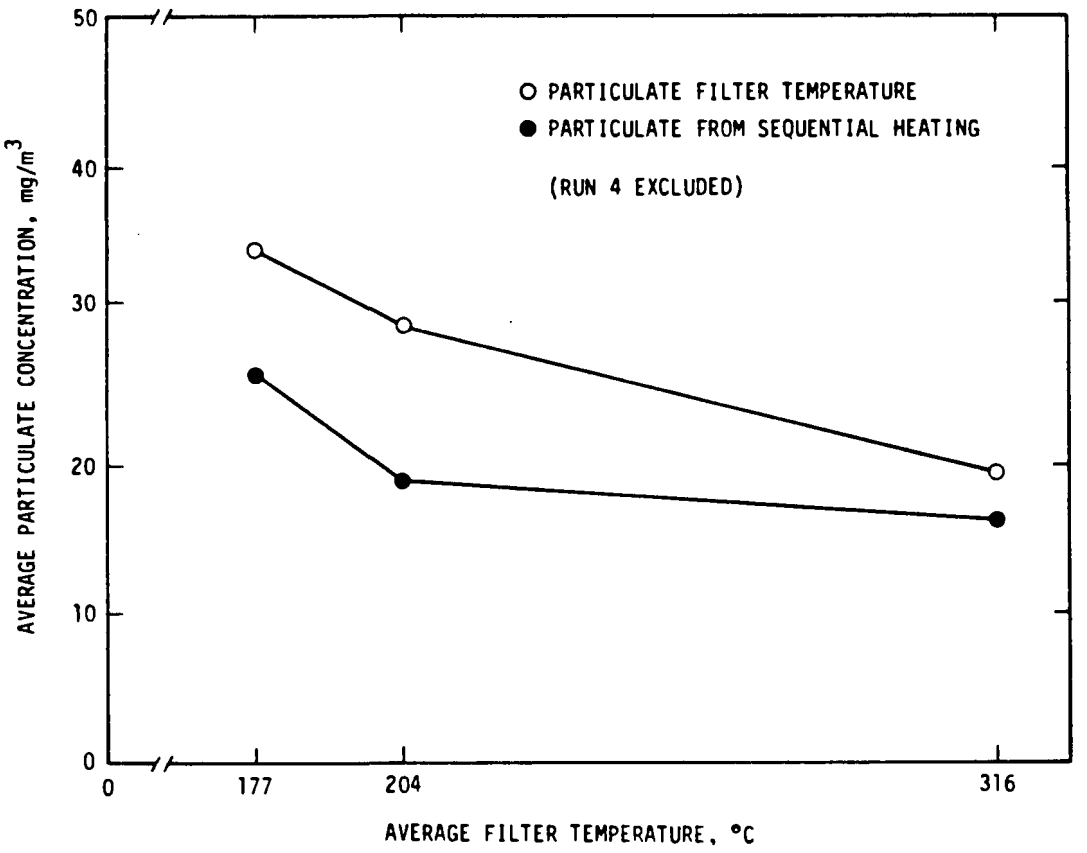


Figure 2-6. Comparison of average particulate concentration determined from sampling at the specified temperature and from sampling at 121°C (250°F) and analyzing after sequentially heating at specified temperatures for NCOG underfiring conditions.

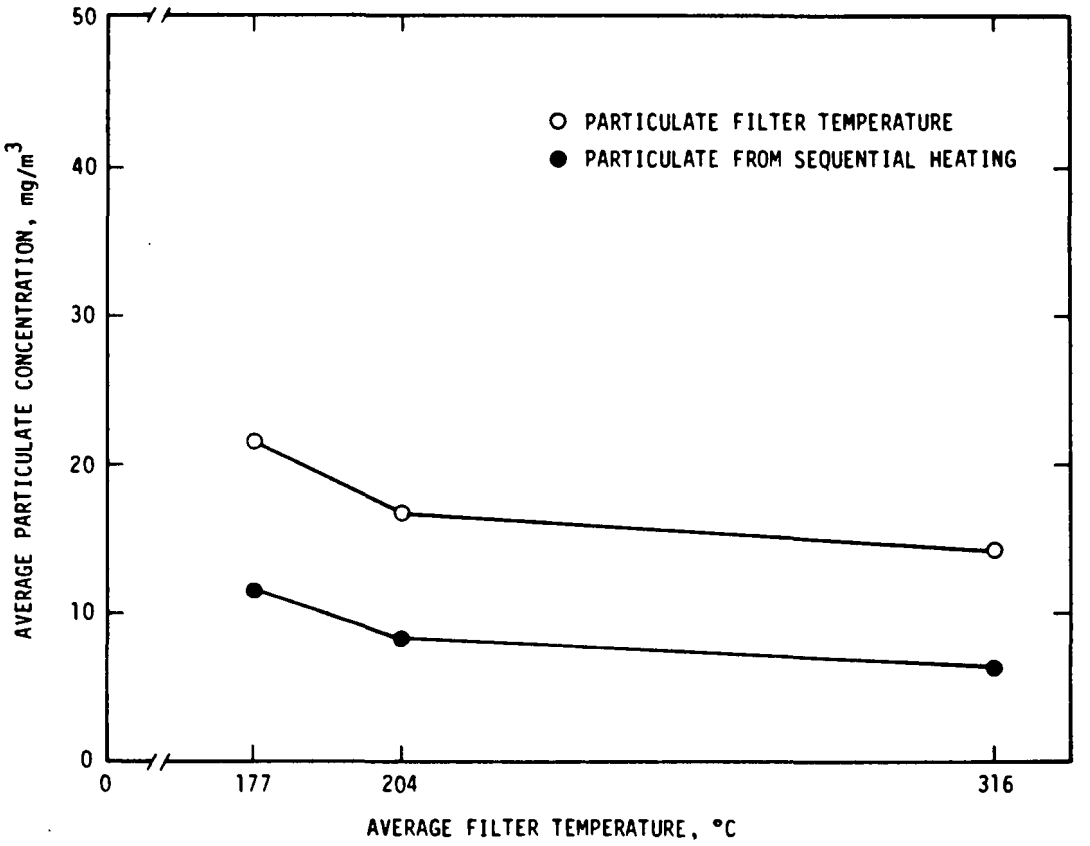


Figure 2-7. Comparison of average particulate concentration determined from sampling at the specified temperature and from sampling at 121°C (250°F) and analyzing after sequentially heating at specified temperatures for DCOG underfiring conditions.

probe and filter collected during NCOG underfiring. Sulfate had a much smaller impact on particulate caught during DCOG underfiring. No water soluble sulfate was found on particulate collected during NCOG underfiring. A few outliers were attributed to incomplete isopropanol extraction.

Average particulate concentration versus average filter temperature determined from actual sampling temperature, actual sampling temperature with IPA extraction, and sampling at 171°C (250°F) with sequential heating prior to analysis are depicted graphically in Figures 2-8 and 2-9 for NCOG and DCOG underfiring, respectively. The data indicate actual sampling temperature will yield a consistently higher concentration than from actual sampling temperature with IPA extraction which will yield a consistently higher concentration than from sequential heating prior to analysis. The data points averaged at the 177°C (250°F) filter heat were highly variable whereas the 204°C (400°F) and 316°C (600°F) filter heats yielded more consistent results.

2.5.1 Total Organic Carbon (Filterable) Results

The TOC content of Sampling Train 5 [121°C (250°F) probe/filter heat] filters was determined by an oxidation/reduction technique. The TOC content was negligible at all three purge temperatures [177°C (350°F), 232°C (450°F), and 316°C (600°F)] when compared with the blank filter TOC content. Air and nitrogen purge blanks for the TOC recovery system averaged 0.9 mg TOC. Filter blanks averaged 1.5 mg TOC/filter. Sample filters averaged between 1.0 and 2.0 mg TOC/filter. A system recovery

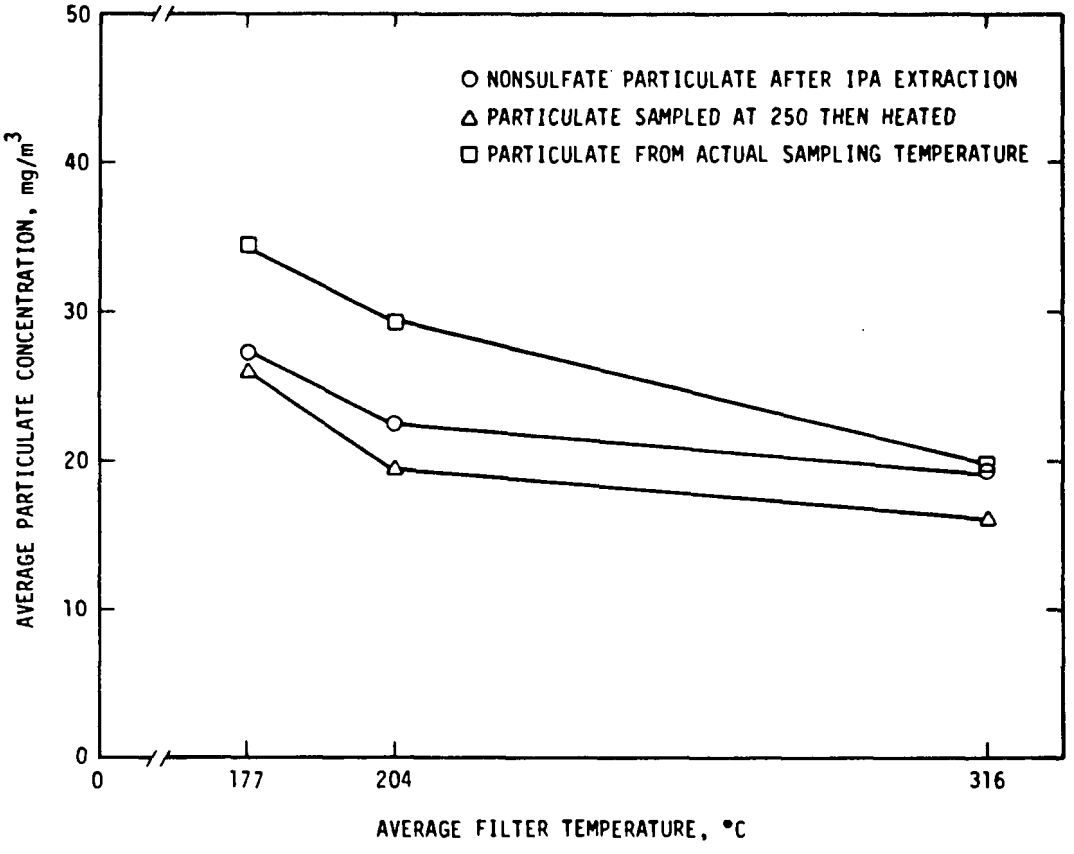


Figure 2-8. Comparison of average particulate concentration from actual sampling temperature, sequential heating, and IPA extraction for NCOG underfiring conditions.

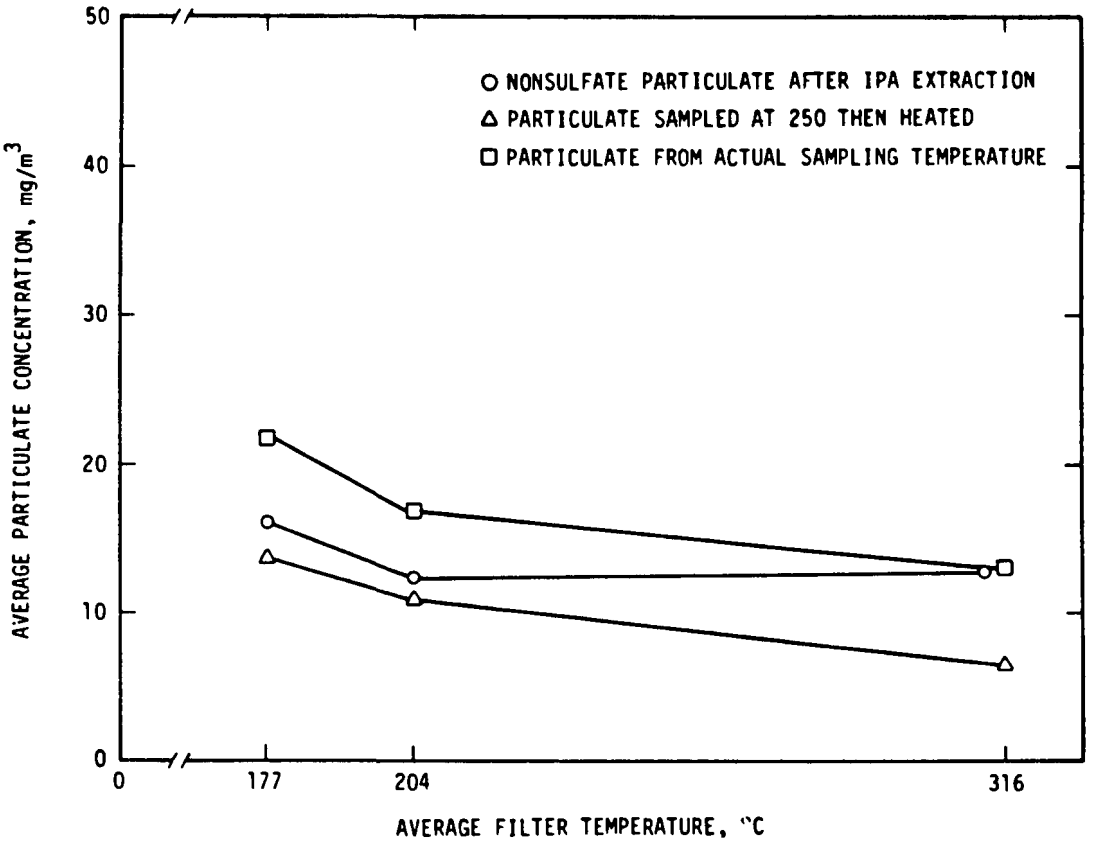


Figure 2-9. Comparison of average particulate concentration from actual sampling temperature, sequential heating, and IPA extraction for DCOG underfiring conditions.

efficiency of 99 percent was determined by treating a decane-spiked filter (10 mg by gravimetric analysis) with the oxidation/reduction technique. Actual laboratory data is presented in Appendix C.

2.6 DISCUSSION OF BACK-HALF RESULTS

Sample trains consisted of either a Method 5 back-half for condensible organics and inorganics determination or a Method 8 back-half for sulfuric acid mist and sulfur dioxide determination.

2.6.1 Sulfuric Acid Mist

The amount of sulfuric acid measured in the back half of the sample train during NCOG underfiring is related to the front half filter/probe temperature. The hotter the filter and probe, the greater the amount of sulfuric acid mist collected in the back half. As the results in Tables 2-37 and 2-38 show, the total sulfuric acid measured by different sampling trains seem to correlate well. This correlation was not as apparent during DCOG underfiring where the amount of sulfur in the flue gas was greatly reduced.

2.6.2 Sulfur Dioxide

The measured SO_2 concentration, which stayed relatively constant throughout each test series, averaged 439 ppm during NCOG underfiring and 33 ppm during DCOG underfiring. Sulfur dioxide concentration data were presented in Tables 2-6 through 2-27 for each individual run.

2.6.3 Condensible Organics and Inorganics

The measured condensible organic concentration was constant throughout both test series. The ampule technique proved to be much more sensitive than the ether/chloroform extraction. High biases (attributed to isopropanol contamination) were observed by the ampule technique but not by the ether/chloroform extraction.

2.7 REDUCED SULFUR ANALYSIS BY METHOD 15

Table 2-39 presents the results obtained through Method 15 analysis of SRU inlet COG during the NCOG and DCOG underfiring test series. Hydrogen sulfide (H_2S) concentrations averaged 1915 ppm v/v during the NCOG test series, whereas carbonyl sulfide (COS) averaged <17 ppm, and carbon disulfide (CS_2) averaged 34 ppm for an average total reduced sulfur (TRS) concentration of 1961 ppm. Hydrogen sulfide concentrations averaged 5086 ppm during the DCOG test series, whereas COS averaged <7 ppm and CS_2 averaged 80 ppm, for an average TRS concentration of 5112 ppm. No changes in process operation or conditions (refer to Section 2.10) were recorded between the two test series to corroborate the large difference in average TRS concentration.

Table 2-40 presents the results obtained through Method 15 analysis of SRU outlet COG during the DCOG underfiring test series. The SRU was bypassed during NCOG underfiring; therefore, no outlet data were collected. Hydrogen sulfide concentrations averaged 7 ppm at the SRU outlet during DCOG underfiring, whereas COS averaged 19 ppm and CS_2 averaged 20 ppm, for an average TRS of 46 ppm. Sulfur dioxide concentrations at the inlet and outlet of the SRU averaged <3 ppm during both test series.

Table 2-41 summarizes the results obtained through Method 15 analysis of No. 1 coke battery exit stack gas. Hydrogen sulfide concentrations averaged <3 ppm during NCOG underfiring; whereas COS averaged <3 ppm CS_2 averaged <2 ppm, for an average TRS of <8 ppm. Hydrogen sulfide, carbonyl sulfide, and carbon disulfide

TABLE 2-39. SUMMARY OF RESULTS OBTAINED THROUGH METHOD 15 ANALYSIS OF SRU INLET COG

Bag sample collection		Corresponding particulate Run No.	Analysis		Concentration, ppm				
Date (1981)	Time		Date (1981)	Time	H_2S	COS	CS_2[a]	SO_2	TRS
NCOG TEST SERIES									
10/27	0930	1	10/27	1000	2000	130	44	<3	2174
			10/28	1354	2100	<3	48	<3	2148
10/27	1430	2	10/27	1535	3800	<3	31	<3	3831
			10/28	1442	1440	<3	34	<3	1474
			10/30	1550	1800	<3	39	<3	1839
10/28	0930	3	10/28	1036	1770	<3	40	<3	1810
			10/28	1420	2200	<3	40	<3	2240
10/28	1605	4	10/28	1642	1700	<3	39	<3	1739
10/29	0930	5	10/29	1118	1500	<3	32	<3	1532
10/29	1400	6	10/29	1454	1320	<3	<2	<3	1320
10/30	1000	7	10/30	1042	1590	<3	31	<3	1621
10/30	1500	8	10/30	1606	1770	<3	33	<3	1803
Average					1915	<17	34	3	1961
DCOG TEST SERIES									
12/8	1230	D1	12/8	1718	2300	<5	62	<6	2362
12/9	1150	-	12/10	1318	6600	21	54	<6	6675
12/10	1130	-	12/10	1336	8700	<5	58	<6	8758
12/10	1455	D2	12/10	1712	5700	<5	190	<6	5890
12/11	0740	-	12/11	1600	4300	<5	72	<6	4372
12/11	1215	D3	12/11	1624	5600	<5	68	<6	5268
12/11	1005	D4	12/12	1224	2400	<5	60	<6	2460
Average					5086	<7	80	<6	5112

[a] CS_2 reported as SO_2 (twice CS_2 value detected).

TABLE 2-40. SUMMARY OF RESULTS OBTAINED THROUGH METHOD 15 ANALYSIS OF SRU OUTLET COG DURING DCOG UNDERFIRING

Bag sample collection		Corresponding particulate Run No.	Analysis		Concentration, ppm				
Date (1981)	Time		Date (1981)	Time	H_2S	COS	CS_2[a]	SO_2	TRS
12/8	1230	D1	12/8	1412	12	25	24	<3	61
12/9	1150	-	12/9	1400[b]	6	21	20	<3	47
			12/10	1248	<2	18	14	<3	32
12/10	1130	-	12/10	1212	4	20	18	<3	42
12/10	1455	D2	12/10	1624	6	20	20	<3	46
12/11	0740	-	12/11	1318	9	18	22	<3	46
			12/11	1436	9	18	22	<3	49
			12/12	1142	6	20	17	<3	43
12/11	1215	D3	12/11	1412	14	19	20	<3	53
12/12	0755	-	12/11	1018	2	19	21	<3	42
12/12	1005	D4	12/12	1054	4	19	20	<3	43
Average					7	19	20	<3	46

[a] CS_2 reported as SO_2 (twice CS_2 value detected).
[b] Not used in average.

TABLE 2-41. SUMMARY OF RESULTS OBTAINED THROUGH METHOD 15 ANALYSIS OF NO. 1 COKE BATTERY EXIT STACK GAS

Bag sample collection		Corresponding particulate Run No.	Analysis		Concentration, ppm				
Date (1981)	Time		Date (1981)	Time	H_2S	COS	CS_2[a]	SO_2	TRS
NCOG TEST SERIES									
10/27	0930	1	10/27	1200	<3	<3	4	180	4
10/27	1430	2	10/27	1606	<3	<3	5	280	5
			10/30	1436	<3	<3	<2	64	<8
10/28	0930	3	10/28	1112	<3	<3	<2	280	<8
10/28	1605	4	10/28	1706	<3	<3	<2	360	<8
10/29	0930	5	10/29	1218	<3	<3	<2	260	<8
10/29	1400	6	10/29	1600	<3	<3	<2	190	<8
10/30	1000	7	10/30	1124	<3	<3	<2	300	<8
10/30	1500	8	10/30	1736	<3	<3	<2	210	<8
Average					<3	<3	<2	236	<8
DCOG TEST SERIES									
12/8	1230	D1	12/8	1500	<2	<2	<2	7	<6
12/10	1330	D2	12/10	1430	<2	<2	<2	18	<6
			12/11	1536	<2	<2	<3	3	<6
12/11	1400	D3	12/11	1500	<2	<2	<2	<3	<6
12/12	1030	D4	12/12	1106	<2	<2	<2	<3	<6
Average					<2	<2	<2	9	<6

[a] CS_2 reported as SO_2 (twice CS_2 value detected).

concentrations all averaged <2 ppm during DCOG underfiring, for an average TRS concentration of <6 ppm.

According to Method 15 analysis, sulfur dioxide concentrations averaged 236 ppm during NCOG underfiring and 9 ppm during DCOG underfiring; however, Method 8 analysis showed an average sulfur dioxide concentration of 439 ppm during NCOG underfiring and 33 ppm during DCOG underfiring.

Harmon Engineering and Testing provided analytical services for determination of reduced-sulfur constituents of selected flue gas samples by EPA Method 15.* The major modification made to Method 15 was the analysis of gas bag samples instead of the usual gas samples continuously extracted via heat-traced Teflon tubing. The highly explosive nature of COG and the great distance between the three sample sites necessitated this modification. Method 15 uses gas chromatographic separation and flame photometric detection to determine the reduced-sulfur constituents and sulfur dioxide concentrations.

The FPD used has a linear response range up to 70 ppm. Self-absorption of the sulfur molecular light occurs at higher concentrations and reduces the slope of the line. Figure 2-10 presents a typical H_2S calibration curve as the concentration increases. Having a dynamic dilution system prior to the sample loop is the preferred method for staying in the FPD linear range. Because the COG bag sample could not be diluted prior to analysis, the sample loop size was reduced. Reduction in sample size

*40 CFR 60, Appendix A, Reference Method 15, July 1980.

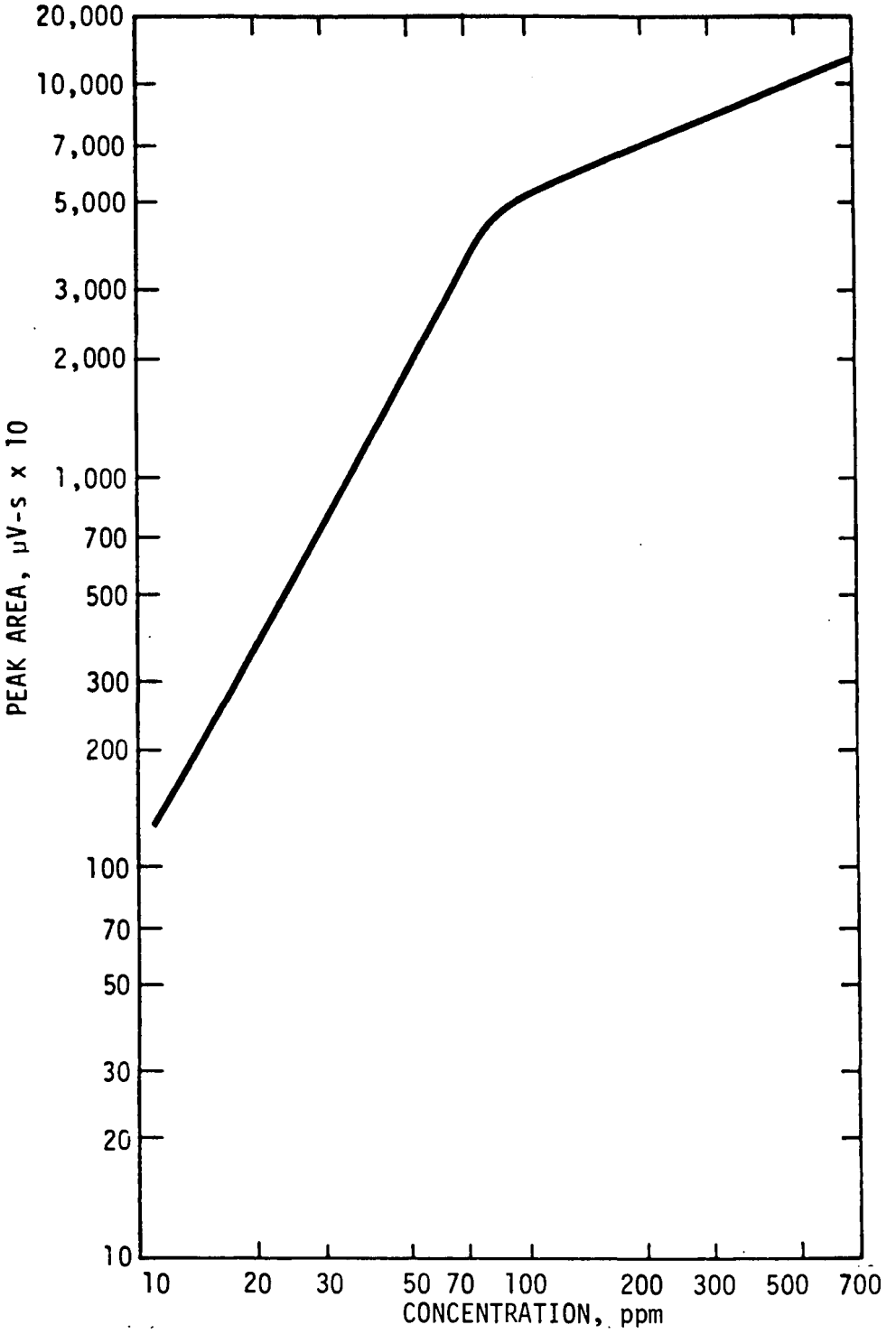


Figure 2-10. H_2S response curve with increasing concentration.

also lowers FPD sensitivity and accuracy. Analysis of the COG inlet sample required a factor of 22 reduction in sample loop size over calibration loop size. Because response was still above the FPD linear response range, self-absorption of the sulfur molecular light is the most likely reason for the high TRS values resulting from the use of Method 15 at the SRU inlet. As self-absorption occurs and the slope of the response versus concentration curve decreases, a relatively small increase in response is interpreted as a large increase in concentration. True calibration in this region of the curve is not possible. The data show an increase in the COS concentration through the SRU during DCOG underfiring. This is most probably due to the small sample loop used for inlet analysis, which was 22 times smaller than the outlet (calibration) loop.

2.8 GAS STREAM FLOW RATE AND COMPOSITION

Tables 2-42 and 2-43 summarize the flue gas conditions data collected at the No. 1 coke battery exit stack during the NCOG and DCOG underfiring test series. Actual volumetric flow rates are expressed in cubic meters per hour (m^3/h) and actual cubic feet per hour (acfh) at stack conditions. Flow rates corrected to standard conditions [20°C and 760 mmHg (68°F and 29.92 in.Hg) and zero percent moisture] are expressed as dry normal cubic meters per hour (dNm^3/h) and dry standard cubic feet per hour (dscfh).

Prior to the first test run of each series a full velocity traverse was performed. Table 2-44 details the data collected from these full velocity traverses. Before the NCOG test series, the volumetric flow rate averaged 45,845 dNm^3/h (1,619,014 dscfh), and the stack temperature averaged 240°C (464°F). Prior to the DCOG test series, the volumetric flow rate was measured at 44,134 dNm^3/h (1,558,567 dscfh), and the stack temperature was 228°C (443°F).

The particulate sampling train nozzles were placed in the stack at an accessible point of average velocity, as determined by the preliminary velocity traverse. This position was maintained throughout the test period. Velocity head and stack temperature were recorded every 10 minutes. Sample trains were operated simultaneously, with few exceptions, within each run. Tables 2-42 and 2-43 also contain all sample train start and stop times.

TABLE 2-42. SUMMARY OF FLUE GAS CONDITIONS DURING NCOG UNDERFIRING TESTING

Run No.	Date (1981)	Sampling period	Flue gas flow rate				Moisture, %	Temperature		Carbon dioxide, %	Oxygen, %
			Actual[a]		Standard[b]						
			m^3/h	acfh	dNm^3/h	dscfh		°C	°F		
1-1	10/27	0910-1110	106,960	3,777,241	48,666	1,718,626	12.3	280	537	4.2	10.5
1-2		0914-1114	106,651	3,766,316	48,106	1,698,840	12.9	281	538	4.2	10.5
1-3		0910-1110	107,648	3,801,518	47,148	1,665,014	15.6	280	536	4.2	10.5
1-4		0914-1114	106,381	3,756,791	48,616	1,716,865	11.8	281	538	4.2	10.5
1-5		0947-1057	94,721	3,345,007	42,057	1,485,228	13.5[c]	288	550	4.2	10.5
1-6		0958-1102	92,677	3,272,822	46,661	1,647,806	1.7[c]	288	550	4.2	10.5
Average[d] (Q)			106,910	3,775,466	48,134	1,699,836	13.2	281	537	4.2	10.5
(6)			102,506	3,619,949	46,876	1,655,397	13.2	283	542	4.2	10.5
2-1	10/27	1355-1555	94,325	3,331,033	42,173	1,489,327	13.7	279	535	4.2	10.5
2-2		1358-1558	94,566	3,339,559	42,266	1,492,594	13.1	284	543	4.2	10.5
2-3		1355-1555	94,240	3,328,042	42,288	1,493,373	13.5	279	534	4.2	10.5
2-4		1358-1558	94,471	3,336,176	42,449	1,499,060	12.6	283	542	4.2	10.5
2-5		1424-1624	98,622	3,482,787	46,059	1,626,567	13.5	259	499	4.2	10.5
2-6		1419-1549	98,086	3,463,857	47,253	1,668,717	10.8	259	499	4.2	10.5
Average (Q)			94,400	3,333,702	42,294	1,493,589	13.2	281	539	4.2	10.5
(6)			95,718	3,380,242	43,748	1,544,940	12.9	274	525	4.2	10.5
3-1	10/28	0955-1155	102,955	3,635,799	47,583	1,680,373	12.2	279	535	2.3	10.9
3-2		0958-1158	102,650	3,625,039	47,844	1,689,592	11.0	282	540	2.3	10.9
3-3		0955-1155	103,600	3,658,571	46,258	1,633,571	15.1	280	536	2.3	10.9
3-4		0958-1158	102,839	3,631,694	47,406	1,674,132	12.0	282	540	2.3	10.9
3-5		0947-1147	113,803	4,018,903	53,499	1,889,290	12.3	270	518	2.3	10.9
3-6		0950-1150	115,055	4,063,123	50,694	1,790,217	17.8	270	518	2.3	10.9
Average (Q)			103,011	3,637,776	47,273	1,669,417	12.6	281	538	2.3	10.9
(6)			106,817	3,772,188	48,881	1,726,196	13.4	277	531	2.3	10.9

(continued)

TABLE 2-42 (continued)

Run No.	Date (1981)	Sampling period	Flue gas flow rate				Moisture, %	Temperature		Carbon dioxide, %	Oxygen, %
			Actual[a]		Standard[b]						
			m^3/h	acfh	dNm^3/h	dscfh		°C	°F		
4-1	10/28	1540-1716	99,070	3,498,604	45,089	1,592,304	14.4	275	527	4.1	11.0
4-2		1543-1718	99,108	3,499,941	45,340	1,601,155	13.6	277	531	4.1	11.0
4-3		1540-1715	98,964	3,494,845	45,107	1,592,934	14.4	274	525	4.1	11.0
4-4		1543-1715	100,893	3,562,981	44,301	1,564,464	14.3	276	529	4.1	11.0
4-5		1423-1706	113,770	4,017,725	52,065	1,838,631	14.7	270	518	4.1	11.0
4-6		1427-1716	113,495	4,008,004	52,670	1,860,026	13.5	270	518	4.1	11.0
Average (Q)			99,509	3,514,093	44,959	1,587,714	14.2	276	528	4.1	11.0
(6)			104,217	3,680,350	47,429	1,674,919	14.2	274	525	4.1	11.0
5-1	10/29	0940-1137	99,656	3,519,316	46,117	1,628,613	13.3	274	524	4.3	11.3
5-2		0943-1133	104,659	3,695,966	48,088	1,698,186	13.5	276	529	4.3	11.3
5-3		0940-1135	100,065	3,533,728	45,624	1,611,199	14.2	276	529	4.3	11.3
5-4		0943-1135	99,119	3,500,352	45,544	1,608,375	13.7	275	527	4.3	11.3
5-5		0943-1137	109,724	3,874,861	50,546	1,785,009	14.1	271	520	4.3	11.3
5-6		0942-1137	109,572	3,869,468	50,881	1,796,847	13.4	271	520	4.3	11.3
Average (Q)			100,875	3,562,340	46,358	1,636,593	13.7	275	527	4.3	11.3
(6)			103,799	3,665,615	47,800	1,688,038	13.7	274	525	4.3	11.3
6-1	10/29	1350-1550	94,435	3,334,937	43,298	1,529,041	14.0	274	526	4.5	10.5
6-2		1353-1553	94,734	3,345,471	43,042	1,520,006	14.4	277	530	4.5	10.5
6-3		1350-1550	94,514	3,337,721	43,511	1,536,556	13.3	277	530	4.5	10.5
6-4		1354-1554	95,053	3,356,748	42,503	1,500,961	15.6	278	532	4.5	10.5
6-5		1353-1553	109,673	3,873,037	50,314	1,776,813	14.7	271	520	4.5	10.5
6-6		1352-1552	109,786	3,877,050	50,346	1,777,953	14.5	271	520	4.5	10.5
Average (Q)			94,684	3,343,719	43,089	1,521,641	14.3	277	530	4.5	10.5
(6)			99,699	3,520,827	45,502	1,606,888	14.4	275	526	4.5	10.5

(continued)

TABLE 2-42 (continued)

Run No.	Date (1981)	Sampling period	Flue gas flow rate				Moisture, %	Temperature		Carbon dioxide, %	Oxygen, %
			Actual[a]		Standard[b]						
			m^3/h	acfh	dNm^3/h	dscfh		°C	°F		
7-1	10/30	0930-1130	100,034	3,532,635	46,329	1,636,079	12.9	277	530	4.0	11.0
7-2		0933-1133	100,343	3,543,545	46,251	1,633,313	12.8	280	537	4.0	11.0
7-3		0930-1130	103,699	3,662,069	44,544	1,573,041	13.4	277	530	4.0	11.0
7-4		0933-1133	100,267	3,540,882	46,386	1,638,107	12.5	280	536	4.0	11.0
7-5		0935-1135	109,520	3,867,652	51,078	1,803,803	13.2	271	520	4.0	11.0
7-6		0934-1134	109,489	3,866,549	51,147	1,806,240	13.0	271	520	4.0	11.0
Average (Q)			101,086	3,569,783	45,878	1,620,135	12.9	279	533	4.0	11.0
(6)			103,892	3,668,889	47,623	1,515,097	13.0	276	529	4.0	11.0
8-1	10/30	1438-1638	101,278	3,576,587	45,435	1,604,520	14.4	285	545	4.3	9.3
8-2		1441-1641	101,279	3,576,610	45,173	1,595,254	15.2	283	542	4.3	9.3
8-3		1438-1638	100,996	3,566,612	46,068	1,626,862	12.9	285	545	4.3	9.3
8-4		1441-1641	101,273	3,576,390	45,672	1,612,867	13.7	286	547	4.3	9.3
8-5		1439-1623	109,733	3,875,168	50,667	1,789,295	14.1	271	520	4.3	9.3
8-6		1438-1608	109,966	3,883,405	50,152	1,771,103	15.1	271	520	4.3	9.3
Average (Q)			101,206	3,574,050	45,587	1,609,876	14.1	285	545	4.3	9.3
(6)			104,088	3,675,795	47,195	1,666,650	14.2	280	537	4.3	9.3

[a]Volumetric flow rate in actual cubic meters per hour (m^3/h) and actual cubic feet per hour (acfh) at stack conditions.

[b]Volumetric flow rate in dry normal cubic meters per hour (dNm^3/h) and dry standard cubic feet per hour (dscfh): Standard conditions = 20°C and 760 mm Hg (68°F and 29.92 in. Hg) and zero percent moisture.

[c]Outlier - not used in calculations.

[d]Average (Q) is average quad train tests.
Average (6) is average of all six tests.

TABLE 2-43. SUMMARY OF FLUE GAS CONDITIONS DURING DCOG UNDERFIRING TESTING

Run No.	Date (1981)	Sampling period	Flue gas flow rate				Moisture, %	Temperature		Carbon dioxide, %	Oxygen, %
			Actual[a]		Standard[b]						
			m^3/h	acfh	dNm^3/h	dscfh		°C	°F		
D1-1	12/8	1205-1335	90,548	3,197,639	45,170	1,595,142	9.9	242	468	4.5	9.4
D1-2		1208-1338	90,863	3,208,783	44,444	1,569,507	11.7	242	468	4.5	9.4
D1-3		1205-1335	91,316	3,224,786	44,715	1,579,103	11.6	242	468	4.5	9.4
D1-4		1208-1338	91,309	3,224,520	44,920	1,586,320	11.0	243	470	4.5	9.4
D1-5[c]			-	-	-	-	-	-	-	-	-
D1-6		1209-1339	80,795	2,853,244	39,471	1,393,914	10.2	252	485	4.5	9.4
Average[d] (Q)			91,009	3,213,932	44,812	1,582,518	11.1	242	469	4.5	9.4
(5)			88,966	3,141,794	43,744	1,544,797	10.9	244	472	4.5	9.4
D2-1	12/10	1341-1511	102,820	3,631,049	49,481	1,747,391	12.2	253	487	4.3	12.3
D2-2		1308-1508	103,171	3,643,425	49,815	1,759,182	12.0	252	486	4.3	12.3
D2-3		1310-1510	103,773	3,664,702	49,927	1,763,133	12.3	252	486	4.3	12.3
D2-4		1312-1512	103,721	3,662,869	50,043	1,767,255	12.1	252	486	4.3	12.3
D2-5		1310-1510	98,778	3,488,292	47,600	1,680,969	12.2	252	486	4.3	12.3
D2-6		1311-1511	98,700	3,485,548	47,775	1,687,140	11.8	252	486	4.3	12.3
Average (Q)			103,371	3,650,511	49,817	1,759,240	12.2	252	486	4.3	12.3
(6)			101,827	3,595,981	49,107	1,734,178	12.1	252	486	4.3	12.3
D3-1	12/11	1131-1540	84,440	2,981,939	41,798	1,476,086	9.9	252	486	4.0	12.0
D3-2		1134-1540	84,484	2,983,501	41,491	1,465,237	10.6	252	486	4.0	12.0
D3-3		1134-1542	86,574	3,057,331	41,852	1,477,970	12.0	252	486	4.0	12.0
D3-4		1139-1548	86,156	3,042,559	42,185	1,489,756	11.5	249	480	4.0	12.0
D3-5		1145-1544	94,944	3,352,885	47,202	1,666,931	9.5	252	486	4.0	12.0
D3-6		1137-1546	95,278	3,364,702	46,443	1,640,093	11.3	252	486	4.0	12.0
Average (Q)			85,414	3,016,332	41,832	1,477,262	11.0	251	486	4.0	12.0
(6)			88,646	3,130,486	43,495	1,536,012	10.8	252	486	4.0	12.0

(continued)

TABLE 2-43 (continued)

Run No.	Date (1981)	Sampling period	Flue gas flow rate				Moisture, %	Temperature		Carbon dioxide, %	Oxygen, %
			Actual[a]		Standard[b]						
			m^3/h	acfh	dNm^3/h	dscfh		°C	°F		
D4-1	12/12	0940-1140	91,867	3,244,223	44,981	1,588,494	11.0	254	490	3.7	11.1
D4-2		0943-1143	91,898	3,245,338	44,895	1,585,451	11.2	254	490	3.7	11.1
D4-3		0940-1140	92,085	3,251,926	44,617	1,575,619	11.8	256	492	3.7	11.1
D4-4[c]		-	-	-	-	-	-	-	-	-	-
D4-5		0940-1140	94,584	3,340,189	45,882	1,620,295	11.9	254	490	3.7	11.1
D4-6		0942-1142	94,488	3,336,804	46,101	1,628,021	11.4	254	490	3.7	11.1
Average (Q)			91,950	3,247,162	44,831	1,583,188	11.3	255	491	3.7	11.1
(5)			92,984	3,283,696	45,295	1,599,576	11.5	254	490	3.7	11.1
D5-1	12/12	1404-1604	93,540	3,303,306	46,412	1,639,024	11.8	244	471	3.7	11.8
D5-2		1407-1607	93,658	3,307,488	46,137	1,629,300	12.5	244	471	3.7	11.8
D5-3		1358-1558	94,219	3,327,285	46,292	1,634,772	12.7	244	471	3.7	11.8
D5-4		1400-1600	94,313	3,330,605	46,074	1,627,070	13.2	244	471	3.7	11.8
D5-5		1358-1558	90,983	3,213,030	44,907	1,585,882	12.3	244	471	3.7	11.8
D5-6		1359-1559	90,680	3,202,302	45,615	1,610,872	10.6	244	471	3.7	11.8
Average (Q)			93,932	3,317,171	46,229	1,632,542	12.6	244	471	3.7	11.8
(6)			92,899	3,280,669	45,906	1,621,153	12.2	244	471	3.7	11.8
D6-1	12/13	0945-1145	86,817	3,065,894	43,962	1,552,508	11.6	235	455	5.1	11.0
D6-2		0947-1147	87,102	3,075,958	43,438	1,534,002	12.8	236	457	5.1	11.0
D6-3		0945-1145	86,868	3,067,686	43,837	1,548,066	11.9	235	455	5.1	11.0
D6-4		0947-1147	86,712	3,062,194	43,681	1,542,579	12.6	232	449	5.1	11.0
D6-5		0945-1145	88,151	3,112,999	44,327	1,565,391	12.2	235	455	5.1	11.0
D6-6		0946-1146	88,127	3,112,161	44,383	1,567,349	12.1	235	455	5.1	11.0
Average (Q)			86,875	3,067,933	43,730	1,544,289	12.2	235	454	5.1	11.0
(6)			87,296	3,082,815	43,938	1,551,649	12.2	235	454	5.1	11.0

[a]Volumetric flow rate in actual cubic meters per hour (m^3/h) and actual cubic feet per hour (acfh) at stack conditions.

[b]Volumetric flow rate in dry normal cubic meters per hour (dNm^3/h) and dry standard cubic feet per hour (dscfh): Standard conditions = 20°C and 760 mm Hg (68°F and 29.92 in. Hg) and zero percent moisture.

[c]Test voided due to excessive post-test leak rate.

[d]Average (Q) is average quad train tests.
Average (5) or (6) is average of all five or six tests.

TABLE 2-44. SUMMARY OF FLUE GAS FLOW RATE AND TEMPERATURE AS MEASURED BY A FULL VELOCITY TRAVERSE

Run No.	Date (1981)	Flue gas flow rate				Temperature	
		Actual[a]		Standard[b]			
		m^3/h	acfh	dNm^3/h	dscfh	°C	°F
NCOG underfiring test series							
Pre. 1	10/22	93,236	3,292,608	47,368	1,672,794	228	442
Pre. 2	10/22	89,465	3,159,420	44,999	1,589,130	233	451
V.T.	10/27	95,169	3,360,858	45,169	1,595,118	259	499
Average		92,623	3,270,962	45,845	1,619,014	240	464
DCOG underfiring test series							
Pre.	12/7	86,169	3,043,045	44,134	1,558,567	228	443

[a]Volumetric flow rate in actual cubic meters per hour (m^3/h) and actual cubic feet per hour (acfh) at stack conditions.

[b]Volumetric flow rate in dry normal cubic meters per hour (dNm^3/h) and dry standard cubic feet per hour (dscfh): Standard conditions = 20°C and 760 mmHg (68°F and 29.92 in.Hg) and zero percent moisture.

During the NCOG underfiring test series, the volumetric flow rate averaged 46,882 dNm^3/h (1,634,766 dscfh), temperature averaged 277°C (531°F), and moisture content averaged 13.6 percent. Oxygen and carbon dioxide contents averaged 10.6 and 4.0 percent, respectively.

During the DCOG underfiring test series, the volumetric flow rate averaged 45,247 dNm^3/h (1,597,894 dscfh), temperature averaged 247°C (476°F), and the moisture content averaged 11.6 percent. Oxygen and carbon dioxide contents averaged 11.3 and 4.2 percent, respectively.

2.9 VISIBLE EMISSIONS

Table 2-45 summarizes visible emissions data collected during the NCOG underfiring test series. Data were not collected during Runs 1, 2, and 3. During Run 4, opacities ranged from 0 to 45 percent and averaged 15 percent. These opacities were markedly higher than those during Runs 5 through 8, which ranged from 0 to 40 percent and averaged 3 percent. Frank Clay of the EPA made the visible emissions observations.

Extreme adverse weather conditions prevented the observation of visible emissions during the DCOG underfiring test series. Cloud cover was 100 percent during the entire test series, and snow fell during most of the test series.

TABLE 2-45. SUMMARY OF VISIBLE EMISSIONS DATA NUMBER 1 COKE BATTERY EXIT STACK, NCOG UNDERFIRING TEST SERIES

Particulate Run No.	Date (1981)	Particulate test time	Corresponding VE run No.	VE set No.	VE observation time	Average % opacity	Range
1	10/27	0910-1114	N/A[a]				
2	10/27	1355-1624	N/A				
3	10/28	0955-1158	N/A				
4	10/28	1423-1716	VE-1	VE-1-1	1455-1500	30	20-45
				VE-1-2	1501-1506	11	0-35
				VE-1-3	1507-1512	7	0-15
				VE-1-4	1513-1518	10	0-25
				VE-1-5	1519-1525	17	10-25
				VE-1-6	1526-1531	10	5-20
				VE-1-7	1532-1537	16	0-25
				VE-1-8	1538-1543	17	10-20
				VE-1-9	1544-1549	18	10-20
				VE-1-10	1550-1551[b]	10	5-15
5	10/29	0940-1137	VE-2	VE-2-1	1035-1040	6	5-10
				VE-2-2	1041-1046	3	0-5
				VE-2-3	1047-1052	3	0-5
				VE-2-4	1053-1058	2	0-5
				VE-2-5	1059-1104	2	0-5
				VE-2-6	1105-1110	0	0
				VE-2-7	1111-1116	0	0
				VE-2-8	1117-1122	0	0
				VE-2-9	1123-1128	0	0
				VE-2-10	1129-1134	0	0-5
6	10/29	1350-1554	VE-4	VE-4-1	1431-1436	1	0-5
				VE-4-2	1437-1442	0	0
				VE-4-3	1443-1448	0	0
				VE-4-4	1449-1454	0	0-5
				VE-4-5	1455-1500	2	0-5
				VE-4-6	1501-1506	0	0
				VE-4-7	1507-1512	0	0

(continued)

TABLE 2-45 (continued)

Particulate Run No.	Date (1981)	Particulate test time	Corresponding VE run No.	VE set No.	VE observation time	Average % opacity	Range
6 (cont'd)	10/29	1350-1554	VE-4	VE-4-8	1513-1518	0	0
				VE-4-9	1519-1524	0	0-5
				VE-4-10	1525-1530	3	0-10
			VE-5	VE-5-1	1536-1541	8	5-10
				VE-5-2	1542-1547	<6	<5-20
				VE-5-3	1548-1553	<18	0-40
				VE-5-4	1554-1559	9	0-20
				VE-5-5	1600-1605	<2	0-5
				VE-5-6	1606-1611	0	0
				VE-5-7	1612-1617[c]	0	0
				VE-5-8	1618-1620[c]	0	0
7	10/30	0930-1135	VE-6	VE-6-1	1003-1008[d]	0	0
				VE-6-2	1011-1012[d]	0	0
				VE-6-3	1018-1023	0	0-5
				VE-6-4	1024-1029	<5	<5-5
				VE-6-5	1030-1035[e]	<2	0-<5
				VE-6-6	1036-1040[e]	0	0
8	10/30	1438-1641	VE-7	VE-7-1	1443-1448	<6	0-15
				VE-7-2	1449-1454	<3	0-5
				VE-7-3	1455-1500	<2	0-5
				VE-7-4	1501-1506	<6	0-15
				VE-7-5	1507-1512	8	5-10
				VE-7-6	1513-1518	<6	0-10
				VE-7-7	1519-1524	<5	0-10
				VE-7-8	1525-1530	<5	<5-10
				VE-7-9	1531-1536[f]	<7	0-15
				VE-7-10	1540-1544[f]	<5	0-10

(continued)

TABLE 2-45 (continued)

Particulate Run No.	Date (1981)	Particulate test time	Corresponding VE run No.	VE set No.	VE observation time	Average % opacity	Range
8 (cont'd)	10/30	1438-1641	VE-8	VE-8-1	1551-1556	11	<5-20
				VE-8-2	1557-1602	<3	0-5
				VE-8-3	1603-1608	0	0
				VE-8-4	1609-1614	0	0
				VE-8-5	1615-1620	0	0
				VE-8-6	1621-1626	0	0
				VE-8-7	1627-1632	2	0-15
				VE-8-8	1633-1638	8	5-10
				VE-8-9	1639-1644	<5	0-10
				VE-8-10	1645-1650	<5	0-5

[a]N/A = Not analyzed.

[b]Two-minute set.

[c]Three-minute set.

[d]Two-minute set.

[e]Three-minute set.

[f]Five-minute set.

2.10 PROCESS DATA

During each test, the process operation was monitored by an MRI representative. Tables 2-46 and 2-47 summarize the process data collected during the NCOG and DCOG test series, respectively. The following parameters were monitored: average COG to battery average coal in battery, number of pushes and charges, number of ovens empty, and exhaust main pressure (push and coke side).

Average COG to Battery No. 1 during the NCOG underfiring testing was 4,820 m^3/h (170,190 ft^3/h). The coal in the battery averaged 640.4 Mg (706.1 tons). There were an average of 6 pushes, 7 charges, and 4 empty ovens during a test run. Exhaust main pressure averaged 78 mmH_2O (3.1 $in.H_2O$) on the push side, and 81 mmH_2O (3.2 $in.H_2O$) on the coke side.

Average COG to Battery No. 1 during the DCOG underfiring testing was 4,339 m^3/h (153,210 ft^3/h). The coal in the battery averaged 596.4 Mg (567.7 tons). There were an average of 6 pushes, 5 charges, and 3 empty ovens during a test run. Exhaust main pressure averaged 57 mmH_2O (2.2 $in.H_2O$) on the push side, and 60 mmH_2O (2.4 $in.H_2O$) on the coke side.

Tables 2-48 and 2-49 summarize the sulfur content of the coal and coke during the NCOG and DCOG test series. During the NCOG test series, the coal and the coke contained an average of 0.82 and 0.70 percent sulfur, respectively. During the DCOG test series, the coal averaged 0.80 percent sulfur, and the coke averaged 0.72 percent sulfur.

TABLE 2-46. NCOG TEST SERIES PROCESS DATA[a]

Run No.	Date (1981)	Time	Average COG to battery[b]		Average coal in battery		No. of pushes	No. of charges	No. of ovens empty	Exhaust main pressure			
										Push side		Coke side	
			m^3/h	ft^3/h	Mg	tons				mmH_2O	$in.H_2O$	mmH_2O	$in.H_2O$
1	10/27	0910-1114	4874	172,120	604.6	666.6	12	12	6	78	3.1	80	3.1
2	10/27	1355-1624	4754	167,880	622.7	686.6	4	3	6	74	2.9	82	3.2
3	10/28	0947-1158	4117	145,390	635.1	700.2	6	5	3	76	3.0	83	3.2
4	10/28	1423-1718	5012	176,990	655.2	722.4	9	11	3	78	3.1	81	3.2
5	10/29	0940-1137	4990	176,220	650.3	717.0	7	6	3	79	3.1	81	3.2
6	10/29	1350-1554	5213	184,070	650.4	717.1	5	7	3	79	3.1	80	3.1
7	10/30	0930-1135	4528	159,880	648.1	714.6	3	6	3	80	3.1	80	3.1
8	10/30	1438-1641	5068	178,940	657.2	724.6	4	4	3	79	3.1	80	3.1
Average			4820	170,190	640.4	706.1	6	7	4	78	3.1	81	3.2

[a]The following information was provided by Republic Steel Corporation: 1) Average amount of coal charged per coke oven: ~15.3 tons/coking cycle. 2) Average amount of coke produced per coke oven: ~10.2 tons/coking cycle. 3) Coking temperature: ~2300°F. (This is the temperature recorded in the flues. The temperature of the coke would be approximately 150°F lower.) 4) Average coking time: ~20.5 hours.

[b]At 40°C (140°F).

TABLE 2-47. DCOG TEST SERIES PROCESS DATA[a]

Run No.	Date (1981)	Time	Average COG to battery[b]		Average coal in battery		No. of pushes	No. of charges	No. of ovens empty	Exhaust main pressure			
										Push side		Coke side	
			m^3/h	ft^3/h	Mg	tons				mmH_2O	$in.H_2O$	mmH_2O	$in.H_2O$
D-1	12/8	1150-1352	4591	162,100	598.6	660.0	11	10	3	64	2.5	62	2.4
D-2	12/10	1305-1512	4521	159,640	598.6	660.0	7	8	3	62	2.4	65	2.6
D-3	12/11	1134-1142 1350-1548	4234	149,520	585.9	646.0	4	4	3	55	2.2	55	2.2
D-4	12/12	0940-1145	4130	145,850	598.6	660.0	4	3	3	55	2.2	60	2.2
D-5	12/12	1355-1607	4348	153,530	598.6	660.0	3	2	3	55	2.2	60	2.4
D-6	12/13	0945-1147	4209	148,620	598.6	660.0	5	5	3	52	2.0	60	2.4
Average			4339	153,210	596.4	657.7	6	5	3	57	2.2	60	2.4

[a]The following information was provided by Republic Steel Corporation: 1) Average amount of coal charged per coke oven: ~14 tons/coking cycle during November/December. 2) Average amount of coke produced per coke oven: ~10 tons/coking cycle during November/December. 3) Coke temperature: ~2175°F to 2250°F. (This is the temperature recorded in the flues. The temperature of the coke would be approximately 150°F lower.) 4) Average coking time: ~24 hours. 5) Btu content of DCOG: 540 Btu/scf.

[b]At 40°C (104°F).

TABLE 2-48. SULFUR CONTENT OF COAL AND COKE DURING NCOG TESTS (PERCENT)

Date analyzed[a]	Coal	Coke
10/25/81	0.75	0.70
10/26/81	0.77	0.72
10/27/81	0.98	0.75
10/28/81	0.80	0.65
10/29/81	0.78	0.70
10/30/81	0.85	0.65
Average	0.82	0.70

TABLE 2-49. SULFUR CONTENT OF COAL AND COKE DURING DCOG TESTS (PERCENT)

Date analyzed[a]	Coal	Coke
12/07/81	0.78	0.78
12/08/81	0.78	0.75
12/09/81	0.83	0.73
12/10/81	0.80	0.68
12/11/81	0.78	0.68
12/12/81	0.87	0.70
12/13/81	0.80	0.70
Average	0.80	0.72

[a]Sulfur content of coal is usually analyzed 1 to 2 days before the coal is charged to the ovens. Sulfur content of coke is usually analyzed the same day the coke is pushed from the ovens.

The MRI process description and data as received by PEDCo are included in Appendix I.

SECTION 3

PROCESS DESCRIPTION

The Republic Steel facility in Cleveland currently operates three Koppers gun-flue coke oven batteries. The testing was conducted on the flue gas from the No. 1 coke oven battery, which consists of 51 ovens. Coke was first pushed from this battery in January 1977. Initial startup of the Sulfiban desulfurization system was in March/April 1981. Coke is produced continuously 24-hours per day. This facility uses byproduct coke ovens to produce furnace coke from coal; the coke is used in blast furnaces for the reduction of iron ore to metallic iron. Figure 3-1 is a simplified process flow diagram.

The gas collecting system has two offtakes, one located at each end of the oven. The volatile products liberated during the coking process pass through the battery's dual collection main and are processed by the byproduct recovery system, which consists of a primary cooler, exhauster, detarrer, ammonia absorber, final cooler, a benzol scrubber, Sulfiban desulfurization system, pressure regulator, and booster. After leaving the byproduct recovery system, the normal or desulfurized coke oven gas (NCOG or DCOG) is used to heat the ovens in the battery.

About 40 percent of the COG (DCOG or NCOG) generated by the battery during the coking process is underfired to the battery

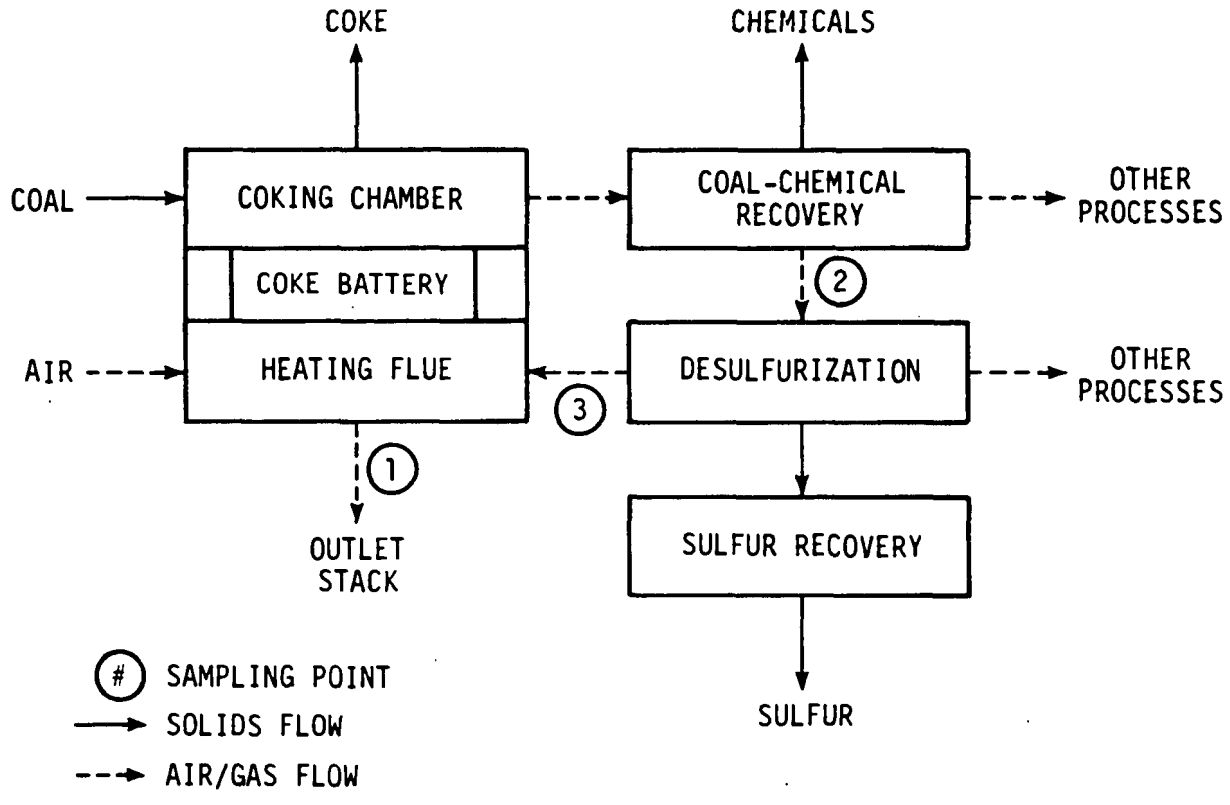


Figure 3-1. Process flow diagram,
Republic Steel-Cleveland Works.

along with combustion air. The products of combustion from underfiring with coke oven gas leave the battery via the waste gas stack. There are no add-on pollution control devices serving the battery stack. Naturally induced stack draft, which is regulated by dampers at the end of each flue gas canal, draws air required for combustion through an airbox at the bottom of the regenerator chambers.

Approximately 15 tons of coal (0.75 to 1.0 percent sulfur) is charged through three openings in the top of each oven. A leveling bar on the pusher machine is used to level the coal before the coking operation begins. The coke ovens are underfired with coke oven gas (NCOG or DCOG), and the firing takes place from either the coke side or the push side. More gas is fired on the coke side of the oven since it is approximately 3 inches wider and, hence, contains more coke to heat up than the pusher side of the oven. Heat for the coking operation is provided by a regenerative combustion system located below the ovens. Since the combustion flue gas contains a significant amount of process heat, two regenerators (one for combustion air and one for combustion waste gas) are located below each oven. Flow between the two regenerators alternates at about 30 minute intervals as the firing of the coke ovens is reversed every 30 minutes to keep the ovens operating within the safe temperature range of the silica refractories.

When the coking operation is complete [skin temperature of the coke has reached 1038° to 1093°C (1900° to 2000°F)], the coke

guide and quench car are moved into place, and the oven doors are removed. The pusher then pushes the coke out of the oven through the coke guide and into the quench car. The coke is then transported to the quench tower, where it is cooled by water sprays. From there, it is removed to the wharf, where it is further cooled before being conveyed to storage.

The operation of each oven is cyclic, but the battery contains a sufficiently large number of ovens to maintain an essentially continuous yield of byproducts. Although the time between charging and discharge is approximately equal for all ovens, charging times are staggered so that the flow of evolved gases from the ovens is constant. This helps to maintain a balance of pressure in the flues, collecting main, and battery stack.

SECTION 4

SAMPLING AND ANALYTICAL PROCEDURES

Samples collected at the exit stack were analyzed for particulate, sulfur dioxide, sulfuric acid mist, and other related pollutants. In addition, grab samples collected at the inlet and outlet (during DCOG underfiring) of the SRU and the exit stack were analyzed for total reduced sulfurs (TRS). This section briefly describes the sampling and analytical procedures used in this test; detailed descriptions of these procedures are presented in Appendix D.

4.1 SAMPLING LOCATIONS

Sampling ports were located at the 15.2-m (50-ft) level of the 68.6-m (225-ft) outlet stack. This site is 6 stack diameters from the nearest downstream flow disturbance and 21 stack diameters from the nearest upstream flow disturbance in the 2.5-m (8.1-ft) diameter stack (see Figure 4-1). Figure 4-2 shows the sampling site configuration and traverse point locations. Twenty-four points were used for velocity traverse. Particulate sampling was conducted at a point of average velocity for the entire 2-hour test period.

Gaseous grab samples were collected at the inlet and outlet of the SRU via positive pressure taps located in the connecting ductwork.

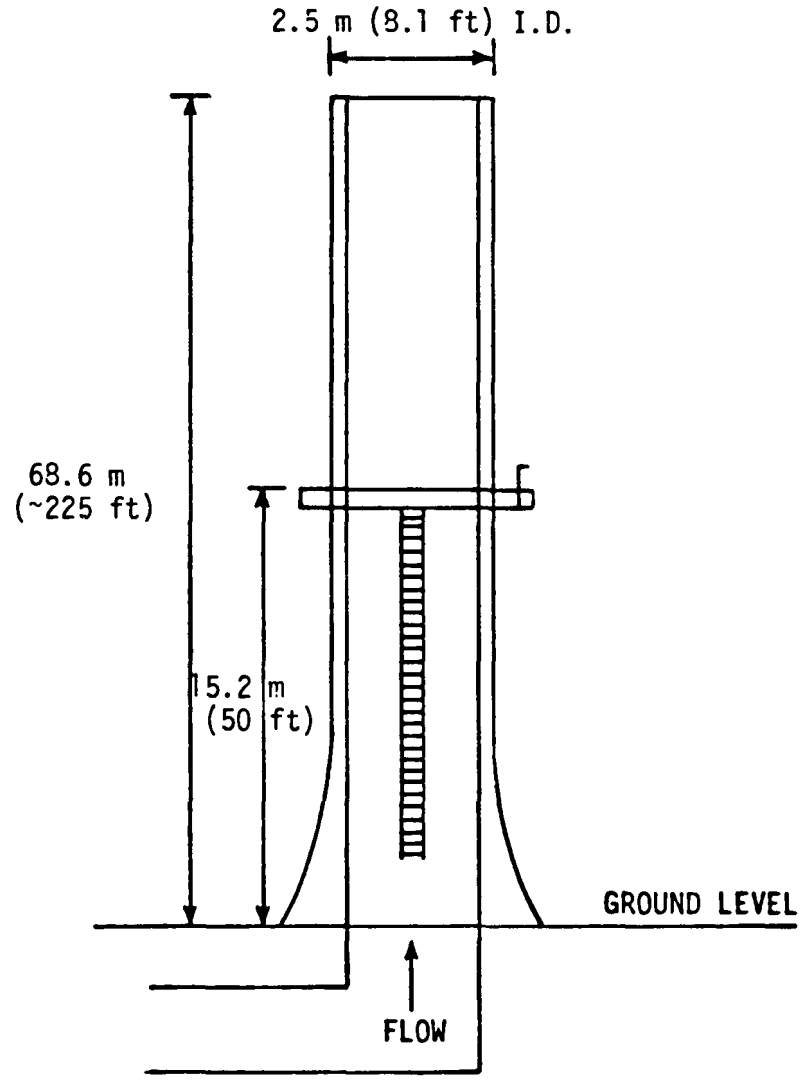
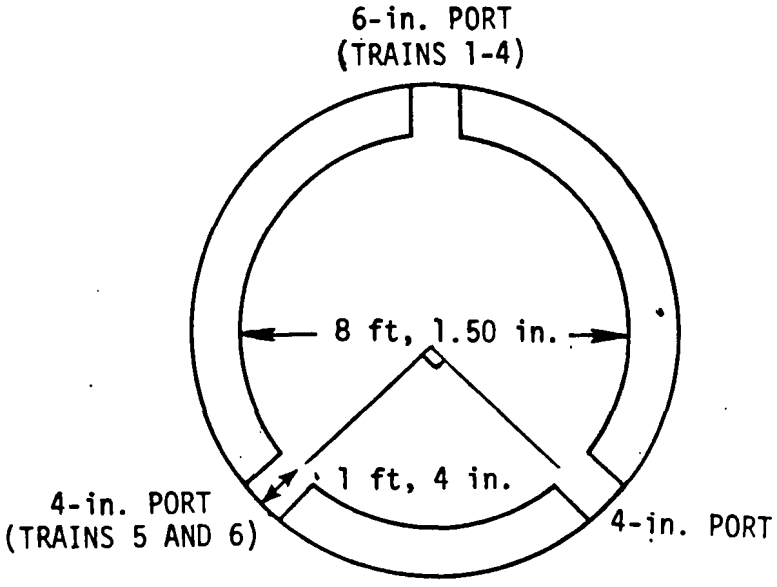


Figure 4-1. Coke Battery No. 1 flue gas exit stack.



VELOCITY TRAVERSE POINT LOCATIONS

POINT NO.	LOCATION, in.
1	2
2	6 1/2
3	11 1/2
4	17 1/4
5	24 3/8
6	34 3/4
7	62 3/4
8	73 1/8
9	80 3/4
10	86
11	91
12	95 1/2

Figure 4-2. Coke Battery No. 1 exit stack sampling site and traverse point locations.

4.2 GAS STREAM FLOW RATE, TEMPERATURE, AND COMPOSITION

Gas stream flow rate and temperature before each test series and in conjunction with each particulate run were measured according to the procedures described in EPA Method 2.* Velocities were measured with an S-type pitot tube and a 0 to 0.25-inch, inclined, draft gauge manometer. Temperatures were measured with a calibrated thermocouple and digital potentiometer. During each particulate test an integrated bag sample was collected, the oxygen and carbon dioxide content was determined by Orsat analysis. Method 3* sampling and analytical procedures were used in all cases.

4.3 PARTICULATE, SULFUR DIOXIDE, AND SULFURIC ACID MIST EMISSION TESTS

Samples were collected from a single point in the exit stack by use of a quad train Method 5 sampling system, a standard EPA Method 5 train, and a particulate sampling train equipped for 315°C (600°F) filter box and probe heat. Sampling was conducted isokinetically by regulating the sampling rate relative to the flue gas velocity. Tables 4-1 through 4-3 detail the sampling and analytical schedules used during the NCOG and DCOG test series. Particulate filters were glass fiber,** sample train back halves consisted of four impingers in a Method 5 water configuration or five impingers in a Method 8 isopropanol,

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*40 CFR 60, Appendix A, Reference Methods 2 and 3, July 1980.

**Whatman Reeve Angel 934 AH.

TABLE 4-1. NCOG UNDERFIRING TEST SERIES, OCTOBER 26-30, 1981, REVISED SAMPLING SCHEDULE

Run No.	Sample train No.	Probe, filter temperature, °C	Probe, filter temperature, °F	Back-half configuration
1	1.1	121	250	Method 8
	1.2	121	250	Method 8
	1.3	177	350	Method 8
	1.4	177	350	Method 8
	1.5	121	250	Method 5
	1.6	316	600	Method 8
2	2.1	121	250	Method 8
	2.2	121	250	Method 8
	2.3	204	400	Method 8
	2.4	204	400	Method 8
	2.5	121	250	Method 5
	2.6	316	600	Method 8
3	3.1-3.6	Same as Run 1		Same as Run 1
4	4.1-4.6	Same as Run 2		Same as Run 2
5	5.1	121	250	Method 8
	5.2	121	250	Method 5
	5.3	177	350	Method 8
	5.4	177	350	Method 5
	5.5	121	250	Method 5
	5.6	316	600	Method 8
6	6.1	121	250	Method 8
	6.2	121	250	Method 5
	6.3	204	400	Method 8
	6.4	204	400	Method 5
	6.5	121	250	Method 5
	6.6	316	600	Method 8
7	7.1	121	250	Method 8
	7.2	121	250	Method 5
	7.3	177	350	Method 8
	7.4	177	350	Method 5
	7.5	204	400	Method 5
	7.6	316	600	Method 8
8	8.1	177	350	Method 8
	8.2	177	350	Method 5
	8.3	204	400	Method 8
	8.4	204	400	Method 5
	8.5	121	250	Method 8
	8.6	316	600	Method 8

Note: All filters were Whatman Reeve Angel 934 AH. Sampling trains 1 through 4 operated simultaneously in quad system. During every run, gas samples were collected at the COG inlet to the battery and at the outlet stack for TRS and SO_2 analysis.

TABLE 4-2. DCOG UNDERFIRING TEST SERIES, DECEMBER 6-13, 1981, REVISED SAMPLING SCHEDULE

Run No.	Sample train No.	Probe, filter temperature, °C	Probe, filter temperature, °F	Back-half configuration
D1	1.1	121	250	Method 8
	1.2	121	250	Method 8
	1.3	177	350	Method 8
	1.4	177	350	Method 8
	1.5	121	250	Method 5
	1.6	316	600	Method 8
D2	2.1-2.6	Same as Run D1		Same as Run D1
D3	3.1	121	250	Method 8
	3.2	121	250	Method 8
	3.3	204	400	Method 8
	3.4	204	400	Method 8
	3.5	121	250	Method 5
	3.6	316	600	Method 8
D4	4.1-4.6	Same as Run D3		Same as Run D3
D5	5.1	121	250	Method 8
	5.2	121	250	Method 5
	5.3	177	350	Method 8
	5.4	177	350	Method 5
	5.5	121	250	Method 5
	5.6	316	600	Method 8
D6	6.1	121	250	Method 8
	6.2	121	250	Method 5
	6.3	204	400	Method 8
	6.4	204	400	Method 5
	6.5	121	250	Method 5
	6.6	316	600	Method 8

Note: All filters were Whatman Reeve Angel 934 AH. Sample trains 1 through 6 operated simultaneously. Gas samples were collected during every run at the inlet and outlet of the desulfurization unit and at the outlet stack for TRS and SO_2 analysis.

TABLE 4-3. NCOG AND DCOG UNDERFIRING TEST SERIES ANALYTICAL SCHEDULE

Run	Sampling train	Filter I.D. No.	Probe and filter temperature, °C	Probe and filter temperature, °F	Laboratory protocol: Front half[a]	Laboratory protocol: Back half
1,3, D1,D2	Method 5 with Method 8 back half	1.1 3.1 D1.1 D2.1	121	250	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	Standard Method 8
	Method 5 with Method 8 back half	1.2 3.2 D1.2 D2.2	121	250	1. Desiccate and weigh 2. Heat 2 h at 177°C (350°F) 3. Reweigh 4. IPA-rinse and titrate 5. H_2O-rinse and titrate	Standard Method 8
	Method 5 with Method 8 back half	1.3 3.3 D1.3 D2.3	177	350	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	Standard Method 8
	Method 5 with Method 8 back half	1.4 3.4 D1.4 D2.4	177	350	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	Standard Method 8
	Method 5 with H_2O in the impingers	1.5 3.5 D1.2 D2.5	121	250	1. Desiccate and weigh 2. Divide filter, desiccate and weigh 3. a. Heat 2 h at 177°C (350°F), heat 4 h at 177°C (350°F), heat 2 h at 204°C (400°F), heat 4 h at 204°C (400°F), heat 2 h at 316°C (600°F), IPA-rinse and titrate, H_2O-rinse and titrate	1. TOC[b] 2. E-C ext.[c]

(continued)

TABLE 4-3 (continued)

Run	Sampling train	Filter I.D. No.	Probe and filter temperature, °C	Probe and filter temperature, °F	Laboratory protocol: Front half[a]	Laboratory protocol: Back-half
					b. 121°C (250°F) → TOC temperature profile → 316°C (600°F)	
	CCS filter holder with Method 8 back half	1.6 3.6 D1.6 D2.6	316	600	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	Standard Method 8
2,4, D3,D4	Method 5 with Method 8 back half	2.1 4.1 D3.1 D4.1	121	250	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	Standard Method 8
	Method 5 with Method 8 back half	2.2 4.2 D3.2 D4.2	121	250	1. Desiccate and weigh 2. Heat 2 h at 204°C (400°F) 3. Reweigh 4. IPA-rinse and titrate 5. H_2O-rinse and titrate	Standard Method 8
	Method 5 with Method 8 back half	2.3 4.3 D3.3 D4.3	204	400	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	Standard Method 8
	Method 5 with Method 8 back half	2.4 4.4 D3.4	204	400	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	Standard Method 8

(continued)

TABLE 4-3 (continued)

Run	Sampling train	Filter I.D. No.	Probe and filter temperature, °C	Probe and filter temperature, °F	Laboratory protocol: Front half[a]	Laboratory protocol: Back half
	Method 5 with H_2O in the impingers	2.5 4.5 D3.5 D4.5	121	250	1. Desiccate and weigh 2. Divide filter, desiccate and weigh 3. a. Heat 2 h at 177°C (350°F), heat 4 h at 177°C (350°F), heat 2 h at 204°C (400°F), heat 4 h at 204°C (400°F), heat 2 h at 316°C (600°F), IPA-rinse and titrate, H_2O-rinse and titrate b. 121°C (250°F) → TOC temperature profile → 316°C (600°F)	1. TOC[b] 2. E-C ext.[c]
	CCS filter holder with Method 8 back half	2.6 4.6 D3.6 D4.6	316	600	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	Standard Method 8
5,D5	Method 5 with Method 8 back half	5.1 D5.1	121	250	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	Standard Method 8
	Method 5 with H_2O in the impingers	5.2 D5.2	121	250	1. Desiccate and weigh 2. Heat 2 h at 177°C (350°F) 3. Reweigh 4. IPA-rinse and titrate 5. H_2O-rinse and titrate	1. TOC[b] 2. E-C ext.[c]
	Method 5 with Method 8 back half	5.3 D5.3	177	350	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	Standard Method 8

(continued)

TABLE 4-3 (continued)

Run	Sampling train	Filter I.D. No.	Probe and filter temperature, °C	Probe and filter temperature, °F	Laboratory protocol: Front half[a]	Laboratory protocol: Back half
	Method 5 with H_2O in the impingers	5.4 D5.4	177	350	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	1. TOC[b] 2. E-C ext.[c]
	Method 5 with H_2O in the impingers	5.5 D5.5	121	250	1. Desiccate and weigh 2. Divide filter, desiccate and weigh 3. a. Heat 2 h at 177°C (350°F), heat 4 h at 177°C (350°F), heat 2 h at 204°C (400°F), heat 4 h at 204°C (400°F), heat 2 h at 316°C (600°F), IPA-rinse and titrate, H_2O-rinse and titrate b. 121°C (250°F) → TOC temperature profile → 316°C (600°F)	1. TOC[b] 2. E-C ext.[c]
	CCS filter holder with Method 8 back half	5.6 D5.6	316	600	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	Standard Method 8
6,D6	Method 5 with Method 8 back half	6.1 D6.1	121	250	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	Standard Method 8
	Method 5 with H_2O in the impingers	6.2 D6.2	121	250	1. Desiccate and weigh 2. Heat 2 h at 204°C (400°F) 3. Reweigh 4. IPA-rinse and titrate 5. H_2O-rinse and titrate	1. TOC[b] 2. E-C ext.[c]

(continued)

TABLE 4-3 (continued)

Run	Sampling train	Filter I.D. No.	Probe and filter temperature, °C	Probe and filter temperature, °F	Laboratory protocol: Front half[a]	Laboratory protocol: Back half
	Method 5 with Method 8 back half	6.3 D6.3	204	400	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	Standard Method 8
	Method 5 with H_2O in the impingers	6.4 D6.4	204	400	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	1. TOC[b] 2. E-C ext.[c]
	Method 5 with H_2O in the impingers	6.5 D6.5	121	250	1. Desiccate and weigh 2. Divide filter, desiccate and weigh 3. a. Heat 2 h at 177°C (350°F), heat 4 h at 177°C (350°F), heat 2 h at 204°C (400°F), heat 4 h at 204°C (400°F), heat 2 h at 316°C (600°F), IPA-rinse and titrate, H_2O-rinse and titrate b. 121°C (250°F) → TOC temperature profile → 316°C (600°F)	1. TOC[b] 2. E-C ext.[c]
	CCS filter holder with Method 8 back half	6.6 D6.6	316	600	1. Desiccate and weigh 2. IPA-rinse and titrate 3. H_2O-rinse and titrate	Standard Method 8
7	Method 5 with Method 8 back half	7.1	121	250	1. Desiccate and weigh 2. Hold	Hold

(continued)

TABLE 4-3 (continued)

Run	Sampling train	Filter I.D. No.	Probe and filter temperature, °C	Probe and filter temperature, °F	Laboratory protocol: Front half[a]	Laboratory protocol: Back half
	Method 5 with H_2O in the impingers	7.2	121	250	1. Desiccate and weigh 2. Hold	Hold
	Method 5 with Method 8 back half	7.3	177	350	1. Desiccate and weigh 2. Hold	Hold
	Method 5 with H_2O in the impingers	7.4	177	350	1. Desiccate and weigh 2. Hold	Hold
	Method 5 with H_2O in the impingers	7.5	204	400	1. Desiccate and weigh 2. Hold	Hold
	CCS filter holder with Method 8 back half	7.6	316	600	1. Desiccate and weigh 2. Hold	Hold
8	Method 5 with Method 8 back half	8.1	177	350	1. Desiccate and weigh 2. Hold	Hold
	Method 5 with H_2O in the impingers	8.2	177	350	1. Desiccate and weigh 2. Hold	Hold
	Method 5 with Method 8 back half	8.3	204	400	1. Desiccate and weigh 2. Hold	Hold

(continued)

TABLE 4-3 (continued)

Run	Sampling train	Filter I.D. No.	Probe and filter temperature, °C	Probe and filter temperature, °F	Laboratory protocol: Front half[a]	Laboratory protocol: Back half
	Method 5 with H_2O in the impingers	8.4	204	400	1. Desiccate and weigh 2. Hold	Hold
	Method 5 with Method 8 back half	8.5	121	250	1. Desiccate and weigh 2. Heat 2 h at 135°C (275°F), heat 4 h at 135°C (275°F), heat 2 h at 149°C (300°F), heat 4 h at 149°C (300°F), heat 2 h at 163°C (325°F), heat 4 h at 163°C (325°F), heat 2 h at 177°C (350°F), heat 4 h at 177°C (350°F), heat 2 h at 204°C (400°F), heat 4 h at 204°C (400°F), heat 2 h at 316°C (600°F), IPA-rinse and titrate, H_2O-rinse and titrate	Hold
	CCS filter holder with Method 8 back half	8.6	316	600	1. Desiccate and weigh 2. Hold	Hold

[a]Front half filter catches were saved after their analysis.

[b]Total organic carbon.

[c]Ether-chloroform extraction.

hydrogen peroxide configuration. Stack, probe, filter, and impinger gas temperatures were monitored for each train during sampling.

After sampling was completed, filters were removed and placed in a petri dish. The nozzle, probe, and filter holder portions of the sample train were then acetone-rinsed. The acetone rinse and particulate caught on the filter media were dried at room temperature, desiccated to a constant weight, and weighed on an analytical balance. Total filterable particulate matter was determined by adding these two values. Selected filters were heated at indicated temperatures for 2 to 4 hours, desiccated to a constant weight, and weighed on an analytical balance. After the indicated heat treatment, the filterable particulate matter content was determined by adding these two values.

Acid sulfate and water-soluble sulfates were determined by washing the particulate catch samples sequentially with IPA and distilled water, and titrating the eluates with barium perchlorate.

Total organic carbon was determined from selected filters by heating to the indicated temperature in the presence of a leak-free nitrogen purge. After the purge gas had been diluted and oxidized, it was collected in a stainless steel tank. An aliquot was injected into a gas chromatograph with oxidation-reduction capabilities.

Sulfuric acid mist and sulfur dioxide concentrations were determined from the sampling trains with Methods 8 back halves.

The first and second impingers contained the acid mist sample, and the third and fourth impingers contained the SO_2 sample. In each case, the concentrations were determined by titrating with barium perchlorate.

The Method 5 impinger contents for selected samples were treated by an ether-chloroform extraction technique to determine organic and inorganic condensibles. The respective extracts were placed in tared beakers and evaporated to dryness. The organic fraction was dried at ambient temperature, and the inorganic fraction, at 105°C (221°F). The beakers were then desiccated to a constant weight and weighed to the nearest 0.1 mg. Condensible total organic carbon also was determined, by subjecting an aliquot of Method 5 back-half water to the ampule technqiue of organic oxidation. This method involves heating the aliquot in a carbon-free atmosphere in the presence of a catalyst and quantitatively determining carbon dioxide.

4.4 REDUCED-SULFUR EMISSION TESTS

Gas samples were analyzed for reduced-sulfur compounds (H_2S, COS, and CS_2) and SO_2 by gas chromatographic (GC) separation and flame photometric detection (FPD). Fifteen-liter Tedlar^R bags were filled with COG via positive-pressure taps located in the ductwork at the inlet and outlet of the SRU or filled with exit stack gas by a leak-free Teflon diaphragm pump. Only Teflon tubing and connections were used during sample collection. Inlet and outlet SRU samples were collected simultaneously.

A sample aliquot was taken for analysis by a sample loop and multiport valve system. Aliquot size was determined by the sample loop size. For separation of the reduced-sulfur and sulfur dioxide components, the sample aliquot was passed through various chromatographic columns. Flow through the sample loop and columns was controlled by electronic integration. After separation, the relative quantity of each component was measured as the electrical potential (μV-s) produced from the flame photometric detector and measured by the integrator. Component calibration curves of response versus concentration were made daily by permeation devices and dynamic dilution. The FPD response was determined to be linear from 0 to 70 ppm. Samples with component concentrations greater than 70 ppm were analyzed in the FPD linear range by reducing the sample loop size. Audit and standard gases were diluted dynamically before they entered the sample loop. Harmon Engineering and Testing of Auburn, Alabama, provided an onsite GC-FPD analysis.

Appendix D presents a complete description of the sampling and analytical procedures used. Appendix A presents calculations, including gas velocity data. Appendices B and C present field and laboratory data sheets, and Appendix E describes the equipment calibration procedures and results.

SECTION 5

QUALITY ASSURANCE

Because the end product of testing is the production of representative emission results, quality assurance is one of the primary facets of stack sampling. Quality assurance guidelines outline what is pertinent to the production of acceptable data and emission data are considered reliable only if the proper quality assurance measures are taken. The steps outlined herein are intended to ensure the production of quality data through our testing and analysis procedures.

Quality control procedures for the standard reference methods were used throughout this test series. These included, but were not limited to, the following:

- Calibration of field sampling equipment. Tables 5-1 through 5-12 summarize calibration of equipment used in this test series. Calibration guidelines are described in more detail in Appendix E.
- Train configuration and calculation checks.
- Onsite quality assurance checks such as leak checks of the sampling train, the pitot tube, and the Orsat line.
- Use of designated analytical equipment and sampling reagents.
- Lab analysis procedures. Tables 5-13 and 5-14 show the results of quality assurance tests for accuracy of the analysis of field samples.

TABLE 5-1. FIELD EQUIPMENT CALIBRATION, QUAD TRAIN NO. 1 (NCOG)

Equipment	I.D. No.	Calibrated against	Allowable deviation	Actual deviation	Within allowable limits	Comments
Meter box	FB-2	Wet test meter	Y ±0.02 Y ΔH @ ±0.15 (Y ±0.05 Y post-test)	-3.0%	✓	
Pitot tube	1001	Standard pitot tube	Cp ±0.01	OK	✓	
Digital indicator	125	Millivolt signals	0.5%	+0.3%	✓	
Thermocouples and stack thermometers	174	ASTM-2F or 3F	1.5% (±2% saturated)	0.4%	✓	
Orsat analyzer	231 CO_2 O_2 CO	Standard gas	±0.5%	+0.2% +0.1% -0.4%	✓ ✓ ✓	
Impinger thermometer		ASTM-2F or 3F	±2°F	OK	✓	
Trip balance	194	Type S weights	±0.5 g	+0.1 g	✓	
Barometer	271	NBS traceable barometer	±0.10 in. Hg. (0.20 post test)	+0.02 in.	✓	
Dry gas thermometer	Inlet Outlet	ASTM-2F or 3F	±5°F	-2°F -1°F	✓ ✓	
Probe nozzle	1 2-1	Caliper	Dn ±0.004 in.	0.001 in. 0.002 in.	✓ ✓	

TABLE 5-2. FIELD EQUIPMENT CALIBRATION, QUAD TRAIN NO. 2 (NCOG)

Equipment	I.D. No.	Calibrated against	Allowable deviation	Actual deviation	Within allowable limits	Comments
Meter box	FB-10	Wet test meter	Y ±0.02 Y ΔH @ ±0.15 (Y ±0.05 Y post-test)	-3.1%	✓	
Pitot tube	1001	Standard pitot tube	Cp ±0.01	OK	✓	
Digital indicator	125	Millivolt signals	0.5%	+0.3%	✓	
Thermocouples and stack thermometers	174	ASTM-2F or 3F	1.5% (±2% saturated)	0.4%	✓	
Orsat analyzer	231 CO_2 O_2 CO	Standard gas	±0.5%	+0.2% +0.1% -0.4%	✓ ✓ ✓	
Impinger thermometer		ASTM-2F or 3F	±2°F	OK	✓	
Trip balance	194	Type S weights	±0.5 g	+0.1 g	✓	
Barometer	271	NBS traceable barometer	+0.10 in. Hg. (0.20 post test)	+0.02 in.	✓	
Dry gas thermometer	Inlet Outlet	ASTM-2F or 3F	±5°F	-2°F -1°F	✓ ✓	
Probe nozzle	2 2-2	Caliper	Dn ±0.004 in.	0.001 in 0.002 in	✓ ✓	

TABLE 5-3. FIELD EQUIPMENT CALIBRATION, QUAD TRAIN NO. 3 (NCOG)

Equipment	I.D. No.	Calibrated against	Allowable deviation	Actual deviation	Within allowable limits	Comments
Meter box	FB-1	Wet test meter	Y ±0.02 Y ΔH @ ±0.15 (Y ±0.05 Y post-test)	-2.2%	✓	
Pitot tube	1001	Standard pitot tube	Cp ±0.01	OK	✓	
Digital indicator	124	Millivolt signals	0.5%	-0.4%	✓	
Thermocouples and stack thermometers	174	ASTM-2F or 3F	1.5% (±2% saturated)	0.4%	✓	
Orsat analyzer	231 CO_2 231 O_2 231 CO	Standard gas	±0.5%	+0.2% +0.1% -0.4%	✓ ✓ ✓	
Impinger thermometer		ASTM-2F or 3F	±2°F	OK	✓	
Trip balance	194	Type S weights	±0.5 g	+0.1 g	✓	
Barometer	271	NBS traceable barometer	±0.10 in. Hg. (0.20 post test)	+0.02 in.	✓	
Dry gas thermometer	Inlet Outlet	ASTM-2F or 3F	±5°F	0°F -1°F	✓ ✓	
Probe nozzle	3 3-3	Caliper	Dn ±0.004 in.	0.001 in. 0.000 in.	✓ ✓	

TABLE 5-4. FIELD EQUIPMENT CALIBRATION, QUAD TRAIN NO. 4 (NCOG)

Equipment	I.D. No.	Calibrated against	Allowable deviation	Actual deviation	Within allowable limits	Comments
Meter box	FB-5	Wet test meter	Y ±0.02 Y ΔH @ ±0.15 (Y ±0.05 Y post-test)	-3.6%	✓	
Pitot tube	1001	Standard pitot tube	Cp ±0.01	OK	✓	
Digital indicator	124	Millivolt signals	0.5%	-0.4%	✓	
Thermocouples and stack thermometers	174	ASTM-2F or 3F	1.5% (±2% saturated)	0.4%	✓	
Orsat analyzer	CO_2 231 O_2 CO	Standard gas	±0.5%	+0.2% +0.1% -0.4%	✓ ✓ ✓	
Impinger thermometer		ASTM-2F or 3F	±2°F	OK	✓	
Trip balance	194	Type S weights	±0.5 g	+0.1 g	✓	
Barometer	271	NBS traceable barometer	+0.10 in. Hg. (0.20 post test)	+0.02 in.	✓	
Dry gas thermometer	Inlet Outlet	ASTM-2F or 3F	±5°F	0°F -1°F	✓ ✓	
Probe nozzle	4 3-4	Caliper	Dn ±0.004 in.	0.000 in. 0.003 in.	✓ ✓	

TABLE 5-5. FIELD EQUIPMENT CALIBRATION, TRAIN NO. 5 (NCOG)

Equipment	I.D. No.	Calibrated against	Allowable deviation	Actual deviation	Within allowable limits	Comments
Meter box	FB-4	Wet test meter	Y ±0.02 Y ΔH @ ±0.15 (Y ±0.05 Y post-test)	-0.6%	✓	
Pitot tube	186	Standard pitot tube	Cp ±0.01	0.00	✓	
Digital indicator	207	Millivolt signals	0.5%	-0.4%	✓	
Thermocouples and stack thermometers	203	ASTM-2F or 3F	1.5% (±2% saturated)	0.3%	✓	
Orsat analyzer	231 CO_2 O_2 CO	Standard gas	±0.5%	+0.2% +0.1% -0.4%	✓ ✓ ✓	
Impinger thermometer		ASTM-2F or 3F	±2°F	OK	✓	
Trip balance	194	Type S weights	±0.5 g	+0.1 g	✓	
Barometer	271	NBS traceable barometer	+0.10 in. Hg. (0.20 post test)	+0.02 in.	✓	
Dry gas thermometer	Inlet Outlet	ASTM-2F or 3F	±5°F	-3°F +1°F	✓ ✓	
Probe nozzle	6-105 6-114 8-103	Caliper	Dn ±0.004 in.	0.001 in. 0.000 in. 0.001 in.	✓ ✓ ✓	

TABLE 5-6. FIELD EQUIPMENT CALIBRATION, TRAIN NO. 6 (NCOG)

Equipment	I.D. No.	Calibrated against	Allowable deviation	Actual deviation	Within allowable limits	Comments
Meter box	FB-8	Wet test meter	Y ±0.02 Y ΔH @ ±0.15 (Y ±0.05 Y post-test)	-0.4%	✓	
Pitot tube	186	Standard pitot tube	Cp ±0.01	0.00	✓	
Digital indicator	207	Millivolt signals	0.5%	-0.4%	✓	
Thermocouples and stack thermometers	203	ASTM-2F or 3F	1.5% (±2% saturated)	0.3%	✓	
Orsat analyzer	231 CO_2 O_2 CO	Standard gas	±0.5%	+0.2% +0.1% -0.4%	✓ ✓ ✓	
Impinger thermometer		ASTM-2F or 3F	±2°F	OK	✓	
Trip balance	194	Type S weights	±0.5 g	+0.1 g	✓	
Barometer	271	NBS traceable barometer	±0.10 in. Hg. (0.20 post test)	+0.02 in.	✓	
Dry gas thermometer	Inlet Outlet	ASTM-2F or 3F	±5°F	+2°F -3°F	✓ ✓	
Probe nozzle	A B	Caliper	Dn ±0.004 in.	0.001 in. 0.001 in.	✓ ✓	

TABLE 5-7. FIELD EQUIPMENT CALIBRATION, QUAD TRAIN NO. 1 (DCOG)

Equipment	I.D. No.	Calibrated against	Allowable deviation	Actual deviation	Within allowable limits	Comments
Meter box	FB-2	Wet test meter	Y ±0.02 Y ΔH@ ±0.15 (Y ±0.05 Y post-test)	-2.7%	✓	
Pitot tube	1001	Standard pitot tube	Cp ±0.01	OK	✓	
Digital indicator	125	Millivolt signals	0.5%	+0.3%	✓	
Thermocouples and stack thermometers	133	ASTM-2F or 3F	1.5% (±2% saturated)	-0.5%	✓	
Orsat analyzer	230 CO_2 230 O_2 230 CO	Standard gas	±0.5%	+0.4% -0.3% -0.5%	✓ ✓ ✓	
Impinger thermometer	1	ASTM-2F or 3F	±2°F	-4°F		Correction factor used
Trip balance	196	Type S weights	±0.5 g	+0.3 g	✓	
Barometer	225	NBS traceable barometer	±0.10 in. Hg. (0.20 post test)	+0.01 in.	✓	
Dry gas thermometer	Inlet Outlet	ASTM-2F or 3F	±5°F	+4°F +2°F	✓ ✓	
Probe nozzle	1-1 2-1	Caliper	Dn ±0.004 in.	0.001 in. 0.001 in.	✓ ✓	

TABLE 5-8. FIELD EQUIPMENT CALIBRATION, QUAD TRAIN NO. 2 (DCOG)

Equipment	I.D. No.	Calibrated against	Allowable deviation	Actual deviation	Within allowable limits	Comments
Meter box	FB-5	Wet test meter	Y ±0.02 Y ΔH @ ±0.15 (Y ±0.05 Y post-test)	-2.3%	✓	
Pitot tube	1001	Standard pitot tube	Cp ±0.01	OK	✓	
Digital indicator	125	Millivolt signals	0.5%	+0.3%	✓	
Thermocouples and stack thermometers	133	ASTM-2F or 3F	1.5% (±2% saturated)	-0.5%	✓	
Orsat analyzer	CO_2	Standard gas	±0.5%	+0.4%	✓	
	230 O_2			-0.3%	✓	
	CO_2			-0.5%	✓	
Impinger thermometer	2	ASTM-2F or 3F	±2°F	-4°F		Correction factor used
Trip balance	196	Type S weights	±0.5 g	+ 0.3 g	✓	
Barometer	225	NBS traceable barometer	±0.10 in. Hg. (0.20 post test)	+0.01 in.	✓	
Dry gas thermometer	Inlet	ASTM-2F or 3F	±5°F	+4°F	✓	
	Outlet			+2°F	✓	
Probe nozzle	1-2	Caliper	Dn ±0.004 in.	0.001 in.	✓	
	2-2			0.000 in.	✓	

TABLE 5-9. FIELD EQUIPMENT CALIBRATION, QUAD TRAIN NO. 3 (DCOG)

Equipment	I.D. No.	Calibrated against	Allowable deviation	Actual deviation	Within allowable limits	Comments
Meter box	FB-8	Wet test meter	Y ±0.02 Y ΔH@ ±0.15 (Y ±0.05 Y post-test)	-0.6%	✓	
Pitot tube	1001	Standard pitot tube	Cp ±0.01	OK	✓	
Digital indicator	124	Millivolt signals	0.5%	-0.5%	✓	
Thermocouples and stack thermometers	133	ASTM-2F or 3F	1.5% (±2% saturated)	-0.5%	✓	
Orsat analyzer	CO_2 230 O_2 CO_2	Standard gas	±0.5%	+0.4% -0.3% -0.5%	✓ ✓ ✓	
Impinger thermometer	3	ASTM-2F or 3F	±2°F	-2°F	✓	
Trip balance	196	Type S weights	±0.5 g	+0.3 g	✓	
Barometer	225	NBS traceable barometer	+0.10 in. Hg. (0.20 post test)	+0.01 in.	✓	
Dry gas thermometer	Inlet Outlet	ASTM-2F or 3F	±5°F	-3°F -2°F	✓ ✓	
Probe nozzle	1-3 2-3	Caliper	Dn ±0.004 in.	0.000 in. 0.001 in.	✓ ✓	

TABLE 5-10. FIELD EQUIPMENT CALIBRATION, QUAD TRAIN NO. 4 (DCOG)

Equipment	I.D. No.	Calibrated against	Allowable deviation	Actual deviation	Within allowable limits	Comments
Meter box	FB-4	Wet test meter	Y ±0.02 Y ΔH @ ±0.15 (Y ±0.05 Y post-test)	+0.9%	✓	
Pitot tube	1001	Standard pitot tube	Cp ±0.01	OK	✓	
Digital indicator	124	Millivolt signals	0.5%	-0.5%	✓	
Thermocouples and stack thermometers	133	ASTM-2F or 3F	1.5% (±2% saturated)	-0.5%	✓	
Orsat analyzer	CO_2 230 O_2 CO_2	Standard gas	±0.5%	+0.4% -0.3% -0.5%	✓ ✓ ✓	
Impinger thermometer	4	ASTM-2F or 3F	±2°F	0°F	✓	
Trip balance	196	Type S weights	±0.5 g	+0.3 g	✓	
Barometer	225	NBS traceable barometer	±0.10 in. Hg. (0.20 post test)	+0.01 in.	✓	
Dry gas thermometer	Inlet Outlet	ASTM-2F or 3F	±5°F	0°F 0°F	✓ ✓	
Probe nozzle	1-4 2-4	Caliper	Dn ±0.004 in.	0.001 in. 0.001 in.	✓ ✓	

TABLE 5-11. FIELD EQUIPMENT CALIBRATION, TRAIN NO. 5 (DCOG)

Equipment	I.D. No.	Calibrated against	Allowable deviation	Actual deviation	Within allowable limits	Comments
Meter box	FB-1	Wet test meter	Y ±0.02 Y ΔH @ ±0.15 (Y ±0.05 Y post-test)	-3.7%	✓	
Pitot tube	034	Standard pitot tube	Cp ±0.01	0.00	✓	
Digital indicator	221	Millivolt signals	0.5%	+0.4%	✓	
Thermocouples and stack thermometers	133	ASTM-2F or 3F	1.5% (±2% saturated)	-0.5%	✓	
Orsat analyzer	230 CO_2 O_2 CO	Standard gas	±0.5%	+0.4% -0.3% -0.5%	✓ ✓ ✓	
Impinger thermometer	5	ASTM-2F or 3F	±2°F	OK	✓	
Trip balance	196	Type S weights	±0.5 g	+0.3 g	✓	
Barometer	225	NBS traceable barometer	±0.10 in. Hg. (0.20 post test)	+0.01 in.	✓	
Dry gas thermometer	Inlet Outlet	ASTM-2F or 3F	±5°F	-2°F -5°F	✓ ✓	
Probe nozzle	352-104 7-101	Caliper	Dn ±0.004 in.	0.002 in. 0.002 in.	✓ ✓	

TABLE 5-12. FIELD EQUIPMENT CALIBRATION, TRAIN NO. 6 (DCOG)

Equipment	I.D. No.	Calibrated against	Allowable deviation	Actual deviation	Within allowable limits	Comments
Meter box	FB-6	Wet test meter	Y ±0.02 Y ΔH @ ±0.15 (Y ±0.05 Y post-test)	-1.6%	✓	
Pitot tube	034	Standard pitot tube	Cp ±0.01	0.00	✓	
Digital indicator	221	Millivolt signals	0.5%	+0.4%	✓	
Thermocouples and stack thermometers	133	ASTM-2F or 3F	1.5% (±2% saturated)	-0.5%	✓	
Orsat analyzer	CO_2 230 O_2 CO_2	Standard gas	±0.5%	+0.4% -0.3% -0.5%	✓ ✓ ✓	
Impinger thermometer	6	ASTM-2F or 3F	±2°F	OK	✓	
Trip balance	196	Type S weights	±0.5 g	+0.3 g	✓	
Barometer	225	NBS traceable barometer	+0.10 in. Hg. (0.20 post test)	+0.01 in.	✓	
Dry gas thermometer	Inlet Outlet	ASTM-2F or 3F	±5°F	-4°F -4°F	✓ ✓	
Probe nozzle	6-108 6-105	Caliper	Dn ±0.004 in.	0.001 in. 0.000 in.	✓ ✓	

TABLE 5-13. FILTER AND REAGENT BLANK ANALYSIS, NCOG TEST SERIES

Sample type and analytical procedure	Lab No. (sample volume, ml)	Blank weight, mg	Comments
Acetone			
Gravimetric	CB 954 (219)	0.4	
	CB 955 (348)	0.7	
IPA extraction	CB 954	<0.3	
H_2O extraction	CB 954	<0.21	
Filter			
Gravimetric	CB 894	0.3	
	CB 895	0.8	
	CB 900	0.3	
	CB 901	0.7	
IPA extraction	CB 901	<0.3	
H_2O extraction	CB 901	<0.42	
Total organic carbon (oxidation technique)	CB 900	1.28	
Method 5 back half			
Ether/chloriform			
Inorganic	CC 026 (196)	4.0	0.01 used in calculations
	CC 027 (384)	3.8	
Organic	CC 026 (150)	1.6	
	CC 027 (150)	1.3	
Total organic carbon (ampute technique)	CC 026 (60)	0.5	
	CC 027 (60)	0.05	
Method 8 IPA solution			
H_2SO_4 titration	CB 982	0.25	
	CB 983	0.22	
	CB 984	0.20	
	CB 985	<0.15	
Method 8 H_2O_2 solution			
SO_2 titration	CC 013-15	<1	

TABLE 5-14. FILTER AND REAGENT BLANK ANALYSIS, DCOG TEST SERIES

Sample type and analytical procedure	Lab No. (sample volume, ml)	Blank weight, mg	Comments
Acetone			
Gravimetric	CC 769 (270)	-0.9	0.0 used in calculation
	CC 770 (275)	1.1	
IPA extraction	CC 769	<0.05	
H_2O extraction	CC 769	<0.24	
Filter			
Gravimetric	CC 666	0.2	
	CC 672	0.1	
	CC 671	0.3	
	CC 673	0.2	
IPA extraction	CC 669	<0.3	
H_2O extraction	CC 669	<0.24	
Total organic carbon (oxidation technique)	CC 666	1.58	
	CC 666	1.65	
Method 5 back half			
Ether/chloriform			
Inorganic	CC 771 (225)	-0.9	0.0 used in calculations
	CC 772 (205)	-0.5	0.0 used in calculations
Organic	CC 771 (150)	4.7	0.01 used in calculations
	CC 772 (150)	-0.3	0.0 used in calculations
Total organic carbon (ampute technique)	CC 771 (60)	0.3	
	CC 772 (60	0.7	
Method 8 IPA solution H_2SO_4 titration	773-6	<0.11	
Method 8 H_2O_2 solution SO_2 titration	CC 778-9	0.0	

- Internal and external audits to ensure accuracy in sampling and and analysis. Onsite audit data sheets are included in Appendix B, Section 1.1 and 2.1.

Audit solutions prepared by EPA were used to check the analytical procedures and reagents prior to onsite SO_2 sample analysis. The results of the onsite analytical audit are presented below:

Audit sample lot No.	Audit solution concentration, mg/dNm^3	Measured concentration, mg/dNm^3	Percent difference
3291 (NCOG)	22.89	22.75	-0.6
3575 (NCOG)	17.16	16.98	-1.0
8026 (DCOG)	381.3	383.3	+0.5
6220 (DCOG)	1334.6	1321.2	-1.0

Table 5-15 details the results obtained by Method 15 analysis of EPA-prepared reduced-sulfur gases.

Sampling equipment, reagents, and analytical procedures for this test series follow and meet all necessary guidelines set forth for accurate test results. Calibrations of particulate sampling equipment are all within limits described for Method 5 in the Federal Register.* Sample analysis and reagent quality also meet with Federal regulations described in Method 5 of the Federal Register.*

*40 CFR 60, Appendix A, Reference Method 5, July 1, 1980.

TABLE 5-15. SUMMARY OF RESULTS OBTAINED THROUGH METHOD 15 ANALYSIS OF AUDIT GASES[a]

Cylinder I.D.	Date	Time	TRS concentration, ppm	Comments
RTI-[b]-704 428 ppm H_2S	1/26/82	1400	449	Dynamic dilution
RTI-705 649 ppm H_2S	12/8/81	1754	797	Bag sample
	12/9/81	1730	540	Dynamic dilution 35.1 to 1
RTI-1584 100 ppm COS	12/9/81	1648	94	Bag sample
	12/9/81	1757	103	Dynamic dilution 3.18 to 1
	12/12/81	1530	96	Bag sample

[a]All acceptable COS results required a correction factor of 1.257 because of an incorrect permeation rate.

[b]RTI = Research Triangle Institute.

APPENDIX A

COMPUTER PRINTOUTS AND EXAMPLE CALCULATIONS

CONCENTRATION CALCULATIONS

$$CS\ (Part),\ mg/m^3 = MN/V_{m_{std}}\ (m^3)$$

$$CS\ (Part),\ gr/dscf = 0.001 \times MN \times 15.43/V_{m_{std}}\ (ft^3)$$

$$CS\ (SO_2 \text{ or } H_2SO_4),\ mg/m^3 = SN/V_{m_{std}}\ (m^3)$$

$$CS\ (SO_2 \text{ or } H_2SO_4),\ ppm = CS\ (SO_2 \text{ or } H_2SO_4),\ mg/m^3 \times 24.06/MW$$

$$CS\ (SO_2 \text{ or } H_2SO_4),\ gr/dscf = 0.001 \times SN \times 15.43/V_{m_{std}}\ (ft^3)$$

where

CS (Part) = concentration of particulate at stated parameters

$CS\ (SO_2)$ = concentration of sulfur dioxide at stated parameters

MN = particulate catch at stated parameter (mg)

$V_{m_{std}}$ = volume method at 68°F and 29.92 in.Hg, (m^3 or ft^3)

SN = sulfur dioxide catch (mg) or sulfuric acid catch (mg)

MW = molecular weight of SO_2 = 64 g/g mole, H_2SO_4 = 98, $H_2SO_4 \cdot 2H_2O$ = 134

1.0 NCOG Underfiring Test Series
October 1981

STACK VELOCITY DATA

PLANT	REPUBLIC STEEL CLEVELAND
DATE	10/22/81
SAMPLING LOCATION	COKE BATTERY STACK-NO.1
RUN NUMBER	PRE-1
CLOCK TIME	954
OPERATOR	CB-DO
AMBIENT TEMP. (DEG.F)	54.
BAR.PRESS.(IN HG)	29.60
STATIC PRESS.(IN H20)	-1.20
MOLECULAR WEIGHT	29.00
STACK INSIDE DIM(IN)	97.500
PITOT TUBE COEFF.	.84
MOISTURE CONTENT(%)	12.00

TRAVERSE POINT NO.	POSITION INCHES	VELOCITY HEAD (IN H20)	STACK TEMP (DEG.F)
01	.0	.020	128.
02	.0	.050	305.
03	.0	.045	430.
04	.0	.060	510.
05	.0	.060	480.
06	.0	.060	486.
07	.0	.070	487.
08	.0	.060	492.
09	.0	.050	497.
10	.0	.070	496.
11	.0	.060	497.
12	.0	.050	497.
AVERAGE		.058	442.

PLANT	REPUBLIC STEEL CLEVELAND
DATE	10/22/81
SAMPLING LOCATION	COKE BATTERY STACK-NO.1
RUN NUMBER	PRE-1

STACK AREA, SQ. FT.	51.849
STACK ABS. PRES., IN HG.	29.51
STACK GAS TEMPERATURE, DEG.F	442.
SQRT(VEL HD X STACK TEMP ABS)	7.2
STACK GAS VELOCITY, ACT. FPS	17.6
STACK GAS VOLUME (WET), ACT. CFM.	54876.8
STACK GAS VOLUME (DRY), ACT. CFM.	48291.5
STACK GAS VOLUME @ 29.92 IN. HG AND 68 DG. F :	
(DRY)	27879.9
(WET)	31681.8

SAMPLE CALCULATIONS

SYMBOLS:

AREA	CROSS-SECTIONAL STACK AREA, SQ FT	PTC	PITOT TUBE COEFFICENT
BPRES	BAROMETRIC PRESSURE, IN HG	SPRES	STATIC PRESSURE, IN H20
DELP	DELTA P	STEMP	STACK TEMPERATURE, DEG F
DIA	DIAMETER OF CIRCULAR STACK, IN	STPRES	STACK PRESSURE, IN HG
DIM1	LENGTH OF RECTANGULAR STACK, IN	STVEL	STACK VELOCITY, AFPM
DIM2	WIDTH OF RECTANGULAR STACK, IN	TEMP	TEMPERATURE, DEG F
MOIST	MOISTURE CONTENT	VH	VELOCITY HEAD, IN H20
MW	MOLECULAR WEIGHT	SVOLFLW	STANDARD VOLUMETRIC FLOW (WET), ACFM
NP	NUMBER OF TRAVERSE POINTS	VOLFLW	VOLUMETRIC FLOW (WET), ACFM
BW	MOLE FRACTION WATER VAPOR	SVOLFLD	STANDARD VOLUMETRIC FLOW (DRY), DSCFM

FORMULAS AND SAMPLE CALCULATIONS:

$$DELP = \frac{SUM[SQRT[VH * TEMP]]}{NP} = \frac{86.2}{12} = 7.2$$

$$STPRES = BPRES + (SPRES/13.6) = 29.60 + (-1.20/13.6) = 29.5 \text{ IN HG}$$

$$STEMP = \frac{SUM[STEMP]}{NP} = \frac{5305.}{12} = 442. \text{ DEG F}$$

$$AREA(CIRCULAR\ STACK) = \frac{3.1416 * (DIA/2)**2}{144} = \frac{3.1416 * (97.500/2)**2}{144} = 51.849 \text{ SQ FT}$$

$$STVEL = \frac{85.49 * PTC * DELP}{SQRT[MW * STPRES]} = \frac{85.49 * .84 * 7.2}{SQRT[29.00 * 29.5]} = 17.6 \text{ AFPM}$$

$$VOLFLW = 60. * STVEL * AREA = 60. * 17.6 * 51.849 = 54876.8 \text{ ACFM}$$

$$SVOLFLW = \frac{VOLFLW * STPRES * (460. + 68.)}{29.92 * (STEMP + 460.)} = \frac{54876.8 * 29.5 * (460. + 68.)}{29.92 * (442.1 + 460.)} = 31681.8 \text{ ACFM}$$

$$SVOLFLD = SVOLFLW * (1 - BW) = 31681.8 * (1 - .12) = 27879.9 \text{ DSCFM}$$

STACK VELOCITY DATA

PLANT	REPUBLIC STEEL CLEVELAND
DATE	10/22/81
SAMPLING LOCATION	COKE BATTERY STACK-NO.1
RUN NUMBER	PRE-2
CLOCK TIME	954
OPERATOR	CB-DO
AMBIENT TEMP. (DEG.F)	54.
BAR.PRESS.(IN HG)	29.60
STATIC PRESS.(IN H20)	-1.20
MOLECULAR WEIGHT	29.00
STACK INSIDE DIM(IN)	97.500
PITOT TUBE COEFF.	.84
MOISTURE CONTENT(%)	12.00

TRAVERSE POINT NO.	POSITION INCHES	VELOCITY HEAD (IN H20)	STACK TEMP (DEG.F)
01	.0	.045	345.
02	.0	.050	392.
03	.0	.060	415.
04	.0	.060	430.
05	.0	.060	452.
06	.0	.060	473.
07	.0	.060	480.
08	.0	.055	483.
09	.0	.050	484.
10	.0	.050	486.
11	.0	.040	487.
12	.0	.040	487.
AVERAGE		.052	451.

PLANT	REPUBLIC STEEL CLEVELAND
DATE	10/22/81
SAMPLING LOCATION	COKE BATTERY STACK-NO.1
RUN NUMBER	PRE-2

STACK AREA, SQ. FT.	51.849
STACK ABS. PRES., IN HG.	29.51
STACK GAS TEMPERATURE, DEG.F	451.
SQRT(VEL HD X STACK TEMP ABS)	6.9
STACK GAS VELOCITY, ACT. FPS	16.9
STACK GAS VOLUME (WET), ACT. CFM.	52657.0
STACK GAS VOLUME (DRY), ACT. CFM.	46338.2
STACK GAS VOLUME @ 29.92 IN. HG AND 68 DG. F :	
(DRY)	26485.5
(WET)	30097.2

SAMPLE CALCULATIONS

SYMBOLS:

AREA	CROSS-SECTIONAL STACK AREA, SQ FT	PTC	PITOT TUBE COEFFICENT
BPRES	BAROMETRIC PRESSURE, IN HG	SPRES	STATIC PRESSURE, IN H2O
DELP	DELTA P	STEMP	STACK TEMPERATURE, DEG F
DIA	DIAMETER OF CIRCULAR STACK, IN	STPRES	STACK PRESSURE, IN HG
DIM1	LENGTH OF RECTANGULAR STACK, IN	STVEL	STACK VELOCITY, AFPM
DIM2	WIDTH OF RECTANGULAR STACK, IN	TEMP	TEMPERATURE, DEG F
MOIST	MOISTURE CONTENT	VH	VELOCITY HEAD, IN H2O
MW	MOLECULAR WEIGHT	SVOLFLW	STANDARD VOLUMETRIC FLOW (WET), ACFM
NP	NUMBER OF TRAVERSE POINTS	VOLFLW	VOLUMETRIC FLOW (WET), ACFM
BW	MOLE FRACTION WATER VAPOR	SVOLFLD	STANDARD VOLUMETRIC FLOW (DRY), DSCFM

FORMULAS AND SAMPLE CALCULATIONS:

$$DELP = \frac{SUM[SQRT[VH * TEMP]]}{NP} = \frac{82.7}{12} = 6.9$$

$$STPRES = BPRES + (SPRES/13.6) = 29.60 + (-1.20/13.6) = 29.5 \text{ IN HG}$$

$$STEMP = \frac{SUM[STEMP]}{NP} = \frac{5414.}{12} = 451. \text{ DEG F}$$

$$AREA(CIRCULAR\ STACK) = \frac{3.1416 * (DIA/2)^{**}2}{144} = \frac{3.1416 * (97.500/2)^{**}2}{144} = 51.849 \text{ SQ FT}$$

$$STVEL = \frac{85.49 * PTC * DELP}{SQRT[MW * STPRES]} = \frac{85.49 * .84 * 6.9}{SQRT[29.00 * 29.5]} = 16.9 \text{ AFPM}$$

$$VOLFLW = 60. * STVEL * AREA = 60. * 16.9 * 51.849 = 52657.0 \text{ ACFM}$$

$$SVOLFLW = \frac{VOLFLW * STPRES * (460. + 68.)}{29.92 * (STEMP + 460.)} = \frac{52657.0 * 29.5 * (460. + 68.)}{29.92 * (451.2 + 460.)} = 30097.2 \text{ ACFM}$$

$$SVOLFLD = SVOLFLW * (1 - BW) = 30097.2 * (1 - .12) = 26485.5 \text{ DSCFM}$$

STACK VELOCITY DATA

PLANT	REPUBLIC STEEL CLEVELAND
DATE	10/27/81
SAMPLING LOCATION	COKE STACK
RUN NUMBER	V.T.
CLOCK TIME	1300
OPERATOR	DO/MP
AMBIENT TEMP. (DEG.F)	62.
BAR.PRESS.(IN HG)	29.39
STATIC PRESS.(IN H20)	-1.20
MOLECULAR WEIGHT	29.00
STACK INSIDE DIM(IN)	97.500
PITOT TUBE COEFF.	.83
MOISTURE CONTENT(%)	12.00

TRAVERSE POINT NO.	POSITION INCHES	VELOCITY HEAD (IN H20)	STACK TEMP (DEG.F)
01	.0	.042	445.
02	.0	.058	484.
03	.0	.045	476.
04	.0	.060	494.
05	.0	.055	515.
06	.0	.056	515.
07	.0	.065	512.
08	.0	.065	511.
09	.0	.064	510.
10	.0	.062	509.
11	.0	.060	507.
12	.0	.055	507.
AVERAGE		.057	499.

PLANT	REPUBLIC STEEL CLEVELAND
DATE	10/27/81
SAMPLING LOCATION	COKE STACK
RUN NUMBER	V.T.

STACK AREA, SQ. FT.	51.849
STACK ABS. PRES., IN HG.	29.30
STACK GAS TEMPERATURE, DEG.F	499.
SQRT(VEL HD X STACK TEMP ABS)	7.4
STACK GAS VELOCITY, ACT. FPS	18.0
STACK GAS VOLUME (WET), ACT. CFM.	56014.3
STACK GAS VOLUME (DRY), ACT. CFM.	49292.5
STACK GAS VOLUME @ 29.92 IN. HG AND 68 DG. F :	
(DRY)	26585.3
(WET)	30210.6

SAMPLE CALCULATIONS

SYMBOLS:

AREA	CROSS-SECTIONAL STACK AREA, SQ FT	PTC	PITOT TUBE COEFFICENT
BPRES	BAROMETRIC PRESSURE, IN HG	SPRES	STATIC PRESSURE, IN H2O
DELP	DELTA P	STEMP	STACK TEMPERATURE, DEG F
DIA	DIAMETER OF CIRCULAR STACK, IN	STPRES	STACK PRESSURE, IN HG
DIM1	LENGTH OF RECTANGULAR STACK, IN	STVEL	STACK VELOCITY, AFPM
DIM2	WIDTH OF RECTANGULAR STACK, IN	TEMP	TEMPERATURE, DEG F
MOIST	MOISTURE CONTENT	VH	VELOCITY HEAD, IN H2O
MW	MOLECULAR WEIGHT	SVOLFLW	STANDARD VOLUMETRIC FLOW (WET), ACFM
NP	NUMBER OF TRAVERSE POINTS	VOLFLW	VOLUMETRIC FLOW (WET), ACFM
BW	MOLE FRACTION WATER VAPOR	SVOLFLD	STANDARD VOLUMETRIC FLOW (DRY), DSCFM

FORMULAS AND SAMPLE CALCULATIONS:

$$DELP = \frac{SUM[SQRT(VH * TEMP)]}{NP} = \frac{88.8}{12} = 7.4$$

$$STPRES = BPRES + (SPRES/13.6) = 29.39 + (-1.20/13.6) = 29.3 \text{ IN HG}$$

$$STEMP = \frac{SUM[STEMP]}{NP} = \frac{5985.}{12} = 499. \text{ DEG F}$$

$$AREA(CIRCULAR\ STACK) = \frac{3.1416 * (DIA/2)**2}{144} = \frac{3.1416 * (97.500/2)**2}{144} = 51.849 \text{ SQ FT}$$

$$STVEL = \frac{85.49 * PTC * DELP}{SQRT[MW * STPRES]} = \frac{85.49 * .83 * 7.4}{SQRT(29.00 * 29.3)} = 18.0 \text{ AFPM}$$

$$VOLFLW = 60. * STVEL * AREA = 60. * 18.0 * 51.849 = 56014.3 \text{ ACFM}$$

$$SVOLFLW = \frac{VOLFLW * STPRES * (460. + 68.)}{29.92 * (STEMP + 460.)} = \frac{56014.3 * 29.3 * (460. + 68.)}{29.92 * (498.8 + 460.)} = 30210.6 \text{ ACFM}$$

$$SVOLFLD = SVOLFLW * (1 - BW) = 30210.6 * (1 - .12) = 26585.3 \text{ DSCFM}$$

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/27/81
SAMPLING LOCATION	NO. 1 COKE BATTERY STACK	RUN NUMBER	1-1
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	5' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE 1 : I.D.	.398
AMBIENT TEMP.(DEG.F)	62.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.39	SAMPLE BOX NUMBER	8
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB2
FILTER NUMBER(S)	3530115	METER HEAD DIFF.	1.76
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 5.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.003		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	910	656.472									
	10.0	920	661.630	.060	.76	.76	519.	67.	67.	2.0	270.	54.
	20.0	930	666.670	.060	.72	.72	538.	68.	68.	2.0	298.	55.
	30.0	940	671.720	.060	.72	.72	545.	72.	68.	3.0	242.	53.
	40.0	950	677.260	.070	.87	.87	545.	75.	68.	3.0	258.	52.
	50.0	1000	682.830	.070	.87	.87	555.	76.	70.	2.0	255.	54.
	60.0	1010	687.920	.060	.72	.72	550.	77.	71.	3.0	248.	54.
	70.0	1020	693.050	.060	.72	.72	520.	78.	72.	3.5	249.	55.
	80.0	1030	698.130	.060	.72	.72	535.	78.	72.	3.6	251.	52.
	90.0	1040	703.250	.060	.72	.72	510.	78.	72.	3.6	252.	53.
	100.0	1050	708.370	.060	.72	.72	544.	79.	73.	3.6	250.	52.
	110.0	1100	713.970	.070	.87	.87	558.	79.	73.	3.6	244.	53.
	120.0	1110	720.086	.090	1.11	1.11	520.	79.	73.	3.6	250.	52.
TOTALS	120.0		63.614									
AVERAGE					.79	.79	537.	76.	71.	3.0	252.	53.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS | TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND | BRUFFEY

TEST 1-1 NO. 1 COKE BATTERY STACK

		ENGLISH UNITS		METRIC UNITS	
TEST DATE		10/27/81		10/27/81	
TB	TIME-START	910		910	
TF	TIME-FINISH	1110		1110	
TT	NET TIME OF TEST, MIN.	120.0		120.0	
NP	NET SAMPLING POINTS	12		12	
Y	METER CALIBRATION FACTOR	1.003		1.003	
DN	SAMPLING NOZZLE DIAMETER	.398	IN	10.1	MM
CP	PITOT TUBE COEFFICIENT	.84		.84	
PM	AVERAGE ORIFICE PRESSURE DROP	.79	IN-H2O	20.2	MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	63.614	CU-FT	1.801	CU-M
TM	AVERAGE GAS METER TEMP	73.0	F	22.8	C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	62.205	SCF	1.761	SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	185.5		185.5	
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.731	SCF	.247	SCM
BWO	PERCENT MOISTURE BY VOLUME	12.31		12.31	
FMD	MOLE FRACTION DRY GAS	.877		.877	
PCO2	PERCENT CO2 BY VOL., DRY	4.20		4.20	
PO2	PERCENT O2 BY VOL., DRY	10.50		10.50	
PCO	PERCENT CO BY VOL., DRY	.00		.00	
PN2	PERCENT N2 BY VOL., DRY	85.30		85.30	
MO	MOLECULAR WT-DRY STACK GAS	29.09		29.09	
MWS	MOLECULAR WT-STACK GAS	27.73		27.73	

PB	BAROMETRIC PRESSURE	29.39	IN-HG	746.51	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.30	IN-HG	744.26	MM-HG
TS	AVERAGE STACK TEMP	537.	F	280.	C
VS	AVG STACK GAS VELOCITY	20.2	FPS	6.2	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1718626.	SCFH	48666.	SCMH
QS	ACTUAL STACK FLOW RATE	3777241.	ACFH	106960.	ACMH
ISO	PERCENT ISOKINETIC	108.6		108.6	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 1-1

NO. 1 COKE BATTERY STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 63.614 * 1.003 * (29.39 + .793 / 13.6)}{(73. + 460.)} = 62.205 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 186. = 8.73 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.73}{62.205 + 8.73} = 12.31 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.3}{100.} = .877$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.20*44/100) + (10.5*32/100) + ((85.3+ .0) * 28/100 = 29.09

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.09* (1. -(12.31/100)) + 18. * (12.31/100) = 27.73

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 96.387 / (SQRT(27.73 * 29.30) * 12. = 20.24 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 20.24 * 7466. 3600/144 = 3777241. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3777241. * 29.30 * (1. - (12.31/100))}{(537. + 460.)} = 1718626.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(537.+460.))*((0.002669*186.)+(63.614*1.003*(29.39+(.793/13.6))/(73.+460.)))}{120. * 20.24 * 29.30 * .398 * .398} = 108.62\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 62.205 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1718626. / (15.43 * 453.6) = .00

Run No. 1.1

Sample volume = 1.76 m^3, 62.21 scf

Example calculations

CS (Part) = 227.1/1.76 = 129.0 mg/m^3

CS (Part) = 0.001 x 227.1 x 15.43/62.21 = 0.56 gr/dscf

CS (SO_2) = 1960 /1.76 = 1113.6 mg/m^3

= 1113.6 x 24.06/64 = 419 ppm

= 0.001 x 1960 x 15.43/62.21 = 0.486 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	226.9	128.9	0.056	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	81.5	46.3	0.020	
As $H_2SO_4 \cdot 2H_2O$	111.4	63.3	0.028	
Sulfur dioxide	1960	1113.6	0.486	419
Sulfuric acid mist				
As H_2SO_4	8.9	5.0	0.002	1
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/27/81
SAMPLING LOCATION	NO.1 COKE BATTERY STACK	RUN NUMBER	1-2
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	5' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE 2 : I.D.	.397
AMBIENT TEMP.(DEG.F)	62.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.39	SAMPLE BOX NUMBER	0
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB1
FILTER NUMBER(S)	3530019	METER HEAD DIFF.	1.80
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.001 CFM @ 6.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.044		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	914	902.817									
	10.0	924	907.590	.060	.76	.76	527.	72.	73.	3.5	283.	49.
	20.0	934	912.260	.060	.72	.72	541.	71.	73.	3.5	245.	50.
	30.0	944	917.320	.070	.87	.87	542.	76.	74.	3.5	263.	49.
	40.0	954	922.400	.070	.87	.87	549.	80.	75.	4.0	253.	50.
	50.0	1004	927.530	.070	.87	.87	561.	81.	75.	4.0	255.	51.
	60.0	1014	932.230	.060	.72	.72	515.	83.	76.	4.0	260.	52.
	70.0	1024	936.910	.060	.72	.72	523.	83.	76.	4.0	251.	54.
	80.0	1034	941.610	.060	.72	.72	538.	84.	77.	4.0	255.	53.
	90.0	1044	946.760	.070	.87	.87	533.	84.	78.	4.0	253.	52.
	100.0	1054	951.470	.060	.72	.72	550.	84.	78.	4.0	258.	51.
	110.0	1104	956.660	.070	.87	.87	562.	84.	79.	4.0	258.	50.
	120.0	1114	961.328	.060	.72	.72	520.	83.	78.	4.0	254.	50.
TOTALS	120.0		58.511									
AVERAGE					.79	.79	538.	80.	76.	3.9	257.	51.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST LEADER: BRUFFEY

TEST 1-2 NO.1 COKE BATTERY STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/27/81	10/27/81
TB	TIME-START	914	914
TF	TIME-FINISH	1114	1114
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.044	1.044
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.79 IN-H2O	20.0 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	58.511 CU-FT	1.657 CU-M
TM	AVERAGE GAS METER TEMP	78.2 F	25.7 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	58.981 SCF	1.670 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	185.7	185.7
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.741 SCF	.248 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.91	12.91
FMD	MOLE FRACTION DRY GAS	.871	.871
PCO2	PERCENT CO2 BY VOL., DRY	4.20	4.20
PO2	PERCENT O2 BY VOL., DRY	10.50	10.50
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.30	85.30
MD	MOLECULAR WT-DRY STACK GAS	29.09	29.09
MWS	MOLECULAR WT-STACK GAS	27.66	27.66

PB	BAROMETRIC PRESSURE	29.39	IN-HG	746.51	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.30	IN-HG	744.26	MM-HG
TS	AVERAGE STACK TEMP	538.	F	281.	C
VS	AVG STACK GAS VELOCITY	20.2	FPS	6.2	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1698840.	SCFH	48106.	SCMH
QS	ACTUAL STACK FLOW RATE	3766316.	ACFH	106651.	ACMH
ISO	PERCENT ISOKINETIC	104.7		104.7	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 1-2

NO.1 COKE BATTERY STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 58.511 * 1.044 * (29.39 + .786 / 13.6)}{(78. + 460.)} = 58.981 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 186. = 8.74 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.74}{58.981 + 8.74} = 12.91 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.9}{100.} = .871$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.20*44/100) + (10.5*32/100) + ((85.3+ .0) * 28/100 = 29.09

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.09* (1. -(12.91/100)) + 18. * (12.91/100) = 27.66

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 95.993 / (SQRT(27.66 * 29.30) * 12. = 20.18 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 20.18 * 7466. 3600/144 = 3766316. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3766316. * 29.30 * (1. - (12.91/100))}{(538. + 460.)} = 1698840.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(538.+460.))*((0.002669* 186.)+(58.511*1.044*(29.39+(.786/13.6))/(78.+460.)))}{120. * 20.18 * 29.30 * .397 * .397} = 104.71\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 58.981 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1698840. / (15.43 * 453.6) = .00

Run No. 1.2

Sample volume = 1.67 m^3, 58.98 scf

Example calculations

CS (Part) = 192.8 / 1.67 = 115.4 mg/m^3

CS (Part) = 0.001 x 192.8 x 15.43/58.98 = 0.050 gr/dscf

CS (SO_2) = 1850 / 1.67 = 1107.8 mg/m^3

= 1107.8 x 24.06/64 = 416 ppm

= 0.001 x 1850 x 15.43/58.98 = 0.484 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	192.8	115.4	0.050	
2-h at 350°F	55.2	33.0	0.014	
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	7.4	4.4	0.002	
As $H_2SO_4 \cdot 2H_2O$	10.1	6.1	0.003	
Sulfur dioxide	1850	1107.8	0.484	416
Sulfuric acid mist				
As H_2SO_4	9.4	5.6	0.002	1
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/27/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	1-3
SAMPLE TYPE	1-3-M8-350	PROBE LENGTH & TYPE	5FT GLASS HEATED
OPERATOR	CLARKE	NOZZLE 3 : I.D.	.394
AMBIENT TEMP.(DEG.F)	72.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.39	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB1
FILTER NUMBER(S)	3530092	METER HEAD DIFF.	1.87
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.		HEATER BOX SETTING	350.
LEAKAGE	.000 CFM @ 3.5 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	.992		
READ & RECORD DATA EVERY 10.0 MINUTES			

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	910	410.867									
	10.0	920	416.000	.060	.78	.78	519.	68.	63.	2.0	308.	52.
	20.0	930	421.475	.060	.78	.78	536.	70.	63.	2.0	337.	40.
	30.0	940	425.775	.060	.78	.78	545.	73.	64.	2.0	346.	40.
	40.0	950	430.695	.070	.87	.87	545.	76.	64.	2.0	347.	40.
	50.0	1000	435.595	.070	.87	.87	555.	78.	66.	2.0	344.	42.
	60.0	1010	440.777	.060	.78	.78	550.	80.	66.	2.0	341.	42.
	70.0	1020	445.910	.060	.78	.78	520.	80.	66.	2.0	337.	42.
	80.0	1030	450.824	.060	.78	.78	535.	80.	67.	2.0	345.	44.
	90.0	1040	455.687	.060	.78	.78	510.	80.	68.	2.0	345.	46.
	100.0	1050	460.660	.060	.78	.78	544.	80.	68.	2.0	336.	46.
	110.0	1100	466.500	.070	.87	.87	558.	80.	68.	3.0	337.	48.
	120.0	1110	471.932	.090	1.10	1.10	516.	78.	60.	3.5	335.	48.
TOTALS	120.0		61.065									
AVERAGE					.83	.83	536.	77.	65.	2.2	338.	44.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST LEADER: CLARKE

TEST 1-3 COKE OVEN OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/27/81	10/27/81
TB	TIME-START	910	910
TF	TIME-FINISH	1110	1110
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.992	.992
DN	SAMPLING NOZZLE DIAMETER	.394 IN	10.0 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.83 IN-H2O	21.1 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	61.065 CU-FT	1.729 CU-M
TM	AVERAGE GAS METER TEMP	71.1 F	21.7 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	59.280 SCF	1.679 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	233.3	233.3
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	10.981 SCF	.311 SCM
BWO	PERCENT MOISTURE BY VOLUME	15.63	15.63
FMD	MOLE FRACTION DRY GAS	.844	.844
PCO2	PERCENT CO2 BY VOL., DRY	4.20	4.20
PO2	PERCENT O2 BY VOL., DRY	10.50	10.50
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.30	85.30
MD	MOLECULAR WT-DRY STACK GAS	29.09	29.09
MWS	MOLECULAR WT-STACK GAS	27.36	27.36

PB	BAROMETRIC PRESSURE	29.39	IN-HG	746.51	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.30	IN-HG	744.26	MM-HG
TS	AVERAGE STACK TEMP	536.	F	280.	C
VS	AVG STACK GAS VELOCITY	20.4	FPS	6.2	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1665014.	SCFH	47148.	SCMH
QS	ACTUAL STACK FLOW RATE	3801518.	ACFH	107648.	ACMH
ISO	PERCENT ISOKINETIC	109.0		109.0	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 1-3

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 61.065 * .992 * (29.39 + .829 / 13.6)}{(71. + 460.)} = 59.280 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 233. = 10.98 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 10.98}{59.280 + 10.98} = 15.63 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 15.6}{100.} = .844$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.20*44/100) + (10.5*32/100) + ((85.3+ .0) * 28/100 = 29.09

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.09* (1. -(15.63/100)) + 18. * (15.63/100) = 27.36

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 96.360 / (SQRT(27.36 * 29.30) * 12. = 20.37 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 20.37 * 7466. 3600/144 = 3801518. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3801518. * 29.30 * (1. - (15.63/100))}{(536. + 460.)} = 1665014. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(536.+460.))*((0.002669* 233.)+(61.065* .992*(29.39+(.829/13.6))/(71.+460.)))}{120. * 20.37 * 29.30 * .394 * .394} = 109.03 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 59.280 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1665014. / (15.43 * 453.6) = .00

Run No. 1.3

Sample volume = 1.68 m^3, 59.28 scf

Example calculations

CS (Part) = 72.9 / 1.68 = 43.4 mg/m^3

CS (Part) = 0.001 x 73 x 15.43/59.28 = 0.019 gr/dscf

CS (SO_2) = 1870 / 1.68 = 1113.1 mg/m^3

= 1113.1 x 24.06/ 64 = 418 ppm

= 0.001 x 1870 x 15.43/59.28 = 0.487 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	72.9	43.4	0.019	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	9.8	5.8	0.002	
As $H_2SO_4 \cdot 2H_2O$	13.4	8.0	0.003	
Sulfur dioxide	1870	1113.1	0.487	418
Sulfuric acid mist				
As H_2SO_4	65.4	38.9	0.017	10
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/27/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	1-4
SAMPLE TYPE	1-4-M8-350	PROBE LENGTH & TYPE	6FT GLASS HEATED
OPERATOR	CLARKE	NOZZLE 4 ; I.D.	.397
AMBIENT TEMP.(DEG.F)	72.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.39	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F85
FILTER NUMBER(S)	3530072	METER HEAD DIFF.	1.86
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.		HEATER BOX SETTING	350.
LEAKAGE	.000 CFM @ 5.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.010		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	914	838.960									
	10.0	924	843.665	.060	.78	.78	527.	71.	72.	1.0	277.	52.
	20.0	934	848.801	.060	.78	.78	541.	71.	71.	1.0	338.	52.
	30.0	944	853.800	.070	.87	.87	532.	74.	72.	1.0	339.	54.
	40.0	954	858.673	.070	.87	.87	549.	76.	72.	1.0	342.	54.
	50.0	1004	863.750	.070	.87	.87	561.	80.	72.	1.0	348.	56.
	60.0	1014	868.473	.060	.78	.78	516.	81.	73.	1.0	344.	54.
	70.0	1024	873.392	.060	.78	.78	523.	82.	74.	1.0	342.	54.
	80.0	1034	878.250	.060	.78	.78	538.	82.	75.	1.0	345.	56.
	90.0	1044	883.476	.070	.87	.87	533.	82.	76.	1.0	339.	56.
	100.0	1054	888.380	.060	.78	.78	550.	83.	77.	1.0	339.	58.
	110.0	1104	893.725	.070	.87	.87	562.	82.	76.	1.0	332.	58.
	120.0	1114	898.155	.060	.78	.78	521.	80.	75.	1.0	341.	60.
TOTALS	120.0		59.195									
AVERAGE					.82	.82	538.	79.	74.	1.0	336.	55.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS | TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND | CLARKE

TEST 1-4 COKE OVEN OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/27/81	10/27/81
TB	TIME-START	914	914
TF	TIME-FINISH	1114	1114
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.010	1.010
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.82 IN-H2O	20.8 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	59.195 CU-FT	1.676 CU-M
TM	AVERAGE GAS METER TEMP	76.2 F	24.6 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	57.947 SCF	1.641 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	165.0	165.0
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.767 SCF	.220 SCM
BWO	PERCENT MOISTURE BY VOLUME	11.82	11.82
FMD	MOLE FRACTION DRY GAS	.882	.882
PCO2	PERCENT CO2 BY VOL., DRY	4.20	4.20
PO2	PERCENT O2 BY VOL., DRY	10.50	10.50
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.30	85.30
MD	MOLECULAR WT-DRY STACK GAS	29.09	29.09
MWS	MOLECULAR WT-STACK GAS	27.78	27.78

PB	BAROMETRIC PRESSURE	29.39	IN-HG	746.51	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.30	IN-HG	744.26	MM-HG
TS	AVERAGE STACK TEMP	538.	F	281.	C
VS	AVG STACK GAS VELOCITY	20.1	FPS	6.1	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1716865.	SCFH	48616.	SCMH
QS	ACTUAL STACK FLOW RATE	3756791.	ACFH	106381.	ACMH
ISO	PERCENT ISOKINETIC	101.8		101.8	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 1-4

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 59.195 * 1.010 * (29.39 + .818 / 13.6)}{(76. + 460.)} = 57.947 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 165. = 7.77 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.77}{57.947 + 7.77} = 11.82 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.8}{100.} = .882$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.20*44/100) + (10.5*32/100) + ((85.3+ .0) * 28/100 = 29.09

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.09* (1. -(11.82/100)) + 18. * (11.82/100) = 27.78

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 95.959 / (SQRT(27.78 * 29.30) * 12. = 20.13 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 20.13 * 7466. 3600/144 = 3756791. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3756791. * 29.30 * (1. - (11.82/100))}{(538. + 460.)} = 1716865.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(538.+460.))*((0.002669*165.)+(59.195*1.010*(29.39+(.818/13.6))/(76.+460.)))}{120. * 20.13 * 29.30 * .397 * .397} = 101.80\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 57.947 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1716865. / (15.43 * 453.6) = .00

Run No. 1.4

Sample volume = 1.64 m^3, 57.95 scf

Example calculations

CS (Part) = 50.6/1.64 = 30.8 mg/m^3

CS (Part) = 0.001 x 50.7 x 15.43/57.95 = 0.013 gr/dscf

CS (SO_2) = 1810/1.64 = 1103.7 mg/m^3

= 1103.7 x 24.06/64 = 415 ppm

= 0.001 x 1810 x 15.43/57.95 = 0.482 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	50.6	30.8	0.013	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	4.7	2.9	0.001	
As $H_2SO_4 \cdot 2H_2O$	6.4	3.9	0.002	
Sulfur dioxide	1810	1103.7	0.482	415
Sulfuric acid mist				
As H_2SO_4	56.0	34.1	0.015	8
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/27/81
SAMPLING LOCATION	COKE OVEN STACK	RUN NUMBER	1-5
SAMPLE TYPE	METHOD 5-250	PROBE LENGTH & TYPE	6' GLASS
OPERATOR	DO	NOZZLE 8-103: I.D.	.520
AMBIENT TEMP.(DEG.F)	62.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.39	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	.00	METER BOX NUMBER	FB4
FILTER NUMBER(S)	3530086	METER HEAD DIFF.	1.88
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.92
PITOT TUBE CDEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 6.0 IN.HG	REFERENCE PRESS. DIFF.	.05
METER CALIB. FACTOR	1.033		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	947	593.361									
	10.0	957	600.570	.050	1.81	1.81	550.	77.	77.	4.7	230.	38.
	20.0	1007	607.750	.050	1.81	1.81	550.	74.	75.	5.1	288.	40.
	30.0	1017	614.950	.050	1.81	1.81	550.	76.	74.	5.2	290.	40.
	40.0	1027	622.140	.050	1.81	1.81	550.	78.	73.	5.3	291.	50.
	50.0	1037	629.310	.050	1.81	1.81	550.	80.	74.	5.3	262.	50.
	60.0	1047	636.500	.050	1.81	1.81	550.	80.	74.	5.3	240.	54.
	70.0	1057	643.640	.050	1.81	1.81	550.	80.	74.	5.5	253.	52.
	70.4	1057	644.151	.050	1.81	1.81	550.	80.	74.	5.5	253.	52.
TOTALS	70.4		50.790									
AVERAGE					1.81	1.81	550.	78.	74.	5.2	263.	47.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS | TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND | DO

TEST 1-5 COKE OVEN STACK

		ENGLISH UNITS		METRIC UNITS	
TEST DATE		10/27/81		10/27/81	
TB	TIME-START	947		947	
TF	TIME-FINISH	1057		1057	
TT	NET TIME OF TEST, MIN.	70.4		70.4	
NP	NET SAMPLING POINTS	8		8	
Y	METER CALIBRATION FACTOR	1.033		1.033	
DN	SAMPLING NOZZLE DIAMETER	.520	IN	13.2	MM
CP	PITOT TUBE COEFFICIENT	.84		.84	
PM	AVERAGE ORIFICE PRESSURE DROP	1.81	IN-H2O	46.0	MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	50.790	CU-FT	1.438	CU-M
TM	AVERAGE GAS METER TEMP	76.3	F	24.6	C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	50.973	SCF	1.443	SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	169.5		169.5	
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.978	SCF	.226	SCM
BWO	PERCENT MOISTURE BY VOLUME	13.53		13.53	
FMD	MOLE FRACTION DRY GAS	.865		.865	
PCO2	PERCENT CO2 BY VOL., DRY	4.20		4.20	
PO2	PERCENT O2 BY VOL., DRY	10.50		10.50	
PCO	PERCENT CO BY VOL., DRY	.00		.00	
PN2	PERCENT N2 BY VOL., DRY	85.30		85.30	
MD	MOLECULAR WT-DRY STACK GAS	29.09		29.09	
MWS	MOLECULAR WT-STACK GAS	27.59		27.59	

PB	BAROMETRIC PRESSURE	29.39	IN-HG	746.51	MM-HG
PSI	STATIC PRES OF STACK GAS	.00	IN-H2O	.00	MM-H2O
PS	STACK PRES, ABS.	29.39	IN-HG	746.51	MM-HG
TS	AVERAGE STACK TEMP	550.	F	288.	C
VS	AVG STACK GAS VELOCITY	17.9	FPS	5.5	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1485228.	SCFH	42057.	SCMH
QS	ACTUAL STACK FLOW RATE	3345007.	ACFH	94721.	ACMH
ISO	PERCENT ISOKINETIC	102.8		102.8	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 1-5

COKE OVEN STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 50.790 * 1.033 * (29.39 + 1.810 / 13.6)}{(76. + 460.)} = 50.973 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 170. = 7.98 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.98}{50.973 + 7.98} = 13.53 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.5}{100.} = .865$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.20*44/100) + (10.5*32/100) + ((85.3+ .0) * 28/100 = 29.09

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.09* (1. -(13.53/100)) + 18. * (13.53/100) = 27.59

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 56.851 / (SQRT(27.59 * 29.39) * 8. = 17.92 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.92 * 7466. 3600/144 = 3345007. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3345007. * 29.39 * (1. - (13.53/100))}{(550. + 460.)} = 1485228.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(550.+460.))*((0.002669*170.)+(50.790*1.033*(29.39+(1.810/13.6))/(76.+460.)))}{70. * 17.92 * 29.39 * .520 * .520} = 102.84\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 50.973 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1485228. / (15.43 * 453.6) = .00

Run No. 1.5

Sample volume = 1.44 m^3, 50.97 scf

Example calculations

CS (Part) = 135.3 / 1.44 = 94.0 mg/m^3

CS (Part) = 0.001 x 135.3 x 15.43/ 50.97 = 0.041 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	135.3	94.0	0.041	
2-h at 350°F	47.5	33.0	0.014	
4-h at 350°F	41.7	29.0	0.013	
2-h at 400°F	37.3	25.9	0.011	
4-h at 400°F	34.5	24.0	0.010	
2-h at 600°F	30.5	21.2	0.009	
Acid sulfates				
As H_2SO_4	0.0	0.0	0.0	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.0	
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles	28.2	19.6	0.008	
Organic condensibles	2.6	1.8	0.001	
TOC (Condensible)	23.4	16.2	0.007	

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/27/81
SAMPLING LOCATION	COKE OVEN STACK	RUN NUMBER	1-6
SAMPLE TYPE	METHOD 8-600	PROBE LENGTH & TYPE	4' QUARTZ
OPERATOR	DO	NOZZLE I.D.	.620
AMBIENT TEMP.(DEG.F)	62.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.39	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F88
FILTER NUMBER(S)	3530210	METER HEAD DIFF.	1.91
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.94
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	600.
THERM. NO.		HEATER BOX SETTING	600.
LEAKAGE	.000 CFM @ 21.0 IN.HG	REFERENCE PRESS. DIFF.	.02
METER CALIB. FACTOR	.982		
READ & RECORD DATA EVERY 10.0 MINUTES			

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	958	88.938									
	10.0	1008	98.960	.050	3.66	3.66	550.	64.	63.	9.6	624.	38.
	20.0	1018	107.100	.050	3.66	2.20	550.	68.	63.	13.9	653.	40.
	30.0	1028	115.080	.050	3.66	2.20	550.	70.	63.	17.7	612.	40.
	40.0	1038	122.680	.050	3.66	2.00	550.	71.	64.	19.4	667.	50.
	50.0	1048	130.090	.050	3.66	1.87	550.	71.	65.	19.7	639.	50.
	60.0	1058	137.250	.050	3.66	1.80	550.	71.	65.	19.8	528.	54.
	64.5	1102	140.342	.050	3.66	1.60	550.	70.	65.	20.2	535.	52.
TOTALS	64.5		51.404									
AVERAGE					3.66	2.19	550.	69.	64.	17.2	608.	46.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS

REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER

DO

TEST 1-6 COKE OVEN STACK

		ENGLISH UNITS		METRIC UNITS	
TEST DATE		10/27/81		10/27/81	
TB	TIME-START	958		958	
TF	TIME-FINISH	1102		1102	
TT	NET TIME OF TEST, MIN.	64.5		64.5	
NP	NET SAMPLING POINTS	7		7	
Y	METER CALIBRATION FACTOR	.982		.982	
DN	SAMPLING NOZZLE DIAMETER	.620	IN	15.7	MM
CP	PITOT TUBE COEFFICIENT	.84		.84	
PM	AVERAGE ORIFICE PRESSURE DROP	2.19	IN-H2O	55.6	MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	51.404	CU-FT	1.456	CU-M
TM	AVERAGE GAS METER TEMP	66.6	F	19.2	C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	49.985	SCF	1.415	SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	17.9		17.9	
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	.843	SCF	.024	SCM
BWO	PERCENT MOISTURE BY VOLUME	1.66		1.66	
FMD	MOLE FRACTION DRY GAS	.983		.983	
PCO2	PERCENT CO2 BY VOL., DRY	4.20		4.20	
PO2	PERCENT O2 BY VOL., DRY	10.50		10.50	
PCO	PERCENT CO BY VOL., DRY	.00		.00	
PN2	PERCENT N2 BY VOL., DRY	85.30		85.30	
MD	MOLECULAR WT-DRY STACK GAS	29.09		29.09	
MWS	MOLECULAR WT-STACK GAS	28.91		28.91	

PB	BAROMETRIC PRESSURE	29.39	IN-HG	746.51	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.30	IN-HG	744.26	MM-HG
TS	AVERAGE STACK TEMP	550.	F	288.	C
VS	AVG STACK GAS VELOCITY	17.5	FPS	5.3	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1647806.	SCFH	46661.	SCMH
QS	ACTUAL STACK FLOW RATE	3272822.	ACFH	92677.	ACMH
ISO	PERCENT ISOKINETIC	69.8		69.8	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 1-6

COKE OVEN STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 51.404 * .982 * (29.39 + 2.190 / 13.6)}{(67. + 460.)} = 49.985 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 18. = .84 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * .84}{49.985 + .84} = 1.66 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 1.7}{100.} = .983$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.20*44/100) + (10.5*32/100) + ((85.3+ .0) * 28/100 = 29.09

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.09* (1. -(1.66/100)) + 18. * (1.66/100) = 28.91

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 49.744 / (SQRT(28.91 * 29.30) * 7. = 17.53 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.53 * 7466. 3600/144 = 3272822. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3272822. * 29.30 * (1. - (1.66/100))}{(550. + 460.)} = 1647806. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(550.+460.))*((0.002669* 18.)+(51.404* .982*(29.39+(2.190/13.6))/(67.+460.)))}{65. * 17.53 * 29.30 * .620 * .620} = 69.78 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 49.985 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1647806. / (15.43 * 453.6) = .00

Run No. 1.6

Sample volume = 1.42 m^3, 49.99 scf

Example calculations

CS (Part) = 27.0 / 1.42 = 19.0 mg/m^3

CS (Part) = 0.001 x 27.0 x 15.43/49.99 = 0.008 gr/dscf

CS (SO_2) = 1120 / 1.42 = 788.7 mg/m^3

= 788.7 x 24.06/64 = 296 ppm

= 0.001 x 1120 x 15.43/49.99 = 0.346 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	27.0	19.0	0.008	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.0	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.0	
Sulfur dioxide	1120	788.7	0.346	296
Sulfuric acid mist				
As H_2SO_4	606[a]	426.8	0.187	105
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

[a]Hydrogen peroxide contaminated.

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/27/81
SAMPLING LOCATION	NO.1 COKE BATTERY STACK	RUN NUMBER	2-1
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	5' HEATED GLASS
OPERATOR	BRUFFEY	NUZZLE 2-1 : I.D.	.397
AMBIENT TEMP.(DEG.F)	64.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.30	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F82
FILTER NUMBER(S)	3530080	METER HEAD DIFF.	1.76
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.001 CFM @ 5.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.003		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1355	720.259									
	10.0	1405	725.000	.050	.62	.62	525.	67.	68.	1.5	250.	55.
	20.0	1415	729.740	.050	.62	.62	519.	68.	68.	2.0	251.	54.
	30.0	1425	734.500	.050	.62	.62	530.	70.	68.	2.0	249.	53.
	40.0	1435	739.240	.050	.62	.62	537.	73.	68.	2.0	245.	53.
	50.0	1445	744.010	.050	.62	.62	535.	74.	69.	2.0	250.	53.
	60.0	1455	748.790	.050	.62	.62	553.	75.	69.	2.5	253.	52.
	70.0	1505	753.600	.050	.62	.62	565.	75.	69.	3.0	249.	50.
	80.0	1515	758.380	.050	.62	.62	511.	75.	69.	3.0	249.	51.
	90.0	1525	763.120	.050	.62	.62	522.	75.	69.	3.0	242.	50.
	100.0	1535	767.890	.050	.62	.62	534.	75.	70.	3.0	242.	51.
	110.0	1545	772.690	.050	.62	.62	534.	75.	70.	3.0	237.	52.
	120.0	1555	777.486	.050	.62	.62	553.	73.	68.	3.0	242.	50.
TOTALS	120.0		57.227									
AVERAGE					.62	.62	535.	73.	69.	2.5	247.	52.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST LEADER: BRUFFEY

TEST 2-1 NO.1 COKE BATTERY STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/27/81	10/27/81
TB	TIME-START	1355	1355
TF	TIME-FINISH	1555	1555
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.003	1.003
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE DRIFICE PRESSURE DROP	.62 IN-H2O	15.7 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	57.227 CU-FT	1.620 CU-M
TM	AVERAGE GAS METER TEMP	70.8 F	21.6 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	55.996 SCF	1.586 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	189.1	189.1
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.901 SCF	.252 SCM
BWO	PERCENT MOISTURE BY VOLUME	13.72	13.72
FMD	MOLE FRACTION DRY GAS	.863	.863
PCO2	PERCENT CO2 BY VOL., DRY	4.20	4.20
PO2	PERCENT O2 BY VOL., DRY	10.50	10.50
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.30	85.30
MD	MOLECULAR WT-DRY STACK GAS	29.09	29.09
MWS	MOLECULAR WT-STACK GAS	27.57	27.57

PB	BAROMETRIC PRESSURE	29.30	IN-HG	744.22	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.21	IN-HG	741.98	MM-HG
TS	AVERAGE STACK TEMP	535.	F	279.	C
VS	AVG STACK GAS VELOCITY	17.8	FPS	5.4	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1489327.	SCFH	42173.	SCMH
QS	ACTUAL STACK FLOW RATE	3331033.	ACFH	94325.	ACMH
ISO	PERCENT ISOKINETIC	113.4		113.4	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 2-1

NO.1 COKE BATTERY STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 57.227 * 1.003 * (29.30 + .620 / 13.6)}{(71. + 460.)} = 55.996 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 189. = 8.90 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.90}{55.996 + 8.90} = 13.72 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.7}{100.} = .863$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.20*44/100) + (10.5*32/100) + ((85.3+ .0) * 28/100 = 29.09

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.09* (1. -(13.72/100)) + 18. * (13.72/100) = 27.57

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 84.631 / (SQRT(27.57 * 29.21) * 12. = 17.85 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.85 * 7466. 3600/144 = 3331033. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3331033. * 29.21 * (1. - (13.72/100))}{(535. + 460.)} = 1489327. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(535.+460.))*((0.002669*189.)+(57.227*1.003*(29.30+(.620/13.6))/(71.+460.)))}{120. * 17.85 * 29.21 * .397 * .397} = 113.40 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 55.996 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1489327. / (15.43 * 453.6) = .00

Run No. 2.1

Sample volume = 1.59 m^3, 56.00 scf

Example calculations

CS (Part) = 183.1/1.59 = 115.1 mg/m^3

CS (Part) = 0.001 x 183.1 x 15.43/56.00 = 0.050 gr/dscf

CS (SO_2) = 1370 /1.59 = 861.6 mg/m^3

= 861.6 x 24.06/64 = 324 ppm

= 0.001 x 1370 x 15.43/56.00 = 0.377 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at: Ambient 2-h at 350°F 4-h at 350°F 2-h at 400°F 4-h at 400°F 2-h at 600°F	183.1	115.2	0.050	
Acid sulfates As H_2SO_4 As $H_2SO_4 \cdot 2H_2O$	61.6 84.2	38.7 53.0	0.017 0.023	
Sulfur dioxide	1370	861.6	0.377	324
Sulfuric acid mist As H_2SO_4	741[a]	466.0	0.204	114
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

[a]Hydrogen peroxide contaminated.

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/27/81
SAMPLING LOCATION	NO.1 COKE BATTERY OUTLET	RUN NUMBER	2-2
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	4' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE 2-2 : I.D.	.397
AMBIENT TEMP.(DEG.F)	69.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.30	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F10
FILTER NUMBER(S)	35300013	METER HEAD DIFF.	1.80
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 5.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.044		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1358	961.498									
	10.0	1408	965.910	.050	.62	.62	573.	71.	72.	1.0	268.	48.
	20.0	1418	970.265	.050	.62	.62	524.	71.	71.	1.0	262.	47.
	30.0	1428	974.650	.050	.62	.62	532.	73.	72.	1.0	262.	49.
	40.0	1438	979.000	.050	.62	.62	540.	76.	72.	1.5	254.	51.
	50.0	1448	983.345	.050	.62	.62	543.	77.	72.	1.0	264.	50.
	60.0	1458	987.710	.050	.62	.62	555.	78.	73.	1.0	265.	50.
	70.0	1508	992.070	.050	.62	.62	568.	78.	73.	2.0	267.	50.
	80.0	1518	996.400	.050	.62	.62	513.	77.	73.	2.0	265.	50.
	90.0	1528	.720	.050	.62	.62	526.	78.	72.	2.4	262.	53.
	100.0	1538	5.090	.050	.62	.62	536.	78.	73.	2.5	263.	54.
	110.0	1548	9.420	.050	.62	.62	541.	77.	72.	2.5	256.	56.
	120.0	1558	13.753	.050	.62	.62	559.	74.	71.	2.6	263.	52.
TOTALS	120.0		52.255									
AVERAGE					.62	.62	543.	76.	72.	1.7	263.	51.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — BRUFFEY

TEST 2-2 NO.1 COKE BATTERY OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/27/81	10/27/81
TB	TIME-START	1358	1358
TF	TIME-FINISH	1558	1558
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.044	1.044
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.62 IN-H2O	15.7 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	52.255 CU-FT	1.480 CU-M
TM	AVERAGE GAS METER TEMP	73.9 F	23.3 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	52.914 SCF	1.498 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	169.2	169.2
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.964 SCF	.226 SCM
BWO	PERCENT MOISTURE BY VOLUME	13.08	13.08
FMD	MOLE FRACTION DRY GAS	.869	.869
PCO2	PERCENT CO2 BY VOL., DRY	4.20	4.20
PO2	PERCENT O2 BY VOL., DRY	10.50	10.50
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.30	85.30
MD	MOLECULAR WT-DRY STACK GAS	29.09	29.09
MWS	MOLECULAR WT-STACK GAS	27.64	27.64

PB	BAROMETRIC PRESSURE	29.30	IN-HG	744.22	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.21	IN-HG	741.98	MM-HG
TS	AVERAGE STACK TEMP	543.	F	284.	C
VS	AVG STACK GAS VELOCITY	17.9	FPS	5.5	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1492594.	SCFH	42266.	SCMH
QS	ACTUAL STACK FLOW RATE	3339559.	ACFH	94566.	ACMH
ISO	PERCENT ISOKINETIC	106.9		106.9	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 2-2

NO.1 COKE BATTERY OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTO = \frac{17.647 * 52.255 * 1.044 * (29.30 + .620 / 13.6)}{(74. + 460.)} = 52.914 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 169. = 7.96 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTO + VWC)

$$BWO = \frac{100. * 7.96}{52.914 + 7.96} = 13.08 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.1}{100.} = .869$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.20*44/100) + (10.5*32/100) + ((85.3+ .0) * 28/100 = 29.09

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.09* (1. -(13.08/100)) + 18. * (13.08/100) = 27.64

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 84.956 / (SQRT(27.64 * 29.21) * 12. = 17.89 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.89 * 7466. 3600/144 = 3339559. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3339559. * 29.21 * (1. - (13.08/100))}{(543. + 460.)} = 1492594. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(543.+460.))*((0.002669*169.)+(52.255*1.044*(29.30+(.620/13.6))/(74.+460.)))}{120. * 17.89 * 29.21 * .397 * .397} = 106.92 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 52.914 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1492594. / (15.43 * 453.6) = .00

Run No. 2.2

Sample volume = 1.50 m^3, 52.9 scf

Example calculations

CS (Part) = 149.2 / 1.50 = 99.5 mg/m^3

CS (Part) = 0.001 x 149.2 x 15.43/52.91 = 0.044 gr/dscf

CS (SO_2) = 1720 / 1.50 = 1146.7 mg/m^3

= 1146.7 x 24.06/64 = 431 ppm

= 0.001 x 1720 x 15.43/52.91 = 0.501 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	149.2	99.5	0.044	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F	24.8	16.5	0.007	
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.0	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.0	
Sulfur dioxide	1720	1146.7	0.502	431
Sulfuric acid mist				
As H_2SO_4	16.0	10.7	0.005	3
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/27/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	2-3
SAMPLE TYPE	2-3-M8-400	PROBE LENGTH & TYPE	5 FT GLASS HEATED
OPERATOR	CLARKE	NOZZLE 2-3: I.D.	.398
AMBIENT TEMP.(DEG.F)	69.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.30	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB1
FILTER NUMBER(S)	3530057	METER HEAD DIFF.	1.87
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	400.
THERM. NO.		HEATER BOX SETTING	400.
LEAKAGE	.000 CFM @ 2.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	.992		
READ & RECORD DATA EVERY 10.0 MINUTES			

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1355	472.072									
	10.0	1405	476.400	.050	.60	.60	525.	64.	60.	2.0	300.	52.
	20.0	1415	480.900	.050	.60	.60	519.	66.	60.	2.0	365.	42.
	30.0	1425	485.375	.050	.60	.60	530.	70.	60.	2.0	389.	52.
	40.0	1435	489.689	.050	.60	.60	537.	72.	61.	2.0	365.	52.
	50.0	1445	494.120	.050	.60	.60	535.	74.	62.	2.0	406.	54.
	60.0	1455	498.525	.050	.60	.60	543.	76.	64.	2.0	383.	54.
	70.0	1505	502.915	.050	.60	.60	565.	76.	62.	2.0	416.	56.
	80.0	1515	507.405	.050	.60	.60	511.	76.	64.	2.0	393.	56.
	90.0	1525	511.695	.050	.60	.60	522.	76.	62.	2.0	404.	52.
	100.0	1535	516.198	.050	.60	.60	534.	76.	63.	2.0	409.	52.
	110.0	1545	520.470	.050	.60	.60	534.	76.	65.	2.0	426.	58.
	120.0	1555	524.984	.050	.60	.60	553.	78.	64.	2.0	414.	58.
TOTALS	120.0		52.912									
AVERAGE					.60	.60	534.	73.	62.	2.0	389.	53.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER: CLARKE

TEST 2-3 COKE OVEN OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/27/81	10/27/81
TB	TIME-START	1355	1355
TF	TIME-FINISH	1555	1555
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.992	.992
DN	SAMPLING NOZZLE DIAMETER	.398 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.60 IN-H2O	15.2 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	52.912 CU-FT	1.498 CU-M
TM	AVERAGE GAS METER TEMP	67.8 F	19.9 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	51.499 SCF	1.458 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	170.4	170.4
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.021 SCF	.227 SCM
BWO	PERCENT MOISTURE BY VOLUME	13.48	13.48
FMD	MOLE FRACTION DRY GAS	.865	.865
PCO2	PERCENT CO2 BY VOL., DRY	4.20	4.20
PO2	PERCENT O2 BY VOL., DRY	10.50	10.50
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.30	85.30
MD	MOLECULAR WT-DRY STACK GAS	29.09	29.09
MWS	MOLECULAR WT-STACK GAS	27.60	27.60

PB	BAROMETRIC PRESSURE	29.30	IN-HG	744.22	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.21	IN-HG	741.98	MM-HG
TS	AVERAGE STACK TEMP	534.	F	279.	C
VS	AVG STACK GAS VELOCITY	17.8	FPS	5.4	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1493373.	SCFH	42288.	SCMH
QS	ACTUAL STACK FLOW RATE	3328042.	ACFH	94240.	ACMH
ISO	PERCENT ISOKINETIC	103.5		103.5	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 2-3

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 52.912 * .992 * (29.30 + .600 / 13.6)}{(68. + 460.)} = 51.499 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 170. = 8.02 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.02}{51.499 + 8.02} = 13.48 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.5}{100.} = .865$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.20*44/100) + (10.5*32/100) + ((85.3+ .0) * 28/100 = 29.09

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.09* (1. -(13.48/100)) + 18. * (13.48/100) = 27.60

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 84.596 / (SQRT(27.60 * 29.21) * 12. = 17.83 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.83 * 7466. 3600/144 = 3328042. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3328042. * 29.21 * (1. - (13.48/100))}{(534. + 460.)} = 1493373. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(534.+460.))*((0.002669*170.)+(52.912*.992*(29.30+(.600/13.6))/(68.+460.)))}{120. * 17.83 * 29.21 * .398 * .398} = 103.49 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 51.499 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1493373. / (15.43 * 453.6) = .00

Run No. 2.3

Sample volume = 1.46 m^3, 51.50 scf

Example calculations

CS (Part) = 46.3 / 1.46 = 31.7 mg/m^3

CS (Part) = 0.001 x 46.3 x 15.43/ 51.50 = 0.014 gr/dscf

CS (SO_2) = 1700 / 1.46 = 1164.3 mg/m^3

= 1164.3 x 24.06/ 64 = 438 ppm

= 0.001 x 1700 x 15.43/ 51.50 = 0.50 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	46.3	31.7	0.014	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	12.2	8.3	0.004	
As $H_2SO_4 \cdot 2H_2O$	16.7	11.4	0.005	
Sulfur dioxide	1700	1164.7	0.509	438
Sulfuric acid mist				
As H_2SO_4	53.0	36.3	0.016	9
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/27/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	2-4
SAMPLE TYPE	2-4-M8-400	PROBE LENGTH & TYPE	6 FT GLASS HEATED
OPERATOR	CLARKE	NOZZLE 2-4: I.D.	.397
AMBIENT TEMP.(DEG.F)	69.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.30	SAMPLE BOX NUMBER	F
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F85
FILTER NUMBER(S)	3530062	METER HEAD DIFF.	1.86
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	400.
THERM. NO.		HEATER BOX SETTING	400.
LEAKAGE	.000 CFM @ 2.0 IN.HG	REFERENCE PRESS. DIFF.	.75
METER CALIB. FACTOR	1.016		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1358	898.353									
	10.0	1408	902.665	.050	.60	.60	573.	68.	69.	1.0	405.	42.
	20.0	1418	906.900	.050	.60	.60	524.	69.	69.	1.0	369.	38.
	30.0	1428	911.186	.050	.60	.60	550.	72.	70.	1.0	386.	40.
	40.0	1438	915.762	.050	.60	.60	539.	74.	70.	1.0	430.	42.
	50.0	1448	919.670	.050	.60	.60	543.	76.	70.	1.0	373.	46.
	60.0	1458	924.085	.050	.60	.60	555.	78.	72.	1.0	394.	48.
	70.0	1508	928.200	.050	.60	.60	568.	78.	72.	1.0	392.	46.
	80.0	1518	932.712	.050	.60	.60	514.	78.	72.	1.0	394.	44.
	90.0	1528	936.920	.050	.60	.60	525.	78.	72.	1.0	422.	42.
	100.0	1538	940.920	.050	.60	.60	536.	78.	72.	1.0	413.	44.
	110.0	1548	945.776	.050	.60	.60	541.	78.	72.	1.0	450.	46.
	120.0	1558	949.848	.050	.60	.60	559.	82.	74.	1.0	418.	48.
TOTALS	120.0		51.495									
AVERAGE					.60	.60	542.	76.	71.	1.0	404.	44.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST LEADER: CLARKE

TEST 2-4 COKE OVEN OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/27/81	10/27/81
TB	TIME-START	1358	1358
TF	TIME-FINISH	1558	1558
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.016	1.016
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.60 IN-H2O	15.2 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	51.495 CU-FT	1.458 CU-M
TM	AVERAGE GAS METER TEMP	73.5 F	23.0 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	50.787 SCF	1.438 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	156.1	156.1
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.348 SCF	.208 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.64	12.64
FMD	MOLE FRACTION DRY GAS	.874	.874
PCO2	PERCENT CO2 BY VOL., DRY	4.20	4.20
PO2	PERCENT O2 BY VOL., DRY	10.50	10.50
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.30	85.30
MD	MOLECULAR WT-DRY STACK GAS	29.09	29.09
MWS	MOLECULAR WT-STACK GAS	27.69	27.69

PB	BAROMETRIC PRESSURE	29.30	IN-HG	744.22	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.21	IN-HG	741.98	MM-HG
TS	AVERAGE STACK TEMP	542.	F	283.	C
VS	AVG STACK GAS VELOCITY	17.9	FPS	5.4	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1499060.	SCFH	42449.	SCMH
QS	ACTUAL STACK FLOW RATE	3336176.	ACFH	94471.	ACMH
ISO	PERCENT ISOKINETIC	102.2		102.2	
MN	FILTERABLE PART MG, EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 2-4

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 51.495 * 1.016 * (29.30 + .600 / 13.6)}{(73. + 460.)} = 50.787 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 156. = 7.35 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.35}{50.787 + 7.35} = 12.64 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.6}{100.} = .874$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.20*44/100) + (10.5*32/100) + ((85.3+ .0) * 28/100 = 29.09

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.09* (1. -(12.64/100)) + 18. * (12.64/100) = 27.69

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 84.945 / (SQRT(27.69 * 29.21) * 12. = 17.87 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.87 * 7466. 3600/144 = 3336176. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3336176. * 29.21 * (1. - (12.64/100))}{(542. + 460.)} = 1499060.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(542.+460.))*((0.002669*156.)+(51.495*1.016*(29.30+(.600/13.6))/(73.+460.)))}{120. * 17.87 * 29.21 * .397 * .397} = 102.18\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 50.787 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1499060. / (15.43 * 453.6) = .00

Run No. 2.4

Sample volume = 1.44 m^3, 50.79 scf

Example calculations

CS (Part) = 61.3 / 1.44 = 42.6 mg/m^3

CS (Part) = 0.001 x 61.3 x 15.43/ 50.79 = 0.019 gr/dscf

CS (SO_2) = 1610 / 1.44 = 1118.0 mg/m^3

= 1118.0 x 24.06/ 64 = 420 ppm

= 0.001 x 1610 x 15.43/ 50.79 = 0.489 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	61.3	42.6	0.019	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	14.4	10.0	0.004	
As $H_2SO_4 \cdot 2H_2O$	19.7	13.7	0.006	
Sulfur dioxide	1610	1118.0	0.489	420
Sulfuric acid mist				
As H_2SO_4	19.6	13.6	0.006	3
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/27/81
SAMPLING LOCATION	COKE OVEN STACK	RUN NUMBER	2-5
SAMPLE TYPE	METHOD 5-250	PROBE LENGTH & TYPE	6' GLASS
OPERATOR	OO	NOZZLE 6-114: I.D.	.377
AMBIENT TEMP.(DEG.F)	63.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.43	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB4
FILTER NUMBER(S)	3530044	METER HEAD DIFF.	1.88
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.92
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.012 CFM @ 7.0 IN.HG	REFERENCE PRESS. DIFF.	.17
METER CALIB. FACTOR	1.033		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1424	645.051									
	10.0	1434	649.480	.057	.63	.63	499.	67.	66.	3.7	234.	50.
	20.0	1444	653.770	.057	.63	.63	499.	68.	66.	3.7	271.	50.
	30.0	1454	658.110	.057	.63	.63	499.	72.	67.	4.0	271.	50.
	40.0	1504	662.460	.057	.63	.63	499.	74.	68.	4.1	238.	48.
	50.0	1514	666.820	.057	.63	.63	499.	77.	69.	4.2	252.	48.
	60.0	1524	671.190	.057	.63	.63	499.	78.	70.	4.4	262.	48.
	70.0	1534	675.560	.057	.63	.63	499.	79.	71.	4.5	248.	48.
	80.0	1544	679.940	.057	.63	.63	499.	80.	72.	4.8	271.	50.
	90.0	1554	684.320	.057	.63	.63	499.	80.	73.	5.0	245.	50.
	100.0	1604	688.710	.057	.63	.63	499.	80.	73.	5.0	252.	50.
	110.0	1614	693.140	.057	.63	.63	499.	80.	73.	5.7	275.	50.
	120.0	1624	697.558	.057	.63	.63	499.	79.	73.	5.7	261.	48.
TOTALS	120.0		52.507									
AVERAGE					.63	.63	499.	76.	70.	4.6	257.	49.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS | TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND | DO

TEST 2-5 COKE OVEN STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/27/81	10/27/81
TB	TIME-START	1424	1424
TF	TIME-FINISH	1624	1624
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.033	1.033
DN	SAMPLING NOZZLE DIAMETER	.377 IN	9.6 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.63 IN-H2O	16.0 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	52.507 CU-FT	1.487 CU-M
TM	AVERAGE GAS METER TEMP	73.1 F	22.8 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	52.922 SCF	1.499 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	175.5	175.5
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.261 SCF	.234 SCM
BWO	PERCENT MOISTURE BY VOLUME	13.50	13.50
FMD	MOLE FRACTION DRY GAS	.865	.865
PCO2	PERCENT CO2 BY VOL., DRY	4.20	4.20
PO2	PERCENT O2 BY VOL., DRY	10.50	10.50
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.30	85.30
MD	MOLECULAR WT-DRY STACK GAS	29.09	29.09
MWS	MOLECULAR WT-STACK GAS	27.59	27.59

PB	BAROMETRIC PRESSURE	29.43	IN-HG	747.52	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.34	IN-HG	745.28	MM-HG
TS	AVERAGE STACK TEMP	499.	F	259.	C
VS	AVG STACK GAS VELOCITY	18.7	FPS	5.7	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1626567.	SCFH	46059.	SCMH
QS	ACTUAL STACK FLOW RATE	3482787.	ACFH	98622.	ACMH
ISO	PERCENT ISOKINETIC	108.8		108.8	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 2-5

COKE OVEN STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 52.507 * 1.033 * (29.43 + .630 / 13.6)}{(73. + 460.)} = 52.922 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 176. = 8.26 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.26}{52.922 + 8.26} = 13.50 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.5}{100.} = .865$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.20*44/100) + (10.5*32/100) + ((85.3+ .0) * 28/100 = 29.09

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.09* (1. -(13.50/100)) + 18. * (13.50/100) = 27.59

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 88.721 / (SQRT(27.59 * 29.34) * 12. = 18.66 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 18.66 * 7466. 3600/144 = 3482787. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3482787. * 29.34 * (1. - (13.50/100))}{(499. + 460.)} = 1626567.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(499.+460.))*((0.002669*176.)+(52.507*1.033*(29.43+(.630/13.6))/(73.+460.)))}{120. * 18.66 * 29.34 * .377 * .377} = 108.82\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 52.922 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1626567. / (15.43 * 453.6) = .00

Run No. 2.5

Sample volume = 1.50 m^3, 52.92 scf

Example calculations

CS (Part) = 90.9 / 1.5 = 60.6 mg/m^3

CS (Part) = 0.001 x 90.9 x 15.43/52.92 = 0.026 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	90.9	60.6	0.026	
2-h at 350°F	34.0	22.7	0.010	
4-h at 350°F	30.7	20.5	0.009	
2-h at 400°F	29.2	19.5	0.008	
4-h at 400°F	27.7	18.5	0.008	
2-h at 600°F	22.5	15.0	0.006	
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles	68.2	45.5	0.020	
Organic condensibles	4.8	3.2	0.001	
TOC (Condensible)	44.3	29.5	0.013	

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/27/81
SAMPLING LOCATION	COKE OVEN STACK	RUN NUMBER	2-6
SAMPLE TYPE	METHOD 8-600	PROBE LENGTH & TYPE	4' QUARTZ
OPERATOR	DO	NOZZLE : I.D.	.590
AMBIENT TEMP.(DEG.F)	63.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.43	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB8
FILTER NUMBER(S)	3530212	METER HEAD DIFF.	1.91
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.94
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	600.
THERM. NO.		HEATER BOX SETTING	600.
LEAKAGE	.000 CFM @ 21.7 IN.HG	REFERENCE PRESS. DIFF.	.03
METER CALIB. FACTOR	.982		
READ & RECORD DATA EVERY 10.0 MINUTES			

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1419	141.627									
	10.0	1429	149.070	.057	3.68	1.90	499.	63.	62.	7.2	617.	42.
	20.0	1439	156.480	.057	3.68	1.90	499.	66.	62.	8.6	584.	44.
	30.0	1449	163.870	.057	3.68	1.90	499.	70.	62.	12.8	596.	50.
	40.0	1459	170.840	.057	3.68	1.80	499.	72.	63.	19.8	619.	60.
	50.0	1509	177.430	.057	3.68	1.49	499.	71.	63.	20.5	567.	58.
	60.0	1519	183.780	.057	3.68	1.38	499.	70.	64.	20.8	576.	56.
	70.0	1529	189.800	.057	3.68	1.28	499.	69.	64.	21.0	588.	56.
	80.0	1539	195.720	.057	3.68	1.15	499.	68.	63.	21.4	616.	54.
	90.0	1549	201.620	.057	3.68	1.13	499.	68.	63.	21.4	635.	50.
TOTALS	90.0		59.993									
AVERAGE					3.68	1.55	499.	69.	63.	17.1	600.	52.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — DO

TEST 2-6 COKE OVEN STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/27/81	10/27/81
TB	TIME-START	1419	1419
TF	TIME-FINISH	1549	1549
TT	NET TIME OF TEST, MIN.	90.0	90.0
NP	NET SAMPLING POINTS	9	9
Y	METER CALIBRATION FACTOR	.982	.982
DN	SAMPLING NOZZLE DIAMETER	.590 IN	15.0 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	1.55 IN-H2O	39.3 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	59.993 CU-FT	1.699 CU-M
TM	AVERAGE GAS METER TEMP	65.7 F	18.7 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	58.424 SCF	1.654 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL, ML.	149.9	149.9
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.056 SCF	.200 SCM
BWO	PERCENT MOISTURE BY VOLUME	10.78	10.78
FMD	MOLE FRACTION DRY GAS	.892	.892
PCO2	PERCENT CO2 BY VOL., DRY	4.20	4.20
PO2	PERCENT O2 BY VOL., DRY	10.50	10.50
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.30	85.30
MD	MOLECULAR WT-DRY STACK GAS	29.09	29.09
MWS	MOLECULAR WT-STACK GAS	27.90	27.90

PB	BAROMETRIC PRESSURE	29.43	IN-HG	747.52	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.34	IN-HG	745.28	MM-HG
TS	AVERAGE STACK TEMP	499.	F	259.	C
VS	AVG STACK GAS VELOCITY	18.6	FPS	5.7	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1668717.	SCFH	47253.	SCMH
QS	ACTUAL STACK FLOW RATE	3463857.	ACFH	98086.	ACMH
ISO	PERCENT ISOKINETIC	63.7		63.7	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 2-6

COKE OVEN STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 59.993 * .982 * (29.43 + 1.548 / 13.6)}{(66. + 460.)} = 58.424 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 150. = 7.06 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.06}{58.424 + 7.06} = 10.78 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 10.8}{100.} = .892$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.20*44/100) + (10.5*32/100) + ((85.3+ .0) * 28/100 = 29.09

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.09* (1. -(10.78/100)) + 18. * (10.78/100) = 27.90

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 66.541 / (SQRT(27.90 * 29.34) * 9. = 18.56 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 18.56 * 7466. 3600/144 = 3463857. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3463857. * 29.34 * (1. - (10.78/100))}{(499. + 460.)} = 1668717.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(499.+460.))*((0.002669*150.)+(59.993*.982*(29.43+(1.548/13.6))/(66.+460.)))}{90. * 18.56 * 29.34 * .590 * .590} = 63.75\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 58.424 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1668717. / (15.43 * 453.6) = .00

Run No. 2.6

Sample volume = 1.65 m^3, 58.42 scf

Example calculations

CS (Part) = 39.5 / 1.65 = 23.9 mg/m^3

CS (Part) = 0.001 x 39.5 x 15.43/ 58.42 = 0.010 gr/dscf

CS (SO_2) = 1940 / 1.65 = 1175.8 mg/m^3

= 1175.8 x 24.06/64 = 442 ppm

= 0.001 x 1940 x 15.43/58.42 = 0.512 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	39.5	23.9	0.010	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	2.6	1.6	0.001	
As $H_2SO_4 \cdot 2H_2O$	3.5	2.1	0.001	
Sulfur dioxide	1940	1175.8	0.512	442
Sulfuric acid mist				
As H_2SO_4	157	95.7	0.041	23
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/28/81
SAMPLING LOCATION	NO1 COKE BATTERY OUTLET	RUN NUMBER	3-1
SAMPLE TYPE	PART/SO2/H2SO4	PROBE LENGTH & TYPE	5' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE : I.D.	.398
AMBIENT TEMP.(DEG.F)	58.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.78	SAMPLE BOX NUMBER	8
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB2
FILTER NUMBER(S)	3530093	METER HEAD DIFF.	1.76
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 3.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.003		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	955	777.764									
	10.0	1005	783.020	.065	.80	.80	546.	54.	55.	2.0	160.	44.
	20.0	1015	788.040	.060	.73	.73	515.	56.	55.	2.0	228.	44.
	30.0	1025	793.070	.060	.73	.73	525.	58.	56.	2.5	251.	43.
	40.0	1035	798.540	.070	.87	.87	536.	61.	55.	2.0	239.	44.
	50.0	1045	803.570	.060	.73	.73	531.	62.	56.	2.5	248.	43.
	60.0	1055	808.620	.060	.73	.73	550.	62.	56.	2.5	248.	44.
	70.0	1105	813.670	.060	.73	.73	558.	63.	56.	2.5	247.	46.
	80.0	1115	818.720	.060	.73	.73	517.	64.	57.	2.5	245.	46.
	90.0	1125	823.350	.050	.61	.61	528.	64.	57.	3.0	242.	44.
	100.0	1135	828.440	.060	.73	.73	539.	64.	57.	3.0	245.	42.
	110.0	1145	833.520	.060	.73	.73	529.	64.	57.	3.0	241.	44.
	120.0	1155	838.555	.060	.73	.73	545.	64.	57.	3.0	234.	43.
TOTALS	120.0		60.791									
AVERAGE					.74	.74	535.	61.	56.	2.5	236.	44.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS

REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER

BRUFFEY

TEST 3-1 ND1 COKE BATTERY OUTLET

		ENGLISH UNITS		METRIC UNITS	
TEST DATE		10/28/81		10/28/81	
TB	TIME-START	955		955	
TF	TIME-FINISH	1155		1155	
TT	NET TIME OF TEST, MIN.	120.0		120.0	
NP	NET SAMPLING POINTS	12		12	
Y	METER CALIBRATION FACTOR	1.003		1.003	
DN	SAMPLING NOZZLE DIAMETER	.398	IN	10.1	MM
CP	PITOT TUBE COEFFICIENT	.84		.84	
PM	AVERAGE ORIFICE PRESSURE DROP	.74	IN-H2O	18.7	MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	60.791	CU-FT	1.721	CU-M
TM	AVERAGE GAS METER TEMP	58.8	F	14.9	C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	61.883	SCF	1.752	SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	183.4		183.4	
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.633	SCF	.244	SCM
BWO	PERCENT MOISTURE BY VOLUME	12.24		12.24	
FMD	MOLE FRACTION DRY GAS	.878		.878	
PCO2	PERCENT CO2 BY VOL., DRY	2.30		2.30	
PO2	PERCENT O2 BY VOL., DRY	10.90		10.90	
PCO	PERCENT CO BY VOL., DRY	.00		.00	
PN2	PERCENT N2 BY VOL., DRY	86.80		86.80	
MD	MOLECULAR WT-DRY STACK GAS	28.80		28.80	
MWS	MOLECULAR WT-STACK GAS	27.48		27.48	

PB	BAROMETRIC PRESSURE	29.78	IN-HG	756.41	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.69	IN-HG	754.17	MM-HG
TS	AVERAGE STACK TEMP	535.	F	279.	C
VS	AVG STACK GAS VELOCITY	19.5	FPS	5.9	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1680373.	SCFH	47583.	SCMH
QS	ACTUAL STACK FLOW RATE	3635799.	ACFH	102955.	ACMH
ISO	PERCENT ISOKINETIC	110.5		110.5	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 3-1

NO1 COKE BATTERY OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 60.791 * 1.003 * (29.78 + .738 / 13.6)}{(59. + 460.)} = 61.883 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 183. = 8.63 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.63}{61.883 + 8.63} = 12.24 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.2}{100.} = .878$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (2.30*44/100) + (10.9*32/100) + ((86.8+ .0) * 28/100 = 28.80

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 28.80* (1. -(12.24/100)) + 18. * (12.24/100) = 27.48

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 92.979 / (SQRT(27.48 * 29.69) * 12. = 19.48 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 19.48 * 7466. 3600/144 = 3635799. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3635799. * 29.69 * (1. - (12.24/100))}{(535. + 460.)} = 1680373.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(535.+460.))*((0.002669*183.)+(60.791*1.003*(29.78+(.738/13.6))/(59.+460.)))}{120. * 19.48 * 29.69 * .398 * .398} = 110.51\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 61.883 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1680373. / (15.43 * 453.6) = .00

Run No. 3.1

Sample volume = 1.75 m^3, 61.88 scf

Example calculations

CS (Part) = 202.0 / 1.75 = 115.4 mg/m^3

CS (Part) = 0.001 x 202.0 x 15.43 / 61.88 = 0.050 gr/dscf

CS (SO_2) = 1790 / 1.75 = 1022.7 mg/m^3

= 1022.8 x 24.06 / 64 = 384 ppm

= 0.001 x 1790 x 15.43 / 61.88 = 0.446 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	202.0	115.4	0.050	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	70.4	40.2	0.017	
As $H_2SO_4 \cdot 2H_2O$	96.2	55.0	0.024	
Sulfur dioxide	1790	1022.8	0.446	384
Sulfuric acid mist				
As H_2SO_4	8.3	4.7	0.002	1
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND, OH	DATE	10/28/81
SAMPLING LOCATION	NO.1 COKE BATTERY	RUN NUMBER	5-2
SAMPLE TYPE	PART/SO2/H2SO4	PROBE LENGTH & TYPE	4' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE : I.D.	.397
AMBIENT TEMP.(DEG.F)	58.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.78	SAMPLE BOX NUMBER	0
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F10
FILTER NUMBER(S)	3530087	METER HEAD DIFF.	1.80
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.015 CFM @ 4.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.044		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	958	15.192									
	10.0	1008	20.070	.065	.80	.80	567.	57.	58.	3.0	213.	40.
	20.0	1018	24.910	.065	.80	.80	519.	58.	58.	3.5	260.	41.
	30.0	1028	29.510	.060	.73	.73	531.	61.	58.	3.5	271.	42.
	40.0	1038	34.130	.060	.73	.73	539.	63.	58.	3.0	268.	43.
	50.0	1048	38.750	.060	.73	.73	536.	64.	59.	3.0	265.	44.
	60.0	1058	43.360	.060	.73	.73	552.	66.	60.	2.5	264.	45.
	70.0	1108	47.980	.060	.73	.73	564.	67.	61.	3.0	265.	46.
	80.0	1118	52.600	.060	.73	.73	520.	67.	61.	3.0	266.	45.
	90.0	1128	56.870	.050	.61	.61	529.	67.	61.	3.0	261.	44.
	100.0	1138	61.510	.060	.73	.73	542.	67.	61.	3.0	266.	43.
	110.0	1148	66.180	.060	.73	.73	533.	67.	61.	3.0	265.	41.
	120.0	1158	70.795	.060	.73	.73	552.	67.	61.	3.0	260.	42.
TOTALS	120.0		55.603									
AVERAGE					.73	.73	540.	64.	60.	3.0	260.	43.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS | TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND, OH | BRUFFEY

TEST 3-2 NO.1 COKE BATTERY

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/28/81	10/28/81
TB	TIME-START	958	958
TF	TIME-FINISH	1158	1158
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.044	1.044
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.73 IN-H2O	18.6 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	55.603 CU-FT	1.574 CU-M
TM	AVERAGE GAS METER TEMP	62.0 F	16.7 C
VMSTO	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	58.547 SCF	1.658 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	154.0	154.0
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.249 SCF	.205 SCM
BWO	PERCENT MOISTURE BY VOLUME	11.02	11.02
FMD	MOLE FRACTION DRY GAS	.890	.890
PCO2	PERCENT CO2 BY VOL., DRY	2.30	2.30
PO2	PERCENT O2 BY VOL., DRY	10.90	10.90
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	86.80	86.80
MD	MOLECULAR WT-DRY STACK GAS	28.80	28.80
MWS	MOLECULAR WT-STACK GAS	27.61	27.61

PB	BAROMETRIC PRESSURE	29.78	IN-HG	756.41	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.69	IN-HG	754.17	MM-HG
TS	AVERAGE STACK TEMP	540.	F	282.	C
VS	AVG STACK GAS VELOCITY	19.4	FPS	5.9	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTO	STACK FLOW RATE, ORY*	1689592.	SCFH	47844.	SCMH
QS	ACTUAL STACK FLOW RATE	3625039.	ACFH	102650.	ACMH
ISO	PERCENT ISOKINETIC	104.5		104.5	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 3-2

NO.1 COKE BATTERY

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 55.603 * 1.044 * (29.78 + .732 / 13.6)}{(62. + 460.)} = 58.547 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 154. = 7.25 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.25}{58.547 + 7.25} = 11.02 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.0}{100.} = .890$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (2.30*44/100) + (10.9*32/100) + ((86.8+ .0) * 28/100 = 28.80

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 28.80* (1. -(11.02/100)) + 18. * (11.02/100) = 27.61

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 92.927 / (SQRT(27.61 * 29.69) * 12. = 19.42 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 19.42 * 7466. 3600/144 = 3625039. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3625039. * 29.69 * (1. - (11.02/100))}{(540. + 460.)} = 1689592. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(540.+460.))*((0.002669*154.)+(55.603*1.044*(29.78+(.732/13.6))/(62.+460.)))}{120. * 19.42 * 29.69 * .397 * .397} = 104.51 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 58.547 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1689592. / (15.43 * 453.6) = .00

Run No. 3.2

Sample volume = 1.66 m^3, 58.55 scf

Example calculations

CS (Part) = 156.9/1.66 = 94.5 mg/m^3

CS (Part) = 0.001 x 156.9 x 15.43/58.55 = 0.041 gr/dscf

CS (SO_2) = 1540 / 1.66 = 927.7 mg/m^3

= 927.7 x 24.06/64 = 349 ppm

= 0.001 x 1540 x 15.43/58.55 = 0.406 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	156.9	94.5	0.041	
2-h at 350°F	34.2	20.6	0.009	
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Sulfur dioxide	1540	927.7	0.406	349
Sulfuric acid mist				
As H_2SO_4	8.6	5.2	0.002	1
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/28/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	3-3
SAMPLE TYPE	3-3-M8-350	PROBE LENGTH & TYPE	4' GLASS HEATED
OPERATOR	CLARKE	NOZZLE : I.D.	.394
AMBIENT TEMP.(DEG.F)	58.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.78	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB1
FILTER NUMBER(S)	3530020	METER HEAD DIFF.	1.87
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.		HEATER BOX SETTING	350.
LEAKAGE	.000 CFM @ 2.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	.992		

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	955	525.179									
	10.0	1005	530.233	.065	.79	.79	546.	60.	55.	2.0	394.	48.
	20.0	1015	535.270	.060	.74	.74	514.	62.	55.	2.0	378.	46.
	30.0	1025	539.887	.060	.74	.74	525.	66.	56.	2.0	335.	48.
	40.0	1035	544.864	.070	.87	.87	537.	69.	58.	2.0	327.	48.
	50.0	1045	549.778	.060	.74	.74	550.	71.	58.	2.0	340.	50.
	60.0	1055	554.615	.060	.74	.74	548.	72.	58.	2.0	352.	52.
	70.0	1105	559.325	.060	.74	.74	558.	74.	60.	2.0	354.	52.
	80.0	1115	564.660	.060	.74	.74	517.	76.	60.	2.0	354.	50.
	90.0	1125	568.622	.050	.60	.60	528.	77.	62.	2.0	350.	52.
	100.0	1135	573.180	.060	.74	.74	537.	76.	62.	2.0	349.	54.
	110.0	1145	578.160	.060	.74	.74	527.	76.	63.	2.0	352.	55.
	120.0	1155	583.158	.060	.74	.74	545.	76.	62.	2.0	346.	50.
TOTALS	120.0		57.979									
AVERAGE					.74	.74	536.	71.	59.	2.0	353.	50.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST LEADER: CLARKE

TEST 3-3 COKE OVEN OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/28/81	10/28/81
TB	TIME-START	955	955
TF	TIME-FINISH	1155	1155
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.992	.992
DN	SAMPLING NOZZLE DIAMETER	.394 IN	10.0 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.74 IN-H2O	18.9 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	57.979 CU-FT	1.642 CU-M
TM	AVERAGE GAS METER TEMP	65.2 F	18.4 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	57.660 SCF	1.633 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL, ML.	218.3	218.3
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	10.275 SCF	.291 SCM
BWO	PERCENT MOISTURE BY VOLUME	15.13	15.13
FMD	MOLE FRACTION DRY GAS	.849	.849
PCO2	PERCENT CO2 BY VOL., DRY	2.30	2.30
PO2	PERCENT O2 BY VOL., DRY	10.90	10.90
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	86.80	86.80
MD	MOLECULAR WT-DRY STACK GAS	28.80	28.80
MWS	MOLECULAR WT-STACK GAS	27.17	27.17

PB	BAROMETRIC PRESSURE	29.78	IN-HG	756.41	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.69	IN-HG	754.17	MM-HG
TS	AVERAGE STACK TEMP	536.	F	280.	C
VS	AVG STACK GAS VELOCITY	19.6	FPS	6.0	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1633571.	SCFH	46258.	SCMH
QS	ACTUAL STACK FLOW RATE	3658571.	ACFH	103600.	ACMH
ISO	PERCENT ISOKINETIC	108.1		108.1	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 3-3

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 57.979 * .992 * (29.78 + .743 / 13.6)}{(65. + 460.)} = 57.660 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 218. = 10.28 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 10.28}{57.660 + 10.28} = 15.13 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 15.1}{100.} = .849$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (2.30*44/100) + (10.9*32/100) + ((86.8+ .0) * 28/100 = 28.80

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 28.80* (1. -(15.13/100)) + 18. * (15.13/100) = 27.17

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 93.030 / (SQRT(27.17 * 29.69) * 12. = 19.60 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 19.60 * 7466. 3600/144 = 3658571. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3658571. * 29.69 * (1. - (15.13/100))}{(536. + 460.)} = 1633571. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(536.+460.))*((0.002669*218.)+(57.979*.992*(29.78+(.743/13.6))/(65.+460.)))}{120. * 19.60 * 29.69 * .394 * .394} = 108.09 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 57.660 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1633571. / (15.43 * 453.6) = .00

Run No. 3.3

Sample volume = 1.63 m^3, 57.66 scf

Example calculations

CS (Part) = 87.3 / 1.63 = 53.6 mg/m^3

CS (Part) = 0.001 x 87.3 x 15.43/ 57.66 = 0.023 gr/dscf

CS (SO_2) = 1680 / 1.63 = 1030.6 mg/m^3

= 1030.6 x 24.06/ 64 = 387 ppm

= 0.001 x 1680 x 15.43/57.66 = 0.450 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	87.3	53.6	0.023	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	25.3	15.5	0.007	
As $H_2SO_4 \cdot 2H_2O$	34.6	21.2	0.009	
Sulfur dioxide	1680	1030.7	0.450	387
Sulfuric acid mist				
As H_2SO_4	67.2	41.2	0.018	10
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/28/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	3-4
SAMPLE TYPE	3-4-M8-350	PROBE LENGTH & TYPE	5 FT GLASS HEATED
OPERATOR	CLARKE	NOZZLE : I.D.	.397
AMBIENT TEMP.(DEG.F)	58.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.78	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB5
FILTER NUMBER(S)	3530046	METER HEAD DIFF.	1.86
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.		HEATER BOX SETTING	350.
LEAKAGE	.000 CFM @ 2.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.010		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	958	950.042									
	10.0	1008	954.880	.065	.79	.79	567.	66.	64.	1.0	284.	40.
	20.0	1018	959.555	.065	.79	.79	519.	67.	64.	1.0	322.	38.
	30.0	1028	964.200	.060	.74	.74	531.	72.	66.	1.0	328.	40.
	40.0	1038	968.911	.060	.74	.74	539.	73.	67.	1.0	314.	40.
	50.0	1048	973.615	.060	.74	.74	537.	77.	69.	1.0	337.	40.
	60.0	1058	978.290	.060	.74	.74	552.	80.	72.	1.0	349.	40.
	70.0	1108	982.900	.060	.74	.74	564.	82.	73.	1.0	353.	42.
	80.0	1118	987.697	.060	.74	.74	520.	84.	74.	1.0	341.	42.
	90.0	1128	992.074	.050	.60	.60	528.	85.	76.	1.0	348.	46.
	100.0	1138	996.815	.060	.74	.74	540.	86.	77.	1.0	356.	44.
	110.0	1148	1.270	.060	.74	.74	532.	85.	78.	1.0	344.	44.
	120.0	1158	6.194	.060	.74	.74	552.	86.	78.	1.0	354.	46.
TOTALS	120.0		56.152									
AVERAGE					.74	.74	540.	79.	72.	1.0	336.	42.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS | TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND | CLARKE

TEST 3-4 COKE OVEN OUTLET

		ENGLISH UNITS		METRIC UNITS	
TEST DATE		10/28/81		10/28/81	
TB	TIME-START	958		958	
TF	TIME-FINISH	1158		1158	
TT	NET TIME OF TEST, MIN.	120.0		120.0	
NP	NET SAMPLING POINTS	12		12	
Y	METER CALIBRATION FACTOR	1.010		1.010	
DN	SAMPLING NOZZLE DIAMETER	.397	IN	10.1	MM
CP	PITOT TUBE COEFFICIENT	.84		.84	
PM	AVERAGE ORIFICE PRESSURE DROP	.74	IN-H2O	18.7	MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	56.152	CU-FT	1.590	CU-M
TM	AVERAGE GAS METER TEMP	75.0	F	23.9	C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	55.806	SCF	1.580	SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	161.9		161.9	
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.621	SCF	.216	SCM
BWO	PERCENT MOISTURE BY VOLUME	12.01		12.01	
FMD	MOLE FRACTION DRY GAS	.880		.880	
PCO2	PERCENT CO2 BY VOL., DRY	2.30		2.30	
PO2	PERCENT O2 BY VOL., DRY	10.90		10.90	
PCO	PERCENT CO BY VOL., DRY	.00		.00	
PN2	PERCENT N2 BY VOL., DRY	86.80		86.80	
MD	MOLECULAR WT-DRY STACK GAS	28.80		28.80	
MWS	MOLECULAR WT-STACK GAS	27.51		27.51	

PB	BAROMETRIC PRESSURE	29.78	IN-HG	756.41	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.69	IN-HG	754.17	MM-HG
TS	AVERAGE STACK TEMP	540.	F	282.	C
VS	AVG STACK GAS VELOCITY	19.5	FPS	5.9	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1674132.	SCFH	47406.	SCMH
QS	ACTUAL STACK FLOW RATE	3631694.	ACFH	102839.	ACMH
ISO	PERCENT ISOKINETIC	100.5		100.5	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 3-4

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 56.152 * 1.010 * (29.78 + .737 / 13.6)}{(75. + 460.)} = 55.806 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 162. = 7.62 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.62}{55.806 + 7.62} = 12.01 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.0}{100.} = .880$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (2.30*44/100) + (10.9*32/100) + ((86.8+ .0) * 28/100 = 28.80

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 28.80* (1. -(12.01/100)) + 18. * (12.01/100) = 27.51

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 92.915 / (SQRT(27.51 * 29.69) * 12. = 19.46 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 19.46 * 7466. 3600/144 = 3631694. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3631694. * 29.69 * (1. - (12.01/100))}{(540. + 460.)} = 1674132.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(540.+460.))*((0.002669* 162.)+(56.152*1.010*(29.78+(.737/13.6))/(75.+460.)))}{120. * 19.46 * 29.69 * .397 * .397} = 100.54\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 55.806 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1674132. / (15.43 * 453.6) = .00

Run No. 3.4

Sample volume = 1.58 m^3, 55.81 scf

Example calculations

CS (Part) = 40.3 / 1.58 = 25.5 mg/m^3

CS (Part) = 0.001 x 40.3 x 15.43/55.81 = 0.011 gr/dscf

CS (SO_2) = 1620 / 1.58 = 1025 mg/m^3

= 1025 x 24.06/64 = 385 ppm

= 0.001 x 1620 x 15.43/55.81 = 0.448 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	40.3	25.5	0.011	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	3,7	2.3	0.001	
As $H_2SO_4 \cdot 2H_2O$	5.0	3.2	0.001	
Sulfur dioxide	1620	1025.3	0.448	385
Sulfuric acid mist				
As H_2SO_4	89.2	56.4	0.025	14
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/28/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	3-5
SAMPLE TYPE	METHOD 5-250	PROBE LENGTH & TYPE	6' GLASS
OPERATOR	DO/MP	NOZZLE 6-105: I.D.	.374
AMBIENT TEMP.(DEG.F)	55.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.78	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB4
FILTER NUMBER(S)	3530058	METER HEAD DIFF.	1.88
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.92
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.012 CFM @ 9.3 IN.HG	REFERENCE PRESS. DIFF.	.18
METER CALIB. FACTOR	1.033		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	947	719.921									
	10.0	957	724.750	.075	.77	.77	518.	60.	59.	7.4	226.	36.
	20.0	1007	729.570	.075	.77	.77	518.	61.	59.	7.7	230.	36.
	30.0	1017	734.430	.075	.77	.77	518.	64.	60.	7.9	234.	38.
	40.0	1027	739.300	.075	.77	.77	518.	69.	62.	8.1	241.	38.
	50.0	1037	744.250	.075	.77	.77	518.	71.	63.	8.2	227.	38.
	60.0	1047	749.140	.075	.77	.77	518.	73.	65.	8.5	225.	38.
	70.0	1057	754.100	.075	.77	.77	518.	75.	67.	8.7	225.	40.
	80.0	1107	759.070	.075	.77	.77	518.	76.	68.	8.8	226.	40.
	90.0	1117	764.050	.075	.77	.77	518.	75.	66.	8.8	228.	40.
	100.0	1127	769.030	.075	.77	.77	518.	75.	69.	8.8	225.	38.
	110.0	1137	774.000	.075	.77	.77	518.	75.	69.	8.8	230.	40.
	120.0	1147	779.017	.075	.77	.77	518.	75.	69.	8.9	227.	40.
TOTALS	120.0		59.096									
AVERAGE					.77	.77	518.	71.	65.	8.4	229.	39.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST LEADER: DO/MP

TEST 3-5 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/28/81	10/28/81
TB	TIME-START	947	947
TF	TIME-FINISH	1147	1147
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.033	1.033
DN	SAMPLING NOZZLE DIAMETER	.374 IN	9.5 MM
CP	PITDT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.77 IN-H2O	19.6 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	59.096 CU-FT	1.673 CU-M
TM	AVERAGE GAS METER TEMP	67.8 F	19.9 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	60.900 SCF	1.724 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	180.7	180.7
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.506 SCF	.241 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.25	12.25
FMD	MOLE FRACTION DRY GAS	.877	.877
PCO2	PERCENT CO2 BY VOL., DRY	2.30	2.30
PO2	PERCENT O2 BY VOL., DRY	10.90	10.90
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	86.80	86.80
MD	MOLECULAR WT-DRY STACK GAS	28.80	28.80
MWS	MOLECULAR WT-STACK GAS	27.48	27.48

PB	BAROMETRIC PRESSURE	29.78	IN-HG	756.41	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.69	IN-HG	754.17	MM-HG
TS	AVERAGE STACK TEMP	518.	F	270.	C
VS	AVG STACK GAS VELOCITY	21.5	FPS	6.6	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1889290.	SCFH	53499.	SCMH
QS	ACTUAL STACK FLOW RATE	4018903.	ACFH	113803.	ACMH
ISO	PERCENT ISOKINETIC	109.5		109.5	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 3-5

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 59.096 * 1.033 * (29.78 + .770 / 13.6)}{(68. + 460.)} = 60.900 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 181. = 8.51 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.51}{60.900 + 8.51} = 12.25 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.3}{100.} = .877$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (2.30*44/100) + (10.9*32/100) + ((86.8+ .0) * 28/100 = 28.80

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 28.80* (1. -(12.25/100)) + 18. * (12.25/100) = 27.48

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 102.774 / (SQRT(27.48 * 29.69) * 12. = 21.53 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 21.53 * 7466. 3600/144 = 4018903. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 4018903. * 29.69 * (1. - (12.25/100))}{(518. + 460.)} = 1889290.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(518.+460.))*((0.002669*181.)+(59.096*1.033*(29.78+(.770/13.6))/(68.+460.)))}{120. * 21.53 * 29.69 * .374 * .374} = 109.54\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 60.900 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1889290. / (15.43 * 453.6) = .00

Run No. 3.5

Sample volume = 1.72 m^3, 60.90 scf

Example calculations

CS (Part) = 171.2 / 1.72 = 99.5 mg/m^3

CS (Part) = 0.001 x 171.2 x 15.43 / 60.90 = 0.043 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06 / ____ = ____ ppm

= 0.001 x ____ x 15.43 / ____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	171.2	99.5	0.043	
2-h at 350°F	29.0	16.9	0.007	
4-h at 350°F	26.8	15.6	0.007	
2-h at 400°F	26.2	15.2	0.007	
4-h at 400°F	25.2	14.6	0.006	
2-h at 600°F	22.0	12.8	0.006	
Acid sulfates				
As H_2SO_4	0.0	0.0	0.0	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.0	
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles	99.1	57.6	0.025	
Organic condensibles	3.2	1.9	0.001	
TOC (Condensible)	77.3	44.9	0.020	

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/28/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	3-6
SAMPLE TYPE	METHOD 8-600	PROBE LENGTH & TYPE	4' QUARTZ
OPERATOR	DO/MP	NOZZLE : I.D.	.590
AMBIENT TEMP.(DEG.F)	55.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.78	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB8
FILTER NUMBER(S)	3530025	METER HEAD DIFF.	1.91
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.94
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	600.
THERM. NO.		HEATER BOX SETTING	600.
LEAKAGE	.000 CFM @ 12.0 IN.HG	REFERENCE PRESS. DIFF.	.03
METER CALIB. FACTOR	.982		

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	950	203.451									
	10.0	1000	208.690	.075	4.72	1.00	518.	54.	52.	4.0	577.	34.
	20.0	1010	214.280	.075	4.72	1.00	518.	56.	52.	4.0	558.	34.
	30.0	1020	219.700	.075	4.72	1.00	518.	60.	53.	4.2	553.	36.
	40.0	1030	225.150	.075	4.72	1.00	518.	64.	54.	4.2	526.	40.
	50.0	1040	230.620	.075	4.72	1.00	518.	66.	55.	4.3	580.	38.
	60.0	1050	236.040	.075	4.72	1.00	518.	68.	57.	6.2	538.	34.
	70.0	1100	241.550	.075	4.72	1.00	518.	69.	58.	8.8	565.	38.
	80.0	1110	247.000	.075	4.72	1.00	518.	69.	59.	9.3	574.	40.
	90.0	1120	252.490	.075	4.72	1.00	518.	69.	59.	9.3	576.	40.
	100.0	1130	257.980	.075	4.72	1.00	518.	69.	60.	9.4	565.	40.
	110.0	1140	263.460	.075	4.72	1.00	518.	70.	61.	9.6	568.	42.
	120.0	1150	268.908	.075	4.72	1.00	518.	70.	61.	11.2	537.	42.
TOTALS	120.0		65.457									
AVERAGE					4.72	1.00	518.	65.	57.	7.0	560.	38.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS

REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER

DO/MP

TEST 3-6 COKE STACK

		ENGLISH UNITS		METRIC UNITS	
TEST DATE		10/28/81		10/28/81	
TB	TIME-START	950		950	
TF	TIME-FINISH	1150		1150	
TT	NET TIME OF TEST, MIN.	120.0		120.0	
NP	NET SAMPLING POINTS	12		12	
Y	METER CALIBRATION FACTOR	.982		.982	
DN	SAMPLING NOZZLE DIAMETER	.590	IN	15.0	MM
CP	PITOT TUBE COEFFICIENT	.84		.84	
PM	AVERAGE ORIFICE PRESSURE DROP	1.00	IN-H2O	25.4	MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	65.457	CU-FT	1.854	CU-M
TM	AVERAGE GAS METER TEMP	61.0	F	16.1	C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	64.992	SCF	1.840	SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	298.2		298.2	
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	14.036	SCF	.397	SCM
BWO	PERCENT MOISTURE BY VOLUME	17.76		17.76	
FMD	MOLE FRACTION DRY GAS	.822		.822	
PCO2	PERCENT CO2 BY VOL., DRY	2.30		2.30	
PO2	PERCENT O2 BY VOL., DRY	10.90		10.90	
PCO	PERCENT CO BY VOL., DRY	.00		.00	
PN2	PERCENT N2 BY VOL., DRY	86.80		86.80	
MD	MOLECULAR WT-DRY STACK GAS	28.80		28.80	
MWS	MOLECULAR WT-STACK GAS	26.89		26.89	

PB	BAROMETRIC PRESSURE	29.78	IN-HG	756.41	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.69	IN-HG	754.17	MM-HG
TS	AVERAGE STACK TEMP	518.	F	270.	C
VS	AVG STACK GAS VELOCITY	21.8	FPS	6.6	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1790217.	SCFH	50694.	SCMH
QS	ACTUAL STACK FLOW RATE	4063123.	ACFH	115055.	ACMH
ISO	PERCENT ISOKINETIC	49.6		49.6	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 3-6

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 65.457 * .982 * (29.78 + 1.000 / 13.6)}{(61. + 460.)} = 64.992 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 298. = 14.04 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 14.04}{64.992 + 14.04} = 17.76 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 17.8}{100.} = .822$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (2.30*44/100) + (10.9*32/100) + ((86.8+ .0) * 28/100 = 28.80

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 28.80* (1. -(17.76/100)) + 18. * (17.76/100) = 26.89

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 102.774 / (SQRT(26.89 * 29.69) * 12. = 21.77 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 21.77 * 7466. 3600/144 = 4063123. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 4063123. * 29.69 * (1. - (17.76/100))}{(518. + 460.)} = 1790217. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(518.+460.))*((0.002669* 298.)+(65.457* .982*(29.78+(1.000/13.6))/(61.+460.)))}{120. * 21.77 * 29.69 * .590 * .590} = 49.58 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 64.992 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1790217. / (15.43 * 453.6) = .00

Run No. 3.6

Sample volume = 1.84 m^3, 64.99 scf

Example calculations

CS (Part) = 36.0 / 1.84 = 19.6 mg/m^3

CS (Part) = 0.001 x 36.0 x 15.43/64.99 = 0.008 gr/dscf

CS (SO_2) = 1720 / 1.84 = 935 mg/m^3

= 935 x 24.06/64 = 351 ppm

= 0.001 x 1720 x 15.43/64.99 = 0.408 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	36.0	19.6	0.008	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	4.2	2.3	0.001	
As $H_2SO_4 \cdot 2H_2O$	5.7	3.1	0.001	
Sulfur dioxide	1720	935	0.408	351
Sulfuric acid mist				
As H_2SO_4	164	89.1	0.039	22
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/28/81
SAMPLING LOCATION	NO.1 COKE BATTERY OUTLET	RUN NUMBER	4-1
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	5' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE : I.D.	.397
AMBIENT TEMP.(DEG.F)	56.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.81	SAMPLE BOX NUMBER	01
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB2
FILTER NUMBER(S)	3530039	METER HEAD DIFF.	1.76
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.014 CFM @ 17.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.003		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1540	838.776									
	10.0	1550	843.860	.060	.73	.73	543.	60.	60.	2.0	255.	47.
	20.0	1600	848.930	.060	.73	.73	556.	62.	60.	2.0	264.	48.
	30.0	1610	854.010	.060	.73	.73	515.	65.	61.	2.0	252.	44.
	40.0	1620	859.090	.060	.73	.73	519.	66.	60.	4.0	261.	42.
	50.0	1630	864.160	.060	.73	.73	529.	66.	60.	3.0	241.	46.
	60.0	1704	869.540	.070	.87	.87	514.	68.	61.	3.0	255.	47.
	62.0	1716	873.150	.030	.37	.37	511.	64.	60.	8.0	248.	0.
TOTALS	62.0		34.374									
AVERAGE					.70	.70	527.	64.	60.	3.4	254.	39.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER: BRUFFEY

TEST 4-1 NO.1 COKE BATTERY OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/28/81	10/28/81
TB	TIME-START	1540	1540
TF	TIME-FINISH	1716	1716
TT	NET TIME OF TEST, MIN.	62.0	62.0
NP	NET SAMPLING POINTS	7	7
Y	METER CALIBRATION FACTOR	1.003	1.003
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.70 IN-H2O	17.7 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	34.374 CU-FT	.973 CU-M
TM	AVERAGE GAS METER TEMP	62.4 F	16.9 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	34.781 SCF	.985 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	124.1	124.1
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	5.841 SCF	.165 SCM
BWO	PERCENT MOISTURE BY VOLUME	14.38	14.38
FMD	MOLE FRACTION DRY GAS	.856	.856
PCO2	PERCENT CO2 BY VOL., DRY	4.10	4.10
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.90	84.90
MD	MOLECULAR WT-DRY STACK GAS	29.10	29.10
MWS	MOLECULAR WT-STACK GAS	27.50	27.50

PB	BAROMETRIC PRESSURE	29.81	IN-HG	757.17	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.72	IN-HG	754.93	MM-HG
TS	AVERAGE STACK TEMP	527.	F	275.	C
VS	AVG STACK GAS VELOCITY	18.7	FPS	5.7	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1592304.	SCFH	45089.	SCMH
QS	ACTUAL STACK FLOW RATE	3498604.	ACFH	99070.	ACMH
ISO	PERCENT ISOKINETIC	127.5		127.5	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 4-1

NO.1 COKE BATTERY OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 34.374 * 1.003 * (29.81 + .699 / 13.6)}{(62. + 460.)} = 34.781 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 124. = 5.84 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 5.84}{34.781 + 5.84} = 14.38 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 14.4}{100.} = .856$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.10*44/100) + (11.0*32/100) + ((84.9+ .0) * 28/100 = 29.10

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.10* (1. -(14.38/100)) + 18. * (14.38/100) = 27.50

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 52.236 / (SQRT(27.50 * 29.72) * 7. = 18.74 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 18.74 * 7466. 3600/144 = 3498604. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3498604. * 29.72 * (1. - (14.38/100))}{(527. + 460.)} = 1592304.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(527.+460.))*((0.002669*124.)+(34.374*1.003*(29.81+(.699/13.6))/(62.+460.)))}{62. * 18.74 * 29.72 * .397 * .397} = 127.51\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 34.781 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1592304. / (15.43 * 453.6) = .00

Run No. 4.1

Sample volume = 0.99 m^3, 34.78 scf

Example calculations

CS (Part) = 139.9/0.99 = 141.3 mg/m^3

CS (Part) = 0.001 x 139.9 x 15.43/34.78 = 0.062 gr/dscf

CS (SO_2) = 1300 /0.99 = 1313.1 mg/m^3

= 1313.1 x 24.06/64 = 493 ppm

= 0.001 x 1300 x 15.43/34.78 = 0.577 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	139.9	141.3	0.062	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	47.5	47.9	0.021	
As $H_2SO_4 \cdot 2H_2O$	64.9	65.6	0.029	
Sulfur dioxide	1300	1313.1	0.577	494
Sulfuric acid mist				
As H_2SO_4	11.5	11.6	0.005	3
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/28/81
SAMPLING LOCATION	NO.1 COKE BATTERY OUTLET	RUN NUMBER	4-2
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	4' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE : I.D.	.397
AMBIENT TEMP.(DEG.F)	56.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.81	SAMPLE BOX NUMBER	Q
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F10
FILTER NUMBER(S)	3530084	METER HEAD DIFF.	1.80
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 6.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.044		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1543	71.235									
	10.0	1553	75.900	.060	.73	.73	547.	66.	66.	2.0	270.	50.
	20.0	1603	80.590	.060	.73	.73	563.	67.	66.	3.0	298.	51.
	30.0	1613	85.260	.060	.73	.73	515.	70.	66.	3.0	256.	50.
	40.0	1623	89.970	.060	.73	.73	520.	71.	66.	3.0	266.	50.
	50.0	1633	94.585	.060	.73	.73	530.	71.	66.	3.0	252.	49.
	55.0	1710	99.580	.070	.87	.87	523.	72.	66.	3.0	253.	50.
	58.0	1718	100.865	.030	.37	.37	516.	68.	67.	1.0	264.	47.
TOTALS	58.0		29.630									
AVERAGE					.70	.70	531.	69.	66.	2.6	266.	50.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — BRUFFEY

TEST 4-2 NO.1 COKE BATTERY OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/28/81	10/28/81
TB	TIME-START	1543	1543
TF	TIME-FINISH	1718	1718
TT	NET TIME OF TEST, MIN.	58.0	58.0
NP	NET SAMPLING POINTS	7	7
Y	METER CALIBRATION FACTOR	1.044	1.044
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.70 IN-H2O	17.7 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	29.630 CU-FT	.839 CU-M
TM	AVERAGE GAS METER TEMP	67.7 F	19.8 C
VMSTO	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	30.890 SCF	.875 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	103.3	103.3
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	4.862 SCF	.138 SCM
BWO	PERCENT MOISTURE BY VOLUME	13.60	13.60
FMO	MOLE FRACTION DRY GAS	.864	.864
PCO2	PERCENT CO2 BY VOL., DRY	4.10	4.10
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.90	84.90
MD	MOLECULAR WT-DRY STACK GAS	29.10	29.10
MWS	MOLECULAR WT-STACK GAS	27.59	27.59

PB	BAROMETRIC PRESSURE	29.81	IN-HG	757.17	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.72	IN-HG	754.93	MM-HG
TS	AVERAGE STACK TEMP	531.	F	277.	C
VS	AVG STACK GAS VELOCITY	18.8	FPS	5.7	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1601155.	SCFH	45340.	SCMH
QS	ACTUAL STACK FLOW RATE	3499941.	ACFH	99108.	ACMH
ISO	PERCENT ISOKINETIC	120.4		120.4	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 4-2

NO.1 COKE BATTERY OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTO = \frac{17.647 * 29.630 * 1.044 * (29.81 + .699 / 13.6)}{(68. + 460.)} = 30.890 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 103. = 4.86 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 4.86}{30.890 + 4.86} = 13.60 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.6}{100.} = .864$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.10*44/100) + (11.0*32/100) + ((84.9+ .0) * 28/100 = 29.10

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.10* (1. -(13.60/100)) + 18. * (13.60/100) = 27.59

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 52.338 / (SQRT(27.59 * 29.72) * 7. = 18.75 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 18.75 * 7466. 3600/144 = 3499941. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3499941. * 29.72 * (1. - (13.60/100))}{(531. + 460.)} = 1601155.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(531.+460.))*((0.002669*103.)+(29.630*1.044*(29.81+(.699/13.6))/(68.+460.)))}{58. * 18.75 * 29.72 * .397 * .397} = 120.39\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 30.890 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1601155. / (15.43 * 453.6) = .00

Run No. 4.2

Sample volume = 0.88 m^3, 30.89 scf

Example calculations

CS (Part) = 113.2/0.88 = 128.6 mg/m^3

CS (Part) = 0.001 x 113.2 x 15.43/30.89 = 0.056 gr/dscf

CS (SO_2) = 1170 /0.88 = 1329.5 mg/m^3

= 1329.5 x 24.06/64 = 500 ppm

= 0.001 x 1170 x 15.43/30.89 = 0.584 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	113.2	128.6	0.056	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F	41.7	47.4	0.021	
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.4	0.4	0.0002	
As $H_2SO_4 \cdot 2H_2O$	0.5	0.6	0.0002	
Sulfur dioxide	1170	1329.5	0.584	500
Sulfuric acid mist				
As H_2SO_4	11.9	13.5	0.006	3
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/28/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	4-3
SAMPLE TYPE	4-3-M8-400	PROBE LENGTH & TYPE	4 FT GLASS HEATED
OPERATOR	CLARKE	NUZZLE : I.D.	.398
AMBIENT TEMP.(DEG.F)	56.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.81	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F81
FILTER NUMBER(S)	3530024	METER HEAD DIFF.	1.87
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	400.
THERM. NO.		HEATER BOX SETTING	400.
LEAKAGE	.000 CFM @ 5.0 IN.HG	REFERENCE PRESS. DIFF.	1.50
METER CALIB. FACTOR	.992		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1540	583.448									
	10.0	1550	588.298	.060	.74	.74	542.	61.	58.	2.0	285.	54.
	20.0	1600	593.200	.060	.74	.74	558.	64.	58.	2.0	340.	52.
	30.0	1610	597.855	.060	.74	.74	514.	68.	58.	2.0	365.	52.
	40.0	1620	602.700	.060	.74	.74	519.	72.	60.	2.0	371.	52.
	50.0	1630	607.666	.060	.74	.74	529.	74.	60.	2.0	366.	52.
	55.0	1640	613.075	.070	.82	.82	499.	76.	62.	3.0	355.	54.
	60.0	1715	616.530	.030	.37	.37	512.	70.	62.	2.0	371.	52.
TOTALS	60.0		33.082									
AVERAGE					.70	.70	525.	69.	60.	2.1	350.	53.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — CLARKE

TEST 4-3 COKE OVEN OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/28/81	10/28/81
TB	TIME-START	1540	1540
TF	TIME-FINISH	1715	1715
TT	NET TIME OF TEST, MIN.	60.0	60.0
NP	NET SAMPLING POINTS	7	7
Y	METER CALIBRATION FACTOR	.992	.992
DN	SAMPLING NOZZLE DIAMETER	.398 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.70 IN-H2O	17.7 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	33.082 CU-FT	.937 CU-M
TM	AVERAGE GAS METER TEMP	64.5 F	18.1 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	32.972 SCF	.934 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL, ML.	118.1	118.1
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	5.559 SCF	.157 SCM
BWO	PERCENT MOISTURE BY VOLUME	14.43	14.43
FMD	MOLE FRACTION DRY GAS	.856	.856
PCO2	PERCENT CO2 BY VOL., DRY	4.10	4.10
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.90	84.90
MD	MOLECULAR WT-DRY STACK GAS	29.10	29.10
MWS	MOLECULAR WT-STACK GAS	27.50	27.50

PB	BAROMETRIC PRESSURE	29.81	IN-HG	757.17	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.72	IN-HG	754.93	MM-HG
TS	AVERAGE STACK TEMP	525.	F	274.	C
VS	AVG STACK GAS VELOCITY	18.7	FPS	5.7	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1592934.	SCFH	45107.	SCMH
QS	ACTUAL STACK FLOW RATE	3494845.	ACFH	98964.	ACMH
ISO	PERCENT ISOKINETIC	124.2		124.2	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 4-3

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 33.082 * .992 * (29.81 + .699 / 13.6)}{(65. + 460.)} = 32.972 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 116. = 5.56 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 5.56}{32.972 + 5.56} = 14.43 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 14.4}{100.} = .856$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.10*44/100) + (11.0*32/100) + ((84.9+ .0) * 28/100 = 29.10

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.10* (1. -(14.43/100)) + 18. * (14.43/100) = 27.50

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 52.174 / (SQRT(27.50 * 29.72) * 7. = 18.72 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 18.72 * 7466. 3600/144 = 3494845. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3494845. * 29.72 * (1. - (14.43/100))}{(525. + 460.)} = 1592934. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(525.+460.))*((0.002669*118.)+(33.082*.992*(29.81+(.699/13.6))/(65.+460.)))}{60. * 18.72 * 29.72 * .398 * .398} = 124.23 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 32.972 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1592934. / (15.43 * 453.6) = .00

Run No. 4.3

Sample volume = 0.93 m^3, 32.97 scf

Example calculations

CS (Part) = 61.1 / 1.93 = 65.7 mg/m^3

CS (Part) = 0.001 x 61.1 x 15.43/ 32.97 = 0.028 gr/dscf

CS (SO_2) = 1250 / 0.93 = 1344 mg/m^3

= 1344 x 24.06/ 64 = 505 ppm

= 0.001 x 1250 x 15.43/ 32.97 = 0.585 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	61.1	65.7	0.028	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	6.4	6.9	0.003	
As $H_2SO_4 \cdot 2H_2O$	8.7	9.4	0.004	
Sulfur dioxide	1250	1344	0.585	505
Sulfuric acid mist				
As H_2SO_4	29.8	32.0	0.014	8
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/28/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	4-4
SAMPLE TYPE	4-4-M8-400	PROBE LENGTH & TYPE	5 FT GLASS HEATED
OPERATOR	CLARKE	NOZZLE : I.D.	.397
AMBIENT TEMP.(DEG.F)	56.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	28.81	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F85
FILTER NUMBER(S)	3530089	METER HEAD DIFF.	1.86
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	400.
THERM. NO.		HEATER BOX SETTING	400.
LEAKAGE	.000 CFM @ 5.0 IN.HG	REFERENCE PRESS. DIFF.	1.50
METER CALIB. FACTOR	1.016		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1543	6.355									
	10.0	1553	11.050	.060	.74	.74	547.	69.	70.	1.0	275.	46.
	20.0	1603	15.885	.060	.74	.74	556.	70.	70.	1.0	355.	42.
	30.0	1613	20.586	.060	.74	.74	515.	74.	70.	1.0	342.	40.
	40.0	1623	25.371	.060	.74	.74	521.	78.	70.	1.0	312.	40.
	50.0	1633	29.486	.060	.74	.74	532.	81.	72.	1.0	325.	47.
	55.0	1708	34.987	.070	.82	.82	519.	82.	72.	1.0	363.	44.
	60.0	1715	37.334	.030	.37	.37	515.	77.	74.	1.0	386.	58.
TOTALS	60.0		30.979									
AVERAGE					.70	.70	529.	76.	71.	1.0	337.	45.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS

REPUBLIC STEEL CLEVELAND

TEST LEADER

CLARKE

TEST 4-4 COKE OVEN OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/28/81	10/28/81
TB	TIME-START	1543	1543
TF	TIME-FINISH	1715	1715
TT	NET TIME OF TEST, MIN.	60.0	60.0
NP	NET SAMPLING POINTS	7	7
Y	METER CALIBRATION FACTOR	1.016	1.016
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.70 IN-H2O	17.7 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	30.979 CU-FT	.877 CU-M
TM	AVERAGE GAS METER TEMP	73.5 F	23.1 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	30.048 SCF	.851 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL, ML.	106.5	106.5
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	5.013 SCF	.142 SCM
BWO	PERCENT MOISTURE BY VOLUME	14.30	14.30
FMD	MOLE FRACTION DRY GAS	.857	.857
PCO2	PERCENT CO2 BY VOL., DRY	4.10	4.10
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.90	84.90
MD	MOLECULAR WT-DRY STACK GAS	29.10	29.10
MWS	MOLECULAR WT-STACK GAS	27.51	27.51

PB	BAROMETRIC PRESSURE	28.81	IN-HG	731.77	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	28.72	IN-HG	729.53	MM-HG
TS	AVERAGE STACK TEMP	529.	F	276.	C
VS	AVG STACK GAS VELOCITY	19.1	FPS	5.8	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1564464.	SCFH	44301.	SCMH
QS	ACTUAL STACK FLOW RATE	3562981.	ACFH	100893.	ACMH
ISO	PERCENT ISOKINETIC	115.9		115.9	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 4-4

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTO = \frac{17.647 * 30.979 * 1.016 * (28.81 + .699 / 13.6)}{(74. + 460.)} = 30.048 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 107. = 5.01 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 5.01}{30.048 + 5.01} = 14.30 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 14.3}{100.} = .857$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.10*44/100) + (11.0*32/100) + ((84.9+ .0) * 28/100 = 29.10

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.10* (1. -(14.30/100)) + 18. * (14.30/100) = 27.51

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 52.303 / (SQRT(27.51 * 28.72) * 7. = 19.09 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 19.09 * 7466. 3600/144 = 3562981. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3562981. * 28.72 * (1. - (14.30/100))}{(529. + 460.)} = 1564464.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(529.+460.))*((0.002669* 107.)+(30.979*1.016*(28.81+(.699/13.6))/(74.+460.)))}{60. * 19.09 * 28.72 * .397 * .397} = 115.86\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 30.048 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1564464. / (15.43 * 453.6) = .00

Run No. 4.4

Sample volume = 0.85 m^3, 30.05 scf

Example calculations

CS (Part) = 78.4 / 0.85 = 92.2 mg/m^3

CS (Part) = 0.001 x 78.4 x 15.43/30.05 = 0.040 gr/dscf

CS (SO_2) = 1160 / 0.85 = 1364 mg/m^3

= 1364 x 24.06/64 = 513 ppm

= 0.001 x 1160 x 15.43/ 30.05 = 0.596 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	78.4	92.2	0.040	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	12.6	14.8	0.006	
As $H_2SO_4 \cdot 2H_2O$	17.2	20.3	0.009	
Sulfur dioxide	1160	1365	0.596	513
Sulfuric acid mist				
As H_2SO_4	10.4	12.2	0.005	3
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/28/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	4-5
SAMPLE TYPE	METHOD 5-250	PROBE LENGTH & TYPE	6' GLASS
OPERATOR	DO/MP	NOZZLE I.D.	.377
AMBIENT TEMP.(DEG.F)	58.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.81	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB4
FILTER NUMBER(S)	3530026	METER HEAD DIFF.	1.88
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.92
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 11.5 IN.HG	REFERENCE PRESS. DIFF.	.17
METER CALIB. FACTOR	1.033		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1423	779.366									
	10.0	1433	784.300	.075	.81	.81	518.	64.	62.	8.9	237.	47.
	20.0	1443	789.220	.075	.81	.81	518.	65.	62.	9.9	255.	47.
	30.0	1453	794.140	.075	.81	.81	518.	66.	62.	10.4	274.	48.
	40.0	1503	799.100	.075	.81	.81	518.	67.	62.	10.7	268.	48.
	50.0	1513	804.000	.075	.81	.81	518.	68.	62.	10.6	244.	44.
	60.0	1523	808.930	.075	.81	.81	518.	68.	62.	10.9	262.	50.
	70.0	1533	813.880	.075	.81	.81	518.	67.	62.	11.2	275.	47.
	80.0	1543	818.830	.075	.81	.81	518.	67.	62.	10.8	275.	46.
	90.0	1553	823.770	.075	.81	.81	518.	67.	62.	10.7	272.	45.
	100.0	1603	828.690	.075	.81	.81	518.	67.	62.	10.5	274.	46.
	110.0	1613	833.660	.075	.81	.81	518.	68.	62.	11.0	270.	46.
	120.0	1623	838.580	.075	.81	.81	518.	68.	62.	10.8	273.	46.
	130.0	1633	843.550	.075	.81	.81	518.	67.	62.	10.7	275.	46.
	140.0	1643	848.497	.075	.81	.81	518.	68.	62.	10.8	273.	46.
	150.0	1706	853.407	.075	.81	.81	518.	67.	64.	10.4	254.	46.
TOTALS	150.0		74.041									
AVERAGE					.81	.81	518.	67.	62.	10.6	265.	47.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — DO/MP

TEST 4-5 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/28/81	10/28/81
TB	TIME-START	1423	1423
TF	TIME-FINISH	1706	1706
TT	NET TIME OF TEST, MIN.	150.0	150.0
NP	NET SAMPLING POINTS	15	15
Y	METER CALIBRATION FACTOR	1.033	1.033
DN	SAMPLING NOZZLE DIAMETER	.377 IN	9.6 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.81 IN-H2O	20.6 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	74.041 CU-FT	2.097 CU-M
TM	AVERAGE GAS METER TEMP	64.5 F	18.1 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	76.860 SCF	2.176 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL, ML.	280.7	280.7
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	13.213 SCF	.374 SCM
BWO	PERCENT MOISTURE BY VOLUME	14.67	14.67
FMD	MOLE FRACTION DRY GAS	.853	.853
PCO2	PERCENT CO2 BY VOL., DRY	4.10	4.10
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.90	84.90
MD	MOLECULAR WT-DRY STACK GAS	29.10	29.10
MWS	MOLECULAR WT-STACK GAS	27.47	27.47

PB	BAROMETRIC PRESSURE	29.81	IN-HG	757.17	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.72	IN-HG	754.93	MM-HG
TS	AVERAGE STACK TEMP	518.	F	270.	C
VS	AVG STACK GAS VELOCITY	21.5	FPS	6.6	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1838631.	SCFH	52065.	SCMH
QS	ACTUAL STACK FLOW RATE	4017725.	ACFH	113770.	ACMH
ISO	PERCENT ISOKINETIC	111.8		111.8	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 4-5

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 74.041 * 1.033 * (29.81 + .810 / 13.6)}{(65. + 460.)} = 76.860 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 281. = 13.21 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 13.21}{76.860 + 13.21} = 14.67 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 14.7}{100.} = .853$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.10*44/100) + (11.0*32/100) + ((84.9+ .0) * 28/100 = 29.10

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.10* (1. -(14.67/100)) + 18. * (14.67/100) = 27.47

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 128.467 / (SQRT(27.47 * 29.72) * 15. = 21.52 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 21.52 * 7466. 3600/144 = 4017725. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 4017725. * 29.72 * (1. - (14.67/100))}{(518. + 460.)} = 1838631. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(518.+460.))*((0.002669* 281.)+(74.041*1.033*(29.81+(.810/13.6))/(65.+460.)))}{150. * 21.52 * 29.72 * .377 * .377} = 111.85 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 76.860 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1838631. / (15.43 * 453.6) = .00

Run No. 4.5

Sample volume = 2.18 m^3, 76.86 scf

Example calculations

CS (Part) = 174.5/2.18 = 80.0 mg/m^3

CS (Part) = 0.001 x 174.5 x 15.43/76.86 = 0.035 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	174.5	80.0	0.035	
2-h at 350°F	137.3	63.0	0.028	
4-h at 350°F	128.8	59.1	0.026	
2-h at 400°F	112.4	51.6	0.022	
4-h at 400°F	104.7	48.0	0.021	
2-h at 600°F	99.0	45.4	0.020	
Acid sulfates				
As H_2SO_4	0.0	0.0	0.0	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.0	
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles	65.7	30.1	0.013	
Organic condensibles	3.1	1.4	0.001	
TOC (Condensible)	14.3	6.6	0.003	

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/28/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	4-6
SAMPLE TYPE	METHOD 8-600	PROBE LENGTH & TYPE	4' QUARTZ
OPERATOR	DO/MP	NOZZLE : I.D.	.620
AMBIENT TEMP.(DEG.F)	58.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.81	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F88
FILTER NUMBER(S)	3530228/3530206	METER HEAD DIFF.	1.91
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.94
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	600.
THERM. NO.		HEATER BOX SETTING	600.
LEAKAGE	.000 CFM @ 24.0 IN.HG	REFERENCE PRESS. DIFF.	.02
METER CALIB. FACTOR	.982		

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1427	269.548									
	10.0	1437	274.840	.075	5.73	1.00	518.	58.	56.	5.5	586.	38.
	20.0	1447	278.700	.075	5.73	.50	518.	60.	56.	10.6	596.	36.
	30.0	1457	282.500	.075	5.73	.50	518.	63.	57.	13.3	608.	38.
	40.0	1507	286.360	.075	5.73	.50	518.	64.	57.	16.2	630.	38.
	50.0	1517	290.190	.075	5.73	.50	518.	65.	58.	18.2	642.	40.
	60.0	1527	294.030	.075	5.73	.50	518.	66.	58.	19.5	620.	42.
	70.0	1537	297.530	.075	5.73	.40	518.	67.	59.	21.5	620.	44.
	80.0	1547	300.570	.075	5.73	.30	518.	68.	60.	21.3	627.	49.
	90.0	1557	303.500	.075	5.73	.30	518.	69.	61.	23.3	631.	43.
	100.0	1714	308.180	.075	5.73	.75	518.	66.	63.	3.7	621.	46.
	110.0	1716	309.023	.075	5.73	.75	518.	66.	61.	3.8	663.	38.
TOTALS	110.0		39.475									
AVERAGE					5.73	.55	518.	65.	59.	14.3	622.	41.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — DO/MP

TEST 4-6 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/28/81	10/28/81
TB	TIME-START	1427	1427
TF	TIME-FINISH	1716	1716
TT	NET TIME OF TEST, MIN.	110.0	110.0
NP	NET SAMPLING POINTS	11	11
Y	METER CALIBRATION FACTOR	.982	.982
DN	SAMPLING NOZZLE DIAMETER	.620 IN	15.7 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.55 IN-H2O	13.9 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	39.475 CU-FT	1.118 CU-M
TM	AVERAGE GAS METER TEMP	61.7 F	16.5 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	39.139 SCF	1.108 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL, ML.	129.4	129.4
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	6.091 SCF	.172 SCM
BWO	PERCENT MOISTURE BY VOLUME	13.47	13.47
FMD	MOLE FRACTION DRY GAS	.865	.865
PCO2	PERCENT CO2 BY VOL., DRY	4.10	4.10
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.90	84.90
MD	MOLECULAR WT-DRY STACK GAS	29.10	29.10
MWS	MOLECULAR WT-STACK GAS	27.60	27.60

PB	BAROMETRIC PRESSURE	29.81	IN-HG	757.17	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.72	IN-HG	754.93	MM-HG
TS	AVERAGE STACK TEMP	518.	F	270.	C
VS	AVG STACK GAS VELOCITY	21.5	FPS	6.5	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1860026.	SCFH	52670.	SCMH
QS	ACTUAL STACK FLOW RATE	4008004.	ACFH	113495.	ACMH
ISO	PERCENT ISOKINETIC	28.4		28.4	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 4-6

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 39.475 * .982 * (29.81 + .545 / 13.6)}{(62. + 460.)} = 39.139 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 129. = 6.09 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 6.09}{39.139 + 6.09} = 13.47 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.5}{100.} = .865$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.10*44/100) + (11.0*32/100) + ((84.9+ .0) * 28/100 = 29.10

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.10* (1. -(13.47/100)) + 18. * (13.47/100) = 27.60

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 94.209 / (SQRT(27.60 * 29.72) * 11. = 21.47 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 21.47 * 7466. 3600/144 = 4008004. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 4008004. * 29.72 * (1. - (13.47/100))}{(518. + 460.)} = 1860026. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(518.+460.))*((0.002669* 129.)+(39.475* .982*(29.81+(.545/13.6))/(62.+460.)))}{110. * 21.47 * 29.72 * .620 * .620} = 28.39 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 39.139 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1860026. / (15.43 * 453.6) = .00

Run No. 4.6

Sample volume = 1.11 m^3, 39.14 scf

Example calculations

CS (Part) = 69.7 / 1.11 = 62.8 mg/m^3

CS (Part) = 0.001 x 69.7 x 15.43/39.14 = 0.027 gr/dscf

CS (SO_2) = 1550/1.11 = 1396 mg/m^3

= 1396 x 24.06/ 64 = 525 ppm

= 0.001 x 1550 x 15.43/39.14 = 0.611 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	69.7	62.8	0.027	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.0	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.0	
Sulfur dioxide	1550	1396	0.611	525
Sulfuric acid mist				
As H_2SO_4	73.7	66.4	0.029	16.3
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/29/81
SAMPLING LOCATION	NO1 COKE BATTERY OUTLET	RUN NUMBER	5-1
SAMPLE TYPE	PART/SO2/H2SO4	PROBE LENGTH & TYPE	5' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE : I.D.	.398
AMBIENT TEMP.(DEG.F)	52.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.86	SAMPLE BOX NUMBER	0
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB2
FILTER NUMBER(S)	3530071	METER HEAD DIFF.	1.76
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 6.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.003		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	940	873.366									
	10.0	950	878.400	.060	.73	.73	530.	52.	52.	2.0	227.	41.
	20.0	1000	883.410	.060	.73	.73	543.	54.	52.	3.0	263.	40.
	30.0	1010	888.430	.060	.73	.73	556.	58.	52.	3.0	259.	41.
	40.0	1020	893.040	.050	.62	.62	518.	62.	53.	2.5	258.	42.
	50.0	1030	898.110	.060	.73	.73	529.	63.	54.	2.5	264.	41.
	60.0	1040	903.100	.060	.73	.73	495.	64.	56.	2.5	260.	42.
	70.0	1050	907.750	.050	.62	.62	531.	66.	56.	2.0	254.	46.
	80.0	1100	912.410	.050	.62	.62	545.	67.	58.	2.5	251.	48.
	90.0	1110	918.700	.100	1.22	1.22	501.	68.	59.	2.5	255.	49.
	100.0	1120	923.380	.050	.62	.62	519.	69.	60.	3.5	260.	52.
	110.0	1130	928.100	.050	.62	.62	530.	69.	61.	4.0	252.	57.
	114.9	1137	930.347	.050	.62	.62	495.	70.	62.	3.0	255.	56.
TOTALS	114.9		56.981									
AVERAGE					.72	.72	524.	64.	56.	2.8	255.	46.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — BRUFFEY

TEST 5-1 NO1 COKE BATTERY OUTLET

		ENGLISH UNITS		METRIC UNITS	
TEST DATE		10/29/81		10/29/81	
TB	TIME-START	940		940	
TF	TIME-FINISH	1137		1137	
TT	NET TIME OF TEST, MIN.	114.9		114.9	
NP	NET SAMPLING POINTS	12		12	
Y	METER CALIBRATION FACTOR	1.003		1.003	
DN	SAMPLING NOZZLE DIAMETER	.398	IN	10.1	MM
CP	PITOT TUBE COEFFICIENT	.84		.84	
PM	AVERAGE ORIFICE PRESSURE DROP	.72	IN-H2O	18.2	MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	56.981	CU-FT	1.614	CU-M
TM	AVERAGE GAS METER TEMP	59.9	F	15.5	C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	58.031	SCF	1.643	SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	189.1		189.1	
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.901	SCF	.252	SCM
BWO	PERCENT MOISTURE BY VOLUME	13.30		13.30	
FMD	MOLE FRACTION DRY GAS	.867		.867	
PCO2	PERCENT CO2 BY VOL., DRY	4.30		4.30	
PO2	PERCENT O2 BY VOL., DRY	11.30		11.30	
PCO	PERCENT CO BY VOL., DRY	.00		.00	
PN2	PERCENT N2 BY VOL., DRY	84.40		84.40	
MD	MOLECULAR WT-DRY STACK GAS	29.14		29.14	
MWS	MOLECULAR WT-STACK GAS	27.66		27.66	

PB	BAROMETRIC PRESSURE	29.86	IN-HG	758.44	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.77	IN-HG	756.20	MM-HG
TS	AVERAGE STACK TEMP	524.	F	274.	C
VS	AVG STACK GAS VELOCITY	18.9	FPS	5.7	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1628613.	SCFH	46117.	SCMH
QS	ACTUAL STACK FLOW RATE	3519316.	ACFH	99656.	ACMH
ISO	PERCENT ISOKINETIC	111.7		111.7	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 5-1

NO1 COKE BATTERY OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 56.981 * 1.003 * (29.86 + .716 / 13.6)}{(60. + 460.)} = 58.031 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 189. = 8.90 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.90}{58.031 + 8.90} = 13.30 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.3}{100.} = .867$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (11.3*32/100) + ((84.4+ .0) * 28/100 = 29.14

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.14* (1. -(13.30/100)) + 18. * (13.30/100) = 27.66

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 90.411 / (SQRT(27.66 * 29.77) * 12. = 18.85 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 18.85 * 7466. 3600/144 = 3519316. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3519316. * 29.77 * (1. - (13.30/100))}{(524. + 460.)} = 1628613.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(524.+460.))*((0.002669*189.)+(56.981*1.003*(29.86+(.716/13.6))/(60.+460.)))}{115. * 18.85 * 29.77 * .398 * .398} = 111.67\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 58.031 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1628613. / (15.43 * 453.6) = .00

Run No. 5.1

Sample volume = 1.64 m^3, 58.03 scf

Example calculations

CS (Part) = 138.6/ 1.64 = 84.5 mg/m^3

CS (Part) = 0.001 x 138.6 x 15.43/ 58.03 = 0.037 gr/dscf

CS (SO_2) = 2070 / 1.64 = 1262 mg/m^3

= 1262 x 24.06/ 64 = 474 ppm

= 0.001 x 2070 x 15.43/58.03 = 0.550 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	138.6	84.5	0.037	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	85.6	52.2	0.023	
As $H_2SO_4 \cdot 2H_2O$	117.0	71.3	0.031	
Sulfur dioxide	2070	1262	0.550	474
Sulfuric acid mist				
As H_2SO_4	34.4	21.0	0.009	5
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/29/81
SAMPLING LOCATION	NO.1 COKE BATTERY OUTLET	RUN NUMBER	5-2
SAMPLE TYPE	PART	PROBE LENGTH & TYPE	4' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE : I.D.	.397
AMBIENT TEMP.(DEG.F)	52.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.86	SAMPLE BOX NUMBER	0
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F10
FILTER NUMBER(S)	3550113	METER HEAD DIFF.	1.80
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.011 CFM @ 23.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.044		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	943	101.037									
	10.0	953	105.700	.060	.73	.73	536.	58.	58.	2.0	261.	40.
	20.0	1003	110.380	.060	.73	.73	548.	60.	58.	2.5	270.	40.
	30.0	1013	115.030	.060	.73	.73	507.	62.	58.	2.0	253.	40.
	40.0	1023	119.330	.050	.62	.62	520.	66.	60.	2.5	253.	42.
	50.0	1033	123.990	.060	.73	.73	533.	67.	61.	3.0	252.	43.
	60.0	1043	128.300	.050	.62	.62	521.	69.	61.	3.0	251.	42.
	70.0	1053	132.610	.050	.62	.62	536.	70.	63.	2.5	248.	47.
	80.0	1103	136.900	.050	.62	.62	549.	71.	64.	3.0	251.	49.
	90.0	1113	142.830	.200	1.22	1.22	510.	72.	65.	3.0	250.	51.
	100.0	1123	147.070	.050	.62	.62	522.	75.	66.	4.0	256.	50.
	110.0	1133	151.348	.050	.62	.62	536.	75.	67.	8.0	249.	55.
TOTALS	110.0		50.311									
AVERAGE					.71	.71	529.	68.	62.	3.2	254.	45.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — BRUFFEY

TEST 5-2 NO.1 COKE BATTERY OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/29/81	10/29/81
TB	TIME-START	943	943
TF	TIME-FINISH	1133	1133
TT	NET TIME OF TEST, MIN.	110.0	110.0
NP	NET SAMPLING POINTS	11	11
Y	METER CALIBRATION FACTOR	1.044	1.044
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.71 IN-H2O	18.1 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	50.311 CU-FT	1.425 CU-M
TM	AVERAGE GAS METER TEMP	64.8 F	18.2 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	52.830 SCF	1.496 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	175.4	175.4
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.256 SCF	.234 SCM
BWO	PERCENT MOISTURE BY VOLUME	13.52	13.52
FMD	MOLE FRACTION DRY GAS	.865	.865
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	11.30	11.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.40	84.40
MD	MOLECULAR WT-DRY STACK GAS	29.14	29.14
MWS	MOLECULAR WT-STACK GAS	27.63	27.63

PB	BAROMETRIC PRESSURE	29.86	IN-HG	758.44	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.77	IN-HG	756.20	MM-HG
TS	AVERAGE STACK TEMP	529.	F	276.	C
VS	AVG STACK GAS VELOCITY	19.8	FPS	6.0	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1698186.	SCFH	48088.	SCMH
QS	ACTUAL STACK FLOW RATE	3695966.	ACFH	104659.	ACMH
ISO	PERCENT ISOKINETIC	102.4		102.4	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 5-2

NO.1 COKE BATTERY OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 50.311 * 1.044 * (29.86 + .715 / 13.6)}{(65. + 460.)} = 52.830 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 175. = 8.26 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.26}{52.830 + 8.26} = 13.52 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.5}{100.} = .865$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (11.3*32/100) + ((84.4+ .0) * 28/100 = 29.14

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.14* (1. -(13.52/100)) + 18. * (13.52/100) = 27.63

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 86.999 / (SQRT(27.63 * 29.77) * 11. = 19.80 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 19.80 * 7466. 3600/144 = 3695966. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3695966. * 29.77 * (1. - (13.52/100))}{(529. + 460.)} = 1698186.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(529.+460.))*((0.002669*175.)+(50.311*1.044*(29.86+(.715/13.6))/(65.+460.)))}{110. * 19.80 * 29.77 * .397 * .397} = 102.36\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 52.830 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1698186. / (15.43 * 453.6) = .00

Run No. 5.2

Sample volume = 1.50 m^3, 52.83 scf

Example calculations

CS (Part) = 185.6/ 1.50 = 123.7 mg/m^3

CS (Part) = 0.001 x 185.6 x 15.43/52.83 = 0.054 gr/dscf

CS (SO_2) = ____ /____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	185.6	123.7	0.054	
2-h at 350°F	36.8	24.5	0.011	
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	3.0	2.0	0.0008	
As $H_2SO_4 \cdot 2H_2O$	4.1	2.7	0.001	
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles	19.0	12.7	0.006	
Organic condensibles	4.2	2.8	0.001	
TOC (Condensible)	58.1	38.7	0.017	

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/29/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	5-3
SAMPLE TYPE	5-3-M8-350	PROBE LENGTH & TYPE	5 FT GLASS HEATED
OPERATOR	CLARKE	NOZZLE : I.D.	.394
AMBIENT TEMP.(DEG.F)	52.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.86	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB1
FILTER NUMBER(S)	3530073	METER HEAD DIFF.	1.87
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.		HEATER BOX SETTING	350.
LEAKAGE	.000 CFM @ 3.0 IN.HG	REFERENCE PRESS. DIFF.	1.50
METER CALIB. FACTOR	.992		

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	940	616.815									
	10.0	950	621.635	.060	.73	.73	530.	55.	50.	2.0	301.	50.
	20.0	1000	626.300	.060	.73	.73	543.	58.	51.	2.0	362.	44.
	30.0	1010	631.028	.060	.73	.73	556.	60.	51.	2.0	352.	44.
	40.0	1020	635.502	.050	.62	.62	518.	65.	52.	2.0	342.	48.
	50.0	1030	639.909	.060	.73	.73	530.	67.	54.	2.0	356.	50.
	60.0	1040	644.604	.060	.73	.73	540.	68.	54.	2.0	358.	56.
	70.0	1050	649.308	.050	.62	.62	531.	70.	56.	2.0	350.	58.
	80.0	1100	653.803	.050	.62	.62	546.	73.	60.	2.0	359.	52.
	90.0	1110	659.385	.100	1.20	1.20	505.	76.	61.	2.5	359.	50.
	100.0	1120	663.440	.050	.62	.62	519.	80.	64.	2.0	354.	52.
	110.0	1130	668.370	.050	.62	.62	530.	80.	64.	2.0	348.	56.
	115.0	1135	670.591	.050	.62	.62	495.	80.	64.	2.0	351.	54.
TOTALS	115.0		53.776									
AVERAGE					.71	.71	529.	69.	57.	2.0	349.	51.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER: CLARKE

TEST 5-3 COKE OVEN OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/29/81	10/29/81
TB	TIME-START	940	940
TF	TIME-FINISH	1135	1135
TT	NET TIME OF TEST, MIN.	115.0	115.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.992	.992
DN	SAMPLING NOZZLE DIAMETER	.394 IN	10.0 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.71 IN-H2O	18.1 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	53.776 CU-FT	1.523 CU-M
TM	AVERAGE GAS METER TEMP	63.0 F	17.2 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	53.838 SCF	1.525 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	189.4	189.4
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.915 SCF	.252 SCM
BWO	PERCENT MOISTURE BY VOLUME	14.21	14.21
FMD	MOLE FRACTION DRY GAS	.858	.858
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	11.30	11.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.40	84.40
MD	MOLECULAR WT-DRY STACK GAS	29.14	29.14
MWS	MOLECULAR WT-STACK GAS	27.56	27.56

PB	BAROMETRIC PRESSURE	29.86	IN-HG	758.44	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.77	IN-HG	756.20	MM-HG
TS	AVERAGE STACK TEMP	529.	F	276.	C
VS	AVG STACK GAS VELOCITY	18.9	FPS	5.8	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1611199.	SCFH	45624.	SCMH
QS	ACTUAL STACK FLOW RATE	3533728.	ACFH	100065.	ACMH
ISO	PERCENT ISOKINETIC	106.8		106.8	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 5-3

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTO = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 53.776 * .992 * (29.86 + .714 / 13.6)}{(63. + 460.)} = 53.838 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 189. = 8.92 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.92}{53.838 + 8.92} = 14.21 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 14.2}{100.} = .858$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (11.3*32/100) + ((84.4+ .0) * 28/100 = 29.14

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.14* (1. -(14.21/100)) + 18. * (14.21/100) = 27.56

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 90.615 / (SQRT(27.56 * 29.77) * 12. = 18.93 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 18.93 * 7466. 3600/144 = 3533728. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3533728. * 29.77 * (1. - (14.21/100))}{(529. + 460.)} = 1611199.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*ON)

$$ISO = \frac{(305.58*(529.+460.))*((0.002669*189.)+(53.776*.992*(29.86+(.714713.6))/(63.+460.)))}{115. * 18.93 * 29.77 * .394 * .394} = 106.77\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 53.838 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1611199. / (15.43 * 453.6) = .00

Run No. 5.3

Sample volume = 1.53 m^3, 53.84 scf

Example calculations

CS (Part) = 50.5 / 1.53 = 33.0 mg/m^3

CS (Part) = 0.001 x 50.5 x 15.43/53.84 = 0.014 gr/dscf

CS (SO_2) = 1970/1.53 = 1287 mg/m^3

= 1287 x 24.06/64 = 484 ppm

= 0.001 x 1970 x 15.43/ 53.84 = 0.564 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	50.5	33.0	0.014	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	9.5	6.2	0.003	
As $H_2SO_4 \cdot 2H_2O$	13.0	8.5	0.004	
Sulfur dioxide	1970	1288	0.564	484
Sulfuric acid mist				
As H_2SO_4	81.5	53.3	0.023	13
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/27/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	5-4
SAMPLE TYPE	5-4-M5-350	PROBE LENGTH & TYPE	6 FT GLASS HEATED
OPERATOR	CLARKE	NOZZLE : I.D.	.396
AMBIENT TEMP.(DEG.F)	52.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.86	SAMPLE BOX NUMBER	1
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F85
FILTER NUMBER(S)	3530107	METER HEAD DIFF.	1.86
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.		HEATER BOX SETTING	350.
LEAKAGE	.000 CFM @ 3.0 IN.HG	REFERENCE PRESS. DIFF.	1.50
METER CALIB. FACTOR	1.016		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	943	38.568									
	10.0	953	43.355	.060	.73	.73	536.	60.	60.	1.0	300.	38.
	20.0	1003	47.374	.060	.73	.73	548.	61.	60.	1.0	395.	38.
	30.0	1013	52.310	.060	.73	.73	507.	64.	60.	1.0	377.	40.
	40.0	1023	56.333	.050	.62	.62	520.	68.	61.	1.0	370.	40.
	50.0	1033	60.739	.060	.73	.73	531.	70.	63.	1.0	363.	42.
	60.0	1043	64.728	.050	.62	.62	510.	74.	65.	1.0	364.	46.
	70.0	1053	69.205	.050	.62	.62	535.	78.	68.	1.0	364.	48.
	80.0	1103	73.425	.050	.62	.62	548.	80.	72.	1.0	373.	48.
	90.0	1113	79.230	.100	1.20	1.20	510.	84.	75.	1.0	371.	48.
	100.0	1123	83.320	.050	.62	.62	522.	87.	77.	1.0	376.	50.
	110.0	1133	87.690	.050	.62	.62	536.	80.	80.	1.0	367.	50.
	112.0	1135	88.721	.050	.62	.62	515.	89.	80.	1.0	369.	48.
TOTALS	112.0		50.153									
AVERAGE					.70	.70	527.	75.	68.	1.0	366.	45.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS

REPUBLIC STEEL CLEVELAND

TEST LEADER

CLARKE

TEST 5-4 COKE OVEN OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/27/81	10/27/81
TB	TIME-START	943	943
TF	TIME-FINISH	1135	1135
TT	NET TIME OF TEST, MIN.	112.0	112.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.016	1.016
DN	SAMPLING NOZZLE DIAMETER	.396 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.70 IN-H2O	17.9 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	50.153 CU-FT	1.420 CU-M
TM	AVERAGE GAS METER TEMP	71.5 F	21.9 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	50.606 SCF	1.433 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL, ML.	171.0	171.0
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.049 SCF	.228 SCM
BWO	PERCENT MOISTURE BY VOLUME	13.72	13.72
FMO	MOLE FRACTION DRY GAS	.863	.863
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	11.30	11.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.40	84.40
MD	MOLECULAR WT-DRY STACK GAS	29.14	29.14
MWS	MOLECULAR WT-STACK GAS	27.61	27.61

PB	BAROMETRIC PRESSURE	29.86	IN-HG	758.44	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.77	IN-HG	756.20	MM-HG
TS	AVERAGE STACK TEMP	527.	F	275.	C
VS	AVG STACK GAS VELOCITY	18.8	FPS	5.7	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1608375.	SCFH	45544.	SCMH
QS	ACTUAL STACK FLOW RATE	3500352.	ACFH	99119.	ACMH
ISO	PERCENT ISOKINETIC	102.2		102.2	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 5-4

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 50.153 * 1.016 * (29.86 + .705 / 13.6)}{(72. + 460.)} = 50.606 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 171. = 8.05 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.05}{50.606 + 8.05} = 13.72 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.7}{100.} = .863$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (11.3*32/100) + ((84.4+ .0) * 28/100 = 29.14

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.14* (1. -(13.72/100)) + 18. * (13.72/100) = 27.61

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 89.847 / (SQRT(27.61 * 29.77) * 12. = 18.75 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 18.75 * 7466. 3600/144 = 3500352. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3500352. * 29.77 * (1. - (13.72/100))}{(527. + 460.)} = 1608375. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(527.+460.))*((0.002669* 171.)+(50.153*1.016*(29.86+(.705/13.6))/(72.+460.)))}{112. * 18.75 * 29.77 * .396 * .396} = 102.19 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 50.606 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1608375. / (15.43 * 453.6) = .00

Run No. 5.4

Sample volume = 1.43 m^3, 50.61 scf

Example calculations

CS (Part) = 32.1 / 1.43 = 22.4 mg/m^3

CS (Part) = 0.001 x 32.1 x 15.43/50.61 = 0.010 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	32.1	22.4	0.010	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.0	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.0	
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles	101.2	70.8	0.031	
Organic condensibles	3.2	2.2	0.001	
TOC (Condensible)	49.2	34.4	0.015	

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/29/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	5-5
SAMPLE TYPE	METHOD 5-250	PROBE LENGTH & TYPE	6' GLASS
OPERATOR	DO/MP	NOZZLE : I.D.	.374
AMBIENT TEMP.(DEG.F)	52.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.86	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB4
FILTER NUMBER(S)	3530104	METER HEAD DIFF.	1.88
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.92
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.004 CFM @ 14.0 IN.HG	REFERENCE PRESS. DIFF.	.18
METER CALIB. FACTOR	1.033		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	943	854.767									
	10.0	953	859.460	.070	.72	.72	520.	55.	54.	8.7	225.	40.
	20.0	1003	864.150	.070	.72	.72	520.	57.	55.	8.7	244.	40.
	30.0	1013	868.850	.070	.72	.72	520.	60.	56.	8.8	252.	40.
	40.0	1023	873.590	.070	.72	.72	520.	64.	58.	9.0	246.	44.
	50.0	1033	878.350	.070	.72	.72	520.	67.	60.	9.0	236.	42.
	60.0	1043	883.170	.070	.72	.72	520.	69.	62.	9.2	243.	44.
	70.0	1053	888.030	.070	.72	.72	520.	71.	64.	9.6	242.	43.
	80.0	1103	892.910	.070	.72	.72	520.	72.	66.	9.8	236.	44.
	90.0	1113	897.820	.070	.72	.72	520.	74.	68.	9.9	234.	42.
	100.0	1123	902.740	.070	.72	.72	520.	75.	69.	10.1	240.	42.
	110.0	1133	907.630	.070	.72	.72	520.	75.	70.	10.7	235.	42.
	113.7	1137	909.368	.070	.72	.72	520.	75.	71.	12.2	241.	44.
TOTALS	113.7		54.601									
AVERAGE					.72	.72	520.	68.	63.	9.6	240.	42.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS

REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER

DO/MP

TEST 5-5 COKE STACK

		ENGLISH UNITS		METRIC UNITS	
TEST DATE		10/29/81		10/29/81	
TB	TIME-START	943		943	
TF	TIME-FINISH	1137		1137	
TT	NET TIME OF TEST, MIN.	113.7		113.7	
NP	NET SAMPLING POINTS	12		12	
Y	METER CALIBRATION FACTOR	1.033		1.033	
DN	SAMPLING NOZZLE DIAMETER	.374	IN	9.5	MM
CP	PITOT TUBE COEFFICIENT	.84		.84	
PM	AVERAGE ORIFICE PRESSURE DROP	.72	IN-H2O	18.3	MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	54.601	CU-FT	1.546	CU-M
TM	AVERAGE GAS METER TEMP	65.3	F	18.5	C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	56.680	SCF	1.605	SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	197.2		197.2	
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	9.282	SCF	.263	SCM
BWO	PERCENT MOISTURE BY VOLUME	14.07		14.07	
FMD	MOLE FRACTION DRY GAS	.859		.859	
PCO2	PERCENT CO2 BY VOL., DRY	4.30		4.30	
PO2	PERCENT O2 BY VOL., DRY	11.30		11.30	
PCO	PERCENT CO BY VOL., DRY	.00		.00	
PN2	PERCENT N2 BY VOL., DRY	84.40		84.40	
MD	MOLECULAR WT-DRY STACK GAS	29.14		29.14	
MWS	MOLECULAR WT-STACK GAS	27.57		27.57	

PB	BAROMETRIC PRESSURE	29.86	IN-HG	758.44	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.77	IN-HG	756.20	MM-HG
TS	AVERAGE STACK TEMP	520.	F	271.	C
VS	AVG STACK GAS VELOCITY	20.8	FPS	6.3	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1785009.	SCFH	50546.	SCMH
QS	ACTUAL STACK FLOW RATE	3874861.	ACFH	109724.	ACMH
ISO	PERCENT ISOKINETIC	113.9		113.9	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 5-5

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 54.601 * 1.033 * (29.86 + .720 / 13.6)}{(65. + 460.)} = 56.680 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 197. = 9.28 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 9.28}{56.680 + 9.28} = 14.07 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 14.1}{100.} = .859$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (11.3*32/100) + ((84.4+ .0) * 28/100 = 29.14

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.14* (1. -(14.07/100)) + 18. * (14.07/100) = 27.57

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 99.390 / (SQRT(27.57 * 29.77) * 12. = 20.76 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 20.76 * 7466. 3600/144 = 3874861. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3874861. * 29.77 * (1. - (14.07/100))}{(520. + 460.)} = 1785009. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*ON*DN)

$$ISO = \frac{(305.58*(520.+460.))*((0.002669* 197.)+(54.601*1.033*(29.86+(.720/13.6))/(65.+460.)))}{114. * 20.76 * 29.77 * .374 * .374} = 113.89 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 56.680 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1785009. / (15.43 * 453.6) = .00

Run No. 5.5

Sample volume = 1.61 m^3, 56.68 scf

Example calculations

CS (Part) = 221.0 / 1.61 = 137.3 mg/m^3

CS (Part) = 0.001 x 221.0 x 15.43/ 56.68 = 0.060 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	221.0	137.3	0.060	
2-h at 350°F	50.4	31.3	0.014	
4-h at 350°F	44.2	27.4	0.012	
2-h at 400°F	36.2	22.5	0.010	
4-h at 400°F	32.3	20.1	0.009	
2-h at 600°F	27.7	17.2	0.008	
Acid sulfates				
As H_2SO_4	0.0	0.0	0.0	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.0	
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles	20.9	13.0	0.006	
Organic condensibles	6.3	3.9	0.002	
TOC (Condensible)	11.8	7.3	0.003	

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/29/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	5-6
SAMPLE TYPE	METHOD 8-600	PROBE LENGTH & TYPE	4' QUARTZ
OPERATOR	DO/MP	NOZZLE I.D.	.590
AMBIENT TEMP.(DEG.F)	52.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.86	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F88
FILTER NUMBER(S)	3530224	METER HEAD DIFF.	1.91
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.94
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 11.0 IN.HG	REFERENCE PRESS. DIFF.	.03
METER CALIB. FACTOR	.982		

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	942	309.372									
	10.0	952	314.030	.070	4.44	.75	520.	49.	47.	3.3	629.	38.
	20.0	1002	318.710	.070	4.44	.75	520.	52.	48.	4.7	604.	36.
	30.0	1012	323.430	.070	4.44	.75	520.	57.	50.	5.2	598.	36.
	40.0	1022	328.160	.070	4.44	.75	520.	60.	51.	5.4	610.	40.
	50.0	1032	332.940	.070	4.44	.75	520.	63.	53.	5.7	617.	44.
	60.0	1042	337.690	.070	4.44	.75	520.	65.	55.	6.0	620.	52.
	70.0	1052	342.440	.070	4.44	.75	520.	66.	56.	7.5	618.	50.
	80.0	1102	347.200	.070	4.44	.75	520.	67.	57.	8.3	618.	50.
	90.0	1112	351.950	.070	4.44	.75	520.	68.	58.	9.3	620.	48.
	100.0	1122	356.770	.070	4.44	.75	520.	69.	59.	9.6	620.	44.
	110.0	1132	361.630	.070	4.44	.75	520.	70.	61.	9.8	619.	44.
	114.8	1137	363.907	.070	4.44	.75	520.	71.	63.	10.0	623.	48.
TOTALS	114.8		54.535									
AVERAGE					4.44	.75	520.	63.	55.	7.1	616.	44.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS

REPUBLIC STEEL CLEVELAND

TEST LEADER

DO/MP

TEST 5-6 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/29/81	10/29/81
TB	TIME-START	942	942
TF	TIME-FINISH	1137	1137
TT	NET TIME OF TEST, MIN.	114.8	114.8
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.982	.982
DN	SAMPLING NOZZLE DIAMETER	.590 IN	15.0 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.75 IN-H2O	19.1 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	54.535 CU-FT	1.544 CU-M
TM	AVERAGE GAS METER TEMP	59.0 F	15.0 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	54.477 SCF	1.543 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	178.8	178.8
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.416 SCF	.238 SCM
BWO	PERCENT MOISTURE BY VOLUME	13.38	13.38
FMD	MOLE FRACTION DRY GAS	.866	.866
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	11.30	11.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.40	84.40
MD	MOLECULAR WT-DRY STACK GAS	29.14	29.14
MWS	MOLECULAR WT-STACK GAS	27.65	27.65

PB	BAROMETRIC PRESSURE	29.86	IN-HG	758.44	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.77	IN-HG	756.20	MM-HG
TS	AVERAGE STACK TEMP	520.	F	271.	C
VS	AVG STACK GAS VELOCITY	20.7	FPS	6.3	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1796847.	SCFH	50881.	SCMH
QS	ACTUAL STACK FLOW RATE	3869468.	ACFH	109572.	ACMH
ISO	PERCENT ISOKINETIC	43.3		43.3	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 5-6

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 54.535 * .982 * (29.86 + .750 / 13.6)}{(59. + 460.)} = 54.477 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 179. = 8.42 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.42}{54.477 + 8.42} = 13.38 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.4}{100.} = .866$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (11.3*32/100) + ((84.4+ .0) * 28/100 = 29.14

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.14* (1. -(13.38/100)) + 18. * (13.38/100) = 27.65

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 99.390 / (SQRT(27.65 * 29.77) * 12. = 20.73 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 20.73 * 7466. 3600/144 = 3869468. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3869468. * 29.77 * (1. - (13.38/100))}{(520. + 460.)} = 1796847. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(520.+460.))*((0.002669* 179.)+(54.535* .982*(29.86+(.750/13.6))/(59.+460.)))}{115. * 20.73 * 29.77 * .590 * .590} = 43.28 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 54.477 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1796847. / (15.43 * 453.6) = .00

Run No. 5.6

Sample volume = 1.54 m^3, 54.48 scf

Example calculations

CS (Part) = 24.9 / 1.54 = 16.2 mg/m^3

CS (Part) = 0.001 x 24.9 x 15.43/ 54.48 = 0.007 gr/dscf

CS (SO_2) = 2050 / 1.54 = 1331 mg/m^3

= 1331 x 24.06/64 = 500 ppm

= 0.001 x 2050 x 15.43/54.48 = 0.581 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	24.9	16.2	0.007	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.0	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.0	
Sulfur dioxide	2050	1331	0.581	500
Sulfuric acid mist				
As H_2SO_4	129	83.8	0.036	20
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/29/81
SAMPLING LOCATION	NO.1 COKE BATTERY OUTLET	RUN NUMBER	6-1
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	5' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE : I.D.	.397
AMBIENT TEMP.(DEG.F)	75.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.88	SAMPLE BOX NUMBER	0
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB2
FILTER NUMBER(S)	3530064	METER HEAD DIFF.	1.76
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 5.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.003		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1350	930.535									
	10.0	1400	935.270	.050	.62	.62	520.	65.	64.	1.5	222.	49.
	20.0	1410	940.000	.050	.62	.62	502.	65.	64.	2.0	245.	52.
	30.0	1420	944.750	.050	.62	.62	523.	67.	64.	2.0	249.	53.
	40.0	1430	949.450	.050	.62	.62	536.	70.	64.	2.5	248.	54.
	50.0	1440	954.200	.050	.62	.62	496.	71.	65.	3.0	243.	52.
	60.0	1450	958.990	.050	.62	.62	537.	71.	65.	3.0	246.	51.
	70.0	1500	963.750	.050	.62	.62	551.	71.	65.	2.5	250.	54.
	80.0	1510	968.900	.060	.73	.73	504.	72.	66.	2.5	251.	55.
	90.0	1520	973.670	.050	.62	.62	523.	73.	67.	2.5	249.	56.
	100.0	1530	978.430	.050	.62	.62	535.	73.	67.	2.5	249.	57.
	110.0	1540	983.190	.050	.62	.62	546.	73.	68.	2.0	248.	56.
	120.0	1550	988.325	.060	.73	.73	535.	73.	68.	3.0	249.	57.
TOTALS	120.0		57.790									
AVERAGE					.64	.64	526.	70.	66.	2.4	246.	54.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS | TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND | BRUFFEY

TEST 6-1 NO.1 COKE BATTERY OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/29/81	10/29/81
TB	TIME-START	1350	1350
TF	TIME-FINISH	1550	1550
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.003	1.003
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.64 IN-H2O	16.2 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	57.790 CU-FT	1.636 CU-M
TM	AVERAGE GAS METER TEMP	68.0 F	20.0 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	57.981 SCF	1.642 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	201.2	201.2
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	9.470 SCF	.268 SCM
BWO	PERCENT MOISTURE BY VOLUME	14.04	14.04
FMD	MOLE FRACTION DRY GAS	.860	.860
PCO2	PERCENT CO2 BY VOL., DRY	4.50	4.50
PO2	PERCENT O2 BY VOL., DRY	10.50	10.50
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.00	85.00
MD	MOLECULAR WT-DRY STACK GAS	29.14	29.14
MWS	MOLECULAR WT-STACK GAS	27.58	27.58

PB	BAROMETRIC PRESSURE	29.88	IN-HG	758.95	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.79	IN-HG	756.71	MM-HG
TS	AVERAGE STACK TEMP	526.	F	274.	C
VS	AVG STACK GAS VELOCITY	17.9	FPS	5.4	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1529041.	SCFH	43298.	SCMH
QS	ACTUAL STACK FLOW RATE	3334937.	ACFH	94435.	ACMH
ISO	PERCENT ISOKINETIC	114.4		114.4	
MN	FILTERABLE PART MG, EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 6-1

NO.1 COKE BATTERY OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 57.790 * 1.003 * (29.88 + .638 / 13.6)}{(68. + 460.)} = 57.981 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 201. = 9.47 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 9.47}{57.981 + 9.47} = 14.04 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 14.0}{100.} = .860$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.50*44/100) + (10.5*32/100) + ((85.0+ .0) * 28/100 = 29.14

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.14* (1. -(14.04/100)) + 18. * (14.04/100) = 27.58

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 85.575 / (SQRT(27.58 * 29.79) * 12. = 17.87 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.87 * 7466. 3600/144 = 3334937. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3334937. * 29.79 * (1. - (14.04/100))}{(526. + 460.)} = 1529041.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(526.+460.))*((0.002669*201.)+(57.790*1.003*(29.88+(.638/13.6))/(68.+460.)))}{120. * 17.87 * 29.79 * .397 * .397} = 114.37\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 57.981 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1529041. / (15.43 * 453.6) = .00

Run No. 6.1

Sample volume = 1.64 m^3, 57.98 scf

Example calculations

CS (Part) = 184.1 / 1.64 = 112.2 mg/m^3

CS (Part) = 0.001 x 184 x 15.43/57.98 = 0.049 gr/dscf

CS (SO_2) = 2000 / 1.64 = 1219.5 mg/m^3

= 1219.5 x 24.06/64 = 458 ppm

= 0.001 x 2000 x 15.43/ 57.98 = 0.532 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	184.1	112.2	0.049	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	71.0	43.3	0.019	
As $H_2SO_4 \cdot 2H_2O$	97.0	59.2	0.026	
Sulfur dioxide	2000	1219.5	0.532	458
Sulfuric acid mist				
As H_2SO_4	24.0	14.6	0.006	4
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/29/81
SAMPLING LOCATION	NO.1 COKE BATTERY OUTLET	RUN NUMBER	6-2
SAMPLE TYPE	PART	PROBE LENGTH & TYPE	4' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE : I.D.	.397
AMBIENT TEMP.(DEG.F)	75.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.88	SAMPLE BOX NUMBER	Q
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F10
FILTER NUMBER(S)	3530098	METER HEAD DIFF.	1.80
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.001 CFM @ 6.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.044		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1353	151.645									
	10.0	1403	156.000	.050	.62	.62	520.	76.	76.	1.0	248.	50.
	20.0	1413	160.350	.050	.62	.62	515.	76.	75.	1.0	266.	50.
	30.0	1423	164.700	.050	.62	.62	528.	78.	76.	2.0	264.	52.
	40.0	1433	169.050	.050	.62	.62	541.	80.	76.	2.5	264.	53.
	50.0	1443	173.420	.050	.62	.62	525.	81.	77.	3.0	265.	54.
	60.0	1453	177.780	.050	.62	.62	543.	81.	76.	3.0	255.	53.
	70.0	1503	182.130	.050	.62	.62	555.	81.	76.	3.5	257.	55.
	80.0	1513	186.860	.060	.73	.73	515.	81.	76.	3.5	254.	57.
	90.0	1523	191.240	.050	.62	.62	524.	81.	76.	3.0	258.	59.
	100.0	1533	195.590	.050	.62	.62	538.	81.	76.	3.0	256.	61.
	110.0	1543	199.910	.050	.62	.62	522.	79.	76.	3.0	251.	61.
	120.0	1553	204.632	.060	.73	.73	538.	79.	75.	4.0	255.	62.
TOTALS	120.0		52.987									
AVERAGE					.64	.64	530.	80.	76.	2.7	258.	56.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS | TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND | BRUFFEY

TEST 6-2 NO.1 COKE BATTERY OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/29/81	10/29/81
TB	TIME-START	1353	1353
TF	TIME-FINISH	1553	1553
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.044	1.044
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.64 IN-H2O	16.2 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	52.987 CU-FT	1.500 CU-M
TM	AVERAGE GAS METER TEMP	77.7 F	25.4 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	54.332 SCF	1.539 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	194.4	194.4
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	9.150 SCF	.259 SCM
BWO	PERCENT MOISTURE BY VOLUME	14.41	14.41
FMD	MOLE FRACTION DRY GAS	.856	.856
PCO2	PERCENT CO2 BY VOL., DRY	4.50	4.50
PO2	PERCENT O2 BY VOL., DRY	10.50	10.50
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.00	85.00
MD	MOLECULAR WT-DRY STACK GAS	29.14	29.14
MWS	MOLECULAR WT-STACK GAS	27.53	27.53

PB	BAROMETRIC PRESSURE	29.88	IN-HG	758.95	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.79	IN-HG	756.71	MM-HG
TS	AVERAGE STACK TEMP	530.	F	277.	C
VS	AVG STACK GAS VELOCITY	17.9	FPS	5.5	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1520006.	SCFH	43042.	SCMH
QS	ACTUAL STACK FLOW RATE	3345471.	ACFH	94734.	ACMH
ISO	PERCENT ISOKINETIC	107.8		107.8	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 6-2

NO.1 COKE BATTERY OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 52.987 * 1.044 * (29.88 + .638 / 13.6)}{(78. + 460.)} = 54.332 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 194. = 9.15 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 9.15}{54.332 + 9.15} = 14.41 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMO = (100. - BWO) / 100.

$$FMD = \frac{100. - 14.4}{100.} = .856$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.50*44/100) + (10.5*32/100) + ((85.0+ .0) * 28/100 = 29.14

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.14* (1. -(14.41/100)) + 18. * (14.41/100) = 27.53

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 85.781 / (SQRT(27.53 * 29.79) * 12. = 17.92 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.92 * 7466. 3600/144 = 3345471. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3345471. * 29.79 * (1. - (14.41/100))}{(530. + 460.)} = 1520006.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(530.+460.))*((0.002669*194.)+(52.987*1.044*(29.88+(.638/13.6))/(78.+460.)))}{120. * 17.92 * 29.79 * .397 * .397} = 107.81\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTO

CS = 0.001 * .0 * 15.43 / 54.332 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1520006. / (15.43 * 453.6) = .00

Run No. 6.2

Sample volume = 1.54 m^3, 54.33 scf

Example calculations

CS (Part) = 150.8 / 1.54 = 97.9 mg/m^3

CS (Part) = 0.001 x 150.8 x 15.43/ 54.33 = 0.043 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/ ____ = ____ ppm

= 0.001 x ____ x 15.43/ ____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	150.8	97.9	0.043	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F	24.2	15.7	0.007	
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.0	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.0	
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles	109.7	71.2	0.031	
Organic condensibles	4.0	2.6	0.001	
TOC (Condensible)	42.3	27.5	0.012	

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/29/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	6-3
SAMPLE TYPE	6-3-M8-400	PROBE LENGTH & TYPE	5' GLASS HEATED
OPERATOR	CLARKE	NOZZLE : I.D.	.398
AMBIENT TEMP.(DEG.F)	75.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.88	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB1
FILTER NUMBER(S)	353101	METER HEAD DIFF.	1.87
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	400.
THERM. NO.		HEATER BOX SETTING	400.
LEAKAGE	.001 CFM @ 3.0 IN.HG	REFERENCE PRESS. DIFF.	1.50
METER CALIB. FACTOR	.992		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1350	671.163									
	10.0	1400	675.675	.050	.62	.62	520.	74.	70.	2.0	310.	54.
	20.0	1410	680.055	.050	.62	.62	502.	74.	69.	2.0	356.	50.
	30.0	1420	684.701	.050	.62	.62	523.	78.	68.	2.0	397.	56.
	40.0	1430	689.000	.050	.62	.62	537.	80.	67.	2.0	422.	58.
	50.0	1440	694.040	.050	.62	.62	547.	80.	69.	2.0	370.	56.
	60.0	1400	698.525	.050	.62	.62	537.	81.	69.	2.0	383.	60.
	70.0	1500	703.200	.050	.62	.62	553.	81.	69.	2.0	368.	60.
	80.0	1510	707.689	.060	.72	.72	553.	82.	70.	2.0	386.	58.
	90.0	1520	712.000	.050	.62	.62	523.	82.	70.	2.0	386.	56.
	100.0	1530	716.520	.050	.62	.62	535.	82.	70.	2.0	379.	54.
	110.0	1540	720.798	.050	.62	.62	499.	82.	71.	2.0	388.	54.
	120.0	1550	725.992	.060	.72	.72	530.	81.	70.	2.0	407.	57.
TOTALS	120.0		54.829									
AVERAGE					.64	.64	530.	80.	69.	2.0	379.	56.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS

REPUBLIC STEEL CLEVELAND

TEST LEADER

CLARKE

TEST 6-3 COKE OVEN OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/29/81	10/29/81
TB	TIME-START	1350	1350
TF	TIME-FINISH	1550	1550
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.992	.992
DN	SAMPLING NOZZLE DIAMETER	.398 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.64 IN-H2O	16.2 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	54.829 CU-FT	1.553 CU-M
TM	AVERAGE GAS METER TEMP	74.5 F	23.6 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	53.737 SCF	1.522 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL, ML.	175.4	175.4
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.256 SCF	.234 SCM
BWO	PERCENT MOISTURE BY VOLUME	13.32	13.32
FMD	MOLE FRACTION DRY GAS	.867	.867
PCO2	PERCENT CO2 BY VOL., DRY	4.50	4.50
PO2	PERCENT O2 BY VOL., DRY	10.50	10.50
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.00	85.00
MD	MOLECULAR WT-DRY STACK GAS	29.14	29.14
MWS	MOLECULAR WT-STACK GAS	27.66	27.66

PB	BAROMETRIC PRESSURE	29.88	IN-HG	758.95	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.79	IN-HG	756.71	MM-HG
TS	AVERAGE STACK TEMP	530.	F	277.	C
VS	AVG STACK GAS VELOCITY	17.9	FPS	5.5	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1536556.	SCFH	43511.	SCMH
QS	ACTUAL STACK FLOW RATE	3337721.	ACFH	94514.	ACMH
ISO	PERCENT ISOKINETIC	104.9		104.9	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 6-3

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 54.829 * .992 * (29.88 + .637 / 13.6)}{(75. + 460.)} = 53.737 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 175. = 8.26 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.26}{53.737 + 8.26} = 13.32 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.3}{100.} = .867$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.50*44/100) + (10.5*32/100) + ((85.0+ .0) * 28/100 = 29.14

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.14* (1. -(13.32/100)) + 18. * (13.32/100) = 27.66

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 85.772 / (SQRT(27.66 * 29.79) * 12. = 17.88 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.88 * 7466. 3600/144 = 3337721. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3337721. * 29.79 * (1. - (13.32/100))}{(530. + 460.)} = 1536556.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(530.+460.))*((0.002669*175.)+(54.829*.992*(29.88+(.637/13.6))/(75.+460.)))}{120. * 17.88 * 29.79 * .398 * .398} = 104.95\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 53.737 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1536556. / (15.43 * 453.6) = .00

Run No. 6.3

Sample volume = 1.52 m^3, 53.74 scf

Example calculations

CS (Part) = 34.3/1.52 = 22.6 mg/m^3

CS (Part) = 0.001 x 34.3 x 15.43/ 53.74= 0.010 gr/dscf

CS (SO_2) =1900 /1.52 = 1250 mg/m^3

=1250 x 24.06/64 = 470ppm

= 0.001 x 1900 x 15.43/53.74 = 0.546 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	34.3	22.6	0.010	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	2.8	1.8	0.0008	
As $H_2SO_4 \cdot 2H_2O$	3.8	2.5	0.001	
Sulfur dioxide	1900	1250	0.546	470
Sulfuric acid mist				
As H_2SO_4	97.6	64.2	0.028	16
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/29/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	6-4
SAMPLE TYPE	6-4-M5-400	PROBE LENGTH & TYPE	6 FT GLASS HEATED
OPERATOR	CLARKE	NOZZLE : I.D.	.397
AMBIENT TEMP.(DEG.F)	75.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.88	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F85
FILTER NUMBER(S)	3530083	METER HEAD DIFF.	1.86
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	400.
THERM. NO.		HEATER BOX SETTING	400.
LEAKAGE	.120 CFM @ 2.0 IN.HG	REFERENCE PRESS. DIFF.	1.50
METER CALIB. FACTOR	1.016		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1354	88.937									
	10.0	1404	93.212	.050	.62	.62	558.	84.	82.	1.0	370.	46.
	20.0	1414	97.425	.050	.62	.62	515.	85.	82.	1.0	401.	44.
	30.0	1424	101.926	.050	.62	.62	526.	88.	83.	1.0	434.	42.
	40.0	1434	106.210	.050	.62	.62	541.	90.	85.	1.0	442.	48.
	50.0	1444	110.736	.050	.62	.62	519.	92.	86.	1.0	395.	52.
	60.0	1454	115.426	.050	.62	.62	537.	94.	88.	1.0	403.	50.
	70.0	1504	119.660	.050	.62	.62	556.	94.	88.	1.0	406.	48.
	80.0	1514	124.111	.060	.72	.72	514.	94.	88.	1.0	411.	46.
	90.0	1524	128.140	.050	.62	.62	524.	94.	88.	1.0	399.	44.
	100.0	1534	132.678	.050	.62	.62	535.	93.	88.	1.0	390.	42.
	110.0	1544	137.220	.050	.62	.62	523.	92.	87.	1.0	407.	44.
	120.0	1554	142.007	.060	.72	.72	539.	92.	87.	1.0	421.	42.
TOTALS	120.0		46.702									
AVERAGE					.64	.64	532.	91.	86.	1.0	407.	46.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — CLARKE

TEST 6-4 COKE OVEN OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/29/81	10/29/81
TB	TIME-START	1354	1354
TF	TIME-FINISH	1554	1554
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.016	1.016
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.64 IN-H2O	16.2 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	46.702 CU-FT	1.322 CU-M
TM	AVERAGE GAS METER TEMP	88.5 F	31.4 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	45.686 SCF	1.294 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	179.5	179.5
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.449 SCF	.239 SCM
BWO	PERCENT MOISTURE BY VOLUME	15.61	15.61
FMD	MOLE FRACTION DRY GAS	.844	.844
PCO2	PERCENT CO2 BY VOL., DRY	4.50	4.50
PO2	PERCENT O2 BY VOL., DRY	10.50	10.50
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.00	85.00
MD	MOLECULAR WT-DRY STACK GAS	29.14	29.14
MWS	MOLECULAR WT-STACK GAS	27.40	27.40

PB	BAROMETRIC PRESSURE	29.88	IN-HG	758.95	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.79	IN-HG	756.71	MM-HG
TS	AVERAGE STACK TEMP	532.	F	278.	C
VS	AVG STACK GAS VELOCITY	18.0	FPS	5.5	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1500961.	SCFH	42503.	SCMH
QS	ACTUAL STACK FLOW RATE	3356748.	ACFH	95053.	ACMH
ISO	PERCENT ISOKINETIC	91.8		91.8	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 6-4

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTO = \frac{17.647 * 46.702 * 1.016 * (29.88 + .637 / 13.6)}{(89. + 460.)} = 45.686 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 180. = 8.45 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.45}{45.686 + 8.45} = 15.61 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMO = \frac{100. - 15.6}{100.} = .844$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.50*44/100) + (10.5*32/100) + ((85.0+ .0) * 28/100 = 29.14

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.14* (1. -(15.61/100)) + 18. * (15.61/100) = 27.40

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 85.862 / (SQRT(27.40 * 29.79) * 12. = 17.98 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.98 * 7466. 3600/144 = 3356748. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3356748. * 29.79 * (1. - (15.61/100))}{(532. + 460.)} = 1500961.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(532.+460.))*((0.002669* 180.)+(46.702*1.016*(29.88+(.637/13.6))/(89.+460.)))}{120. * 17.98 * 29.79 * .397 * .397} = 91.80\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 45.686 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1500961. / (15.43 * 453.6) = .00

Run No. 6.4

Sample volume = 1.29 m^3, 45.69 scf

Example calculations

CS (Part) = 26.9/1.29 = 20.8 mg/m^3

CS (Part) = 0.001 x 26.9 x 15.43/45.69 = 0.009 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	26.9	20.8	0.009	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.0	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.0	
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles	118.3	91.7	0.040	
Organic condensibles	5.9	4.6	0.002	
TOC (Condensible)	154.0	119.4	0.052	

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/29/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	6-5
SAMPLE TYPE	METHOD 5-250	PROBE LENGTH & TYPE	6' GLASS
OPERATOR	DO-MP	NOZZLE I.D.	.374
AMBIENT TEMP.(DEG.F)	61.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.88	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	.00	METER BOX NUMBER	FB4
FILTER NUMBER(S)		METER HEAD DIFF.	1.88
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.92
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.016 CFM @ 10.0 IN.HG	REFERENCE PRESS. DIFF.	.18
METER CALIB. FACTOR	1.033		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1353	909.697									
	10.0	1403	914.440	.070	.72	.72	520.	64.	64.	8.4	225.	45.
	20.0	1413	919.130	.070	.72	.72	520.	65.	64.	8.7	253.	44.
	30.0	1423	923.810	.070	.72	.72	520.	67.	63.	8.7	249.	44.
	40.0	1433	928.440	.070	.72	.72	520.	69.	64.	8.7	247.	45.
	50.0	1443	933.160	.070	.72	.72	520.	70.	65.	8.6	240.	44.
	60.0	1453	937.860	.070	.72	.72	520.	71.	65.	8.7	245.	45.
	70.0	1503	942.550	.070	.72	.72	520.	72.	66.	8.7	248.	47.
	80.0	1513	947.240	.070	.72	.72	520.	72.	66.	8.7	251.	45.
	90.0	1523	951.910	.070	.72	.72	520.	72.	66.	8.7	251.	40.
	100.0	1533	956.610	.070	.72	.72	520.	72.	67.	8.7	251.	40.
	110.0	1543	961.300	.070	.72	.72	520.	72.	67.	8.7	247.	40.
	120.0	1553	965.996	.070	.72	.72	520.	72.	67.	8.8	246.	43.
TOTALS	120.0		56.299									
AVERAGE					.72	.72	520.	70.	65.	8.7	246.	44.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS

REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER

DO-MP

TEST 6-5 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/29/81	10/29/81
TB	TIME-START	1353	1353
TF	TIME-FINISH	1553	1553
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.033	1.033
DN	SAMPLING NOZZLE DIAMETER	.374 IN	9.5 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.72 IN-H2O	18.3 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	56.299 CU-FT	1.594 CU-M
TM	AVERAGE GAS METER TEMP	67.6 F	19.8 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	58.228 SCF	1.649 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	213.8	213.8
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	10.064 SCF	.285 SCM
BWO	PERCENT MOISTURE BY VOLUME	14.74	14.74
FMD	MOLE FRACTION DRY GAS	.853	.853
PCO2	PERCENT CO2 BY VOL., DRY	4.50	4.50
PO2	PERCENT O2 BY VOL., DRY	10.50	10.50
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.00	85.00
MD	MOLECULAR WT-DRY STACK GAS	29.14	29.14
MWS	MOLECULAR WT-STACK GAS	27.50	27.50

PB	BAROMETRIC PRESSURE	29.88	IN-HG	758.95	MM-HG
PSI	STATIC PRES OF STACK GAS	.00	IN-H2O	.00	MM-H2O
PS	STACK PRES, ABS.	29.88	IN-HG	758.95	MM-HG
TS	AVERAGE STACK TEMP	520.	F	271.	C
VS	AVG STACK GAS VELOCITY	20.7	FPS	6.3	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1776813.	SCFH	50314.	SCMH
QS	ACTUAL STACK FLOW RATE	3873037.	ACFH	109673.	ACMH
ISO	PERCENT ISOKINETIC	111.4		111.4	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 6-5

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 56.299 * 1.033 * (29.88 + .720 / 13.6)}{(68. + 460.)} = 58.228 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 214. = 10.06 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 10.06}{58.228 + 10.06} = 14.74 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 14.7}{100.} = .853$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.50*44/100) + (10.5*32/100) + ((85.0+ .0) * 28/100 = 29.14

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.14* (1. -(14.74/100)) + 18. * (14.74/100) = 27.50

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 99.390 / (SQRT(27.50 * 29.88) * 12. = 20.75 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 20.75 * 7466. 3600/144 = 3873037. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3873037. * 29.88 * (1. - (14.74/100))}{(520. + 460.)} = 1776813.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*ON)

$$ISO = \frac{(305.58*(520.+460.))*((0.002669*214.)+(56.299*1.033*(29.88+(.720/13.6))/(68.+460.)))}{120. * 20.75 * 29.88 * .374 * .374} = 111.37\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 58.228 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1776813. / (15.43 * 453.6) = .00

Run No. 6.5

Sample volume = 1.65 m^3, 58.23 scf

Example calculations

CS (Part) = 195.7/1.65 = 118.6 mg/m^3

CS (Part) = 0.001 x 195.7 x 15.43/58.23 = 0.052 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	195.7	118.6	0.052	
2-h at 350°F	42.3	25.6	0.011	
4-h at 350°F	37.6	22.8	0.010	
2-h at 400°F	33.2	20.1	0.009	
4-h at 400°F	30.3	18.4	0.008	
2-h at 600°F	25.8	15.6	0.007	
Acid sulfates				
As H_2SO_4	0.0	0.0	0.0	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.0	
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles	20.0	12.1	0.005	1
Organic condensibles	6.4	3.9	0.002	
TOC (Condensible)	15.2	9.2	0.004	

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/29/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	6-6
SAMPLE TYPE	METHOD 8-600	PROBE LENGTH & TYPE	4' QUARTZ
OPERATOR	DD/MP	NOZZLE : I.D.	.620
AMBIENT TEMP.(DEG.F)	61.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.88	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB8
FILTER NUMBER(S)	3530209	METER HEAD DIFF.	1.91
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.92
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 7.0 IN.HG	REFERENCE PRESS. DIFF.	.02
METER CALIB. FACTOR	.982		
READ & RECORD DATA EVERY 10.0 MINUTES			

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1352	364.163									
	10.0	1402	368.920	.070	5.32	.75	520.	61.	60.	3.6	586.	38.
	20.0	1412	373.680	.070	5.32	.75	520.	62.	60.	3.7	582.	36.
	30.0	1422	378.370	.070	5.32	.75	520.	65.	60.	3.7	509.	36.
	40.0	1432	383.050	.070	5.32	.75	520.	68.	61.	3.9	542.	40.
	50.0	1442	387.780	.070	5.32	.75	520.	70.	62.	4.0	545.	38.
	60.0	1452	392.500	.070	5.32	.75	520.	72.	63.	4.3	583.	38.
	70.0	1502	397.230	.070	5.32	.75	520.	72.	63.	4.4	584.	40.
	80.0	1512	401.960	.070	5.32	.75	520.	73.	64.	4.7	594.	40.
	90.0	1522	406.690	.070	5.32	.75	520.	73.	65.	4.8	587.	38.
	100.0	1532	411.420	.070	5.32	.75	520.	73.	65.	4.9	601.	38.
	110.0	1542	416.150	.070	5.32	.75	520.	73.	65.	5.1	599.	38.
	120.0	1552	420.865	.070	5.32	.75	520.	73.	65.	6.5	600.	40.
TOTALS	120.0		56.702									
AVERAGE					5.32	.75	520.	70.	63.	4.5	576.	38.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — DO/MP

TEST 6-6 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/29/81	10/29/81
TB	TIME-START	1352	1352
TF	TIME-FINISH	1552	1552
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.982	.982
DN	SAMPLING NOZZLE DIAMETER	.620 IN	15.7 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.75 IN-H2O	19.1 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	56.702 CU-FT	1.606 CU-M
TM	AVERAGE GAS METER TEMP	66.2 F	19.0 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	55.903 SCF	1.583 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	201.7	201.7
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	9.494 SCF	.269 SCM
BWO	PERCENT MOISTURE BY VOLUME	14.52	14.52
FMD	MOLE FRACTION DRY GAS	.855	.855
PCO2	PERCENT CO2 BY VOL., DRY	4.50	4.50
PO2	PERCENT O2 BY VOL., DRY	10.50	10.50
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.00	85.00
MD	MOLECULAR WT-DRY STACK GAS	29.14	29.14
MWS	MOLECULAR WT-STACK GAS	27.52	27.52

PB	BAROMETRIC PRESSURE	29.88	IN-HG	758.95	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.79	IN-HG	756.71	MM-HG
TS	AVERAGE STACK TEMP	520.	F	271.	C
VS	AVG STACK GAS VELOCITY	20.8	FPS	6.3	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1777953.	SCFH	50346.	SCMH
QS	ACTUAL STACK FLOW RATE	3877050.	ACFH	109786.	ACMH
ISO	PERCENT ISOKINETIC	38.9		38.9	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 6-6

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 56.702 * .982 * (29.88 + .750 / 13.6)}{(66. + 460.)} = 55.903 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 202. = 9.49 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 9.49}{55.903 + 9.49} = 14.52 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 14.5}{100.} = .855$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.50*44/100) + (10.5*32/100) + ((85.0+ .0) * 28/100 = 29.14

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.14* (1. -(14.52/100)) + 18. * (14.52/100) = 27.52

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 99.390 / (SQRT(27.52 * 29.79) * 12. = 20.77 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 20.77 * 7466. 3600/144 = 3877050. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3877050. * 29.79 * (1. - (14.52/100))}{(520. + 460.)} = 1777953.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*ON)

$$ISO = \frac{(305.58*(520.+460.))*((0.002669* 202.)+(56.702* .982*(29.88+(.750/13.6))/(66.+460.)))}{120. * 20.77 * 29.79 * .620 * .620} = 38.88\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 55.903 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1777953. / (15.43 * 453.6) = .00

Run No. 6.6

Sample volume = 1.58 m^3, 55.90 scf

Example calculations

CS (Part) = 30.9 / 1.58 = 19.6 mg/m^3

CS (Part) = 0.001 x 30.9 x 15.43/ 55.90 = 0.008 gr/dscf

CS (SO_2) = 2010 / 1.58 = 1272 mg/m^3

= 1272 x 24.06/ 64 = 478 ppm

= 0.001 x 2010 x 15.43/ 55.90 = 0.555 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	30.9	19.6	0.008	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.0	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.0	
Sulfur dioxide	2010	1272	0.555	478
Sulfuric acid mist				
As H_2SO_4	115	72.8	0.032	18
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/30/81
SAMPLING LOCATION	NO.1 COKE BATTERY OUTLET	RUN NUMBER	7-1
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	6' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE I.D.	.398
AMBIENT TEMP.(DEG.F)	54.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.92	SAMPLE BOX NUMBER	0
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB2
FILTER NUMBER(S)	3530043	METER HEAD DIFF.	1.76
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 5.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.003		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	930	988.550									
	10.0	940	993.730	.060	.73	.73	516.	55.	54.	1.5	240.	46.
	20.0	950	998.590	.060	.73	.73	536.	56.	54.	1.5	247.	44.
	30.0	1000	3.600	.060	.73	.73	550.	60.	54.	1.5	252.	46.
	40.0	1010	9.050	.070	.87	.87	503.	63.	55.	2.0	254.	46.
	50.0	1020	13.680	.050	.62	.62	514.	66.	57.	2.5	258.	47.
	60.0	1030	18.350	.050	.62	.62	540.	67.	58.	2.5	257.	49.
	70.0	1040	23.840	.070	.87	.87	523.	69.	60.	2.5	254.	56.
	80.0	1050	28.590	.050	.62	.62	565.	70.	61.	2.5	256.	59.
	90.0	1100	33.300	.050	.62	.62	562.	70.	62.	2.5	249.	60.
	100.0	1110	39.130	.080	1.00	1.00	505.	70.	63.	3.0	244.	57.
	110.0	1120	43.820	.050	.62	.62	516.	71.	63.	3.5	252.	55.
	120.0	1130	48.499	.050	.62	.62	527.	71.	64.	3.5	255.	53.
TOTALS	120.0		59.949									
AVERAGE					.72	.72	530.	66.	59.	2.4	252.	52.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST LEADER: BRUFFEY

TEST 7-1 NO.1 COKE BATTERY OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/30/81	10/30/81
TB	TIME-START	930	930
TF	TIME-FINISH	1130	1130
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.003	1.003
DN	SAMPLING NOZZLE DIAMETER	.398 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.72 IN-H2O	18.3 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	59.949 CU-FT	1.698 CU-M
TM	AVERAGE GAS METER TEMP	62.2 F	16.8 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	60.903 SCF	1.725 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	192.1	192.1
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	9.042 SCF	.256 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.93	12.93
FMD	MOLE FRACTION DRY GAS	.871	.871
PCO2	PERCENT CO2 BY VOL., DRY	4.00	4.00
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.00	85.00
MD	MOLECULAR WT-DRY STACK GAS	29.08	29.08
MWS	MOLECULAR WT-STACK GAS	27.65	27.65

PB	BAROMETRIC PRESSURE	29.92	IN-HG	759.97	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H20	-30.48	MM-H20
PS	STACK PRES, ABS.	29.83	IN-HG	757.73	MM-HG
TS	AVERAGE STACK TEMP	530.	F	277.	C
VS	AVG STACK GAS VELOCITY	18.9	FPS	5.8	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1636079.	SCFH	46329.	SCMH
QS	ACTUAL STACK FLOW RATE	3532635.	ACFM	100034.	ACMH
ISO	PERCENT ISOKINETIC	111.7		111.7	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 7-1

NO.1 COKE BATTERY OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 59.949 * 1.003 * (29.92 + .721 / 13.6)}{(62. + 460.)} = 60.903 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 192. = 9.04 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 9.04}{60.903 + 9.04} = 12.93 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.9}{100.} = .871$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.00*44/100) + (11.0*32/100) + ((85.0+ .0) * 28/100 = 29.08

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.08* (1. -(12.93/100)) + 18. * (12.93/100) = 27.65

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 90.827 / (SQRT(27.65 * 29.83) * 12. = 18.93 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 18.93 * 7466. 3600/144 = 3532635. ACFM

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3532635. * 29.83 * (1. - (12.93/100))}{(530. + 460.)} = 1636079.\ SCFM$$

PERCENT ISOKINETIC

ISO = (305.56*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.56*(530.+460.))*((0.002669*192.)+(59.949*1.003*(29.92+(.721/13.6))/(62.+460.)))}{120. * 18.93 * 29.83 * .398 * .398} = 111.71\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 60.903 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1636079. / (15.43 * 453.6) = .00

Run No. 7.1

Sample volume = 1.73 m^3, 60.90 scf

Example calculations

CS (Part) = 195.8 / 1.73 = 113.2 mg/m^3

CS (Part) = 0.001 x 195.8 x 15.43 / 60.90 = 0.050 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06 / ____ = ____ ppm

= 0.001 x ____ x 15.43 / ____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	195.8	113.2	0.050	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/30/81
SAMPLING LOCATION	NO.1 COKE BATTERY OUTLET	RUN NUMBER	7-2
SAMPLE TYPE	PART	PROBE LENGTH & TYPE	5' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE # I.D.	.377
AMBIENT TEMP.(DEG.F)	54.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.93	SAMPLE BOX NUMBER	8
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	P10
FILTER NUMBER(S)	3530066	METER HEAD DIFF.	1.80
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 6.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.044		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	933	204.803									
	10.0	943	209.480	.060	.73	.73	528.	58.	58.	1.5	259.	42.
	20.0	953	214.180	.060	.73	.73	541.	60.	58.	1.5	266.	44.
	30.0	1003	218.880	.060	.73	.73	557.	64.	60.	2.0	264.	46.
	40.0	1013	223.930	.070	.87	.87	504.	67.	61.	2.5	262.	45.
	50.0	1023	228.290	.050	.62	.62	528.	70.	61.	2.5	264.	47.
	60.0	1033	232.670	.050	.62	.62	549.	71.	63.	2.5	259.	49.
	70.0	1043	237.720	.070	.87	.87	547.	72.	64.	3.0	258.	50.
	80.0	1053	242.080	.050	.62	.62	565.	73.	66.	2.5	258.	59.
	90.0	1103	246.450	.050	.62	.62	565.	74.	66.	3.0	253.	62.
	100.0	1113	251.890	.080	1.00	1.00	507.	74.	67.	3.0	246.	56.
	110.0	1123	256.250	.050	.62	.62	518.	75.	68.	3.0	253.	55.
	120.0	1133	260.606	.050	.62	.62	533.	76.	69.	3.0	258.	52.
TOTALS	120.0		55.803									
AVERAGE					.72	.72	537.	70.	63.	2.5	258.	51.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS

REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER

BRUFFEY

TEST 7-2 NO.1 COKE BATTERY OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/30/81	10/30/81
TB	TIME-START	933	933
TF	TIME-FINISH	1133	1133
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.044	1.044
DN	SAMPLING NOZZLE DIAMETER	.377 IN	9.6 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.72 IN-H2O	18.3 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	55.803 CU-FT	1.580 CU-M
TM	AVERAGE GAS METER TEMP	66.5 F	19.1 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	58.552 SCF	1.658 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	181.8	181.8
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.557 SCF	.242 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.75	12.75
FMD	MOLE FRACTION DRY GAS	.872	.872
PCO2	PERCENT CO2 BY VOL., DRY	4.00	4.00
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.00	85.00
MD	MOLECULAR WT-DRY STACK GAS	29.08	29.08
MWS	MOLECULAR WT-STACK GAS	27.67	27.67

PB	BAROMETRIC PRESSURE	29.93	IN-HG	760.22	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.84	IN-HG	757.98	MM-HG
TS	AVERAGE STACK TEMP	537.	F	280.	C
VS	AVG STACK GAS VELOCITY	19.0	FPS	5.8	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1633313.	SCFH	46251.	SCMH
QS	ACTUAL STACK FLOW RATE	3543545.	ACFH	100343.	ACMH
ISO	PERCENT ISOKINETIC	119.9		119.9	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 7-2

NO.1 COKE BATTERY OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 59.803 * 1.044 * (29.93 + .721 / 13.6)}{(66. + 460.)} = 58.552 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 182. = 8.56 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.56}{58.552 + 8.56} = 12.75 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.8}{100.} = .872$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.00*44/100) + (11.0*32/100) + ((85.0+ .0) * 28/100 = 29.08

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.08* (1. -(12.75/100)) + 18. * (12.75/100) = 27.67

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 91.155 / (SQRT(27.67 * 29.84) * 12. = 18.98 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 18.98 * 7466. 3600/144 = 3543545. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3543545. * 29.84 * (1. - (12.75/100))}{(537. + 460.)} = 1633313. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(537.+460.))*((0.002669*182.)+(55.803*1.044*(29.93+(.721/13.6))/(66.+460.)))}{120. * 18.98 * 29.84 * .377 * .377} = 119.90 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 58.552 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1633313. / (15.43 * 453.6) = .00

Run No. 7.2

Sample volume = 1.66 m^3, 58.55 scf

Example calculations

CS (Part) = 187.1 / 1.66 = 112.7 mg/m^3

CS (Part) = 0.001 x 187.1 x 15.43/ 58.55 = 0.099 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	187.1	112.7	0.049	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/30/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	7-3
SAMPLE TYPE	7-3-M8-350	PROBE LENGTH & TYPE	9FT GLASS HEATED
OPERATOR	CLARKE	NOZZLE I.D.	.394
AMBIENT TEMP.(DEG.F)	52.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	27.92	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB1
FILTER NUMBER(S)	3530079	METER HEAD DIFF.	1.27
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.		HEATER BOX SETTING	350.
LEAKAGE	.000 CFM @ 3.0 IN.HG	REFERENCE PRESS. DIFF.	1.50
METER CALIB. FACTOR	.992		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	930	726.791									
	10.0	940	731.350	.060	.72	.72	516.	56.	52.	2.0	335.	44.
	20.0	950	736.370	.060	.72	.72	536.	58.	52.	2.0	386.	44.
	30.0	1000	741.183	.060	.72	.72	550.	63.	52.	2.0	326.	46.
	40.0	1010	746.020	.070	.87	.87	503.	66.	52.	2.0	346.	48.
	50.0	1020	750.170	.050	.62	.62	507.	69.	56.	2.0	403.	50.
	60.0	1030	757.675	.050	.62	.62	540.	70.	56.	2.0	396.	54.
	70.0	1040	760.025	.070	.87	.87	536.	72.	58.	2.0	376.	54.
	80.0	1050	764.303	.050	.62	.62	565.	73.	59.	2.0	382.	52.
	90.0	1100	766.910	.050	.62	.62	562.	74.	60.	2.0	319.	52.
	100.0	1110	774.160	.080	.99	.99	505.	74.	62.	2.0	331.	50.
	110.0	1120	778.537	.050	.62	.62	516.	74.	63.	2.0	339.	50.
	120.0	1130	782.703	.050	.62	.62	528.	77.	64.	2.0	357.	52.
TOTALS	120.0		55.912									
AVERAGE					.72	.72	530.	69.	57.	2.0	358.	50.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER: CLARKE

TEST 7-3 COKE OVEN OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/30/81	10/30/81
TB	TIME-START	930	930
TF	TIME-FINISH	1130	1130
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.992	.992
DN	SAMPLING NOZZLE DIAMETER	.394 IN	10.0 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.72 IN-H2O	18.2 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	55.912 CU-FT	1.583 CU-M
TM	AVERAGE GAS METER TEMP	63.0 F	17.2 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	52.351 SCF	1.482 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	171.9	171.9
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.091 SCF	.229 SCM
BWO	PERCENT MOISTURE BY VOLUME	13.39	13.39
FMD	MOLE FRACTION DRY GAS	.866	.866
PCO2	PERCENT CO2 BY VOL., DRY	4.00	4.00
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.00	85.00
MD	MOLECULAR WT-DRY STACK GAS	29.08	29.08
MWS	MOLECULAR WT-STACK GAS	27.60	27.60

PB	BAROMETRIC PRESSURE	27.92	IN-HG	709.17	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	27.83	IN-HG	706.93	MM-HG
TS	AVERAGE STACK TEMP	530.	F	277.	C
VS	AVG STACK GAS VELOCITY	19.6	FPS	6.0	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1573041.	SCFH	44544.	SCMH
QS	ACTUAL STACK FLOW RATE	3662069.	ACFH	103699.	ACMH
ISO	PERCENT ISOKINETIC	101.9		101.9	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 7-3

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 55.912 * .992 * (27.92 + .718 / 13.6)}{(63. + 460.)} = 52.351 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 172. = 8.09 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.09}{52.351 + 8.09} = 13.39 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.4}{100.} = .866$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.00*44/100) + (11.0*32/100) + ((85.0+ .0) * 28/100 = 29.08

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.08* (1. -(13.39/100)) + 18. * (13.39/100) = 27.60

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 90.860 / (SQRT(27.60 * 27.83) * 12. = 19.62 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 19.62 * 7466. 3600/144 = 3662069. ACFM

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3662069. * 27.83 * (1. - (13.39/100))}{(530. + 460.)} = 1573041.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(530.+460.))*((0.002669*172.)+(55.912*.992*(27.92+(.718/13.6))/(63.+460.)))}{120. * 19.62 * 27.83 * .394 * .394} = 101.91\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 92.351 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1573041. / (15.43 * 453.6) = .00

Run No. 7.3

Sample volume = 1.48 m^3, 52.35 scf

Example calculations

CS (Part) = 64.8 / 1.48 = 43.8 mg/m^3

CS (Part) = 0.001 x 64.8 x 15.43/ 52.35 = 0.019 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/ ____ = ____ ppm

= 0.001 x ____ x 15.43/ ____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	64.8	43.8	0.019	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/30/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	7-4
SAMPLE TYPE	7-4-M5-350	PROBE LENGTH & TYPE	6 FT GLASS HEATED
OPERATOR	CLARKE	NOZZLE I.D.	.397
AMBIENT TEMP.(DEG.F)	52.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.92	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB5
FILTER NUMBER(S)	353005$	METER HEAD DIFF.	1.86
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.		HEATER BOX SETTING	350.
LEAKAGE	.015 CFM @ 3.0 IN.HG	REFERENCE PRESS. DIFF.	1.50
METER CALIB. FACTOR	1.016		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	933	142.828									
	10.0	943	147.074	.060	.72	.72	528.	60.	60.	1.0	348.	36.
	20.0	953	151.900	.060	.72	.72	541.	61.	60.	1.0	390.	34.
	30.0	1003	156.405	.060	.72	.72	557.	65.	60.	1.0	332.	32.
	40.0	1013	161.801	.070	.87	.87	504.	67.	61.	1.0	346.	36.
	50.0	1023	165.595	.050	.62	.62	528.	71.	62.	1.0	369.	40.
	60.0	1033	170.186	.050	.62	.62	544.	72.	65.	1.0	350.	44.
	70.0	1043	175.043	.070	.87	.87	547.	76.	68.	1.0	342.	43.
	80.0	1053	177.365	.050	.62	.62	564.	78.	70.	1.0	340.	44.
	90.0	1103	183.575	.050	.62	.62	564.	78.	70.	1.0	349.	46.
	100.0	1113	188.728	.080	.99	.99	507.	78.	71.	1.0	350.	42.
	110.0	1123	193.253	.050	.62	.62	518.	80.	72.	1.0	366.	44.
	120.0	1133	197.533	.050	.62	.62	531.	81.	73.	1.0	354.	46.
TOTALS	120.0		54.705									
AVERAGE					.72	.72	536.	72.	66.	1.0	353.	41.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER: CLARKE

TEST 7-4 COKE OVEN OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/30/81	10/30/81
TB	TIME-START	933	933
TF	TIME-FINISH	1133	1133
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.016	1.016
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.72 IN-H2O	18.2 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	54.705 CU-FT	1.549 CU-M
TM	AVERAGE GAS METER TEMP	69.1 F	20.6 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	55.560 SCF	1.573 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	168.1	168.1
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.912 SCF	.224 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.47	12.47
FMD	MOLE FRACTION DRY GAS	.875	.875
PCO2	PERCENT CO2 BY VOL., DRY	4.00	4.00
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.00	85.00
MD	MOLECULAR WT-DRY STACK GAS	29.08	29.08
MWS	MOLECULAR WT-STACK GAS	27.70	27.70

PB	BAROMETRIC PRESSURE	29.92	IN-HG	759.97	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.83	IN-HG	757.73	MM-HG
TS	AVERAGE STACK TEMP	536.	F	280.	C
VS	AVG STACK GAS VELOCITY	19.0	FPS	5.8	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1638107.	SCFH	46386.	SCMH
QS	ACTUAL STACK FLOW RATE	3540882.	ACFH	100267.	ACMH
ISO	PERCENT ISOKINETIC	102.3		102.3	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 7-4

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 54.705 * 1.016 * (29.92 + .718 / 13.6)}{(69. + 460.)} = 55.560 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 168. = 7.91 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.91}{55.560 + 7.91} = 12.47 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.5}{100.} = .875$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.00*44/100) + (11.0*32/100) + ((85.0+ .0) * 28/100 = 29.08

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.08* (1. -(12.47/100)) + 18. * (12.47/100) = 27.70

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 91.123 / (SQRT(27.70 * 29.83) * 12. = 18.97 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 18.97 * 7466. 3600/144 = 3540882. ACFM

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3540882. * 29.83 * (1. - (12.47/100))}{(536. + 460.)} = 1638107.\ SCFM$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(536.+460.))*((0.002669*168.)+(54.705*1.016*(29.92+(.718/13.6))/(69.+460.)))}{120. * 18.97 * 29.83 * .397 * .397} = 102.29\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 55.560 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1638107. / (15.43 * 453.6) = .00

Run No. 7.4

Sample volume = 1.57 m^3, 55.56 scf

Example calculations

CS (Part) = 62.6 / 1.57 = 39.9 mg/m^3

CS (Part) = 0.001 x 62.6 x 15.43/55.56 = 0.017 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	62.6	39.9	0.017	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/30/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	7-5
SAMPLE TYPE	METHOD 5-400	PROBE LENGTH & TYPE	6' GLASS
OPERATOR	DO/MP	NOZZLE # I.D.	.374
AMBIENT TEMP.(DEG.F)	50.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.92	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB4
FILTER NUMBER(S)	3530035	METER HEAD DIFF.	1.88
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.92
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.018 CFM @ 12.0 IN.HG	REFERENCE PRESS. DIFF.	.18
METER CALIB. FACTOR	1.033		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	935	966.353									
	10.0	945	971.030	.070	.72	.72	520.	53.	53.	10.5	367.	44.
	20.0	955	975.680	.070	.72	.72	520.	57.	54.	10.4	383.	46.
	30.0	1005	980.370	.070	.72	.72	520.	61.	56.	10.8	388.	42.
	40.0	1015	985.090	.070	.72	.72	520.	65.	59.	11.1	385.	44.
	50.0	1025	989.790	.070	.72	.72	520.	69.	61.	11.1	388.	46.
	60.0	1035	994.490	.070	.72	.72	520.	71.	64.	11.0	388.	42.
	70.0	1045	999.250	.070	.72	.72	520.	74.	66.	11.2	386.	44.
	80.0	1055	3.950	.070	.72	.72	520.	76.	69.	10.9	380.	46.
	90.0	1105	8.670	.070	.72	.72	520.	76.	70.	11.2	389.	44.
	100.0	1115	13.430	.070	.72	.72	520.	77.	72.	11.2	385.	50.
	110.0	1125	18.170	.070	.72	.72	520.	77.	73.	11.0	391.	50.
	120.0	1135	22.890	.070	.72	.72	520.	78.	74.	11.0	394.	56.
TOTALS	120.0		56.537									
AVERAGE					.72	.72	520.	70.	64.	10.9	385.	46.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER: DO/MP

TEST 7-5 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/30/81	10/30/81
TB	TIME-START	935	935
TF	TIME-FINISH	1135	1135
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.033	1.033
DN	SAMPLING NOZZLE DIAMETER	.374 IN	9.5 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.72 IN-H2O	18.3 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	56.537 CU-FT	1.601 CU-M
TM	AVERAGE GAS METER TEMP	66.9 F	19.4 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	58.631 SCF	1.660 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	189.1	189.1
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.901 SCF	.252 SCM
BWO	PERCENT MOISTURE BY VOLUME	13.18	13.18
FMD	MOLE FRACTION DRY GAS	.868	.868
PCO2	PERCENT CO2 BY VOL., DRY	4.00	4.00
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.00	85.00
MD	MOLECULAR WT-DRY STACK GAS	29.08	29.08
MWS	MOLECULAR WT-STACK GAS	27.62	27.62

PB	BAROMETRIC PRESSURE	29.92	IN-HG	759.97	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.83	IN-HG	757.73	MM-HG
TS	AVERAGE STACK TEMP	520.	F	271.	C
VS	AVG STACK GAS VELOCITY	20.7	FPS	6.3	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1803803.	SCFH	51078.	SCMH
QS	ACTUAL STACK FLOW RATE	3867652.	ACFH	109520.	ACMH
ISO	PERCENT ISOKINETIC	110.5		110.5	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 7-5

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 56.537 * 1.033 * (29.92 + .720 / 13.6)}{(67. + 460.)} = 58.631 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 189. = 8.90 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.90}{58.631 + 8.90} = 13.18 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.2}{100.} = .868$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.00*44/100) + (11.0*32/100) + ((85.0+ .0) * 28/100 = 29.08

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.08* (1. -(13.18/100)) + 18. * (13.18/100) = 27.62

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 99.390 / (SQRT(27.62 * 29.83) * 12. = 20.72 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 20.72 * 7466. 3600/144 = 3867652. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3867652. * 29.83 * (1. - (13.18/100))}{(520. + 460.)} = 1803803.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(520.+460.))*((0.002669*189.)+(56.537*1.033*(29.92+(.720/13.6))/(67.+460.)))}{120. * 20.72 * 29.83 * .374 * .374} = 110.46\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 58.631 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1803803. / (15.43 * 453.6) = .00

Run No. 7.5

Sample volume = 1.66 m^3, 58.63 scf

Example calculations

CS (Part) = 40.2/ 1.66= 24.2 mg/m^3

CS (Part) = 0.001 x 40.2 x 15.43/58.63 = 0.010 gr/dscf

CS (SO_2) = ____ /____ = ____ mg/m^3

= ____ x 24.06/___ = ___ ppm

= 0.001 x ____ x 15.43/_____ = _____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at: Ambient 2-h at 350°F 4-h at 350°F 2-h at 400°F 4-h at 400°F 2-h at 600°F	40.2	24.2	0.010	
Acid sulfates As H_2SO_4 As $H_2SO_4 \cdot 2H_2O$				
Sulfur dioxide				
Sulfuric acid mist As H_2SO_4 As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/30/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	7-6
SAMPLE TYPE	METHOD 8-600	PROBE LENGTH & TYPE	4' QUARTZ
OPERATOR	DO/MP	NOZZLE : I.D.	.590
AMBIENT TEMP.(DEG.F)	50.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.92	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F88
FILTER NUMBER(S)	3530215	METER HEAD DIFF.	1.91
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.94
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 8.0 IN.HG	REFERENCE PRESS. DIFF.	.03
METER CALIB. FACTOR	.982		
READ & RECORD DATA EVERY 10.0 MINUTES			

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	934	421.124									
	10.0	944	425.840	.070	4.42	.75	520.	47.	46.	3.1	615.	38.
	20.0	954	430.480	.070	4.42	.75	520.	52.	47.	3.2	601.	40.
	30.0	1004	435.190	.070	4.42	.75	520.	57.	49.	3.7	593.	40.
	40.0	1014	439.950	.070	4.42	.75	520.	62.	51.	4.0	586.	46.
	50.0	1024	444.670	.070	4.42	.75	520.	65.	53.	4.2	585.	52.
	60.0	1034	449.400	.070	4.42	.75	520.	68.	56.	4.2	577.	44.
	70.0	1044	454.130	.070	4.42	.75	520.	69.	58.	4.3	574.	44.
	80.0	1054	458.820	.070	4.42	.75	520.	70.	60.	5.2	569.	40.
	90.0	1104	463.510	.070	4.42	.75	520.	70.	61.	6.3	571.	40.
	100.0	1114	468.200	.070	4.42	.75	520.	72.	63.	7.3	587.	44.
	110.0	1124	472.970	.070	4.42	.75	520.	73.	63.	7.7	590.	44.
	120.0	1134	477.838	.070	4.42	.75	520.	74.	65.	7.9	594.	46.
TOTALS	120.0		56.714									
AVERAGE					4.42	.75	520.	65.	56.	5.1	587.	43.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — DO/MP

TEST 7-6 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/30/81	10/30/81
TB	TIME-START	934	934
TF	TIME-FINISH	1134	1134
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.982	.982
DN	SAMPLING NOZZLE DIAMETER	.590 IN	15.0 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.75 IN-H2O	19.1 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	56.714 CU-FT	1.606 CU-M
TM	AVERAGE GAS METER TEMP	60.5 F	15.8 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	56.604 SCF	1.603 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL, ML.	180.3	180.3
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.487 SCF	.240 SCM
BWO	PERCENT MOISTURE BY VOLUME	13.04	13.04
FMD	MOLE FRACTION DRY GAS	.870	.870
PCO2	PERCENT CO2 BY VOL., DRY	4.00	4.00
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.00	85.00
MO	MOLECULAR WT-DRY STACK GAS	29.08	29.08
MWS	MOLECULAR WT-STACK GAS	27.64	27.64

PB	BAROMETRIC PRESSURE	29.92	IN-HG	759.97	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.83	IN-HG	757.73	MM-HG
TS	AVERAGE STACK TEMP	520.	F	271.	C
VS	AVG STACK GAS VELOCITY	20.7	FPS	6.3	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1806240.	SCFH	51147.	SCMH
QS	ACTUAL STACK FLOW RATE	3866549.	ACFH	109489.	ACMH
ISO	PERCENT ISOKINETIC	42.8		42.8	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 7-6

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 56.714 * .982 * (29.92 + .750 / 13.6)}{(60. + 460.)} = 56.604 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 180. = 8.49 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.49}{56.604 + 8.49} = 13.04 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.0}{100.} = .870$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.00*44/100) + (11.0*32/100) + ((85.0+ .0) * 28/100 = 29.08

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.08* (1. -(13.04/100)) + 18. * (13.04/100) = 27.64

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 99.390 / (SQRT(27.64 * 29.83) * 12. = 20.71 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 20.71 * 7466. 3600/144 = 3866549. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3866549. * 29.83 * (1. - (13.04/100))}{(520. + 460.)} = 1806240. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(520.+460.))*[(0.002669* 180.)+(56.714* .982*[29.92+(.750/13.6))/(60.+460.)))}{120. * 20.71 * 29.83 * .590 * .590} = 42.79 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 56.604 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1806240. / (15.43 * 453.6) = .00

Run No. 7.6

Sample volume = 1.60 m^3, 56.60 scf

Example calculations

CS (Part) = 24.3 / 1.60 = 15.2 mg/m^3

CS (Part) = 0.001 x 24.3 x 15.43/ 56.60 = 0.007 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	24.3	15.2	0.007	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/30/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	8-1
SAMPLE TYPE	8-3-M8-350	PROBE LENGTH & TYPE	4 FT GLASS HEATED
OPERATOR	CLARKE	NOZZLE I.D.	.378
AMBIENT TEMP.(DEG.F)	65.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.93	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F81
FILTER NUMBER(S)	3530061	METER HEAD DIFF.	1.87
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.		HEATER BOX SETTING	350.
LEAKAGE	.000 CFM @ 3.0 IN.HG	REFERENCE PRESS. DIFF.	1.50
METER CALIB. FACTOR	.992		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1438	783.033									
	10.0	1448	787.530	.050	.62	.62	540.	75.	70.	2.0	319.	56.
	20.0	1458	792.020	.050	.62	.62	558.	76.	69.	2.0	347.	56.
	30.0	1508	796.760	.060	.73	.73	570.	80.	70.	2.0	320.	56.
	40.0	1518	801.150	.050	.62	.62	519.	82.	71.	3.0	332.	58.
	50.0	1528	805.468	.050	.62	.62	530.	83.	72.	2.0	289.	60.
	60.0	1538	810.000	.050	.62	.62	537.	84.	72.	2.0	298.	58.
	70.0	1548	814.800	.060	.73	.73	542.	86.	73.	2.0	314.	58.
	80.0	1608	819.987	.070	.87	.87	559.	86.	74.	2.0	342.	58.
	90.0	1618	824.901	.060	.73	.73	575.	86.	74.	2.0	351.	58.
	100.0	1628	829.699	.060	.73	.73	526.	86.	74.	3.0	351.	58.
	110.0	1638	834.999	.070	.87	.87	536.	86.	74.	3.0	365.	57.
	120.0	1648[a]	840.297	.070	.87	.87	546.	86.	74.	3.0	359.	58.
TOTALS	120.0		57.264									
AVERAGE					.72	.72	545.	83.	72.	2.3	332.	58.

[a]Final time should be 1638.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS

REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER

CLARKE

TEST 8-1 COKE OVEN OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/30/81	10/30/81
TB	TIME-START	1438	1438
TF	TIME-FINISH	1648	1648
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.992	.992
DN	SAMPLING NOZZLE DIAMETER	.378 IN	9.6 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.72 IN-H2O	18.3 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	57.264 CU-FT	1.622 CU-M
TM	AVERAGE GAS METER TEMP	77.6 F	25.3 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	55.906 SCF	1.583 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	199.8	199.8
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	9.405 SCF	.266 SCM
BWO	PERCENT MOISTURE BY VOLUME	14.40	14.40
FMD	MOLE FRACTION DRY GAS	.856	.856
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	9.30	9.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	86.40	86.40
MD	MOLECULAR WT-DRY STACK GAS	29.06	29.06
MWS	MOLECULAR WT-STACK GAS	27.47	27.47

PB	BAROMETRIC PRESSURE	29.93	IN-HG	760.22	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.84	IN-HG	757.98	MM-HG
TS	AVERAGE STACK TEMP	545.	F	285.	C
VS	AVG STACK GAS VELOCITY	19.2	FPS	5.8	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1604520.	SCFH	45435.	SCMH
QS	ACTUAL STACK FLOW RATE	3576587.	ACFH	101278.	ACMH
ISO	PERCENT ISOKINETIC	115.9		115.9	
MN	FILTERABLE PART MG, EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 8-1

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 57.264 * .992 * (29.93 + .719 / 13.6)}{(78. + 460.)} = 55.906 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 200. = 9.40 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 9.40}{55.906 + 9.40} = 14.40 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 14.4}{100.} = .856$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (9.3*32/100) + ((86.4+ .0) * 28/100 = 29.06

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.06* (1. -(14.40/100)) + 18. * (14.40/100) = 27.47

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 91.672 / (SQRT(27.47 * 29.84) * 12. = 19.16 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 19.16 * 7466. 3600/144 = 3576587. ACFM

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3576587. * 29.84 * (1. - (14.40/100))}{(545. + 460.)} = 1604520.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VH*Y*(PS+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(545.+460.))*((0.002669* 200.)+(57.264* .992*(29.93+(.719/13.6))/(78.+460.)))}{120. * 19.16 * 29.84 * .378 * .378} = 115.92\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 55.906 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1604520. / (15.43 * 453.6) = .00

Run No. 8.1

Sample volume = 1.58 m^3, 55.91 scf

Example calculations

CS (Part) = 65.3/1.58 = 41.3 mg/m^3

CS (Part) = 0.001 x 65.3 x 15.43/ 55.91 = 0.018 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	65.3	41.3	0.018	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/30/81
SAMPLING LOCATION	COKE OVEN OUTLET	RUN NUMBER	8-2
SAMPLE TYPE	8-2-M5-350	PROBE LENGTH & TYPE	5 FT GLASS HEATED
OPERATOR	CLARKE	NOZZLE : I.D.	.397
AMBIENT TEMP.(DEG.F)	65.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.93	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F85
FILTER NUMBER(S)	3530034	METER HEAD DIFF.	1.86
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.88
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.		HEATER BOX SETTING	350.
LEAKAGE	.000 CFM @ 3.0 IN.HG	REFERENCE PRESS. DIFF.	1.50
METER CALIB. FACTOR	1.016		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1441	197.754									
	10.0	1451	202.330	.050	.62	.62	540.	85.	84.	1.0	338.	50.
	20.0	1501	206.710	.050	.62	.62	559.	85.	84.	1.0	364.	48.
	30.0	1511	211.485	.060	.73	.73	570.	87.	84.	1.0	343.	46.
	40.0	1521	215.873	.050	.62	.62	521.	89.	84.	1.0	338.	46.
	50.0	1531	220.536	.050	.62	.62	529.	90.	84.	1.0	315.	46.
	60.0	1541	224.460	.050	.62	.62	540.	91.	84.	1.0	319.	44.
	70.0	1551	229.315	.060	.73	.73	546.	90.	84.	1.0	305.	46.
	80.0	1601	234.210	.070	.87	.87	563.	90.	83.	1.0	319.	44.
	90.0	1611	238.500	.060	.73	.73	518.	91.	83.	1.0	329.	46.
	100.0	1621	243.000	.060	.73	.73	529.	90.	83.	1.0	346.	44.
	110.0	1631	248.026	.070	.87	.87	540.	90.	83.	1.0	361.	44.
	120.0	1641	253.000	.070	.87	.87	547.	90.	83.	1.0	352.	45.
TOTALS	120.0		55.246									
AVERAGE					.72	.72	542.	89.	84.	1.0	336.	46.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS | TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND | CLARKE

TEST 8-2 COKE OVEN OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/30/81	10/30/81
TB	TIME-START	1441	1441
TF	TIME-FINISH	1641	1641
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.016	1.016
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.72 IN-H2O	18.3 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	55.246 CU-FT	1.564 CU-M
TM	AVERAGE GAS METER TEMP	86.3 F	30.2 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	54.364 SCF	1.539 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	206.2	206.2
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	9.706 SCF	.275 SCM
BWO	PERCENT MOISTURE BY VOLUME	15.15	15.15
FMD	MOLE FRACTION DRY GAS	.849	.849
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	9.30	9.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	86.40	86.40
MD	MOLECULAR WT-DRY STACK GAS	29.06	29.06
MWS	MOLECULAR WT-STACK GAS	27.38	27.38

PB	BAROMETRIC PRESSURE	29.93	IN-HG	760.22	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.84	IN-HG	757.98	MM-HG
TS	AVERAGE STACK TEMP	542.	F	283.	C
VS	AVG STACK GAS VELOCITY	19.2	FPS	5.8	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1595254.	SCFH	45173.	SCMH
QS	ACTUAL STACK FLOW RATE	3576610.	ACFH	101279.	ACMH
ISO	PERCENT ISOKINETIC	102.8		102.8	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 8-2

COKE OVEN OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 55.246 * 1.016 * (29.93 + .719 / 13.6)}{(86. + 460.)} = 54.364 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 206. = 9.71 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 9.71}{54.364 + 9.71} = 15.15 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 15.1}{100.} = .849$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (9.3*32/100) + ((86.4+ .0) * 28/100 = 29.06

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.06* (1. -(15.15/100)) + 18. * (15.15/100) = 27.38

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 91.534 / (SQRT(27.38 * 29.84) * 12. = 19.16 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 19.16 * 7866. 3600/144 = 3576610. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3576610. * 29.84 * (1. - (15.15/100))}{(542. + 460.)} = 1595254. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(542.+460.))*((0.002669*206.)+(55.246*1.016*(29.93+(.719/13.6))/(86.+460.)))}{120. * 19.16 * 29.84 * .397 * .397} = 102.78 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 54.364 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1595254. / (15.43 * 453.6) = .00

Run No. 8.2

Sample volume = 1.54 m^3, 54.36 scf

Example calculations

CS (Part) = 76.0 / 1.54 = 49.4 mg/m^3

CS (Part) = 0.001 x 76.0 x 15.43/54.36 = 0.022 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	76.0	49.4	0.022	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/30/81
SAMPLING LOCATION	NO.1 COKE BATTERY OUTLET	RUN NUMBER	8-3
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	5' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE : I.D.	.397
AMBIENT TEMP.(DEG.F)	78.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.93	SAMPLE BOX NUMBER	8
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB2
FILTER NUMBER(S)	3530120	METER HEAD DIFF.	1.76
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.		HEATER BOX SETTING	350.
LEAKAGE	.000 CFM @ 5.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.003		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1438	48.689									
	10.0	1448	53.490	.050	.62	.62	540.	76.	74.	2.0	354.	49.
	20.0	1458	58.200	.050	.62	.62	558.	77.	75.	2.0	376.	52.
	30.0	1508	63.360	.060	.73	.73	570.	81.	76.	2.0	388.	55.
	40.0	1518	68.090	.050	.62	.62	519.	83.	77.	2.5	387.	56.
	50.0	1528	72.820	.050	.62	.62	530.	85.	78.	2.5	367.	57.
	60.0	1538	77.640	.050	.62	.62	537.	86.	79.	3.0	368.	59.
	70.0	1548	82.800	.060	.73	.73	543.	87.	80.	3.0	387.	61.
	80.0	1558	88.390	.070	.87	.87	599.	88.	80.	3.0	400.	60.
	90.0	1608	93.580	.060	.73	.73	575.	89.	81.	4.5	406.	66.
	100.0	1618	98.790	.060	.73	.73	527.	88.	82.	4.5	404.	69.
	110.0	1628	104.320	.070	.87	.87	538.	87.	82.	4.5	408.	67.
	120.0	1638	109.886	.070	.87	.87	545.	87.	81.	4.0	409.	65.
TOTALS	120.0		61.197									
AVERAGE					.72	.72	545.	85.	79.	3.1	388.	60.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS | TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND | BRUFFEY

TEST 8-3 NO.1 COKE BATTERY OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/30/81	10/30/81
TB	TIME-START	1438	1438
TF	TIME-FINISH	1638	1638
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.003	1.003
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.72 IN-H2O	18.3 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	61.197 CU-FT	1.733 CU-M
TM	AVERAGE GAS METER TEMP	81.6 F	27.6 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	59.962 SCF	1.698 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	189.4	189.4
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.915 SCF	.252 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.94	12.94
FMD	MOLE FRACTION DRY GAS	.871	.871
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	9.30	9.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	86.40	86.40
MD	MOLECULAR WT-DRY STACK GAS	29.06	29.06
MWS	MOLECULAR WT-STACK GAS	27.63	27.63

PB	BAROMETRIC PRESSURE	29.93	IN-HG	760.22	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.84	IN-HG	757.98	MM-HG
TS	AVERAGE STACK TEMP	545.	F	285.	C
VS	AVG STACK GAS VELOCITY	19.1	FPS	5.8	MPS
AS	STACK AREA	7486.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1626862.	SCFH	46068.	SCMH
QS	ACTUAL STACK FLOW RATE	3566612.	ACFH	100996.	ACMH
ISO	PERCENT ISOKINETIC	111.2		111.2	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 8-3

NO.1 COKE BATTERY OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 61.197 * 1.003 * (29.93 + .719 / 13.6)}{(82. + 460.)} = 59.962 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 189. = 8.92 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.92}{59.962 + 8.92} = 12.94 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.9}{100.} = .871$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.3*44/100) + (9.3*32/100) + ((86.4+ .0) * 28/100 = 29.06

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.06* (1. -(12.94/100)) + 18. * (12.94/100) = 27.63

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 91.684 / (SQRT(27.63 * 29.84) * 12. = 19.11 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 19.11 * 7466. 3600/144 = 3566612. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3566612. * 29.84 * (1. - (12.94/100))}{(545. + 460.)} = 1626862. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(545.+460.))*((0.002669* 189.)+(61.197*1.003*(29.93+(.719/13.6))/(82.+460.)))}{120. * 19.11 * 29.84 * .397 * .397} = 111.16 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 59.962 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1626862. / (15.43 * 453.6) = .00

Run No. 8.3

Sample volume = 1.70 m^3, 59.96 scf

Example calculations

CS (Part) = 66.1 / 1.70 = 38.9 mg/m^3

CS (Part) = 0.001 x 66.1 x 15.43/59.96 = 0.017 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	66.1	38.9	0.017	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/30/81
SAMPLING LOCATION	NO.1 COKE BATTERY OUTLET	RUN NUMBER	8-4
SAMPLE TYPE	PART	PROBE LENGTH & TYPE	4' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE # I.D.	.397
AMBIENT TEMP.(DEG.F)	78.	ASSUMED MOISTURE	12.0
BAR.PRESS.(IN.HG)	29.93	SAMPLE BOX NUMBER	0
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F10
FILTER NUMBER(S)	3530117	METER HEAD DIFF.	1.80
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.		HEATER BOX SETTING	350.
LEAKAGE	.250 CFM @ 5.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.044		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1441	260.898									
	10.0	1451	265.580	.050	.62	.62	540.	90.	90.	1.0	392.	52.
	20.0	1501	269.920	.050	.62	.62	558.	91.	91.	1.5	398.	53.
	30.0	1510	274.780	.060	.73	.73	564.	94.	92.	2.0	406.	55.
	40.0	1520	279.070	.050	.62	.62	525.	96.	92.	2.0	348.	57.
	50.0	1531	283.450	.050	.62	.62	530.	97.	93.	2.0	359.	56.
	60.0	1541	287.830	.050	.62	.62	540.	97.	93.	3.0	377.	59.
	70.0	1551	292.580	.060	.73	.73	547.	97.	93.	4.0	403.	60.
	80.0	1601	297.760	.070	.87	.87	564.	78.	94.	4.5	413.	64.
	90.0	1611	302.530	.060	.73	.73	580.	97.	93.	4.0	404.	66.
	100.0	1621	307.200	.060	.73	.73	529.	97.	93.	4.5	406.	68.
	110.0	1631	312.460	.070	.87	.87	544.	97.	93.	5.0	405.	66.
	120.0	1641	317.529	.070	.87	.87	547.	96.	92.	5.0	407.	64.
TOTALS	120.0		56.631									
AVERAGE					.72	.72	547.	94.	92.	3.2	393.	60.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER: BRUFFEY

TEST 8-4 NO.1 COKE BATTERY OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/30/81	10/30/81
TB	TIME-START	1441	1441
TF	TIME-FINISH	1641	1641
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.044	1.044
DN	SAMPLING NOZZLE DIAMETER	.397 IN	10.1 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.72 IN-H2O	18.3 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	56.631 CU-FT	1.604 CU-M
TM	AVERAGE GAS METER TEMP	93.2 F	34.0 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	56.551 SCF	1.601 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL, ML.	191.3	191.3
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	9.004 SCF	.255 SCM
BWO	PERCENT MOISTURE BY VOLUME	13.74	13.74
FMD	MOLE FRACTION DRY GAS	.863	.863
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	9.30	9.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	86.40	86.40
MD	MOLECULAR WT-DRY STACK GAS	29.06	29.06
MWS	MOLECULAR WT-STACK GAS	27.54	27.54

PB	BAROMETRIC PRESSURE	29.93	IN-HG	760.22	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.84	IN-HG	757.98	MM-HG
TS	AVERAGE STACK TEMP	547.	F	286.	C
VS	AVG STACK GAS VELOCITY	19.2	FPS	5.8	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1612867.	SCFH	45672.	SCMH
QS	ACTUAL STACK FLOW RATE	3576390.	ACFH	101273.	ACMH
ISO	PERCENT ISOKINETIC	105.8		105.8	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 8-4

NO.1 COKE BATTERY OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 56.631 * 1.044 * (29.93 + .719 / 13.6)}{(93. + 460.)} = 56.551 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 191. = 9.00 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 9.00}{56.551 + 9.00} = 13.74 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.7}{100.} = .863$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (9.3*32/100) + ((86.4+ .0) * 28/100 = 29.06

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.06* (1. -(13.74/100)) + 18. * (13.74/100) = 27.54

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 91.790 / (SQRT(27.54 * 29.84) * 12. = 19.16 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 19.16 * 7466. 3600/144 = 3576390. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3576390. * 29.84 * (1. - (13.74/100))}{(547. + 460.)} = 1612867. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(547.+460.))*((0.002669* 191.)+(56.651*1.044*(29.93+(.719/13.6))/(93.+460.)))}{120. * 19.16 * 29.84 * .397 * .397} = 105.75 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 56.551 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1612867. / (15.43 * 453.6) = .00

Run No. 8.4

Sample volume = 1.60 m^3, 56.55 scf

Example calculations

CS (Part) = 60.5 / 1.60 = 37.8 mg/m^3

CS (Part) = 0.001 x 60.5 x 15.43/56.55 = 0.016 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	60.5	37.8	0.016	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/30/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	8-5
SAMPLE TYPE	METHOD 5-250	PROBE LENGTH & TYPE	6' GLASS
OPERATOR	DD/MP	NOZZLE I.D.	.374
AMBIENT TEMP.(DEG.F)	67.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.93	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB4
FILTER NUMBER(S)	3530008	METER HEAD DIFF.	1.88
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.92
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.020 CFM @ 15.5 IN.HG	REFERENCE PRESS. DIFF.	.18
METER CALIB. FACTOR	1.033		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1439	23.414									
	10.0	1449	28.150	.070	.72	.72	520.	70.	70.	10.9	259.	49.
	20.0	1459	32.880	.070	.72	.72	520.	72.	70.	10.5	270.	47.
	30.0	1509	37.600	.070	.72	.72	520.	73.	70.	10.4	273.	47.
	40.0	1519	42.320	.070	.72	.72	520.	75.	71.	10.4	270.	48.
	50.0	1529	47.040	.070	.72	.72	520.	76.	71.	10.4	267.	52.
	60.0	1539	51.740	.070	.72	.72	520.	76.	71.	10.4	268.	52.
	70.0	1549	56.440	.070	.72	.72	520.	77.	71.	10.7	268.	57.
	80.0	1559	61.150	.070	.72	.72	520.	77.	72.	10.9	266.	53.
	90.0	1609	65.860	.070	.72	.72	520.	78.	73.	11.7	268.	52.
	100.0	1619	70.550	.070	.72	.72	520.	78.	73.	13.1	270.	52.
	104.2	1623	72.492	.070	.72	.72	520.	78.	73.	15.5	264.	53.
TOTALS	104.2		49.078									
AVERAGE					.72	.72	520.	75.	71.	11.4	268.	51.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER: DO/MP

TEST 8-5 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/30/81	10/30/81
TB	TIME-START	1439	1439
TF	TIME-FINISH	1623	1623
TT	NET TIME OF TEST, MIN.	104.2	104.2
NP	NET SAMPLING POINTS	11	11
Y	METER CALIBRATION FACTOR	1.033	1.033
DN	SAMPLING NOZZLE DIAMETER	.374 IN	9.5 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.72 IN-H2O	18.3 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	49.078 CU-FT	1.390 CU-M
TM	AVERAGE GAS METER TEMP	73.4 F	23.0 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	50.289 SCF	1.424 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL, ML.	175.0	175.0
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.237 SCF	.233 SCM
BWO	PERCENT MOISTURE BY VOLUME	14.07	14.07
FMD	MOLE FRACTION DRY GAS	.859	.859
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	9.30	9.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	86.40	86.40
MD	MOLECULAR WT-DRY STACK GAS	29.06	29.06
MWS	MOLECULAR WT-STACK GAS	27.50	27.50

PB	BAROMETRIC PRESSURE	29.93	IN-HG	760.22	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.84	IN-HG	757.98	MM-HG
TS	AVERAGE STACK TEMP	520.	F	271.	C
VS	AVG STACK GAS VELOCITY	20.8	FPS	6.3	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1789295.	SCFH	50667.	SCMH
QS	ACTUAL STACK FLOW RATE	3875168.	ACFH	109733.	ACMH
ISO	PERCENT ISOKINETIC	110.0		110.0	
MN	FILTERABLE PART MG. EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 8-5

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 49.078 * 1.033 * (29.93 + .720 / 13.6)}{(73. + 460.)} = 50.289 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 175. = 8.24 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.24}{50.289 + 8.24} = 14.07 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 14.1}{100.} = .859$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (9.3*32/100) + ((86.4+ .0) * 28/100 = 29.06

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.06* (1. -(14.07/100)] + 18. * (14.07/100) = 27.50

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 91.108 / (SQRT(27.50 * 29.84) * 11. = 20.76 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 20.76 * 7466. 3600/144 = 3875168. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3875168. * 29.84 * (1. - (14.07/100))}{(520. + 460.)} = 1789295. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(520.+460.))*((0.002669*175.)+(49.078*1.033*(29.93+(.720/13.6))/(73.+460.)))}{104. * 20.76 * 29.84 * .374 * .374} = 110.00 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 50.289 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1789295. / (15.43 * 453.6) = .00

Run No. 8.5

Sample volume = 1.42 m^3, 50.29 scf

Example calculations

CS (Part) = 183.6/1.42 = 129.3 mg/m^3

CS (Part) = 0.001 x 183.6 x 15.43/50.29 = _____ gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x _____ x 15.43/_____ = _____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	183.9	129.5	0.056	
2-h at 275°F	75.5	53.2	0.023	
4-h at 275°F	66.7	47.0	0.021	
2-h at 300°F	64.5	45.4	0.020	
4-h at 300°F	62.4	43.9	0.019	
2-h at 325°F	61.0	43.0	0.019	
4-h at 325°F	59.9	42.2	0.018	
2-h at 350°F	57.9	40.8	0.018	
4-h at 350°F	57.4	40.4	0.017	
2-h at 400°F	52.9	37.2	0.016	
4-h at 400°F	50.9	35.8	0.016	
2-h at 600°F	45.6	32.1	0.014	
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	10/30/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	8-6
SAMPLE TYPE	METHOD 8=600	PROBE LENGTH & TYPE	4' QUARTZ
OPERATOR	DO/MP	NOZZLE : I.D.	.620
AMBIENT TEMP.(DEG.F)	67.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.93	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F88
FILTER NUMBER(S)	3530219	METER HEAD DIFF.	1.91
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.94
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 22.0 IN.HG	REFERENCE PRESS. DIFF.	.02
METER CALIB. FACTOR	.982		
READ & RECORD DATA EVERY 10.0 MINUTES			

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1438	478.058									
	10.0	1448	482.690	.070	5.44	.75	520.	67.	67.	4.8	584.	50.
	20.0	1458	487.420	.070	5.44	.75	520.	69.	67.	8.3	593.	46.
	30.0	1508	492.180	.070	5.44	.75	520.	72.	67.	11.3	601.	44.
	40.0	1518	496.930	.070	5.44	.75	520.	73.	68.	13.6	592.	48.
	50.0	1528	501.640	.070	5.44	.75	520.	75.	69.	15.2	601.	48.
	60.0	1538	506.460	.070	5.44	.75	520.	75.	69.	16.5	603.	50.
	70.0	1548	511.190	.070	5.44	.75	520.	75.	69.	16.7	599.	54.
	80.0	1558	515.910	.070	5.44	.75	520.	74.	69.	17.7	595.	54.
	90.0	1608	520.658	.070	5.44	.75	520.	75.	70.	21.7	600.	56.
TOTALS	90.0		42.600									
AVERAGE					5.44	.75	520.	73.	68.	14.0	596.	50.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS

REPUBLIC STEEL CLEVELAND

TEST LEADER

DO/MP

TEST 8-6 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		10/30/81	10/30/81
TS	TIME-START	1438	1438
TF	TIME-FINISH	1608	1608
TT	NET TIME OF TEST, MIN.	90.0	90.0
NP	NET SAMPLING POINTS	9	9
Y	METER CALIBRATION FACTOR	.982	.982
DN	SAMPLING NOZZLE DIAMETER	.620 IN	15.7 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.75 IN-H2O	19.1 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	42.600 CU-FT	1.206 CU-M
TM	AVERAGE GAS METER TEMP	70.6 F	21.4 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	41.722 SCF	1.181 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	158.0	158.0
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.437 SCF	.211 SCM
BWO	PERCENT MOISTURE BY VOLUME	15.13	15.13
FMD	MOLE FRACTION DRY GAS	.849	.849
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	9.30	9.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	86.40	86.40
MD	MOLECULAR WT-DRY STACK GAS	29.06	29.06
MWS	MOLECULAR WT-STACK GAS	27.39	27.39

PB	BAROMETRIC PRESSURE	29.93	IN-HG	760.22	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.84	IN-HG	757.98	MM-HG
TS	AVERAGE STACK TEMP	520.	F	271.	C
VS	AVG STACK GAS VELOCITY	20.8	FPS	6.3	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1771103.	SCFH	50152.	SCMH
QS	ACTUAL STACK FLOW RATE	3883405.	ACFH	109966.	ACMH
ISO	PERCENT ISOKINETIC	38.8		38.8	
MN	FILTERABLE PART MG, EPA 5	.0		.0	
CS	FILTERABLE PART	.0000	GR/DSCF*	.000	MG/DSCM
PMR	FILTERABLE PART EMISSION RATE	.000	LB/HR	.00	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 8-6

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 42.600 * .982 * (29.93 + .750 / 13.6)}{(71. + 460.)} = 41.722 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 158. = 7.44 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.44}{41.722 + 7.44} = 15.13 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 15.1}{100.} = .849$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (9.3*32/100) + ((86.4+ .0) * 28/100 = 29.06

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.06* (1. -(15.13/100)) + 18. * (15.13/100) = 27.39

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 74.543 / (SQRT(27.39 * 29.84) * 9. = 20.81 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 20.81 * 7466. 3600/144 = 3883405. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)] / (TS + 460.)

$$QSSTD = \frac{17.647 * 3883405. * 29.84 * (1. - (15.13/100))}{(520. + 460.)} = 1771103.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(520.+460.))*((0.002669* 158.)+(42.600* .982*(29.93+(.750/13.6)))/(71.+460.)))}{90. * 20.81 * 29.84 * .620 * .620} = 38.84\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0 * 15.43 / 41.722 = .000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .000 * 1771103. / (15.43 * 453.6) = .00

Run No. 8.6

Sample volume = 1.18 m^3, 41.72 scf

Example calculations

CS (Part) = 45.1 / 1.18 = 38.2 mg/m^3

CS (Part) = 0.001 x 45.1 x 15.43/41.72 = 0.017 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	45.1	38.2	0.017	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
As $H_2SO_4 \cdot 2H_2O$				
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

2.0 DCOG Underfiring Test Series
December 1981

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/08/81
SAMPLING LOCATION	NO.1 COKE BATTERY OUTLET	RUN NUMBER	D1-1
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	4' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE : I.D.	.401
AMBIENT TEMP.(DEG.F)	36.	ASSUMED MOISTURE	14.0
BAR.PRESS.(IN.HG)	29.21	SAMPLE BOX NUMBER	0
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB2
FILTER NUMBER(S)	3530314	METER HEAD DIFF.	1.08
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.82
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 6.0 IN.HG	REFERENCE PRESS. DIFF.	.00
METER CALIB. FACTOR	1.003		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1205	259.553									
	10.0	1215	263.720	.050	.67	.67	452.	32.	32.	4.0	239.	34.
	20.0	1225	268.480	.050	.67	.67	463.	32.	33.	4.0	255.	36.
	30.0	1235	273.200	.050	.67	.67	472.	33.	32.	4.0	245.	36.
	40.0	1245	277.960	.050	.67	.67	467.	35.	32.	4.0	248.	37.
	50.0	1255	282.680	.050	.67	.67	488.	35.	32.	5.0	251.	36.
	60.0	1305	287.420	.050	.67	.67	492.	35.	33.	6.0	243.	37.
	70.0	1315	292.730	.050	.67	.67	450.	36.	33.	5.5	244.	39.
	80.0	1325	296.860	.050	.67	.67	459.	36.	33.	6.0	241.	40.
	90.0	1335	301.587	.050	.67	.67	469.	36.	33.	6.0	246.	40.
TOTALS	90.0		42.034									
AVERAGE					.67	.67	468.	34.	33.	4.9	246.	37.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS | TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND | BRUFFEY

TEST D1-1 NO.1 COKE BATTERY OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/08/81	12/08/81
TB	TIME-START	1205	1205
TF	TIME-FINISH	1335	1335
TT	NET TIME OF TEST, MIN.	90.0	90.0
NP	NET SAMPLING POINTS	9	9
Y	METER CALIBRATION FACTOR	1.003	1.003
DN	SAMPLING NOZZLE DIAMETER	.401 IN	10.2 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.67 IN-H2O	17.0 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	42.034 CU-FT	1.190 CU-M
TM	AVERAGE GAS METER TEMP	33.5 F	.8 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	44.111 SCF	1.249 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	103.2	103.2
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	4.858 SCF	.138 SCM
BWO	PERCENT MOISTURE BY VOLUME	9.92	9.92
FMD	MOLE FRACTION DRY GAS	.901	.901
PCO2	PERCENT CO2 BY VOL., DRY	4.50	4.50
PO2	PERCENT O2 BY VOL., DRY	9.40	9.40
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	86.10	86.10
MD	MOLECULAR WT-DRY STACK GAS	29.10	29.10
MWS	MOLECULAR WT-STACK GAS	28.00	28.00

PB	BAROMETRIC PRESSURE	29.21	IN-HG	741.93	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.12	IN-HG	739.69	MM-HG
TS	AVERAGE STACK TEMP	468.	F	242.	C
VS	AVG STACK GAS VELOCITY	17.1	FPS	5.2	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1595142.	SCFH	45170.	SCMH
QS	ACTUAL STACK FLOW RATE	3197639.	ACFH	90548.	ACMH
ISO	PERCENT ISOKINETIC	109.0		109.0	
MN	MG, EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D1-1

NO.1 COKE BATTERY OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 42.034 * 1.003 * (29.21 + .670 / 13.6)}{(34. + 460.)} = 44.111 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 103. = 4.86 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 4.86}{44.111 + 4.86} = 9.92 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 9.9}{100.} = .901$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.50*44/100) + (9.4*32/100) + ((86.1+ .0) * 28/100 = 29.10

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.10* (1. -(9.92/100)) + 18. * (9.92/100) = 28.00

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 61.304 / (SQRT(28.00 * 29.12) * 9. = 17.13 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.13 * 7466. 3600/144 = 3197639. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3197639. * 29.12 * (1. - (9.92/100))}{(468. + 460.)} = 1595142. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(468.+460.))*((0.002669* 103.)+(42.034*1.003*(29.21+(.670/13.6))/(34.+460.)))}{90. * 17.13 * 29.12 * .401 * .401} = 109.00 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 44.111 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1595142. / (15.43 * 453.6) = .00000

Run No. D1.1

Sample volume = 1.25 m^3, 44.11 scf

Example calculations

CS (Part) = 32.6/1.25 = 26.1 mg/m^3

CS (Part) = 0.001 x 32.6 x 15.43/44.11 = 0.011 gr/dscf

CS (SO_2) = 69.7/1.25 = 55.8 mg/m^3

= 55.8 x 24.06/64 = 21 ppm

= 0.001 x 69.7 x 15.43/ 44.11 = 0.040 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	32.6	26.1	0.011	
2-h at 350°F	21.8	17.4	0.008	
4-h at 350°F	21.1	16.9	0.007	
2-h at 400°F	16.8	13.4	0.006	
4-h at 400°F	16.4	13.1	0.006	
2-h at 600°F	14.6	11.7	0.005	
Acid sulfates				
As H_2SO_4	0.0	0.0	0.0	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.0	
Water soluble sulfates				
As $SO_4^=$	<0.3	<0.2	0.000	
Sulfur dioxide	69.7	55.8	0.024	21
Sulfuric acid mist				
As H_2SO_4	115*	92.0	0.040	22
Inorganic condensibles	N/A			
Organic condensibles	N/A			
TOC (Condensible)	N/A			

*Field analysis, isopropanol contaminated.

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/08/81
SAMPLING LOCATION	NO.1 COKE BATTERY OUTLET	RUN NUMBER	D1-2
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	5' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE : I.D.	.401
AMBIENT TEMP.(DEG.F)	36.	ASSUMED MOISTURE	14.0
BAR.PRESS.(IN.HG)	29.21	SAMPLE BOX NUMBER	8
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F85
FILTER NUMBER(S)	3530324	METER HEAD DIFF.	1.86
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.84
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 5.0 IN.HG	REFERENCE PRESS. DIFF.	.00
METER CALIB. FACTOR	1.016		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1208	349.502									
	10.0	1218	353.780	.050	.59	.59	435.	37.	38.	2.0	269.	33.
	20.0	1228	357.980	.050	.59	.59	465.	38.	38.	2.0	270.	34.
	30.0	1238	362.170	.050	.59	.59	473.	39.	39.	2.0	273.	36.
	40.0	1248	366.380	.050	.59	.59	471.	40.	39.	2.0	272.	37.
	50.0	1258	370.540	.050	.59	.59	484.	41.	39.	3.0	270.	36.
	60.0	1308	374.760	.050	.59	.59	495.	43.	40.	2.0	273.	37.
	70.0	1318	378.910	.050	.59	.59	453.	43.	40.	2.5	275.	35.
	80.0	1328	383.140	.050	.59	.59	462.	43.	40.	2.0	270.	34.
	90.0	1338	387.318	.050	.59	.59	474.	43.	40.	2.0	279.	30.
TOTALS	90.0		37.816									
AVERAGE					.59	.59	468.	41.	39.	2.2	272.	35.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — BRUFFEY

TEST D1-2 NO.1 COKE BATTERY OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/08/81	12/08/81
TB	TIME-START	1208	1208
TF	TIME-FINISH	1338	1338
TT	NET TIME OF TEST, MIN.	90.0	90.0
NP	NET SAMPLING POINTS	9	9
Y	METER CALIBRATION FACTOR	1.016	1.016
DN	SAMPLING NOZZLE DIAMETER	.401 IN	10.2 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.59 IN-H2O	15.0 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	37.816 CU-FT	1.071 CU-M
TM	AVERAGE GAS METER TEMP	40.0 F	4.4 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	39.669 SCF	1.123 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	111.4	111.4
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	5.244 SCF	.148 SCM
BWO	PERCENT MOISTURE BY VOLUME	11.68	11.68
FMD	MOLE FRACTION DRY GAS	.883	.883
PCO2	PERCENT CO2 BY VOL., DRY	4.50	4.50
PO2	PERCENT O2 BY VOL., DRY	9.40	9.40
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	86.10	86.10
MD	MOLECULAR WT-DRY STACK GAS	29.10	29.10
MWS	MOLECULAR WT-STACK GAS	27.80	27.80

PB	BAROMETRIC PRESSURE	29.21	IN-HG	741.93	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.12	IN-HG	739.69	MM-HG
TS	AVERAGE STACK TEMP	468.	F	242.	C
VS	AVG STACK GAS VELOCITY	17.2	FPS	5.2	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1569507.	SCFH	44444.	SCMH
QS	ACTUAL STACK FLOW RATE	3208783.	ACFH	90863.	ACMH
ISO	PERCENT ISOKINETIC	99.6		99.6	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D1-2

NO.1 COKE BATTERY OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 37.816 * 1.016 * (29.21 + .590 / 13.6)}{(40. + 460.)} = 39.669 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 111. = 5.24 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 5.24}{39.669 + 5.24} = 11.68 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.7}{100.} = .883$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.50*44/100) + (9.4*32/100) + ((86.1+ .0) * 28/100 = 29.10

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.10* (1. -(11.68/100)) + 18. * (11.68/100) = 27.80

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 61.303 / (SQRT(27.80 * 29.12) * 9. = 17.19 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.19 * 7466. 3600/144 = 3208783. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3208783. * 29.12 * (1. - (11.68/100))}{(468. + 460.)} = 1569507. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(468.+460.))*((0.002669*111.)+(37.816*1.016*(29.21+(.590/13.6))/(40.+460.)))}{90. * 17.19 * 29.12 * .401 * .401} = 99.62 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 39.669 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1569507. / (15.43 * 453.6) = .00000

Run No. D1.2

Sample volume = 1.12 m^3, 39.67 scf

Example calculations

CS (Part) = 37.4/1.12 = 33.4 mg/m^3

CS (Part) = 0.001 x 37.4 x 15.43/ 39.67 = 0.014 gr/dscf

CS (SO_2) =116.1/1.12 = 103.7 mg/m^3

= 103.7 x 24.06/64 = 39 ppm

= 0.001 x 116.1 x 15.43/39.67 = 0.045 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	37.4	33.4	0.014	
2-h at 350°F	22.0	19.6	0.008	
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	2.0	1.8	0.001	
As $H_2SO_4 \cdot 2H_2O$	2.7	2.4	0.001	
Water soluble sulfates				
As $SO_4^=$	2.1	1.9	0.001	
Sulfur dioxide	116.1	103.7	0.045	39
Sulfuric acid mist				
As H_2SO_4	3.5	3.1	0.001	1
Inorganic condensibles	N/A			
Organic condensibles	N/A			
TOC (Condensible)	N/A			

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIO	DATE	12/08/81
SAMPLING LOCATION	STACK OUTLET	RUN NUMBER	D1-3
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	4 FOOT GLASS
OPERATOR	DAN FITZGERALD	NOZZLE 1-3 : I.D.	.402
AMBIENT TEMP.(DEG.F)	36.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.21	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F84
FILTER NUMBER(S)	3530349	METER HEAD DIFF.	1.88
STACK INSIDE DIM.(IN)	97.75 .00		
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.	133	HEATER BOX SETTING	350.
LEAKAGE	.012 CFM @ 5.0 IN.HG		
METER CALIB. FACTOR	1.033	K FACTOR	12094.5
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H20)	ORIFICE PRESSURE DIFFERENTIAL (IN.H20)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1205	165.363									
	10.0	1215	169.785	.050	.66	.66	452.	37.	37.	1.0	381.	38.
	20.0	1225	174.100	.050	.66	.66	463.	38.	37.	1.0	373.	39.
	30.0	1235	178.120	.050	.65	.65	472.	41.	38.	1.0	378.	43.
	40.0	1245	182.375	.050	.66	.66	467.	43.	38.	2.0	375.	44.
	50.0	1255	186.670	.050	.64	.64	488.	45.	38.	3.0	373.	46.
	60.0	1305	190.950	.050	.64	.64	492.	46.	39.	3.5	369.	47.
	70.0	1315	195.325	.050	.66	.66	450.	47.	40.	3.5	370.	50.
	80.0	1325	199.630	.050	.66	.66	459.	47.	40.	4.0	372.	52.
	90.0	1335	203.870	.050	.65	.65	470.	47.	40.	4.5	372.	54.
TOTALS	90.0		38.507									
AVERAGE					.65	.65	468.	43.	39.	2.6	374.	46.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO — DAN FITZGERALD

TEST D1-3 STACK OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/08/81	12/08/81
TB	TIME-START	1205	1205
TF	TIME-FINISH	1335	1335
TT	NET TIME OF TEST, MIN.	90.0	90.0
NP	NET SAMPLING POINTS	9	9
Y	METER CALIBRATION FACTOR	1.033	1.033
DN	SAMPLING NOZZLE DIAMETER	.402 IN	10.2 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.65 IN-H2O	16.6 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	38.507 CU-FT	1.090 CU-M
TM	AVERAGE GAS METER TEMP	41.0 F	5.0 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	40.994 SCF	1.161 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	113.9	113.9
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	5.361 SCF	.152 SCM
BWO	PERCENT MOISTURE BY VOLUME	11.57	11.57
FMD	MOLE FRACTION DRY GAS	.884	.884
PCO2	PERCENT CO2 BY VOL., DRY	4.50	4.50
PO2	PERCENT O2 BY VOL., DRY	9.40	9.40
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	86.10	86.10
MD	MOLECULAR WT-DRY STACK GAS	29.10	29.10
MWS	MOLECULAR WT-STACK GAS	27.81	27.81

PB	BAROMETRIC PRESSURE	29.21	IN-HG	741.93	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.12	IN-HG	739.69	MM-HG
TS	AVERAGE STACK TEMP	468.	F	242.	C
VS	AVG STACK GAS VELOCITY	17.2	FPS	5.2	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1579103.	SCFH	44715.	SCMH
QS	ACTUAL STACK FLOW RATE	3224786.	ACFH	91316.	ACMH
ISO	PERCENT ISOKINETIC	102.3		102.3	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 01-3

STACK OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 38.507 * 1.033 * (29.21 + .653 / 13.6)}{(41. + 460.)} = 40.994 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 114. = 5.36 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 5.36}{40.994 + 5.36} = 11.57 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.6}{100.} = .884$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.50*44/100) + (9.4*32/100) + ((86.1+ .0) * 28/100 = 29.10

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.10* (1. -(11.57/100)) + 18. * (11.57/100) = 27.81

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 61.308 / (SQRT(27.81 * 29.12) * 9. = 17.19 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.19 * 7505. 3600/144 = 3224786. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3224786. * 29.12 * (1. - (11.57/100))}{(468. + 460.)} = 1579103.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(468.+460.))*((0.002669* 114.)+(38.507*1.033*(29.21+(.653/13.6))/(41.+460.)))}{90. * 17.19 * 29.12 * .402 * .402} = 102.34\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 40.994 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1579103. / (15.43 * 453.6) = .00000

Run No. D1.3

Sample volume = 1.16 m^3, 40.99 scf

Example calculations

CS (Part) = 34.0 / 1.16 = 29.3 mg/m^3

CS (Part) = 0.001 x 34.0 x 15.43/40.99 = 0.013 gr/dscf

CS (SO_2) = 117.0 / 1.16 = 100.9 mg/m^3

= 100.9 x 24.06/64 = 38 ppm

= 0.001 x 117.0 x 15.43/ 40.99 = 0.044 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	34.0	29.3	0.013	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Water soluble sulfates				
As $SO_4^=$	2.5	2.1	0.001	
Sulfur dioxide	117.0	100.9	0.044	38
Sulfuric acid mist				
As H_2SO_4	9.3	8.0	0.004	2
Inorganic condensibles	N/A			
Organic condensibles	N/A			
TOC (Condensible)	N/A			

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIO	DATE	12/08/81
SAMPLING LOCATION	STACK OUTLET #1 BATTERY	RUN NUMBER	D1-4
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	5 FOOT GLASS
OPERATOR	DAN FITZGERALD	NOZZLE 1-4 : I.D.	.401
AMBIENT TEMP.(DEG.F)	36.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.21	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB8
FILTER NUMBER(S)	3530363	METER HEAD DIFF.	1.91
STACK INSIDE DIM.(IN)	97.75 .00		
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.	133	HEATER BOX SETTING	350.
LEAKAGE	.001 CFM @ 5.0 IN.HG		
METER CALIB. FACTOR	.982	K FACTOR	12094.5
READ & RECORD DATA EVERY 10.0 MINUTES			

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1208	597.103									
	10.0	1218	601.255	.050	.66	.66	455.	36.	34.	1.5	304.	40.
	20.0	1228	605.610	.050	.66	.66	465.	38.	32.	1.5	332.	42.
	30.0	1238	610.030	.050	.65	.65	473.	40.	35.	1.5	341.	40.
	40.0	1248	614.360	.050	.66	.66	471.	42.	36.	1.5	339.	40.
	50.0	1258	618.650	.050	.64	.64	484.	44.	36.	2.5	330.	42.
	60.0	1308	622.940	.050	.63	.63	495.	44.	36.	3.0	338.	43.
	70.0	1318	627.325	.050	.66	.66	453.	45.	37.	3.5	335.	44.
	80.0	1328	631.705	.050	.66	.66	462.	45.	37.	3.5	334.	46.
	90.0	1338	636.074	.050	.65	.65	474.	45.	37.	3.5	343.	47.
TOTALS	90.0		38.971									
AVERAGE					.65	.65	470.	42.	36.	2.4	333.	43.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO — DAN FITZGERALD

TEST D1-4 STACK OUTLET #1 BATTERY

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/08/81	12/08/81
TB	TIME-START	1208	1208
TF	TIME-FINISH	1338	1338
TT	NET TIME OF TEST, MIN.	90.0	90.0
NP	NET SAMPLING POINTS	9	9
Y	METER CALIBRATION FACTOR	.982	.982
DN	SAMPLING NOZZLE DIAMETER	.401 IN	10.2 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.65 IN-H2O	16.6 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	38.971 CU-FT	1.104 CU-M
TM	AVERAGE GAS METER TEMP	38.8 F	3.8 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	39.611 SCF	1.122 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL, ML.	103.5	103.5
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	4.872 SCF	.138 SCM
BWO	PERCENT MOISTURE BY VOLUME	10.95	10.95
FMD	MOLE FRACTION DRY GAS	.890	.890
PCO2	PERCENT CO2 BY VOL., DRY	4.50	4.50
PO2	PERCENT O2 BY VOL., DRY	9.40	9.40
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	86.10	86.10
MD	MOLECULAR WT-DRY STACK GAS	29.10	29.10
MWS	MOLECULAR WT-STACK GAS	27.88	27.88

PB	BAROMETRIC PRESSURE	29.21	IN-HG	741.93	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.12	IN-HG	739.69	MM-HG
TS	AVERAGE STACK TEMP	470.	F	243.	C
VS	AVG STACK GAS VELOCITY	17.2	FPS	5.2	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTO	STACK FLOW RATE, DRY*	1586320.	SCFH	44920.	SCMH
QS	ACTUAL STACK FLOW RATE	3224520.	ACFH	91309.	ACMH
ISO	PERCENT ISOKINETIC	98.9		98.9	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D1-4

STACK OUTLET #1 BATTERY

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 38.971 * .982 * (29.21 + .652 / 13.6)}{(39. + 460.)} = 39.611 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 104. = 4.87 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 4.87}{39.611 + 4.87} = 10.95 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.0}{100.} = .890$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.50*44/100) + (9.4*32/100) + ((86.1+ .0) * 28/100 = 29.10

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.10* (1. -(10.95/100)) + 18. * (10.95/100) = 27.88

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 61.378 / (SQRT(27.88 * 29.12) * 9. = 17.19 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.19 * 7505. 3600/144 = 3224520. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3224520. * 29.12 * (1. - (10.95/100))}{(470. + 460.)} = 1586320.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(470.+460.))*((0.002669* 104.)+(38.971* .982*(29.21+(.652/13.6))/(39.+460.)))}{90. * 17.19 * 29.12 * .401 * .401} = 98.93\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 39.611 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1586320. / (15.43 * 453.6) = .00000

Run No. D1.4

Sample volume = 1.12 m^3, 39.61 scf

Example calculations

CS (Part) = 43.3/1.12 = 38.7 mg/m^3

CS (Part) = 0.001 x 43.3 x 15.43/39.61 = 0.017 gr/dscf

CS (SO_2) = 115.8/1.12 = 103.4 mg/m^3

= 103.4 x 24.06/64 = 39 ppm

= 0.001 x 115.8 x 15.43/39.61 = 0.045 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at: Ambient, 2-h at 350°F, 4-h at 350°F, 2-h at 400°F, 4-h at 400°F, 2-h at 600°F	43.3	38.7	0.017	
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Water soluble sulfates				
As $SO_4^=$	0.0	0.0	0.000	
Sulfur dioxide	115.8	103.4	0.045	39
Sulfuric acid mist				
As H_2SO_4	9.2	8.2	0.004	2
Inorganic condensibles	N/A			
Organic condensibles	N/A			
TOC (Condensible)	N/A			

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/08/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	D1-6
SAMPLE TYPE	M8-600	PROBE LENGTH & TYPE	6' GLASS
OPERATOR	DU	NOZZLE : I.D.	.379
AMBIENT TEMP.(DEG.F)	37.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.21	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB6
FILTER NUMBER(S)	3530220	METER HEAD DIFF.	1.51
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.71
PITOT TUBE COEFF.	.83	PROBE HEATER SETTING	600.
THERM. NO.		HEATER BOX SETTING	600.
LEAKAGE	.012 CFM @ 8.0 IN.HG	REFERENCE PRESS. DIFF.	.22
METER CALIB. FACTOR	.967		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1209	646.852									
	10.0	1219	650.750	.040	.35	.35	485.	34.	37.	3.2	569.	34.
	20.0	1229	654.450	.040	.35	.35	485.	35.	37.	3.0	573.	34.
	30.0	1239	658.220	.040	.35	.35	485.	36.	37.	3.0	510.	33.
	40.0	1249	661.860	.040	.35	.35	485.	39.	37.	3.2	447.	33.
	50.0	1259	665.690	.040	.35	.35	485.	40.	37.	4.0	489.	33.
	60.0	1309	669.490	.040	.35	.35	485.	41.	37.	6.0	486.	34.
	70.0	1319	673.300	.040	.35	.35	485.	41.	37.	6.5	514.	33.
	80.0	1329	677.120	.040	.35	.35	485.	42.	37.	6.8	516.	34.
	90.0	1339	680.811	.040	.35	.35	485.	42.	37.	7.1	529.	34.
TOTALS	90.0		33.959									
AVERAGE					.35	.35	485.	39.	37.	4.8	515.	34.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — DO

TEST D1-6 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/08/81	12/08/81
TB	TIME-START	1209	1209
TF	TIME-FINISH	1339	1339
TT	NET TIME OF TEST, MIN.	90.0	90.0
NP	NET SAMPLING POINTS	9	9
Y	METER CALIBRATION FACTOR	.967	.967
DN	SAMPLING NOZZLE DIAMETER	.379 IN	9.6 MM
CP	PITOT TUBE COEFFICIENT	.83	.83
PM	AVERAGE ORIFICE PRESSURE DROP	.35 IN-H2O	8.9 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	33.959 CU-FT	.962 CU-M
TM	AVERAGE GAS METER TEMP	37.9 F	3.3 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	34.024 SCF	.963 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	81.8	81.8
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	3.850 SCF	.109 SCM
BWO	PERCENT MOISTURE BY VOLUME	10.17	10.17
FMD	MOLE FRACTION DRY GAS	.898	.898
PCO2	PERCENT CO2 BY VOL., DRY	4.50	4.50
PO2	PERCENT O2 BY VOL., DRY	9.40	9.40
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	86.10	86.10
MD	MOLECULAR WT-DRY STACK GAS	29.10	29.10
MWS	MOLECULAR WT-STACK GAS	27.97	27.97

PB	BAROMETRIC PRESSURE	29.21	IN-HG	741.93	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.12	IN-HG	739.69	MM-HG
TS	AVERAGE STACK TEMP	485.	F	252.	C
VS	AVG STACK GAS VELOCITY	15.3	FPS	4.7	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1393914.	SCFH	39471.	SCMH
QS	ACTUAL STACK FLOW RATE	2853244.	ACFH	80795.	ACMH
ISO	PERCENT ISOKINETIC	107.7		107.7	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 01-6

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 33.959 * .967 * (29.21 + .350 / 13.6)}{(58. + 460.)} = 34.024 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 82. = 3.85 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 3.85}{34.024 + 3.85} = 10.17 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 10.2}{100.} = .898$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.50*44/100) + (9.4*32/100) + ((86.1+ .0) * 28/100 = 29.10

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.10* (1. -(10.17/100)) + 18. * (10.17/100) = 27.97

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .83 * 55.334 / (SQRT(27.97 * 29.12) * 9. = 15.29 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 15.29 * 7466. 3600/144 = 2853244. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 2853244. * 29.12 * (1. - (10.17/100))}{(485. + 460.)} = 1393914.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(485.+460.))*((0.002669*82.)+(33.959*.967*(29.21+(.350/13.6))/(38.+460.)))}{90. * 15.29 * 29.12 * .379 * .379} = 107.70\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 34.024 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1393914. / (15.43 * 453.6) = .00000

Run No. D1.6

Sample volume = 0.96 m^3, 34.02 scf

Example calculations

CS (Part) = 27.3 / 0.96 = 28.4 mg/m^3

CS (Part) = 0.001 x 27.3 x 15.43/34.02 = 0.012 gr/dscf

CS (SO_2) = 97.9/0.96 = 102.0 mg/m^3

= 102.0 x 24.06/64 = 38 ppm

= 0.001 x 97.9 x 15.43/34.02 = 0.044 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	27.3	28.4	0.012	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.0	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.0	
Water soluble sulfates				
As $SO_4^=$	1.6	1.7	0.001	
Sulfur dioxide	97.9	102.0	0.044	38
Sulfuric acid mist				
As H_2SO_4	6.3	6.6	0.003	2
Inorganic condensibles	N/A			
Organic condensibles	N/A			
TOC (Condensible)	N/A			

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/10/81
SAMPLING LOCATION	OUTLET STACK	RUN NUMBER	D2-1
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	5' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE : I.D.	.404
AMBIENT TEMP.(DEG.F)	28.	ASSUMED MOISTURE	14.0
BAR.PRESS.(IN.HG)	29.51	SAMPLE BOX NUMBER	0
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB2
FILTER NUMBER(S)	3530310	METER HEAD DIFF.	1.76
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.82
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 6.0 IN.HG	REFERENCE PRESS. DIFF.	.14
METER CALIB. FACTOR	1.003		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1341	312.901									
	10.0	1351	317.810	.060	.79	.79	500.	35.	32.	3.0	180.	34.
	20.0	1401	323.165	.065	.86	.86	491.	35.	30.	3.0	238.	36.
	30.0	1411	328.287	.064	.84	.84	505.	36.	30.	3.0	245.	40.
	40.0	1421	333.390	.066	.87	.87	465.	37.	30.	3.5	234.	37.
	50.0	1431	338.747	.068	.90	.90	476.	37.	30.	5.0	253.	36.
	60.0	1441	343.910	.060	.79	.79	491.	37.	30.	5.5	254.	38.
	70.0	1451	349.180	.064	.84	.84	473.	39.	30.	5.8	260.	42.
	80.0	1501	354.465	.064	.84	.84	488.	38.	30.	6.0	262.	42.
	90.0	1511	359.484	.060	.79	.79	496.	38.	30.	6.0	273.	42.
TOTALS	90.0		46.583									
AVERAGE					.84	.84	487.	37.	30.	4.5	244.	39.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — BRUFFEY

TEST D2-1 OUTLET STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/10/81	12/10/81
TB	TIME-START	1341	1341
TF	TIME-FINISH	1511	1511
TT	NET TIME OF TEST, MIN.	90.0	90.0
NP	NET SAMPLING POINTS	9	9
Y	METER CALIBRATION FACTOR	1.003	1.003
DN	SAMPLING NOZZLE DIAMETER	.404 IN	10.3 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.84 IN-H2O	21.2 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	46.583 CU-FT	1.319 CU-M
TM	AVERAGE GAS METER TEMP	33.6 F	.9 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	49.401 SCF	1.399 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	145.9	145.9
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	6.868 SCF	.194 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.20	12.20
FMD	MOLE FRACTION DRY GAS	.878	.878
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	12.30	12.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	83.40	83.40
MD	MOLECULAR WT-DRY STACK GAS	29.18	29.18
MWS	MOLECULAR WT-STACK GAS	27.82	27.82

PB	BAROMETRIC PRESSURE	29.51	IN-HG	749.55	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.42	IN-HG	747.31	MM-HG
TS	AVERAGE STACK TEMP	487.	F	253.	C
VS	AVG STACK GAS VELOCITY	19.5	FPS	5.9	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1747391.	SCFH	49481.	SCMH
QS	ACTUAL STACK FLOW RATE	3631049.	ACFH	102820.	ACMH
ISO	PERCENT ISOKINETIC	109.8		109.8	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D2-1

OUTLET STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 46.583 * 1.003 * (29.51 + .836 / 13.6)}{(34. + 460.)} = 49.401 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 146. = 6.87 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 6.87}{49.401 + 6.87} = 12.20 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.2}{100.} = .878$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (12.3*32/100) + ((83.4+ .0) * 28/100 = 29.18

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.18* (1. -(12.20/100)) + 18. * (12.20/100) = 27.82

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 69.746 / (SQRT(27.82 * 29.42) * 9. = 19.45 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 19.45 * 7466. 3600/144 = 3631049. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3631049. * 29.42 * (1. - (12.20/100))}{(487. + 460.)} = 1747391. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*ON)

$$ISO = \frac{(305.58*(487.+460.))*((0.002669* 146.)+(46.583*1.003*(29.51+(.836/13.6))/(34.+460.)))}{90. * 19.45 * 29.42 * .404 * .404} = 109.78 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 49.401 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1747391. / (15.43 * 453.6) = .00000

Run No. D2.1

Sample volume = 1.40 m^3, 49.40 scf

Example calculations

CS (Part) = 249.9 / 1.40 = 178.5 mg/m^3

CS (Part) = 0.001 x 249.9 x 15.43/ 49.40 = 0.078 gr/dscf

CS (SO_2) = 120.8/ 1.40 = 86.3 mg/m^3

= 86.3 x 24.06/ 64 = 32 ppm

= 0.001 x 120.8 x 15.43/ 49.4 = 0.038 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at: Ambient 2-h at 350°F 4-h at 350°F 2-h at 400°F 4-h at 400°F 2-h at 600°F	249.9[a]	178.5	0.078	
Acid sulfates As H_2SO_4 As $H_2SO_4 \cdot 2H_2O$	1.0 1.4	0.7 1.0	0.0003 0.0004	
Water soluble sulfates As $SO_4^=$	0.9	0.6	0.0003	
Sulfur dioxide	120.8	86.3	0.038	32
Sulfuric acid mist As H_2SO_4	13.7	9.8	0.004	2
Inorganic condensibles	N/A			
Organic condensibles	N/A			
TOC (Condensible)	N/A			

[a]Acetone rinse contaminated with oil.

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/10/81
SAMPLING LOCATION	OUTLET STACK	RUN NUMBER	D2-2
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	4' HEATED GLASS
OPERATOR	BRUFFEY	NOZZLE : I.D.	.400
AMBIENT TEMP.(DEG.F)	28.	ASSUMED MOISTURE	14.0
BAR.PRESS.(IN.HG)	29.51	SAMPLE BOX NUMBER	0
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB7
FILTER NUMBER(S)	3530050	METER HEAD DIFF.	1.71
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.84
PITOT TUBE COEFF.	.84	PRUBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 5.0 IN.HG	REFERENCE PRESS. DIFF.	.14
METER CALIB. FACTOR	1.004		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1308	423.038									
	10.0	1318	427.790	.060	.73	.73	500.	39.	35.	1.5	223.	35.
	20.0	1328	433.075	.067	.88	.88	481.	43.	36.	2.0	200.	36.
	30.0	1338	438.330	.068	.90	.90	489.	46.	36.	2.0	210.	38.
	40.0	1348	443.500	.061	.74	.74	478.	46.	36.	2.0	199.	39.
	50.0	1358	448.300	.065	.70	.70	491.	46.	35.	2.0	220.	37.
	60.0	1408	452.740	.064	.80	.80	505.	46.	35.	3.0	232.	40.
	70.0	1418	457.880	.066	.85	.85	465.	46.	35.	3.0	218.	34.
	80.0	1428	463.160	.068	.89	.89	476.	46.	36.	3.5	238.	35.
	90.0	1438	468.020	.060	.73	.73	491.	46.	36.	4.0	240.	36.
	100.0	1448	473.010	.064	.80	.80	473.	47.	36.	4.0	246.	40.
	110.0	1458	478.050	.064	.80	.80	488.	46.	35.	4.5	252.	40.
	120.0	1508	482.903	.061	.74	.74	496.	46.	35.	4.5	269.	40.
TOTALS	120.0		59.865									
AVERAGE					.80	.80	486.	45.	36.	3.0	229.	38.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS: REPUBLIC STEEL CLEVELAND

TEST LEADER: BRUFFEY

TEST D2-2 OUTLET STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/10/81	12/10/81
TB	TIME-START	1308	1308
TF	TIME-FINISH	1508	1508
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.004	1.004
DN	SAMPLING NOZZLE DIAMETER	.400 IN	10.2 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.80 IN-H2O	20.2 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	59.865 CU-FT	1.695 CU-M
TM	AVERAGE GAS METER TEMP	40.4 F	4.7 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	62.678 SCF	1.775 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	181.9	181.9
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.562 SCF	.242 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.02	12.02
FMD	MOLE FRACTION DRY GAS	.880	.880
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	12.30	12.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	83.40	83.40
MD	MOLECULAR WT-DRY STACK GAS	29.18	29.18
MWS	MOLECULAR WT-STACK GAS	27.84	27.84

PB	BAROMETRIC PRESSURE	29.51	IN-HG	749.55	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.42	IN-HG	747.31	MM-HG
TS	AVERAGE STACK TEMP	486.	F	252.	C
VS	AVG STACK GAS VELOCITY	19.5	FPS	5.9	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1759182.	SCFH	49815.	SCMH
QS	ACTUAL STACK FLOW RATE	3643425.	ACFH	103171.	ACMH
ISO	PERCENT ISOKINETIC	105.9		105.9	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D2-2

OUTLET STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 59.865 * 1.004 * (29.51 + .797 / 13.6)}{(40. + 460.)} = 62.678 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 182. = 8.56 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.56}{62.678 + 8.56} = 12.02 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.0}{100.} = .880$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (12.3*32/100) + ((83.4+ .0) * 28/100 = 29.18

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.18* (1. -(12.02/100)) + 18. * (12.02/100) = 27.84

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 93.346 / (SQRT(27.84 * 29.42) * 12. = 19.52 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 19.52 * 7466. 3600/144 = 3643425. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3643425. * 29.42 * (1. - (12.02/100))}{(486. + 460.)} = 1759182.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(486.+460.))*((0.002669* 182.)+(59.865*1.004*(29.51+(.797/13.6))/(40.+460.)))}{120. * 19.52 * 29.42 * .400 * .400} = 105.85\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 62.678 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1759182. / (15.43 * 453.6) = .00000

Run No. D2.2

Sample volume = 1.78 m^3, 62.68 scf

Example calculations

CS (Part) = 38.3 / 1.78 = 21.5 mg/m^3

CS (Part) = 0.001 x 38.3 x 15.43/62.68 = 0.009 gr/dscf

CS (SO_2) = 159.4 / 1.78 = 89.6 mg/m^3

= 89.6 x 24.06/ 64 = 34 ppm

= 0.001 x 159.4 x 15.43/ 62.68 = 0.039 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	38.3	21.5	0.009	
2-h at 350°F	24.6	13.8	0.006	
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	2.6	1.5	0.001	
As $H_2SO_4 \cdot 2H_2O$	3.5	2.0	0.001	
Water soluble sulfates				
As $SO_4^=$	2.0	1.1	0.001	
Sulfur dioxide	159.4	89.6	0.039	34
Sulfuric acid mist				
As H_2SO_4	14.4*	8.1	0.004	2
Inorganic condensibles	N/A			
Organic condensibles	N/A			
TOC (Condensible)	N/A			

*Field analysis.

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIO	DATE	12/10/81
SAMPLING LOCATION	STACK OUTLET #1 BATTERY	RUN NUMBER	D2-3
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	4 FOOT GLASS
OPERATOR	DAN FITZGERALD	NOZZLE : I.D.	.404
AMBIENT TEMP.(DEG.F)	20.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.51	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB8
FILTER NUMBER(S)	3530341	METER HEAD DIFF.	1.91
STACK INSIDE DIM.(IN)	97.75 .00		
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.	133	HEATER BOX SETTING	350.
LEAKAGE	.000 CFM @ 6.5 IN.HG		
METER CALIB. FACTOR	.982	K FACTOR	12337.4

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1310	695.528									
	10.0	1320	700.300	.060	.77	.77	500.	36.	35.	2.5	360.	37.
	20.0	1330	705.335	.067	.88	.88	481.	41.	35.	3.0	363.	39.
	30.0	1340	710.200	.068	.88	.88	489.	44.	35.	3.0	361.	40.
	40.0	1350	714.850	.061	.80	.80	478.	45.	35.	4.0	366.	40.
	50.0	1400	720.000	.065	.84	.84	491.	45.	35.	5.0	370.	37.
	60.0	1410	725.200	.064	.85	.85	465.	45.	35.	5.0	373.	40.
	70.0	1420	729.600	.066	.84	.84	505.	45.	35.	5.0	361.	40.
	80.0	1430	734.800	.068	.89	.89	476.	45.	35.	5.0	334.	54.
	90.0	1440	740.100	.060	.79	.79	491.	45.	35.	6.0	377.	60.
	100.0	1450	744.200	.064	.84	.84	474.	45.	35.	6.0	367.	55.
	110.0	1500	749.600	.063	.82	.82	488.	45.	35.	6.5	363.	55.
	120.0	1510	754.460	.062	.80	.80	496.	45.	35.	6.5	365.	55.
TOTALS	120.0		58.932									
AVERAGE					.83	.83	486.	44.	35.	4.8	363.	46.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO — DAN FITZGERALD

TEST D2-3 STACK OUTLET #1 BATTERY

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/10/81	12/10/81
TB	TIME-START	1310	1310
TF	TIME-FINISH	1510	1510
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.982	.982
DN	SAMPLING NOZZLE DIAMETER	.404 IN	10.3 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.83 IN-H2O	21.2 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	58.932 CU-FT	1.669 CU-M
TM	AVERAGE GAS METER TEMP	39.4 F	4.1 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	60.470 SCF	1.712 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	180.6	180.6
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.501 SCF	.241 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.33	12.33
FMD	MOLE FRACTION DRY GAS	.877	.877
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	12.30	12.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	83.40	83.40
MD	MOLECULAR WT-DRY STACK GAS	29.18	29.18
MWS	MOLECULAR WT-STACK GAS	27.80	27.80

PB	BAROMETRIC PRESSURE	29.51	IN-HG	749.55	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.42	IN-HG	747.31	MM-HG
TS	AVERAGE STACK TEMP	486.	F	252.	C
VS	AVG STACK GAS VELOCITY	19.5	FPS	6.0	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1763133.	SCFH	49927.	SCMH
QS	ACTUAL STACK FLOW RATE	3664702.	ACFH	103773.	ACMH
ISO	PERCENT ISOKINETIC	100.4		100.4	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D2-3

STACK OUTLET #1 BATTERY

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 58.932 * .982 * (29.51 + .833 / 13.6)}{(39. + 460.)} = 60.470 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 181. = 8.50 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.50}{60.470 + 8.50} = 12.33 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.3}{100.} = .877$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (12.3*32/100) + ((83.4+ .0) * 28/100 = 29.18

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.18* (1. -(12.33/100)) + 18. * (12.33/100) = 27.80

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 93.354 / (SQRT(27.80 * 29.42) * 12. = 19.53 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 19.53 * 7505. 3600/144 = 3664702. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3664702. * 29.42 * (1. - (12.33/100))}{(486. + 460.)} = 1763133.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(486.+460.))*((0.002669*181.)+(58.932*.982*(29.51+(.833/13.6))/(39.+460.)))}{120. * 19.53 * 29.42 * .404 * .404} = 100.40\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 60.470 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1763133. / (15.43 * 453.6) = .00000

Run No. D2.3

Sample volume = 1.71 m^3, 60.47 scf

Example calculations

CS (Part) = 34.8 / 1.71 = 20.4 mg/m^3

CS (Part) = 0.001 x 34.8 x 15.43/60.47 = 0.009 gr/dscf

CS (SO_2) = 155.0/1.71 = 90.6 mg/m^3

= 90.6 x 24.06/64 = 34 ppm

= 0.001 x 155.0 x 15.43/60.47 = 0.040 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	34.8	20.4	0.009	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.6	0.3	0.0001	
As $H_2SO_4 \cdot 2H_2O$	0.8	0.5	0.0001	
Water soluble sulfates				
As $SO_4^=$	3.5	2.0	0.001	
Sulfur dioxide	155.0	90.6	0.040	34
Sulfuric acid mist				
As H_2SO_4	8.7	5.1	0.002	1
Inorganic condensibles	N/A			
Organic condensibles	N/A			
TOC (Condensible)	N/A			

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIO	DATE	12/10/81
SAMPLING LOCATION	STACK OUTLET #1 BATTERY	RUN NUMBER	D2-4
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	4 FOOT GLASS
OPERATOR	DAN FITZGERALD	NOZZLE : I.D.	.404
AMBIENT TEMP.(DEG.F)	20.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.51	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB4
FILTER NUMBER(S)	3530311	METER HEAD DIFF.	1.88
STACK INSIDE DIM.(IN)	97.75 .00		
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.	133	HEATER BOX SETTING	350.
LEAKAGE	.000 CFM @ 6.0 IN.HG		
METER CALIB. FACTOR	1.033	K FACTOR	12337.4
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1312	253.209									
	10.0	1322	257.945	.060	.77	.77	500.	40.	40.	2.5	400.	42.
	20.0	1332	262.940	.067	.88	.88	481.	42.	40.	3.0	405.	40.
	30.0	1342	268.415	.068	.88	.88	489.	45.	38.	3.0	389.	39.
	40.0	1352	273.160	.061	.80	.80	478.	46.	39.	3.0	395.	40.
	50.0	1402	277.600	.065	.84	.84	491.	47.	39.	4.5	387.	41.
	60.0	1412	282.600	.064	.85	.85	465.	48.	39.	4.5	388.	40.
	70.0	1422	287.500	.066	.84	.84	505.	48.	39.	4.5	373.	56.
	80.0	1432	293.800	.068	.89	.89	476.	48.	39.	5.0	373.	54.
	90.0	1442	297.800	.060	.79	.79	491.	48.	39.	5.0	396.	64.
	100.0	1452	302.900	.064	.84	.84	474.	48.	39.	5.0	381.	60.
	110.0	1502	307.600	.063	.82	.82	488.	48.	39.	5.0	370.	60.
	120.0	1512	312.205	.062	.80	.80	496.	48.	39.	5.5	385.	60.
TOTALS	120.0		58.996									
AVERAGE					.83	.83	486.	46.	39.	4.2	387.	50.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO — DAN FITZGERALD

TEST D2-4 STACK OUTLET #1 BATTERY

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/10/81	12/10/81
TB	TIME-START	1312	1312
TF	TIME-FINISH	1512	1512
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.033	1.033
DN	SAMPLING NOZZLE DIAMETER	.404 IN	10.3 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.83 IN-H2O	21.2 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	58.996 CU-FT	1.671 CU-M
TM	AVERAGE GAS METER TEMP	42.7 F	5.9 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	63.263 SCF	1.791 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	184.6	184.6
VWC	VOLUME OF WATER VAPUR AT STANDARD CONDITIONS*	8.689 SCF	.246 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.08	12.08
FMD	MOLE FRACTION DRY GAS	.879	.879
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	12.30	12.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	83.40	83.40
MD	MOLECULAR WT-DRY STACK GAS	29.18	29.18
MWS	MOLECULAR WT-STACK GAS	27.83	27.83

PB	BAROMETRIC PRESSURE	29.51	IN-HG	749.55	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.42	IN-HG	747.31	MM-HG
TS	AVERAGE STACK TEMP	486.	F	252.	C
VS	AVG STACK GAS VELOCITY	19.5	FPS	6.0	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1767255.	SCFH	50043.	SCMH
QS	ACTUAL STACK FLOW RATE	3662869.	ACFH	103721.	ACMH
ISO	PERCENT ISOKINETIC	104.8		104.8	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D2-4

STACK OUTLET #1 BATTERY

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 58.996 * 1.033 * (29.51 + .833 / 13.6)}{(43. + 460.)} = 63.263 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 185. = 8.69 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.69}{63.263 + 8.69} = 12.08 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.1}{100.} = .879$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (12.3*32/100) + ((83.4+ .0) * 28/100 = 29.18

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.18* (1. -(12.08/100)) + 18. * (12.08/100) = 27.83

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 93.354 / (SQRT(27.83 * 29.42) * 12. = 19.52 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 19.52 * 7505. 3600/144 = 3662869. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3662869. * 29.42 * (1. - (12.08/100))}{(486. + 460.)} = 1767255.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(486.+460.))*((0.002669* 185.)+(58.996*1.033*(29.51+(.833/13.6))/(83.+460.)))}{120. * 19.52 * 29.42 * .404 * .404} = 104.79\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 63.263 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1767255. / (15.43 * 453.6) = .00000

Run No. D2.4

Sample volume = 1.79 m^3, 63.26 scf

Example calculations

CS (Part) = 37.2 / 1.79 = 20.8 mg/m^3

CS (Part) = 0.001 x 37.2 x 15.43/63.26 = 0.009 gr/dscf

CS (SO_2) = 131.8 / 1.79 = 73.6 mg/m^3

= 73.6 x 24.06/64 = 28 ppm

= 0.001 x 131.8 x 15.43/63.26 = 0.032 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	37.2	20.8	0.009	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.4	0.2	0.0001	
As $H_2SO_4 \cdot 2H_2O$	0.5	0.3	0.0001	
Water soluble sulfates				
As $SO_4^=$	4.8	2.7	0.001	
Sulfur dioxide	131.8	73.6	0.032	28
Sulfuric acid mist				
As H_2SO_4	54.8	30.6	0.013	8
Inorganic condensibles	N/A			
Organic condensibles	N/A			
TOC (Condensible)	N/A			

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/10/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	02-5
SAMPLE TYPE	M5-250	PROBE LENGTH & TYPE	6' GLASS
OPERATOR	DU	NOZZLE : I.D.	.431
AMBIENT TEMP.(DEG.F)	28.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.51	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB1
FILTER NUMBER(S)	3530003	METER HEAD DIFF.	1.87
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.71
PITOT TUBE COEFF.	.85	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 3.0 IN.HG	REFERENCE PRESS. DIFF.	.12
METER CALIB. FACTOR	.992		

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1310	925.417									
	10.0	1320	931.070	.060	.89	.89	501.	43.	36.	2.0	268.	34.
	20.0	1330	936.220	.060	.89	.89	481.	43.	35.	2.0	253.	34.
	30.0	1340	941.400	.060	.89	.89	489.	46.	36.	2.0	193.	33.
	40.0	1350	946.600	.060	.89	.89	478.	49.	36.	2.1	258.	35.
	50.0	1400	951.860	.060	.89	.89	491.	52.	37.	2.2	318.	35.
	60.0	1410	957.100	.060	.89	.89	505.	54.	38.	2.2	268.	35.
	70.0	1420	962.320	.060	.89	.89	465.	55.	39.	2.2	268.	34.
	80.0	1430	967.550	.060	.89	.89	477.	55.	39.	2.2	247.	34.
	90.0	1440	972.810	.060	.89	.89	491.	55.	39.	2.2	291.	38.
	100.0	1450	978.100	.060	.89	.89	474.	55.	40.	2.2	249.	38.
	110.0	1500	983.320	.060	.89	.89	488.	55.	40.	2.2	218.	37.
	120.0	1510	988.572	.060	.89	.89	496.	55.	40.	2.2	270.	37.
TOTALS	120.0		63.155									
AVERAGE					.89	.89	486.	51.	38.	2.1	258.	35.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS | TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND | DU

TEST D2-5 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/10/81	12/10/81
TB	TIME-START	1310	1310
TF	TIME-FINISH	1510	1510
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.992	.992
DN	SAMPLING NOZZLE DIAMETER	.431 IN	10.9 MM
CP	PITOT TUBE COEFFICIENT	.83	.83
PM	AVERAGE ORIFICE PRESSURE DROP	.89 IN-H2O	22.6 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	63.155 CU-FT	1.788 CU-M
TM	AVERAGE GAS METER TEMP	44.7 F	7.0 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	64.791 SCF	1.835 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	190.7	190.7
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.976 SCF	.254 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.17	12.17
FMD	MOLE FRACTION DRY GAS	.878	.878
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	12.30	12.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	83.40	83.40
MD	MOLECULAR WT-ORY STACK GAS	29.18	29.18
MWS	MOLECULAR WT-STACK GAS	27.82	27.82

PB	BAROMETRIC PRESSURE	29.51	IN-HG	749.55	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.42	IN-HG	747.31	MM-HG
TS	AVERAGE STACK TEMP	486.	F	252.	C
VS	AVG STACK GAS VELOCITY	18.7	FPS	5.7	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1680969.	SCFH	47600.	SCMH
QS	ACTUAL STACK FLOW RATE	3488292.	ACFH	98778.	ACMH
ISO	PERCENT ISOKINETIC	98.6		98.6	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D2-5

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 63.155 * .992 * (29.51 + .890 / 13.6)}{(45. + 460.)} = 64.791 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 191. = 8.98 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.98}{64.791 + 8.98} = 12.17 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.2}{100.} = .878$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (12.3*32/100) + ((83.4+ .0) * 28/100 = 29.18

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.18* (1. -(12.17/100)) + 18. * (12.17/100) = 27.82

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .83 * 90.421 / (SQRT(27.82 * 29.42) * 12. = 18.69 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 18.69 * 7466. 3600/144 = 3488292. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3488292. * 29.42 * (1. - (12.17/100))}{(486. + 460.)} = 1680969.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(486.+460.))*((0.002669*191.)+(63.155*.992*(29.51+(.890/13.6))/(45.+460.)))}{120. * 18.69 * 29.42 * .431 * .431} = 98.63\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 64.791 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1680969. / (15.43 * 453.6) = .00000

Run No. D2.5

Sample volume = 1.84 m^3, 64.79 scf

Example calculations

CS (Part) = 41.1 / 1.84 = 22.3 mg/m^3

CS (Part) = 0.001 x 41.1 x 15.43/64.79 = 0.010 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	41.1	22.3	0.010	
2-h at 350°F	23.4	12.7	0.005	
4-h at 350°F	19.2	10.4	0.004	
2-h at 400°F	18.8	10.2	0.004	
4-h at 400°F	17.7	9.6	0.004	
2-h at 600°F	15.1	8.2	0.003	
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Water soluble sulfates				
As $SO_4^=$	0.0	0.0	0.000	
Sulfur dioxide	N/A			
Sulfuric acid mist				
As H_2SO_4	N/A			
Inorganic condensibles	152.6	82.9	0.036	
Organic condensibles	0.8	0.43	0.0002	
TOC (Condensible)	8.6	4.7	0.002	

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/10/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	D2-6
SAMPLE TYPE	M8-660	PROBE LENGTH & TYPE	5' GLASS
OPERATOR	DU	NOZZLE : I.D.	.378
AMBIENT TEMP.(DEG.F)	28.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.51	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F86
FILTER NUMBER(S)	3530202	METER HEAD DIFF.	1.51
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.90
PITOT TUBE COEFF.	.83	PROBE HEATER SETTING	600.
THERM. NO.		HEATER BOX SETTING	600.
LEAKAGE	.028 CFM @ 10.0 IN.HG	REFERENCE PRESS. DIFF.	.17
METER CALIB. FACTOR	.967		

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1311	681.490									
	10.0	1321	686.480	.060	.63	.63	501.	29.	31.	3.5	532.	32.
	20.0	1331	691.430	.060	.63	.63	481.	30.	30.	4.6	558.	32.
	30.0	1341	696.440	.060	.63	.63	489.	35.	31.	5.2	570.	33.
	40.0	1351	701.420	.060	.63	.63	478.	39.	31.	5.8	578.	34.
	50.0	1401	706.430	.060	.63	.63	491.	40.	31.	6.7	578.	33.
	60.0	1411	711.450	.060	.63	.63	505.	42.	32.	7.2	586.	33.
	70.0	1421	716.490	.060	.63	.63	465.	42.	32.	7.3	589.	33.
	80.0	1431	721.490	.060	.63	.63	477.	43.	33.	7.3	578.	35.
	90.0	1441	726.540	.060	.63	.63	491.	43.	33.	7.6	580.	36.
	100.0	1451	731.500	.060	.63	.63	474.	43.	34.	7.8	579.	37.
	110.0	1501	736.480	.060	.63	.63	488.	43.	34.	8.3	555.	36.
	120.0	1511	741.503	.060	.63	.63	496.	43.	34.	9.6	545.	38.
TOTALS	120.0		58.333									
AVERAGE					.63	.63	486.	39.	32.	6.7	569.	34.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — DO

TEST D2-6 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/10/81	12/10/81
TB	TIME-START	1311	1311
TF	TIME-FINISH	1511	1511
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.967	.967
DN	SAMPLING NOZZLE DIAMETER	.378 IN	9.6 MM
CP	PITOT TUBE COEFFICIENT	.83	.83
PM	AVERAGE ORIFICE PRESSURE DROP	.63 IN-H2O	16.0 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	58.333 CU-FT	1.652 CU-M
TM	AVERAGE GAS METER TEMP	35.8 F	2.1 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	59.347 SCF	1.681 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL, ML.	168.3	168.3
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.922 SCF	.224 SCM
BWO	PERCENT MOISTURE BY VOLUME	11.78	11.78
FMD	MOLE FRACTION DRY GAS	.882	.882
PCO2	PERCENT CO2 BY VOL., DRY	4.30	4.30
PO2	PERCENT O2 BY VOL., DRY	12.30	12.30
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	83.40	83.40
MD	MOLECULAR WT-DRY STACK GAS	29.18	29.18
MWS	MOLECULAR WT-STACK GAS	27.86	27.86

PB	BAROMETRIC PRESSURE	29.51	IN-HG	749.55	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.42	IN-HG	747.31	MM-HG
TS	AVERAGE STACK TEMP	486.	F	252.	C
VS	AVG STACK GAS VELOCITY	18.7	FPS	5.7	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1687140.	SCFH	47775.	SCMH
QS	ACTUAL STACK FLOW RATE	3485548.	ACFH	98700.	ACMH
ISO	PERCENT ISOKINETIC	117.0		117.0	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D2-6

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 58.333 * .967 * (29.51 + .630 / 13.6)}{(36. + 460.)} = 59.347 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 168. = 7.92 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.92}{59.347 + 7.92} = 11.78 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.8}{100.} = .882$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.30*44/100) + (12.3*32/100) + ((83.4+ .0) * 28/100 = 29.18

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.18* (1. -(11.78/100)) + 18. * (11.78/100) = 27.86

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .83 * 90.421 / (SQRT(27.86 * 29.42) * 12. = 18.67 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 18.67 * 7466. 3600/144 = 3485548. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3485548. * 29.42 * (1. - (11.78/100))}{(486. + 460.)} = 1687140.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(486.+460.))*((0.002669*168.)+(58.333*.967*(29.51+(.630/13.6))/(36.+460.)))}{120. * 18.67 * 29.42 * .378 * .378} = 117.03\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 59.347 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1687140. / (15.43 * 453.6) = .00000

Run No. D2.6

Sample volume = 1.68 m^3, 59.35 scf

Example calculations

CS (Part) = 30.3 / 1.68 = 18.0 mg/m^3

CS (Part) = 0.001 x 30.3 x 15.43/ 59.35 = 0.008 gr/dscf

CS (SO_2) = 152.8/ 1.68 = 91.0 mg/m^3

= 91.0 x 24.06/64 = 34 ppm

= 0.001 x 152.8 x 15.43/59.35 = 0.040 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	30.3	18.0	0.008	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	<0.3	<0.2	0.0001	
As $H_2SO_4 \cdot 2H_2O$	<0.4	<0.3	0.0001	
Water soluble sulfates				
As $SO_4^=$	<0.3	<0.2	0.0001	
Sulfur dioxide	152.8	91.0	0.040	34
Sulfuric acid mist				
As H_2SO_4	10.7	6.4	0.003	2
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/11/81
SAMPLING LOCATION	OUTLET STACK	RUN NUMBER	03-1
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	5' HEATED GLASS
OPERATOR	CB	NOZZLE : I.D.	.401
AMBIENT TEMP.(DEG.F)	28.	ASSUMED MOISTURE	14.0
BAR.PRESS.(IN.HG)	29.55	SAMPLE BOX NUMBER	0
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB2
FILTER NUMBER(S)	3530025	METER HEAD DIFF.	1.76
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.82
PITOT TUBE COEFF.	.83	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.002 CFM @ 4.0 IN.HG	REFERENCE PRESS. DIFF.	.14
METER CALIB. FACTOR	1.003		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1131	361.265									
	4.0	1141	362.968	.055	.72	.72	475.	35.	33.	2.0	275.	0.
	10.0	1350	366.860	.048	.62	.62	498.	35.	32.	2.0	247.	35.
	20.0	1400	371.160	.049	.64	.64	508.	35.	32.	2.0	269.	37.
	30.0	1410	375.330	.048	.62	.62	470.	36.	32.	3.0	248.	42.
	40.0	1420	379.750	.050	.65	.65	480.	40.	32.	2.0	242.	46.
	50.0	1430	383.570	.038	.50	.50	485.	44.	34.	2.0	252.	44.
	60.0	1440	387.200	.035	.46	.46	482.	46.	36.	2.0	240.	51.
	70.0	1450	391.130	.042	.54	.54	500.	48.	36.	2.0	250.	50.
	80.0	1500	395.030	.040	.52	.52	466.	48.	36.	2.0	247.	49.
	90.0	1510	398.880	.040	.52	.52	480.	48.	37.	3.0	250.	50.
	100.0	1520	402.560	.043	.56	.56	485.	48.	38.	3.0	239.	52.
	110.0	1530	407.170	.044	.57	.57	505.	48.	38.	3.0	230.	54.
	120.0	1540	411.081	.045	.58	.58	485.	48.	38.	3.0	230.	54.
TOTALS	120.0		49.816									
AVERAGE					.58	.58	486.	43.	35.	2.4	248.	43.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS | TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND | CB

TEST D3-1 OUTLET STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/11/81	12/11/81
TB	TIME-START	1131	1131
TF	TIME-FINISH	1540	1540
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	13	13
Y	METER CALIBRATION FACTOR	1.003	1.003
DN	SAMPLING NOZZLE DIAMETER	.401 IN	10.2 MM
CP	PITOT TUBE COEFFICIENT	.83	.83
PM	AVERAGE ORIFICE PRESSURE DROP	.58 IN-H2O	14.7 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	49.816 CU-FT	1.411 CU-M
TM	AVERAGE GAS METER TEMP	39.0 F	3.9 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	52.294 SCF	1.481 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	122.4	122.4
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	5.761 SCF	.163 SCM
BWO	PERCENT MOISTURE BY VOLUME	9.92	9.92
FMD	MOLE FRACTION DRY GAS	.901	.901
PCO2	PERCENT CO2 BY VOL., DRY	4.00	4.00
PO2	PERCENT O2 BY VOL., DRY	12.00	12.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.00	84.00
MD	MOLECULAR WT-DRY STACK GAS	29.12	29.12
MWS	MOLECULAR WT-STACK GAS	28.02	28.02

PB	BAROMETRIC PRESSURE	29.55	IN-HG	750.57	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.46	IN-HG	748.33	MM-HG
TS	AVERAGE STACK TEMP	486.	F	252.	C
VS	AVG STACK GAS VELOCITY	16.0	FPS	4.9	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1476086.	SCFH	41798.	SCMH
QS	ACTUAL STACK FLOW RATE	2981939.	ACFH	84440.	ACMH
ISO	PERCENT ISOKINETIC	104.7		104.7	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D3-1

OUTLET STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 49.816 * 1.003 * (29.55 + .577 / 13.6)}{(39. + 460.)} = 52.294 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 122. = 5.76 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 5.76}{52.294 + 5.76} = 9.92 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 9.9}{100.} = .901$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.00*44/100) + (12.0*32/100) + ((84.0+ .0) * 28/100 = 29.12

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.12* (1. -(9.92/100)) + 18. * (9.92/100) = 28.02

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .83 * 84.090 / (SQRT(28.02 * 29.46) * 13. = 15.98 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 15.98 * 7466. 3600/144 = 2981939. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 2981939. * 29.46 * (1. - (9.92/100))}{(486. + 460.)} = 1476086.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(486.+460.))*((0.002669*122.)+(49.816*1.003*(29.55+(.577/13.6))/(39.+460.)))}{120. * 15.98 * 29.46 * .401 * .401} = 104.73\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 52.294 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1476086. / (15.43 * 453.6) = .00000

Run No. D3.1

Sample volume = 1.48 m^3, 52.29 scf

Example calculations

CS (Part) = 38.6/1.48 = 26.1 mg/m^3

CS (Part) = 0.001 x 38.6 x 15.43/52.29 = 0.011 gr/dscf

CS (SO_2) = 90.1/ 1.48= 60.9 mg/m^3

= 60.9 x 24.06/64 = 23 ppm

= 0.001 x 90.1 x 15.43/52.29 = 0.026 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	38.6	26.1	0.011	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.3	0.2	0.0001	
As $H_2SO_4 \cdot 2H_2O$	0.4	0.3	0.0001	
Water soluble sulfates				
As $SO_4^=$	6.0	4.0	0.002	
Sulfur dioxide	90.1	60.9	0.026	23
Sulfuric acid mist				
As H_2SO_4	84.0	56.8	0.025	14
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/01/81
SAMPLING LOCATION	OUTLET STACK	RUN NUMBER	03-2
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	4' GLASS
OPERATOR	BRUFFEY	NOZZLE : I.D.	.401
AMBIENT TEMP.(DEG.F)	28.	ASSUMED MOISTURE	14.0
BAR.PRESS.(IN.HG)	29.55	SAMPLE BOX NUMBER	8
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB7
FILTER NUMBER(S)	3530309	METER HEAD DIFF.	.71
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.84
PITOT TUBE COEFF.	.83	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.003 CFM @ 5.0 IN.HG	REFERENCE PRESS. DIFF.	.14
METER CALIB. FACTOR	1.024		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1134	483.135									
	7.0	1141	486.635	.055	.72	.72	475.	40.	36.	2.0	310.	0.
	10.0	1350	489.200	.048	.62	.62	498.	40.	36.	2.5	295.	39.
	20.0	1400	493.770	.048	.62	.62	508.	44.	38.	2.5	300.	44.
	30.0	1410	498.350	.048	.62	.62	470.	48.	38.	2.5	272.	44.
	40.0	1420	502.950	.050	.65	.65	480.	50.	38.	3.0	276.	47.
	50.0	1430	507.640	.038	.50	.50	485.	52.	40.	3.0	280.	47.
	60.0	1440	511.800	.035	.46	.46	482.	55.	42.	3.0	265.	55.
	70.0	1450	515.680	.042	.54	.54	500.	56.	42.	3.0	262.	53.
	80.0	1500	519.900	.040	.52	.52	505.	56.	44.	3.5	253.	55.
	90.0	1510	524.000	.040	.52	.52	466.	56.	45.	4.0	258.	55.
	100.0	1520	528.470	.043	.56	.56	480.	56.	45.	4.2	250.	55.
	110.0	1530	532.990	.044	.57	.57	485.	56.	45.	4.2	245.	54.
	120.0	1540	537.320	.045	.58	.58	485.	56.	46.	4.2	245.	54.
TOTALS	120.0		54.185									
AVERAGE					.58	.58	486.	51.	41.	3.2	270.	46.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — BRUFFEY

TEST D3-2 OUTLET STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/01/81	12/01/81
TB	TIME-START	1134	1134
TF	TIME-FINISH	1540	1540
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	13	13
Y	METER CALIBRATION FACTOR	1.024	1.024
DN	SAMPLING NOZZLE DIAMETER	.401 IN	10.2 MM
CP	PITOT TUBE COEFFICIENT	.83	.83
PM	AVERAGE ORIFICE PRESSURE DROP	.58 IN-H2O	14.6 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	54.185 CU-FT	1.534 CU-M
TM	AVERAGE GAS METER TEMP	46.2 F	7.9 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	57.246 SCF	1.621 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	144.7	144.7
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	6.811 SCF	.193 SCM
BWO	PERCENT MOISTURE BY VOLUME	10.63	10.63
FMD	MOLE FRACTION DRY GAS	.894	.894
PCO2	PERCENT CO2 BY VOL., DRY	4.00	4.00
PO2	PERCENT O2 BY VOL., DRY	12.00	12.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.00	84.00
MD	MOLECULAR WT-DRY STACK GAS	29.12	29.12
MWS	MOLECULAR WT-STACK GAS	27.94	27.94

PB	BAROMETRIC PRESSURE	29.55	IN-HG	750.57	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.46	IN-HG	748.33	MM-HG
TS	AVERAGE STACK TEMP	486.	F	252.	C
VS	AVG STACK GAS VELOCITY	16.0	FPS	4.9	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1465237.	SCFH	41491.	SCMH
QS	ACTUAL STACK FLOW RATE	2983501.	ACFH	84484.	ACMH
ISO	PERCENT ISOKINETIC	115.5		115.5	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D3-2

OUTLET STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 54.185 * 1.024 * (29.55 + .575 / 13.6)}{(46. + 460.)} = 57.246 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 145. = 6.81 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 6.81}{57.246 + 6.81} = 10.63 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 10.6}{100.} = .894$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.00*44/100) + (12.0*32/100) + ((84.0+ .0) * 28/100 = 29.12

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.12* (1. -(10.63/100)) + 18. * (10.63/100) = 27.94

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .83 * 84.016 / (SQRT(27.94 * 29.46) * 13. = 15.98 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 15.98 * 7466. 3600/144 = 2983501. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 2983501. * 29.46 * (1. - (10.63/100))}{(486. + 460.)} = 1465237.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(486.+460.))*((0.002669*145.)+(54.185*1.024*(29.55+(.575/13.6))/(46.+460.)))}{120. * 15.98 * 29.46 * .401 * .401} = 115.49\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 57.246 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1465237. / (15.43 * 453.6) = .00000

Run No. D3.2

Sample volume = 1.62 m^3, 57.25 scf

Example calculations

CS (Part) = 34.5 / 1.62 = 21.3 mg/m^3

CS (Part) = 0.001 x 34.5 x 15.43/57.25 = 0.009 gr/dscf

CS (SO_2) = 152.8/ 1.62 = 94.3 mg/m^3

= 94.3 x 24.06/ 64 = 35 ppm

= 0.001 x 152.8 x 15.43/ 57.25 = 0.041 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	34.5	21.3	0.009	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F	18.1	11.2	0.005	
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	1.8	1.1	0.0005	
As $H_2SO_4 \cdot 2H_2O$	2.5	1.5	0.001	
Water soluble sulfates				
As $SO_4^=$	0.0	0.0	0.000	
Sulfur dioxide	152.8	94.3	0.041	35
Sulfuric acid mist				
As H_2SO_4	7.0	4.3	0.002	1
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIO	DATE	12/11/81
SAMPLING LOCATION	STACK OUTLET #1 BATTERY	RUN NUMBER	03-3
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	4 FOOT GLASS
OPERATOR	DAN FTIZGERALD	NOZZLE : I.D.	.402
AMBIENT TEMP.(DEG.F)	28.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.55	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F88
FILTER NUMBER(S)	3530345	METER HEAD DIFF.	1.91
STACK INSIDE DIM.(IN)	97.75 .00		
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	400.
THERM. NO.	133	HEATER BOX SETTING	400.
LEAKAGE	.004 CFM @ 10.0 IN.HG		
METER CALIB. FACTOR	.982	K FACTOR	11628.0
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1134	754.742									
	10.0	1353	759.100	.055	.68	.68	475.	39.	38.	9.0	389.	40.
	20.0	1403	763.255	.048	.58	.58	498.	35.	33.	8.0	442.	44.
	30.0	1413	767.550	.054	.65	.65	508.	38.	33.	9.0	406.	48.
	40.0	1423	771.675	.048	.60	.60	470.	42.	34.	9.0	411.	47.
	50.0	1433	775.930	.050	.62	.62	480.	45.	35.	10.0	411.	50.
	60.0	1448	779.750	.038	.47	.47	485.	47.	36.	8.5	414.	52.
	70.0	1453	783.375	.035	.43	.43	482.	48.	38.	7.5	430.	55.
	80.0	1503	787.225	.042	.51	.51	500.	50.	40.	7.5	409.	55.
	90.0	1513	791.185	.040	.48	.48	505.	51.	41.	7.5	398.	59.
	100.0	1523	794.960	.040	.50	.50	466.	52.	42.	7.5	410.	57.
	110.0	1533	798.960	.043	.53	.53	480.	53.	43.	8.0	407.	60.
	120.0	1542	803.032	.044	.54	.54	485.	54.	44.	8.0	399.	60.
TOTALS	120.0		48.290									
AVERAGE					.55	.55	486.	46.	38.	8.3	411.	52.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO — DAN FITZGERALD

TEST D3-3 STACK OUTLET #1 BATTERY

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/11/81	12/11/81
TB	TIME-START	1134	1134
TF	TIME-FINISH	1542	1542
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.982	.982
DN	SAMPLING NOZZLE DIAMETER	.402 IN	10.2 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.55 IN-H2O	13.9 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	48.290 CU-FT	1.367 CU-M
TM	AVERAGE GAS METER TEMP	42.1 F	5.6 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	49.315 SCF	1.396 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	143.2	143.2
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	6.740 SCF	.191 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.02	12.02
FMD	MOLE FRACTION DRY GAS	.880	.880
PCO2	PERCENT CO2 BY VOL., DRY	4.00	4.00
PO2	PERCENT O2 BY VOL., DRY	12.00	12.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.00	84.00
MD	MOLECULAR WT-DRY STACK GAS	29.12	29.12
MWS	MOLECULAR WT-STACK GAS	27.78	27.78

PB	BAROMETRIC PRESSURE	29.55	IN-HG	750.57	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.46	IN-HG	748.33	MM-HG
TS	AVERAGE STACK TEMP	486.	F	252.	C
VS	AVG STACK GAS VELOCITY	16.3	FPS	5.0	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1477970.	SCFH	41852.	SCMH
QS	ACTUAL STACK FLOW RATE	3057331.	ACFH	86574.	ACMH
ISO	PERCENT ISOKINETIC	98.7		98.7	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D3-3

STACK OUTLET #1 BATTERY

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 48.290 * .982 * (29.55 + .549 / 13.6)}{(42. + 460.)} = 49.315 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 143. = 6.74 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 6.74}{49.315 + 6.74} = 12.02 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.0}{100.} = .880$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.00*44/100) + (12.0*32/100) + ((84.0+ .0) * 28/100 = 29.12

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.12* (1. -(12.02/100)) + 18. * (12.02/100) = 27.78

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 77.908 / (SQRT(27.78 * 29.46) * 12. = 16.30 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 16.30 * 7505. 3600/144 = 3057331. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3057331. * 29.46 * (1. - (12.02/100))}{(486. + 460.)} = 1477970. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(486.+460.))*((0.002669* 143.)+(48.290* .982*(29.55+(.549/13.6))/(42.+460.)))}{120. * 16.30 * 29.46 * .402 * .402} = 98.65 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 49.315 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1477970. / (15.43 * 453.6) = .00000

Run No. D3.3

Sample volume = 1.40 m^3, 49.32 scf

Example calculations

CS (Part) = 30.9 / 1.40 = 22.1 mg/m^3

CS (Part) = 0.001 x 30.9 x 15.43/49.32 = 0.010 gr/dscf

CS (SO_2) = 130.8/ 1.40 = 93.4 mg/m^3

= 93.4 x 24.06/ 64 = 35 ppm

= 0.001 x 130.8 x 15.43/49.32 = 0.041 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	30.9	22.1	0.010	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Water soluble sulfates				
As $SO_4^=$	4.1	2.9	0.001	
Sulfur dioxide	130.8	93.4	0.041	35
Sulfuric acid mist				
As H_2SO_4	12.0	8.6	0.004	2
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIO	DATE	12/11/81
SAMPLING LOCATION	STACK OUTLET #1 BATTERY	RUN NUMBER	D3-4
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	5 FOOT GLASS
OPERATOR	DAN FITZGERALD	NOZZLE : I.D.	.401
AMBIENT TEMP.(DEG.F)	28.	ASSUMED MOISTURE	13.2
BAR.PRESS.(IN.HG)	29.55	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F84
FILTER NUMBER(S)	3530313	METER HEAD DIFF.	1.88
STACK INSIDE DIM.(IN)	97.75 .00		
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	400.
THERM. NO.	133	HEATER BOX SETTING	400.
LEAKAGE	.014 CFM @ 5.0 IN.HG		
METER CALIB. FACTOR	1.033	K FACTOR	11628.0
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1139	312.428									
	10.0	1358	316.815	.055	.68	.68	475.	43.	42.	4.0	404.	42.
	20.0	1408	320.830	.048	.58	.58	498.	39.	33.	4.0	440.	46.
	30.0	1418	325.155	.054	.65	.65	508.	42.	38.	4.5	400.	50.
	40.0	1428	329.265	.048	.60	.60	470.	47.	39.	4.0	404.	50.
	50.0	1438	333.490	.050	.62	.62	400.	49.	40.	4.0	392.	53.
	60.0	1448	337.130	.038	.47	.47	485.	51.	42.	3.0	405.	56.
	70.0	1458	340.640	.035	.43	.43	482.	53.	43.	3.0	422.	60.
	80.0	1508	344.525	.042	.51	.51	500.	53.	44.	3.5	415.	59.
	90.0	1518	348.140	.040	.48	.48	505.	54.	45.	3.0	395.	60.
	100.0	1528	351.965	.040	.50	.50	466.	55.	47.	3.5	395.	59.
	110.0	1538	356.310	.043	.53	.53	480.	57.	48.	3.5	360.	61.
	120.0	1548	360.313	.044	.54	.54	485.	59.	50.	3.5	364.	59.
TOTALS	120.0		47.885									
AVERAGE					.55	.55	480.	50.	43.	3.6	400.	55.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO — DAN FTIZGERALD

TEST D3-4 STACK OUTLET #1 BATTERY

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/11/81	12/11/81
TB	TIME-START	1139	1139
TF	TIME-FINISH	1548	1548
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.033	1.033
DN	SAMPLING NOZZLE DIAMETER	.401 IN	10.2 MM
CP	PITOT TUBE CDEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.55 IN-H2O	13.9 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	47.885 CU-FT	1.356 CU-M
TM	AVERAGE GAS METER TEMP	46.4 F	8.0 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	51.009 SCF	1.444 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	141.1	141.1
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	6.642 SCF	.188 SCM
BWO	PERCENT MOISTURE BY VOLUME	11.52	11.52
FMD	MOLE FRACTION DRY GAS	.885	.885
PCO2	PERCENT CO2 BY VOL., DRY	4.00	4.00
PO2	PERCENT O2 BY VOL., DRY	12.00	12.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.00	84.00
MD	MOLECULAR WT-DRY STACK GAS	29.12	29.12
MWS	MOLECULAR WT-STACK GAS	27.84	27.84

PB	BAROMETRIC PRESSURE	29.55	IN-HG	750.57	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.46	IN-HG	748.33	MM-HG
TS	AVERAGE STACK TEMP	480.	F	249.	C
VS	AVG STACK GAS VELOCITY	16.2	FPS	4.9	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1489756.	SCFH	42185.	SCMH
QS	ACTUAL STACK FLOW RATE	3042559.	ACFH	86156.	ACMH
ISO	PERCENT ISOKINETIC	101.7		101.7	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 03-4

STACK OUTLET #1 BATTERY

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 47.885 * 1.033 * (29.55 + .549 / 13.6)}{(46. + 460.)} = 51.009 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 141. = 6.64 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 6.64}{51.009 + 6.64} = 11.52 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.5}{100.} = .885$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.00*44/100) + (12.0*32/100) + ((84.0+ .0) * 28/100 = 29.12

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.12* (1. -(11.52/100)) + 18. * (11.52/100) = 27.84

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 77.610 / (SQRT(27.84 * 29.46) * 12. = 16.22 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 16.22 * 7505. 3600/144 = 3042559. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3042559. * 29.46 * (1. - (11.52/100))}{(480. + 460.)} = 1489756.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(480.+460.))*((0.002669*141.)+(47.885*1.033*(29.55+(.549/13.6))/(46.+460.)))}{120. * 16.22 * 29.46 * .401 * .401} = 101.74\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 51.009 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1489756. / (15.43 * 453.6) = .00000

Run No. D3.4

Sample volume = 1.44 m^3, 51.01 scf

Example calculations

CS (Part) = 38.7 / 1.44 = 26.9 mg/m^3

CS (Part) = 0.001 x 38.7 x 15.43/51.01 = 0.012 gr/dscf

CS (SO_2) = 143.4/1.44 = 99.6 mg/m^3

= 99.6 x 24.06/64 = 37 ppm

= 0.001 x 143.4 x 15.43/51.01 = 0.043 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at: Ambient 2-h at 350°F 4-h at 350°F 2-h at 400°F 4-h at 400°F 2-h at 600°F	38.7	26.9	0.012	
Acid sulfates As H_2SO_4 As $H_2SO_4 \cdot 2H_2O$	1.9 2.6	1.3 1.8	0.001 0.001	
Water soluble sulfates As $SO_4^=$	0.8	0.5	0.0002	
Sulfur dioxide	143.4	99.6	0.043	37
Sulfuric acid mist As H_2SO_4	8.2	5.7	0.002	1
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/11/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	D3-5
SAMPLE TYPE	M5-250	PROBE LENGTH & TYPE	5' GLASS
OPERATOR	DD	NOZZLE : I.D.	.434
AMBIENT TEMP.(DEG.F)	28.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.55	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB1
FILTER NUMBER(S)	3530410	METER HEAD DIFF.	1.87
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.71
PITOT TUBE COEFF.	.83	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 3.0 IN.HG	REFERENCE PRESS. DIFF.	.12
METER CALIB. FACTOR	.992		

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1145	988.766									
	10.0	1354	993.870	.056	.86	.86	475.	43.	37.	.5	228.	38.
	20.0	1404	998.960	.056	.86	.86	498.	42.	36.	.5	297.	38.
	30.0	1414	4.060	.056	.86	.86	508.	45.	36.	.5	243.	38.
	40.0	1424	9.180	.056	.86	.86	470.	51.	37.	1.0	279.	39.
	50.0	1434	14.330	.056	.86	.86	480.	56.	39.	1.0	236.	40.
	60.0	1444	19.490	.056	.86	.86	485.	60.	42.	1.0	254.	40.
	70.0	1454	24.680	.056	.86	.86	482.	61.	43.	1.0	282.	38.
	80.0	1504	29.880	.056	.86	.86	500.	62.	45.	1.0	232.	38.
	90.0	1514	35.090	.056	.86	.86	505.	64.	47.	1.0	280.	42.
	100.0	1524	40.300	.056	.86	.86	466.	65.	47.	1.0	231.	44.
	110.0	1534	45.510	.056	.86	.86	480.	65.	48.	1.0	219.	45.
	120.0	1544	50.756	.056	.86	.86	485.	64.	48.	1.5	268.	46.
TOTALS	120.0		61.990									
AVERAGE					.86	.86	486.	57.	42.	.9	254.	41.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS | TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND | DU

TEST 03-5 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/11/81	12/11/81
TB	TIME-START	1145	1145
TF	TIME-FINISH	1544	1544
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.992	.992
DN	SAMPLING NOZZLE DIAMETER	.434 IN	11.0 MM
CP	PITOT TUBE COEFFICIENT	.83	.83
PM	AVERAGE ORIFICE PRESSURE DROP	.86 IN-H2O	21.8 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	61.990 CU-FT	1.755 CU-M
TM	AVERAGE GAS METER TEMP	49.3 F	9.6 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	63.099 SCF	1.787 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	141.1	141.1
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	6.642 SCF	.188 SCM
BWO	PERCENT MOISTURE BY VOLUME	9.52	9.52
FMD	MOLE FRACTION DRY GAS	.905	.905
PCO2	PERCENT CO2 BY VOL., DRY	4.00	4.00
PO2	PERCENT O2 BY VOL., DRY	12.00	12.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.00	84.00
MD	MOLECULAR WT-DRY STACK GAS	29.12	29.12
MWS	MOLECULAR WT-STACK GAS	28.06	28.06

PB	BAROMETRIC PRESSURE	29.55	IN-HG	750.57	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.46	IN-HG	748.33	MM-HG
TS	AVERAGE STACK TEMP	486.	F	252.	C
VS	AVG STACK GAS VELOCITY	18.0	FPS	5.5	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1666931.	SCFH	47202.	SCMH
QS	ACTUAL STACK FLOW RATE	3352885.	ACFH	94944.	ACMH
ISO	PERCENT ISOKINETIC	95.5		95.5	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D3-5

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 61.990 * .992 * (29.55 + .860 / 13.6)}{(49. + 460.)} = 63.099 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 141. = 6.64 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 6.64}{63.099 + 6.64} = 9.52 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 9.5}{100.} = .905$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.00*44/100) + (12.0*32/100) + ((84.0+ .0) * 28/100 = 29.12

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.12* (1. -(9.52/100)) + 18. * (9.52/100) = 28.06

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .83 * 87.347 / (SQRT(28.06 * 29.46) * 12. = 17.96 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.96 * 7466. 3600/144 = 3352885. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3352885. * 29.46 * (1. - (9.52/100))}{(486. + 460.)} = 1666931. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(486.+460.))*((0.002669*141.)+(61.990*.992*(29.55+(.860/13.6))/(49.+460.)))}{120. * 17.96 * 29.46 * .434 * .434} = 95.53 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 63.099 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1666931. / (15.43 * 453.6) = .00000

Run No. D3.5

Sample volume = 1.79 m^3, 63.10 scf

Example calculations

CS (Part) = 35.0/1.79 = 19.6 mg/m^3

CS (Part) = 0.001 x 35.0 x 15.43/63.10 = 0.008 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	35.0	19.6	0.008	
2-h at 350°F	22.2	12.4	0.005	
4-h at 350°F	19.9	11.1	0.005	
2-h at 400°F	15.7	8.8	0.004	
4-h at 400°F	15.7	8.8	0.004	
2-h at 600°F	13.4	7.5	0.003	
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Water soluble sulfates				
As $SO_4^=$	0.9	0.5	0.0002	
Sulfur dioxide				
Sulfuric acid mist As H_2SO_4				
Inorganic condensibles	28.9	16.1	0.007	
Organic condensibles	2.0	1.1	0.0005	
TOC (Condensible)	3.4	1.9	0.0008	

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/11/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	03-6
SAMPLE TYPE	M8-600	PROBE LENGTH & TYPE	4' GLASS
OPERATOR	DD	NOZZLE : I.D.	.379
AMBIENT TEMP.(DEG.F)	28.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.55	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB6
FILTER NUMBER(S)	3530218	METER HEAD DIFF.	1.51
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.90
PITOT TUBE COEFF.	.83	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.016 CFM @ 10.5 IN.HG	REFERENCE PRESS. DIFF.	.16
METER CALIB. FACTOR	.967		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1137	741.956									
	10.0	1356	746.950	.056	.63	.63	475.	35.	35.	3.3	517.	42.
	20.0	1406	751.960	.056	.63	.63	498.	34.	35.	3.4	555.	41.
	30.0	1416	756.990	.056	.63	.63	508.	37.	35.	3.6	546.	40.
	40.0	1426	762.060	.056	.63	.63	470.	43.	35.	3.7	536.	40.
	50.0	1436	767.060	.056	.63	.63	480.	48.	36.	3.7	534.	40.
	60.0	1446	772.060	.056	.63	.63	485.	51.	38.	4.0	547.	40.
	70.0	1456	777.130	.056	.63	.63	482.	52.	39.	4.8	538.	42.
	80.0	1506	782.200	.056	.63	.63	500.	52.	40.	6.2	538.	42.
	90.0	1516	787.270	.056	.63	.63	505.	53.	42.	7.4	538.	44.
	100.0	1526	792.340	.056	.63	.63	466.	53.	42.	8.0	538.	44.
	110.0	1536	797.420	.056	.63	.63	480.	53.	42.	8.7	522.	46.
	120.0	1546	802.493	.056	.63	.63	485.	52.	42.	9.2	524.	46.
TOTALS	120.0		60.537									
AVERAGE					.63	.63	486.	47.	38.	5.5	536.	42.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS

REPUBLIC STEEL CLEVELAND

TEST TEAM LEADER

DO

TEST D3-6 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/11/81	12/11/81
TB	TIME-START	1137	1137
TF	TIME-FINISH	1546	1546
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.967	.967
DN	SAMPLING NOZZLE DIAMETER	.379 IN	9.6 MM
CP	PITOT TUBE COEFFICIENT	.83	.83
PM	AVERAGE ORIFICE PRESSURE DROP	.63 IN-H2O	16.0 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	60.537 CU-FT	1.714 CU-M
TM	AVERAGE GAS METER TEMP	42.7 F	5.9 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	60.824 SCF	1.722 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	164.5	164.5
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.743 SCF	.219 SCM
BWO	PERCENT MOISTURE BY VOLUME	11.29	11.29
FMD	MOLE FRACTION DRY GAS	.887	.887
PCO2	PERCENT CO2 BY VOL., DRY	4.00	4.00
PO2	PERCENT O2 BY VOL., DRY	12.00	12.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.00	84.00
MD	MOLECULAR WT-DRY STACK GAS	29.12	29.12
MWS	MOLECULAR WT-STACK GAS	27.86	27.86

PB	BAROMETRIC PRESSURE	29.55	IN-HG	750.57	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.46	IN-HG	748.33	MM-HG
TS	AVERAGE STACK TEMP	486.	F	252.	C
VS	AVG STACK GAS VELOCITY	18.0	FPS	5.5	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1640093.	SCFH	46443.	SCMH
QS	ACTUAL STACK FLOW RATE	3364702.	ACFH	95278.	ACMH
ISO	PERCENT ISOKINETIC	122.7		122.7	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D3-6

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 60.537 * .967 * (29.55 + .630 / 13.6)}{(43. + 460.)} = 60.824 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 165. = 7.74 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.74}{60.824 + 7.74} = 11.29 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.3}{100.} = .887$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (4.00*44/100) + (12.0*32/100) + ((84.0+ .0) * 28/100 = 29.12

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.12* (1. -(11.29/100)) + 18. * (11.29/100) = 27.86

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .83 * 87.347 / (SQRT(27.86 * 29.46) * 12. = 18.03 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 18.03 * 7466. 3600/144 = 3364702. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3364702. * 29.46 * (1. - (11.29/100))}{(486. + 460.)} = 1640093.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(486.+460.))*((0.002669*165.)+(60.537*.967*(29.55+(.630/13.6))/(43.+460.)))}{120. * 18.03 * 29.46 * .379 * .379} = 122.73\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 60.824 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1640093. / (15.43 * 453.6) = .00000

Run No. D3.6

Sample volume = 1.72 m^3, 60.82 scf

Example calculations

CS (Part) = 25.5 / 1.72 = 0.006 mg/m^3

CS (Part) = 0.001 x 25.5 x 15.43/ 60.82 = 0.006 gr/dscf

CS (SO_2) = 169.1/ 1.72 = 98.3 mg/m^3

= 98.3 x 24.06/64 = 37 ppm

= 0.001 x 169.1 x 15.43/ 60.82 = 0.043 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	25.5	14.8	0.006	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Water soluble sulfates				
As $SO_4^=$	2.2	1.3	0.0005	
Sulfur dioxide	169.1	98.3	0.043	37
Sulfuric acid mist				
As H_2SO_4	12.8	7.4	0.003	2
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIO	DATE	12/12/81
SAMPLING LOCATION	STACK OUTLET #1 BATTERY	RUN NUMBER	D4-1
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	5 FOOT GLASS
OPERATOR	ARMSTRONG	NOZZLE : I.D.	.404
AMBIENT TEMP.(DEG.F)	35.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.72	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F82
FILTER NUMBER(S)	3530325	METER HEAD DIFF.	1.76
STACK INSIDE DIM.(IN)	97.75 .00	C FACTOR	.80
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.	133	HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 7.0 IN.HG	REFERENCE PRESS. DIFF.	.14
METER CALIB. FACTOR	1.003		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	940	411.613									
	10.0	950	416.200	.047	.62	.62	487.	38.	37.	2.5	292.	37.
	20.0	1000	420.910	.050	.66	.66	495.	40.	37.	3.0	304.	37.
	30.0	1010	425.660	.048	.64	.64	507.	42.	37.	3.0	320.	44.
	40.0	1020	430.260	.050	.66	.66	474.	44.	38.	3.5	304.	45.
	50.0	1030	435.130	.053	.70	.70	485.	45.	38.	5.0	315.	47.
	60.0	1040	439.830	.049	.65	.65	498.	46.	38.	5.0	302.	46.
	70.0	1050	444.630	.052	.68	.68	483.	46.	38.	5.0	319.	50.
	80.0	1100	449.380	.048	.64	.64	499.	46.	38.	5.0	315.	50.
	90.0	1110	454.000	.050	.66	.66	510.	47.	40.	5.5	301.	53.
	100.0	1120	458.800	.051	.67	.67	474.	48.	40.	6.0	285.	52.
	110.0	1130	463.800	.056	.74	.74	482.	48.	40.	6.5	266.	53.
	120.0	1140	468.564	.050	.66	.66	490.	48.	40.	7.0	266.	55.
TOTALS	120.0		56.951									
AVERAGE					.67	.67	490.	45.	38.	4.8	299.	47.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO — ARMSTRONG

TEST D4-1 STACK OUTLET #1 BATTERY

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/12/81	12/12/81
TB	TIME-START	940	940
TF	TIME-FINISH	1140	1140
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.003	1.003
DN	SAMPLING NOZZLE DIAMETER	.404 IN	10.3 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.67 IN-H2O	16.9 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	56.951 CU-FT	1.613 CU-M
TM	AVERAGE GAS METER TEMP	41.6 F	5.3 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	59.821 SCF	1.694 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	157.3	157.3
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.404 SCF	.210 SCM
BWO	PERCENT MOISTURE BY VOLUME	11.01	11.01
FMD	MOLE FRACTION DRY GAS	.890	.890
PCO2	PERCENT CO2 BY VOL., DRY	3.70	3.70
PO2	PERCENT O2 BY VOL., DRY	11.10	11.10
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.20	85.20
MD	MOLECULAR WT-DRY STACK GAS	29.04	29.04
MWS	MOLECULAR WT-STACK GAS	27.82	27.82

PB	BAROMETRIC PRESSURE	29.72	IN-HG	754.89	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.63	IN-HG	752.65	MM-HG
TS	AVERAGE STACK TEMP	490.	F	255.	C
VS	AVG STACK GAS VELOCITY	17.3	FPS	5.3	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1588494.	SCFH	44981.	SCMH
QS	ACTUAL STACK FLOW RATE	3244223.	ACFH	91867.	ACMH
ISO	PERCENT ISOKINETIC	110.2		110.2	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D4-1

STACK OUTLET #1 BATTERY

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 56.951 * 1.003 * (29.72 + .665 / 13.6)}{(42. + 460.)} = 59.821 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 157. = 7.40 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.40}{59.821 + 7.40} = 11.01 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.0}{100.} = .890$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (3.70*44/100) + (11.1*32/100) + ((85.2+ .0) * 28/100 = 29.04

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.04* (1. -(11.01/100)) + 18. * (11.01/100) = 27.82

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 82.965 / (SQRT(27.82 * 29.63) * 12. = 17.29 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.29 * 7505. 3600/144 = 3244223. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3244223. * 29.63 * (1. - (11.01/100))}{(490. + 460.)} = 1588494.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*UN*DN)

$$ISO = \frac{(305.58*(490.+460.))*((0.002669*157.)+(56.951*1.003*(29.72+(.665/13.6))/(42.+460.)))}{120. * 17.29 * 29.63 * .404 * .404} = 110.24\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 59.821 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1588494. / (15.43 * 453.6) = .00000

Run No. D4.1

Sample volume = 1.69 m^3, 59.82 scf

Example calculations

CS (Part) = 28.5 / 1.69 = 16.9 mg/m^3

CS (Part) = 0.001 x 28.5 x 15.43/59.82 = 0.007 gr/dscf

CS (SO_2) = 135.6 / 1.69 = 80.2 mg/m^3

= 80.2 x 24.06/64 = 30 ppm

= 0.001 x 135.6 x 15.43/59.82 = 0.035 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	28.5	16.9	0.007	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Water soluble sulfates				
As $SO_4^=$	0.0	0.0	0.000	
Sulfur dioxide	135.6	80.2	0.035	30
Sulfuric acid mist				
As H_2SO_4	42.3	25.0	0.011	6
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIU	DATE	12/12/81
SAMPLING LOCATION	STACK OUTLET #1 BATTERY	RUN NUMBER	D4-2
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	4 FOOT GLASS
OPERATOR	ARMSTRONG	NOZZLE : I.D.	.400
AMBIENT TEMP.(DEG.F)	35.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.72	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB7
FILTER NUMBER(S)	3530332	METER HEAD DIFF.	1.71
STACK INSIDE DIM.(IN)	97.75 .00	C FACTOR	.78
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.	133	HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 5.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.004		

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	943	537.680									
	10.0	953	542.190	.047	.60	.60	487.	44.	40.	2.0	302.	39.
	20.0	1003	546.960	.050	.68	.68	495.	50.	40.	2.2	265.	39.
	30.0	1013	551.670	.048	.66	.66	507.	52.	41.	3.0	255.	47.
	40.0	1023	556.500	.050	.68	.68	474.	54.	42.	3.2	245.	47.
	50.0	1033	561.450	.053	.72	.72	485.	56.	43.	3.5	255.	48.
	60.0	1043	566.240	.049	.67	.67	496.	56.	43.	3.8	249.	50.
	70.0	1053	571.140	.052	.70	.70	483.	58.	44.	3.8	272.	48.
	80.0	1103	575.920	.048	.66	.66	499.	58.	45.	4.0	260.	51.
	90.0	1113	580.730	.050	.68	.68	510.	58.	46.	4.0	260.	50.
	100.0	1123	585.000	.051	.69	.69	474.	60.	48.	4.2	255.	49.
	110.0	1133	590.670	.056	.76	.76	482.	60.	48.	4.0	246.	54.
	120.0	1143	595.468	.050	.68	.68	490.	61.	48.	5.0	246.	52.
TOTALS	120.0		57.788									
AVERAGE					.68	.68	490.	56.	44.	3.6	259.	48.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO — ARMSTRONG

TEST D4-2 STACK OUTLET #1 BATTERY

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/12/81	12/12/81
TB	TIME-START	943	943
TF	TIME-FINISH	1143	1143
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.004	1.004
DN	SAMPLING NOZZLE DIAMETER	.400 IN	10.2 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.68 IN-H2O	17.3 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	57.788 CU-FT	1.636 CU-M
TM	AVERAGE GAS METER TEMP	49.8 F	9.9 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	59.790 SCF	1.693 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	160.7	160.7
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.564 SCF	.214 SCM
BWO	PERCENT MOISTURE BY VOLUME	11.23	11.23
FMO	MOLE FRACTION DRY GAS	.888	.888
PCO2	PERCENT CO2 BY VOL., DRY	3.70	3.70
PO2	PERCENT O2 BY VOL., DRY	11.10	11.10
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.20	85.20
MD	MOLECULAR WT-DRY STACK GAS	29.04	29.04
MWS	MOLECULAR WT-STACK GAS	27.80	27.80

PB	BAROMETRIC PRESSURE	29.72	IN-HG	754.89	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.63	IN-HG	752.65	MM-HG
TS	AVERAGE STACK TEMP	490.	F	255.	C
VS	AVG STACK GAS VELOCITY	17.3	FPS	5.3	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1585451.	SCFH	44895.	SCMH
QS	ACTUAL STACK FLOW RATE	3245338.	ACFH	91898.	ACMH
ISO	PERCENT ISOKINETIC	112.6		112.6	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 04-2

STACK OUTLET #1 BATTERY

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 57.788 * 1.004 * (29.72 + .682 / 13.6)}{(50. + 460.)} = 59.790 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 161. = 7.56 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.56}{59.790 + 7.56} = 11.23 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.2}{100.} = .888$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (3.70*44/100) + (11.1*32/100) + ((85.2+ .0) * 28/100 = 29.04

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.04* (1. -(11.23/100)) + 18. * (11.23/100) = 27.80

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 82.958 / (SQRT(27.80 * 29.63) * 12. = 17.30 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.30 * 7505. 3600/144 = 3245338. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3245338. * 29.63 * (1. - (11.23/100))}{(490. + 460.)} = 1585451. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(490.+460.))*((0.002669*161.)+(57.788*1.004*(29.72+(.682/13.6))/(50.+460.)))}{120. * 17.30 * 29.63 * .400 * .400} = 112.61 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 59.790 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1585451. / (15.43 * 453.6) = .00000

Run No. D4.2

Sample volume = 1.69 m^3, 59.79 scf

Example calculations

CS (Part) = 45.2/ 1.69 = 26.7 mg/m^3

CS (Part) = 0.001 x 45.2 x 15.43/59.79 = 0.012 gr/dscf

CS (SO_2) = 130.5/1.69 = 77.2 mg/m^3

= 77.2 x 24.06/64 = 29 ppm

= 0.001 x 130.5 x 15.43/59.79 = _____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	45.2	26.7	0.012	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F	13.5	8.0	0.003	
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Water soluble sulfates				
As $SO_4^=$	0.9	0.5	0.0002	
Sulfur dioxide	130.5	77.2	0.034	29
Sulfuric acid mist				
As H_2SO_4	15.9	9.4	0.004	2
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIO	DATE	12/12/81
SAMPLING LOCATION	STACK OUTLET #1 BATTERY	RUN NUMBER	04-3
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	4 FOOT GLASS
OPERATOR	DAN FITZGERALD	NOZZLE : I.D.	.404
AMBIENT TEMP.(DEG.F)	35.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.72	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F88
FILTER NUMBER(S)	3530087	METER HEAD DIFF.	1.91
STACK INSIDE DIM.(IN)	97.75 .00		
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	400.
THERM. NO.	133	HEATER BOX SETTING	400.
LEAKAGE	.007 CFM @ 6.0 IN.HG		
METER CALIB. FACTOR	.982	K FACTOR	11856.2
READ & RECORD DATA EVERY 10.0 MINUTES			

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	940	804.107									
	10.0	950	808.315	.047	.59	.59	487.	38.	37.	2.5	410.	42.
	20.0	1000	812.330	.050	.62	.62	495.	43.	37.	3.0	406.	43.
	30.0	1010	816.380	.048	.59	.59	507.	46.	38.	4.0	405.	43.
	40.0	1020	820.675	.050	.63	.63	474.	47.	38.	4.5	405.	44.
	50.0	1030	825.190	.053	.66	.66	485.	48.	39.	5.0	402.	44.
	60.0	1040	829.340	.049	.61	.61	496.	49.	40.	5.0	408.	47.
	70.0	1050	833.740	.052	.65	.65	483.	50.	40.	5.0	416.	50.
	80.0	1100	837.945	.048	.59	.59	499.	50.	41.	5.0	411.	51.
	90.0	1110	842.280	.050	.61	.61	510.	50.	42.	5.0	415.	52.
	100.0	1120	846.560	.051	.64	.64	494.	52.	43.	5.5	412.	52.
	110.0	1130	851.145	.056	.70	.70	482.	54.	44.	5.5	413.	53.
	120.0	1140	855.456	.050	.62	.62	490.	56.	46.	5.0	410.	53.
TOTALS	120.0		51.349									
AVERAGE					.63	.63	492.	49.	40.	4.6	409.	48.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO — DAN FITZGERALD

TEST D4-3 STACK OUTLET #1 BATTERY

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/12/81	12/12/81
TB	TIME-START	940	940
TF	TIME-FINISH	1140	1140
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.982	.982
DN	SAMPLING NOZZLE DIAMETER	.404 IN	10.3 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.63 IN-H2O	15.9 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	51.349 CU-FT	1.454 CU-M
TM	AVERAGE GAS METER TEMP	44.5 F	6.9 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	52.502 SCF	1.487 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL, ML.	149.3	149.3
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.028 SCF	.199 SCM
BWO	PERCENT MOISTURE BY VOLUME	11.81	11.81
FMD	MOLE FRACTION DRY GAS	.882	.882
PCO2	PERCENT CO2 BY VOL., DRY	3.70	3.70
PO2	PERCENT O2 BY VOL., DRY	11.10	11.10
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.20	85.20
MD	MOLECULAR WT-DRY STACK GAS	29.04	29.04
MWS	MOLECULAR WT-STACK GAS	27.73	27.73

PB	BAROMETRIC PRESSURE	29.72	IN-HG	754.89	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.63	IN-HG	752.65	MM-HG
TS	AVERAGE STACK TEMP	492.	F	255.	C
VS	AVG STACK GAS VELOCITY	17.3	FPS	5.3	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1575619.	SCFH	44617.	SCMH
QS	ACTUAL STACK FLOW RATE	3251926.	ACFH	92085.	ACMH
ISO	PERCENT ISOKINETIC	97.5		97.5	
MN	MG, EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 04-3

STACK OUTLET #1 BATTERY

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 51.349 * .982 * (29.72 + .626 / 13.6)}{(45. + 460.)} = 52.502 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 149. = 7.03 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.03}{52.502 + 7.03} = 11.81 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.8}{100.} = .882$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (3.70*44/100) + (11.1*32/100) + ((85.2+ .0) * 28/100 = 29.04

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.04* (1. -(11.81/100)) + 18. * (11.81/100) = 27.73

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 83.031 / (SQRT(27.73 * 29.63) * 12. = 17.33 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.33 * 7505. 3600/144 = 3251926. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3251926. * 29.63 * (1. - (11.81/100))}{(492. + 460.)} = 1575619.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(492.+460.))*((0.002669*149.)+(51.349*.982*(29.72+(.626/13.6))/(45.+460.)))}{120. * 17.33 * 29.63 * .404 * .404} = 97.54\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 52.502 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1575619. / (15.43 * 453.6) = .00000

Run No. D4.3

Sample volume = 1.49 m^3, 52.50 scf

Example calculations

CS (Part) = 24.8 / 1.49 = 16.6 mg/m^3

CS (Part) = 0.001 x 24.8 x 15.43/52.50 = 0.007 gr/dscf

CS (SO_2) = 118.3/1.49 = 79.4 mg/m^3

= 79.4 x 24.06/64 = 30 ppm

= 0.001 x 118.3 x 15.43/52.50 = 0.035 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	24.8	16.6	0.007	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.7	0.5	0.0002	
As $H_2SO_4 \cdot 2H_2O$	0.9	0.6	0.0003	
Water soluble sulfates				
As $SO_4^=$	3.2	2.1	0.0001	
Sulfur dioxide	118.3	79.4	0.035	30
Sulfuric acid mist				
As H_2SO_4	6.7	4.5	0.002	1
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/12/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	D4-5
SAMPLE TYPE	M5-250	PROBE LENGTH & TYPE	5' GLASS
OPERATOR	DO	NOZZLE : I.D.	.431
AMBIENT TEMP.(DEG.F)	35.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.72	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB1
FILTER NUMBER(S)	3530320	METER HEAD DIFF.	1.87
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.71
PITOT TUBE COEFF.	.83	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 3.0 IN.HG	REFERENCE PRESS. DIFF.	.13
METER CALIB. FACTOR	.992		

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	940	72.306									
	10.0	950	77.320	.055	.81	.81	487.	40.	35.	2.0	256.	40.
	20.0	1000	82.320	.055	.81	.81	495.	43.	35.	2.0	283.	42.
	30.0	1010	87.250	.055	.81	.81	507.	49.	36.	2.0	249.	42.
	40.0	1020	92.220	.055	.81	.81	474.	54.	38.	2.0	265.	44.
	50.0	1030	97.240	.055	.81	.81	485.	57.	40.	2.0	280.	44.
	60.0	1040	102.260	.055	.81	.81	496.	59.	41.	2.0	246.	46.
	70.0	1050	107.290	.055	.81	.81	483.	61.	43.	2.0	237.	46.
	80.0	1100	112.340	.055	.81	.81	499.	62.	44.	2.1	286.	46.
	90.0	1110	117.400	.055	.81	.81	510.	63.	45.	2.1	249.	48.
	100.0	1120	122.440	.055	.81	.81	474.	63.	46.	2.1	233.	48.
	110.0	1130	127.520	.055	.81	.81	482.	64.	47.	2.2	298.	48.
	120.0	1140	132.653	.055	.81	.81	490.	65.	47.	2.2	269.	48.
TOTALS	120.0		60.347									
AVERAGE					.81	.81	490.	57.	41.	2.1	263.	45.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — DO

TEST D4-5 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/12/81	12/12/81
TB	TIME-START	940	940
TF	TIME-FINISH	1140	1140
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.992	.992
DN	SAMPLING NOZZLE DIAMETER	.431 IN	10.9 MM
CP	PITOT TUBE COEFFICIENT	.83	.83
PM	AVERAGE ORIFICE PRESSURE DROP	.81 IN-H2O	20.6 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	60.347 CU-FT	1.709 CU-M
TM	AVERAGE GAS METER TEMP	49.0 F	9.5 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	61.802 SCF	1.750 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	176.6	176.6
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.313 SCF	.235 SCM
BWO	PERCENT MOISTURE BY VOLUME	11.86	11.86
FMD	MOLE FRACTION DRY GAS	.881	.881
PCO2	PERCENT CO2 BY VOL., DRY	3.70	3.70
PO2	PERCENT O2 BY VOL., DRY	11.10	11.10
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.20	85.20
MD	MOLECULAR WT-DRY STACK GAS	29.04	29.04
MWS	MOLECULAR WT-STACK GAS	27.73	27.73

PB	BAROMETRIC PRESSURE	29.72	IN-HG	754.89	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.63	IN-HG	752.65	MM-HG
TS	AVERAGE STACK TEMP	490.	F	255.	C
VS	AVG STACK GAS VELOCITY	17.9	FPS	5.5	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1620295.	SCFH	45882.	SCMH
QS	ACTUAL STACK FLOW RATE	5340189.	ACFH	94584.	ACMH
ISO	PERCENT ISOKINETIC	97.6		97.6	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D4-5

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 60.347 * .992 * (29.72 + .810 / 13.6)}{(49. + 460.)} = 61.802 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 177. = 8.31 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.31}{61.802 + 8.31} = 11.86 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.9}{100.} = .881$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (5.70*44/100) + (11.1*32/100) + ((85.2+ .0) * 28/100 = 29.04

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.04* (1. -(11.86/100)) + 18. * (11.86/100) = 27.73

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .83 * 86.747 / (SQRT(27.73 * 29.63) * 12. = 17.90 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.90 * 7466. 3600/144 = 3340189. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3340189. * 29.63 * (1. - (11.86/100))}{(490. + 460.)} = 1620295.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(490.+460.))*((0.002669*177.)+(60.347*.992*(29.72+(.810/13.6))/(49.+460.)))}{120. * 17.90 * 29.63 * .431 * .431} = 97.60\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 61.802 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1620295. / (15.43 * 453.6) = .00000

Run No. D4.5

Sample volume = 1.75 m^3, 61.80 scf

Example calculations

CS (Part) = 31.2 / 1.75 = 17.8 mg/m^3

CS (Part) = 0.001 x 31.2 x 15.43/61.8 = 0.008 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	31.2	17.8	0.008	
2-h at 350°F	21.7	12.4	0.005	
4-h at 350°F	20.2	11.5	0.005	
2-h at 400°F	15.1	8.6	0.004	
4-h at 400°F	14.9	8.5	0.004	
2-h at 600°F	12.3	7.0	0.003	
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Water soluble sulfates				
As $SO_4^=$	0.0	0.0	0.000	
Sulfur dioxide				
Sulfuric acid mist As H_2SO_4				
Inorganic condensibles	84.5	48.3	0.021	
Organic condensibles	2.9	1.6	0.0007	
TOC (Condensible)	8.5	4.8	0.002	

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIO	DATE	12/12/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	04-6
SAMPLE TYPE	M8-600	PROBE LENGTH & TYPE	4' GLASS
OPERATOR	DD	NOZZLE : I.D.	.378
AMBIENT TEMP.(DEG.F)	35.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.72	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F86
FILTER NUMBER(S)	3530226	METER HEAD DIFF.	1.51
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.90
PITOT TUBE COEFF.	.83	PROBE HEATER SETTING	600.
THERM. NO.		HEATER BOX SETTING	600.
LEAKAGE	.000 CFM @ 12.5 IN.HG	REFERENCE PRESS. DIFF.	.16
METER CALIB. FACTOR	.967		

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	942	821.807									
	10.0	952	826.570	.055	.58	.58	487.	35.	38.	4.0	543.	37.
	20.0	1002	831.360	.055	.58	.58	495.	37.	38.	5.8	585.	38.
	30.0	1012	836.180	.055	.58	.58	507.	40.	38.	7.3	599.	38.
	40.0	1022	841.040	.055	.58	.58	474.	44.	38.	7.8	646.	38.
	50.0	1032	845.910	.055	.58	.58	485.	47.	39.	7.9	633.	40.
	60.0	1042	850.750	.055	.58	.58	496.	48.	39.	8.2	620.	40.
	70.0	1052	855.580	.055	.58	.58	483.	50.	40.	9.3	625.	42.
	80.0	1102	860.440	.055	.58	.58	499.	50.	40.	10.2	634.	42.
	90.0	1112	865.290	.055	.58	.58	510.	50.	40.	10.9	636.	44.
	100.0	1122	870.180	.055	.58	.58	474.	50.	42.	11.3	637.	44.
	110.0	1132	875.100	.055	.58	.58	482.	51.	42.	11.8	628.	46.
	120.0	1142	880.080	.055	.58	.58	490.	51.	43.	11.6	617.	48.
TOTALS	120.0		58.273									
AVERAGE					.58	.58	490.	46.	40.	8.8	617.	41.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO — DO

TEST D4-6 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/12/81	12/12/81
TB	TIME-START	942	942
TF	TIME-FINISH	1142	1142
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.967	.967
DN	SAMPLING NOZZLE DIAMETER	.378 IN	9.6 MM
CP	PITOT TUBE COEFFICIENT	.83	.83
PM	AVERAGE ORIFICE PRESSURE DROP	.58 IN-H2O	14.7 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	58.273 CU-FT	1.650 CU-M
TM	AVERAGE GAS METER TEMP	42.9 F	6.1 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	58.849 SCF	1.666 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	160.0	160.0
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.531 SCF	.213 SCM
BWO	PERCENT MOISTURE BY VOLUME	11.35	11.35
FMD	MOLE FRACTION DRY GAS	.887	.887
PCO2	PERCENT CO2 BY VOL., DRY	3.70	3.70
PO2	PERCENT O2 BY VOL., DRY	11.10	11.10
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	85.20	85.20
MD	MOLECULAR WT-DRY STACK GAS	29.04	29.04
MWS	MOLECULAR WT-STACK GAS	27.78	27.78

PB	BAROMETRIC PRESSURE	29.72	IN-HG	754.89	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.63	IN-HG	752.65	MM-HG
TS	AVERAGE STACK TEMP	490.	F	255.	C
VS	AVG STACK GAS VELOCITY	17.9	FPS	5.4	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1628021.	SCFH	46101.	SCMH
QS	ACTUAL STACK FLOW RATE	3336804.	ACFH	94488.	ACMH
ISO	PERCENT ISOKINETIC	120.3		120.3	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D4-6

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 58.273 * .967 * (29.72 + .580 / 13.6)}{(43. + 460.)} = 58.849 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 160. = 7.53 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.53}{58.849 + 7.53} = 11.35 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.3}{100.} = .887$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (3.70*44/100) + (11.1*32/100) + ((85.2+ .0) * 28/100 = 29.04

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.04* (1. -(11.35/100)) + 18. * (11.35/100) = 27.78

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .83 * 86.747 / (SQRT(27.78 * 29.63) * 12. = 17.88 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.88 * 7466. 3600/144 = 3336804. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3336804. * 29.63 * (1. - (11.35/100))}{(490. + 460.)} = 1628021.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(490.+460.))*((0.002669*160.)+(58.273*.967*(29.72+(.580/13.6))/(43.+460.)))}{120. * 17.88 * 29.63 * .378 * .378} = 120.26\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 58.849 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1628021. / (15.43 * 453.6) = .00000

Run No. D4.6

Sample volume = 1.67 m^3, 58.85 scf

Example calculations

CS (Part) = 17.5 / 1.67 = 10.5 mg/m^3

CS (Part) = 0.001 x 17.5 x 15.43/58.85 = 0.004 gr/dscf

CS (SO_2) = 90.1/1.67 = 54.0 mg/m^3

= 54.0 x 24.06/64 = 20 ppm

= 0.001 x 90.1 x 15.43/58.58 = 0.024 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	17.5	10.5	0.004	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Water soluble sulfates				
As $SO_4^=$	0.0	0.0	0.000	
Sulfur dioxide	90.1	54.0	0.024	20
Sulfuric acid mist				
As H_2SO_4	74.7	44.7	0.020	11
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIO	DATE	12/12/81
SAMPLING LOCATION	STACK OUTLET #1 BATTERY	RUN NUMBER	05-1
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	5 FOOT GLASS
OPERATOR		NOZZLE : I.D.	.401
AMBIENT TEMP.(DEG.F)	36.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.78	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB2
FILTER NUMBER(S)	3530325	METER HEAD DIFF.	1.76
STACK INSIDE DIM.(IN)	97.75 .00		
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.	133	HEATER BOX SETTING	250.
LEAKAGE	.016 CFM @ 5.5 IN.HG		
METER CALIB. FACTOR	1.003		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1404	469.955									
	10.0	1414	474.660	.050	.66	.66	500.	38.	38.	2.0	251.	56.
	20.0	1424	479.410	.052	.68	.68	458.	40.	40.	2.0	246.	56.
	30.0	1434	484.430	.057	.75	.75	465.	41.	40.	2.5	275.	45.
	40.0	1444	489.310	.055	.72	.72	476.	44.	40.	3.0	259.	45.
	50.0	1454	494.020	.050	.66	.66	452.	44.	40.	3.2	247.	47.
	60.0	1504	498.750	.050	.66	.66	477.	45.	40.	3.9	252.	49.
	70.0	1514	503.500	.050	.66	.66	490.	46.	40.	4.2	242.	50.
	80.0	1524	508.450	.055	.72	.72	458.	46.	40.	4.4	260.	56.
	90.0	1534	513.390	.055	.72	.72	465.	46.	40.	4.4	244.	56.
	100.0	1544	518.450	.055	.72	.72	476.	46.	40.	4.5	254.	57.
	110.0	1554	523.300	.055	.72	.72	458.	46.	40.	4.8	258.	62.
	120.0	1604	528.233	.055	.72	.72	477.	46.	40.	5.0	245.	57.
TOTALS	120.0		58.278									
AVERAGE					.70	.70	471.	44.	40.	3.7	253.	53.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO

TEST 05-1 STACK OUTLET #1 BATTERY

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/12/81	12/12/81
TB	TIME-START	1404	1404
TF	TIME-FINISH	1604	1604
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.003	1.003
DN	SAMPLING NOZZLE DIAMETER	.401 IN	10.2 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.70 IN-H2O	17.8 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	58.278 CU-FT	1.650 CU-M
TM	AVERAGE GAS METER TEMP	41.9 F	5.5 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	61.308 SCF	1.736 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	174.9	174.9
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.233 SCF	.233 SCM
BWO	PERCENT MOISTURE BY VOLUME	11.84	11.84
FMD	MOLE FRACTION DRY GAS	.882	.882
PCO2	PERCENT CO2 BY VOL., DRY	3.70	3.70
PO2	PERCENT O2 BY VOL., DRY	11.80	11.80
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.50	84.50
MD	MOLECULAR WT-DRY STACK GAS	29.06	29.06
MWS	MOLECULAR WT-STACK GAS	27.75	27.75

PB	BAROMETRIC PRESSURE	29.78	IN-HG	756.41	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.69	IN-HG	754.17	MM-HG
TS	AVERAGE STACK TEMP	471.	F	244.	C
VS	AVG STACK GAS VELOCITY	17.6	FPS	5.4	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1639024.	SCFH	46412.	SCMH
QS	ACTUAL STACK FLOW RATE	3303306.	ACFH	93540.	ACMH
ISO	PERCENT ISOKINETIC	111.1		111.1	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D5-1

STACK OUTLET #1 BATTERY

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 58.278 * 1.003 * (29.78 + .699 / 13.6)}{(42. + 460.)} = 61.308 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 175. = 8.23 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.23}{61.308 + 8.23} = 11.84 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.8}{100.} = .882$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (3.70*44/100) + (11.8*32/100) + ((84.5+ .0) * 28/100 = 29.06

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.06* (1. -(11.84/100)) + 18. * (11.84/100) = 27.75

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 84.461 / (SQRT(27.75 * 29.69) * 12. = 17.61 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.61 * 7505. 3600/144 = 3303306. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3303306. * 29.69 * (1. - (11.84/100))}{(471. + 460.)} = 1639024. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(471.+460.))*((0.002669* 175.)+(58.278*1.003*(29.78+(.699/13.6))/(42.+460.)))}{120. * 17.61 * 29.69 * .401 * .401} = 111.14 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 61.308 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1639024. / (15.43 * 453.6) = .00000

Run No. D5.1

Sample volume = 1.74 m^3, 61.31 scf

Example calculations

CS (Part) = 23.3/1.74 = 13.4 mg/m^3

CS (Part) = 0.001 x 23.3 x 15.43/61.31 = 0.006 gr/dscf

CS (SO_2) = 131.8/1.74 = 75.7 mg/m^3

= 75.7 x 24.06/64 = 28 ppm

= 0.001 x 131.8 x 15.43/61.31 = 0.033 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	23.3	13.4	0.006	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	3.4	1.9	0.001	
As $H_2SO_4 \cdot 2H_2O$	4.6	2.6	0.001	
Water soluble sulfates				
As $SO_4^=$	3.7	2.1	0.001	
Sulfur dioxide	131.8	75.7	0.033	28
Sulfuric acid mist				
As H_2SO_4	8.8	5.0	0.002	1
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIO	DATE	12/12/81
SAMPLING LOCATION	STACK OUTLET #1 BATTERY	RUN NUMBER	05-2
SAMPLE TYPE	PART	PROBE LENGTH & TYPE	4 FOOT GLASS
OPERATOR		NOZZLE : I.D.	.401
AMBIENT TEMP.(DEG.F)	36.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.78	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F87
FILTER NUMBER(S)		METER HEAD DIFF.	1.71
STACK INSIDE DIM.(IN)	97.75 .00		
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.	133	HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 4.0 IN.HG		
METER CALIB. FACTOR	1.004		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1407	595.890									
	10.0	1417	600.660	.050	.68	.68	500.	46.	44.	1.0	260.	46.
	20.0	1427	605.520	.052	.70	.70	458.	47.	44.	1.5	252.	46.
	30.0	1437	610.640	.057	.77	.77	465.	50.	44.	1.5	288.	47.
	40.0	1447	615.630	.055	.74	.74	476.	53.	44.	2.0	269.	47.
	50.0	1457	620.450	.050	.68	.68	452.	56.	45.	2.0	246.	49.
	60.0	1507	625.280	.050	.68	.68	477.	57.	45.	2.0	260.	51.
	70.0	1517	630.080	.050	.68	.68	490.	58.	46.	2.0	248.	47.
	80.0	1527	635.100	.055	.74	.74	458.	60.	46.	2.0	270.	55.
	90.0	1537	640.150	.055	.74	.74	465.	60.	47.	2.0	250.	53.
	100.0	1547	645.170	.055	.74	.74	476.	60.	48.	2.0	260.	59.
	110.0	1557	650.210	.055	.74	.74	458.	60.	48.	2.0	270.	59.
	120.0	1607	655.250	.055	.74	.74	477.	60.	48.	2.0	261.	40.
TOTALS	120.0		59.360									
AVERAGE					.72	.72	471.	56.	46.	1.8	261.	50.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO

TEST D5-2 STACK OUTLET #1 BATTERY

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/12/81	12/12/81
TB	TIME-START	1407	1407
TF	TIME-FINISH	1607	1607
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.004	1.004
DN	SAMPLING NOZZLE DIAMETER	.401 IN	10.2 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.72 IN-H2O	18.3 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	59.360 CU-FT	1.681 CU-M
TM	AVERAGE GAS METER TEMP	50.7 F	10.4 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	61.441 SCF	1.740 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	186.0	186.0
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.755 SCF	.248 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.47	12.47
FMD	MOLE FRACTION DRY GAS	.875	.875
PCO2	PERCENT CO2 BY VOL., DRY	3.70	3.70
PO2	PERCENT O2 BY VOL., DRY	11.80	11.80
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.50	84.50
MD	MOLECULAR WT-DRY STACK GAS	29.06	29.06
MWS	MOLECULAR WT-STACK GAS	27.68	27.68

PB	BAROMETRIC PRESSURE	29.78	IN-HG	756.41	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.69	IN-HG	754.17	MM-HG
TS	AVERAGE STACK TEMP	471.	F	244.	C
VS	AVG STACK GAS VELOCITY	17.6	FPS	5.4	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1629300.	SCFH	46137.	SCMH
QS	ACTUAL STACK FLOW RATE	3307488.	ACFH	93658.	ACMH
ISO	PERCENT ISOKINETIC	112.0		112.0	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D5-2

STACK OUTLET #1 BATTERY

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 59.360 * 1.004 * (29.78 + .719 / 13.6)}{(51. + 460.)} = 61.441 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 186. = 8.76 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.76}{61.441 + 8.76} = 12.47 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.5}{100.} = .875$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (3.70*44/100) + (11.8*32/100) + ((84.5+ .0) * 28/100 = 29.06

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.06* (1. -(12.47/100)) + 18. * (12.47/100) = 27.68

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 84.461 / (SQRT(27.68 * 29.69) * 12. = 17.63 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.63 * 7505. 3600/144 = 3307488. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3307488. * 29.69 * (1. - (12.47/100))}{(471. + 460.)} = 1629300.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(471.+460.))*((0.002669*186.)+(59.360*1.004*(29.78+(.719/13.6))/(51.+460.)))}{120. * 17.63 * 29.69 * .401 * .401} = 112.05\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 61.441 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1629300. / (15.43 * 453.6) = .00000

Run No. D5.2

Sample volume = 1.74 m^3, 61.44 scf

Example calculations

CS (Part) = 20.0/1.74 = 11.5 mg/m^3

CS (Part) = 0.001 x 20.0 x 15.43/61.44 = 0.005 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	20.0	11.5	0.005	
2-h at 350°F	8.7	5.0	0.002	
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.8	0.5	0.0002	
As $H_2SO_4 \cdot 2H_2O$	1.1	0.6	0.0003	
Water soluble sulfates				
As $SO_4^=$	1.7	1.0	0.0004	
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
Inorganic condensibles	74.5	42.8	0.019	
Organic condensibles	0.7	0.40	0.0002	
TOC (Condensible)	202	116	0.05	IPA contaminated

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIO	DATE	12/12/81
SAMPLING LOCATION	STACK OUTLET #1 BATTERY	RUN NUMBER	D5-3
SAMPLE TYPE	PARTICULATE/SO2	PROBE LENGTH & TYPE	4 FOOT GLASS
OPERATOR	DAN FITZGERALD	NOZZLE : I.D.	.402
AMBIENT TEMP.(DEG.F)	36.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.78	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F88
FILTER NUMBER(S)	3530323	METER HEAD DIFF.	1.91
STACK INSIDE DIM.(IN)	97.75 .00		
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.	133	HEATER BOX SETTING	350.
LEAKAGE	.014 CFM @ 11.0 IN.HG		
METER CALIB. FACTOR	.982	K FACTOR	11856.2

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1358	856.004									
	10.0	1408	860.320	.050	.62	.62	500.	46.	44.	8.0	370.	43.
	20.0	1418	864.760	.055	.71	.71	458.	44.	45.	9.0	358.	44.
	30.0	1428	869.320	.055	.70	.70	465.	50.	45.	10.5	355.	43.
	40.0	1438	873.935	.055	.70	.70	476.	52.	43.	11.0	364.	49.
	50.0	1448	878.410	.050	.65	.65	452.	54.	46.	10.0	359.	50.
	60.0	1458	883.170	.057	.72	.72	477.	55.	47.	10.5	355.	54.
	70.0	1508	887.660	.055	.69	.69	490.	56.	48.	10.0	358.	59.
	80.0	1518	892.255	.055	.71	.71	458.	57.	48.	10.0	345.	59.
	90.0	1528	896.900	.055	.70	.70	465.	58.	50.	10.0	355.	60.
	100.0	1538	901.340	.050	.64	.64	476.	58.	50.	9.0	354.	59.
	110.0	1548	905.770	.052	.64	.64	458.	58.	51.	9.0	355.	56.
	120.0	1558	910.397	.057	.72	.72	477.	58.	52.	9.5	353.	52.
TOTALS	120.0		54.393									
AVERAGE					.68	.68	471.	54.	47.	9.7	357.	52.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO — DAN FITZGERALD

TEST D5-3 STACK OUTLET #1 BATTERY

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/12/81	12/12/81
TB	TIME-START	1358	1358
TF	TIME-FINISH	1558	1558
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.982	.982
DN	SAMPLING NOZZLE DIAMETER	.402 IN	10.2 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.68 IN-H2O	17.4 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	54.393 CU-FT	1.540 CU-M
TM	AVERAGE GAS METER TEMP	50.6 F	10.3 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	55.066 SCF	1.559 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	170.2	170.2
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.011 SCF	.227 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.70	12.70
FMD	MOLE FRACTION DRY GAS	.873	.873
PCO2	PERCENT CO2 BY VOL., DRY	3.70	3.70
PO2	PERCENT O2 BY VOL., DRY	11.80	11.80
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.50	84.50
MD	MOLECULAR WT-DRY STACK GAS	29.06	29.06
MWS	MOLECULAR WT-STACK GAS	27.66	27.66

PB	BAROMETRIC PRESSURE	29.78	IN-HG	756.41	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.69	IN-HG	754.17	MM-HG
TS	AVERAGE STACK TEMP	471.	F	244.	C
VS	AVG STACK GAS VELOCITY	17.7	FPS	5.4	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1634772.	SCFH	46292.	SCMH
QS	ACTUAL STACK FLOW RATE	3327285.	ACFH	94219.	ACMH
ISO	PERCENT ISOKINETIC	99.6		99.6	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D5-3

STACK OUTLET #1 BATTERY

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 54.393 * .982 * (29.78 + .683 / 13.6)}{(51. + 460.)} = 55.066 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 170. = 8.01 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.01}{55.066 + 8.01} = 12.70 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.7}{100.} = .873$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (3.70*44/100) + (11.8*32/100) + ((84.5+ .0) * 28/100 = 29.06

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.06* (1. -(12.70/100)) + 18. * (12.70/100) = 27.66

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 84.927 / (SQRT(27.66 * 29.69) * 12. = 17.73 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.73 * 7505. 3600/144 = 3327285. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3327285. * 29.69 * (1. - (12.70/100))}{(471. + 460.)} = 1634772.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(471.+460.))*((0.002669*170.)+(54.393*.982*(29.78+(.683/13.6))/(51.+460.)))}{120. * 17.73 * 29.69 * .402 * .402} = 99.59\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 55.066 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1634772. / (15.43 * 453.6) = .00000

Run No. D5.3

Sample volume = 1.56 m^3, 55.07 scf

Example calculations

CS (Part) = 16.3 / 1.56 = 10.4 mg/m^3

CS (Part) = 0.001 x 16.3 x 15.43/ 55.07 = 0.004 gr/dscf

CS (SO_2) = 123.1 / 1.56 = 79.2 mg/m^3

= 79.2 x 24.06/ 64 = 30 ppm

= 0.001 x 123.6 x 15.43/55.07 = 0.035 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	16.3	10.4	0.004	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	2.2	1.4	0.001	
As $H_2SO_4 \cdot 2H_2O$	3.0	1.9	0.001	
Water soluble sulfates				
As $SO_4^=$	1.6	1.0	0.0004	
Sulfur dioxide	123.6	79.2	0.035	30
Sulfuric acid mist				
As H_2SO_4	7.8	5.0	0.002	1
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIO	DATE	12/12/81
SAMPLING LOCATION	STACK OUTLET #1 BATTERY	RUN NUMBER	D5-4
SAMPLE TYPE	PART	PROBE LENGTH & TYPE	5 FOOT GLASS
OPERATOR	DAN FITZGERALD	NOZZLE : I.D.	.401
AMBIENT TEMP.(DEG.F)	36.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.78	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F84
FILTER NUMBER(S)	3530335	METER HEAD DIFF.	1.88
STACK INSIDE DIM.(IN)	97.75 .00		
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	350.
THERM. NO.	133	HEATER BOX SETTING	350.
LEAKAGE	.019 CFM @ 3.0 IN.HG		
METER CALIB. FACTOR	1.033	K FACTOR	11856.2
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1400	412.927									
	10.0	1410	417.135	.050	.62	.62	500.	51.	51.	2.0	352.	42.
	20.0	1420	421.690	.055	.71	.71	458.	52.	52.	2.5	362.	43.
	30.0	1430	426.235	.055	.70	.70	465.	57.	52.	2.5	347.	45.
	40.0	1440	430.800	.055	.70	.70	476.	61.	54.	2.5	344.	48.
	50.0	1450	435.175	.050	.65	.65	452.	64.	55.	2.0	367.	52.
	60.0	1500	439.825	.057	.72	.72	477.	66.	57.	2.5	345.	54.
	70.0	1510	444.395	.055	.69	.69	490.	68.	58.	2.5	348.	58.
	80.0	1520	449.040	.055	.71	.71	458.	68.	60.	2.5	344.	59.
	90.0	1530	453.645	.055	.70	.70	465.	70.	60.	2.5	350.	59.
	100.0	1540	458.030	.050	.64	.64	476.	70.	62.	2.0	352.	62.
	110.0	1550	462.430	.052	.64	.64	458.	70.	62.	2.0	350.	57.
	120.0	1600	467.086	.057	.72	.72	477.	69.	62.	2.5	352.	49.
TOTALS	120.0		54.159									
AVERAGE					.68	.68	471.	64.	57.	2.3	351.	52.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO — DAN FTIZGERALD

TEST D5-4 STACK OUTLET #1 BATTERY

		ENGLISH UNITS		METRIC UNITS	
TEST DATE		12/12/81		12/12/81	
TB	TIME-START	1400		1400	
TF	TIME-FINISH	1600		1600	
TT	NET TIME OF TEST, MIN.	120.0		120.0	
NP	NET SAMPLING POINTS	12		12	
Y	METER CALIBRATION FACTOR	1.033		1.033	
DN	SAMPLING NOZZLE DIAMETER	.401	IN	10.2	MM
CP	PITOT TUBE COEFFICIENT	.84		.84	
PM	AVERAGE ORIFICE PRESSURE DROP	.68	IN-H2O	17.4	MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	54.159	CU-FT	1.534	CU-M
TM	AVERAGE GAS METER TEMP	60.5	F	15.8	C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	56.586	SCF	1.602	SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	182.8		182.8	
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.604	SCF	.244	SCM
BWO	PERCENT MOISTURE BY VOLUME	13.20		13.20	
FMD	MOLE FRACTION DRY GAS	.868		.868	
PCO2	PERCENT CO2 BY VOL., DRY	3.70		3.70	
PO2	PERCENT O2 BY VOL., DRY	11.80		11.80	
PCO	PERCENT CO BY VOL., DRY	.00		.00	
PN2	PERCENT N2 BY VOL., DRY	84.50		84.50	
MD	MOLECULAR WT-DRY STACK GAS	29.06		29.06	
MWS	MOLECULAR WT-STACK GAS	27.60		27.60	

PB	BAROMETRIC PRESSURE	29.78	IN-HG	756.41	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.69	IN-HG	754.17	MM-HG
TS	AVERAGE STACK TEMP	471.	F	244.	C
VS	AVG STACK GAS VELOCITY	17.8	FPS	5.4	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1627070.	SCFH	46074.	SCMH
QS	ACTUAL STACK FLOW RATE	3330605.	ACFH	94313.	ACMH
ISO	PERCENT ISOKINETIC	103.3		103.3	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D5-4

STACK OUTLET #1 BATTERY

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 54.159 * 1.033 * (29.78 + .683 / 13.6)}{(60. + 460.)} = 56.586 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 183. = 8.60 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.60}{56.586 + 8.60} = 13.20 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 13.2}{100.} = .868$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (3.70*44/100) + (11.8*32/100) + ((84.5+ .0) * 28/100 = 29.06

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.06* (1. -(13.20/100)) + 18. * (13.20/100) = 27.60

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 84.927 / (SQRT(27.60 * 29.69) * 12. = 17.75 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.75 * 7505. 3600/144 = 3330605. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3330605. * 29.69 * (1. - (13.20/100))}{(471. + 460.)} = 1627070.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(471.+460.))*((0.002669*183.)+(54.159*1.033*(29.78+(.683/13.6))/(60.+460.)))}{120. * 17.75 * 29.69 * .401 * .401} = 103.34\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 56.586 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1627070. / (15.43 * 453.6) = .00000

Run No. D5.4

Sample volume = 1.60 m^3, 56.59 scf

Example calculations

CS (Part) = 19.1 / 1.60 = 11.9 mg/m^3

CS (Part) = 0.001 x 19.1 x 15.43/ 56.59 = 0.005 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	19.1	11.9	0.005	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.6	0.4	0.0002	
As $H_2SO_4 \cdot 2H_2O$	0.8	0.5	0.0002	
Water soluble sulfates				
As $SO_4^=$	3.8	2.4	0.001	
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
Inorganic condensibles	158.1	98.8	0.043	
Organic condensibles	4.0	2.5	0.001	
TOC (Condensible)	572	357	0.156	IPA contaminated

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/12/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	D5-5
SAMPLE TYPE	M5-250	PROBE LENGTH & TYPE	5' GLASS
OPERATOR	DD	NOZZLE : I.D.	.434
AMBIENT TEMP.(DEG.F)	40.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.78	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB1
FILTER NUMBER(S)		METER HEAD DIFF.	1.87
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.71
PITOT TUBE COEFF.	.83	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 2.5 IN.HG	REFERENCE PRESS. DIFF.	.13
METER CALIB. FACTOR	.992		

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1358	133.219									
	10.0	1408	138.090	.052	.76	.76	500.	45.	42.	.5	237.	44.
	20.0	1418	142.910	.052	.76	.76	458.	48.	42.	.5	218.	44.
	30.0	1428	147.760	.052	.76	.76	465.	53.	42.	.5	282.	46.
	40.0	1438	152.610	.052	.76	.76	476.	57.	43.	.5	252.	46.
	50.0	1448	157.480	.052	.76	.76	452.	60.	44.	.5	275.	47.
	60.0	1458	162.360	.052	.76	.76	477.	61.	46.	.5	230.	48.
	70.0	1508	167.270	.052	.76	.76	490.	63.	46.	.5	271.	48.
	80.0	1518	172.140	.052	.76	.76	458.	65.	48.	.5	218.	48.
	90.0	1528	177.040	.052	.76	.76	465.	65.	49.	1.0	252.	48.
	100.0	1538	182.000	.052	.76	.76	476.	66.	50.	1.0	268.	50.
	110.0	1548	186.900	.052	.76	.76	458.	67.	50.	1.0	220.	50.
	120.0	1558	191.818	.052	.76	.76	477.	67.	51.	1.0	283.	51.
TOTALS	120.0		58.599									
AVERAGE					.76	.76	471.	60.	46.	.7	251.	48.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS | TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND | DO

TEST D5-5 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/12/81	12/12/81
TB	TIME-START	1358	1358
TF	TIME-FINISH	1558	1558
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.992	.992
DN	SAMPLING NOZZLE DIAMETER	.434 IN	11.0 MM
CP	PITOT TUBE COEFFICIENT	.83	.83
PM	AVERAGE ORIFICE PRESSURE DROP	.76 IN-H2O	19.3 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	58.599 CU-FT	1.659 CU-M
TM	AVERAGE GAS METER TEMP	52.9 F	11.6 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	59.671 SCF	1.690 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL,ML.	177.8	177.8
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.369 SCF	.237 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.30	12.30
FMD	MOLE FRACTION DRY GAS	.877	.877
PCO2	PERCENT CO2 BY VOL., DRY	3.70	3.70
PO2	PERCENT O2 BY VOL., DRY	11.80	11.80
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.50	84.50
MD	MOLECULAR WT-DRY STACK GAS	29.06	29.06
MWS	MOLECULAR WT-STACK GAS	27.70	27.70

PB	BAROMETRIC PRESSURE	29.78	IN-HG	756.41	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.69	IN-HG	754.17	MM-HG
TS	AVERAGE STACK TEMP	471.	F	244.	C
VS	AVG STACK GAS VELOCITY	17.2	FPS	5.2	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1585882.	SCFH	44907.	SCMH
QS	ACTUAL STACK FLOW RATE	3213030.	ACFH	90983.	ACMH
ISO	PERCENT ISOKINETIC	95.0		95.0	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D5-5

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 58.599 * .992 * (29.78 + .760 / 13.6)}{(53. + 460.)} = 59.671 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 178. = 8.37 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.37}{59.671 + 8.37} = 12.30 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.3}{100.} = .877$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (3.70*44/100) + (11.8*32/100) + ((84.5+ .0) * 28/100 = 29.06

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.06* (1. -(12.30/100)) + 18. * (12.30/100) = 27.70

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .83 * 83.492 / (SQRT(27.70 * 29.69) * 12. = 17.21 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.21 * 7466. 3600/144 = 3213030. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3213030. * 29.69 * (1. - (12.30/100))}{(471. + 460.)} = 1585882. \text{ SCFH}$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(471.+460.))*((0.002669*178.)+(58.599*.992*(29.78+(.760/13.6))/(53.+460.)))}{120. * 17.21 * 29.69 * .434 * .434} = 94.96 \text{ PERCENT}$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 59.671 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1585882. / (15.43 * 453.6) = .00000

Run No. D5.5

Sample volume = 1.69 m^3, 59.67 scf

Example calculations

CS (Part) = 15.9 / 1.69 = 9.4 mg/m^3

CS (Part) = 0.001 x 15.9 x 15.43/ 59.67 = 0.004 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/ ____ = ____ ppm

= 0.001 x ____ x 15.43/ ____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	15.9	9.4	0.004	
2-h at 350°F	6.9	4.1	0.002	
4-h at 350°F	5.3	3.1	0.001	
2-h at 400°F	4.5	2.7	0.001	
4-h at 400°F	4.5	2.7	0.001	
2-h at 600°F	2.4	1.4	0.001	
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Water soluble sulfates				
As $SO_4^=$	0.0	0.0	0.000	
Sulfur dioxide				
Sulfuric acid mist As H_2SO_4				
Inorganic condensibles	15.6	9.2	0.004	
Organic condensibles	1.4	0.83	0.0004	
TOC (Condensible)	3.6	2.1	0.0009	

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/12/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	D5-6
SAMPLE TYPE	M8-600	PROBE LENGTH & TYPE	4' GLASS
OPERATOR	DO	NOZZLE : I.D.	.379
AMBIENT TEMP.(DEG.F)	40.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.78	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB6
FILTER NUMBER(S)		METER HEAD DIFF.	1.51
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.90
PITOT TUBE COEFF.	.83	PROBE HEATER SETTING	600.
THERM. NO.		HEATER BOX SETTING	600.
LEAKAGE	.008 CFM @ 11.5 IN.HG	REFERENCE PRESS. DIFF.	.16
METER CALIB. FACTOR	.967		

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	1359	881.913									
	10.0	1409	886.620	.052	.55	.55	500.	39.	41.	4.3	555.	42.
	20.0	1419	891.270	.052	.55	.55	458.	40.	41.	4.8	598.	42.
	30.0	1429	895.980	.052	.55	.55	465.	44.	41.	7.2	620.	44.
	40.0	1439	900.700	.052	.55	.55	476.	47.	41.	7.6	620.	46.
	50.0	1449	905.420	.052	.55	.55	452.	49.	42.	7.5	623.	46.
	60.0	1459	910.120	.052	.55	.55	477.	50.	42.	8.8	608.	47.
	70.0	1509	914.850	.052	.55	.55	490.	51.	42.	10.0	607.	47.
	80.0	1519	919.580	.052	.55	.55	458.	52.	43.	10.3	605.	48.
	90.0	1529	924.320	.052	.55	.55	465.	52.	43.	10.8	600.	48.
	100.0	1539	929.120	.052	.55	.55	476.	52.	44.	11.2	594.	49.
	110.0	1549	933.880	.052	.55	.55	458.	52.	44.	11.0	587.	49.
	120.0	1559	938.607	.052	.55	.55	477.	53.	44.	11.2	586.	49.
TOTALS	120.0		56.694									
AVERAGE					.55	.55	471.	48.	42.	8.7	600.	46.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — DO

TEST 05-6 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/12/81	12/12/81
TB	TIME-START	1359	1359
TF	TIME-FINISH	1559	1559
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.967	.967
DN	SAMPLING NOZZLE DIAMETER	.379 IN	9.6 MM
CP	PITOT TUBE COEFFICIENT	.83	.83
PM	AVERAGE ORIFICE PRESSURE DROP	.55 IN-H2O	14.0 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	56.694 CU-FT	1.605 CU-M
TM	AVERAGE GAS METER TEMP	45.4 F	7.4 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	57.087 SCF	1.617 SCM
VLC	TOTAL H2O COLLECTED IN IMPINGERS AND SILICA GEL, ML.	144.1	144.1
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	6.783 SCF	.192 SCM
BWO	PERCENT MOISTURE BY VOLUME	10.62	10.62
FMD	MOLE FRACTION DRY GAS	.894	.894
PCO2	PERCENT CO2 BY VOL., DRY	3.70	3.70
PO2	PERCENT O2 BY VOL., DRY	11.80	11.80
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	84.50	84.50
MD	MOLECULAR WT-DRY STACK GAS	29.06	29.06
MWS	MOLECULAR WT-STACK GAS	27.89	27.89

PB	BAROMETRIC PRESSURE	29.78	IN-HG	756.41	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.69	IN-HG	754.17	MM-HG
TS	AVERAGE STACK TEMP	471.	F	244.	C
VS	AVG STACK GAS VELOCITY	17.2	FPS	5.2	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1610872.	SCFH	45615.	SCMH
QS	ACTUAL STACK FLOW RATE	3202302.	ACFH	90680.	ACMH
ISO	PERCENT ISOKINETIC	117.3		117.3	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D5-6

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 56.694 * .967 * (29.78 + .550 / 13.6)}{(45. + 460.)} = 57.087 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 144. = 6.78 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 6.78}{57.087 + 6.78} = 10.62 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 10.6}{100.} = .894$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (3.70*44/100) + (11.8*32/100) + ((84.5+ .0) * 28/100 = 29.06

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.06* (1. -(10.62/100)) + 18. * (10.62/100) = 27.89

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .83 * 83.492 / (SQRT(27.89 * 29.69) * 12. = 17.16 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 17.16 * 7466. 3600/144 = 3202302. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3202302. * 29.69 * (1. - (10.62/100))}{(471. + 460.)} = 1610872.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(471.+460.))*((0.002669*144.)+(56.694*.967*(29.78+(.550/13.6))/(45.+460.)))}{120. * 17.16 * 29.69 * .379 * .379} = 117.28\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 57.087 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1610872. / (15.43 * 453.6) = .00000

Run No. D5.6

Sample volume = 1.62 m^3, 57.09 scf

Example calculations

CS (Part) = 12.9 / 1.62 = 8.0 mg/m^3

CS (Part) = 0.001 x 12.9 x 15.43/57.09 = 0.003 gr/dscf

CS (SO_2) = 129.0 / 1.62 = 79.6 mg/m^3

= 79.6 x 24.06/64 = 30 ppm

= 0.001 x 129.0 x 15.43/57.09 = 0.035 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	12.9	8.0	0.0003	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.3	0.2	0.0001	
As $H_2SO_4 \cdot 2H_2O$	0.4	0.2	0.0001	
Water soluble sulfates				
As $SO_4^{=}$	1.4	0.9	0.0003	
Sulfur dioxide	129.0	79.6	0.035	30
Sulfuric acid mist				
As H_2SO_4	8.2	5.1	0.002	1
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/13/81
SAMPLING LOCATION	COKE OUTLET	RUN NUMBER	D6-1
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	5 FT GLASS
OPERATOR	ARMSTRONG	NOZZLE : I.D.	.404
AMBIENT TEMP.(DEG.F)	32.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.79	SAMPLE BOX NUMBER	Q
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB2
FILTER NUMBER(S)		METER HEAD DIFF.	1.76
STACK INSIDE DIM.(IN)	97.75 .00	C FACTOR	.78
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.004 CFM @ 6.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.003		
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	945	531.010									
	10.0	955	535.645	.050	.62	.62	455.	35.	35.	1.5	259.	41.
	20.0	1005	539.880	.046	.56	.56	463.	38.	35.	2.5	262.	39.
	30.0	1015	544.220	.048	.59	.59	465.	41.	35.	2.5	290.	40.
	40.0	1025	548.405	.045	.55	.55	443.	44.	35.	3.0	261.	40.
	50.0	1035	552.640	.046	.56	.56	456.	44.	36.	4.2	284.	40.
	60.0	1045	557.145	.050	.62	.62	463.	44.	36.	4.8	280.	45.
	70.0	1055	561.000	.047	.58	.58	447.	45.	37.	5.1	265.	47.
	80.0	1105	565.770	.045	.55	.55	460.	45.	38.	5.1	271.	45.
	90.0	1115	570.135	.047	.58	.58	460.	46.	37.	5.0	263.	45.
	100.0	1125	574.400	.045	.55	.55	440.	46.	38.	5.0	265.	46.
	110.0	1135	578.920	.050	.62	.62	448.	46.	40.	5.5	236.	52.
	120.0	1145	583.020	.045	.55	.55	461.	46.	40.	5.5	302.	54.
TOTALS	120.0		52.010									
AVERAGE					.58	.58	455.	43.	37.	4.1	270.	45.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — ARMSTRONG

TEST D6-1 COKE OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/13/81	12/13/81
TB	TIME-START	945	945
TF	TIME-FINISH	1145	1145
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.003	1.003
DN	SAMPLING NOZZLE DIAMETER	.404 IN	10.3 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.58 IN-H2O	14.7 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	52.010 CU-FT	1.473 CU-M
TM	AVERAGE GAS METER TEMP	40.1 F	4.5 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	54.917 SCF	1.555 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	153.0	153.0
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.202 SCF	.204 SCM
BWO	PERCENT MOISTURE BY VOLUME	11.59	11.59
FMO	MOLE FRACTION DRY GAS	.884	.884
PCO2	PERCENT CO2 BY VOL., DRY	5.10	5.10
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	83.90	83.90
MD	MOLECULAR WT-DRY STACK GAS	29.26	29.26
MWS	MOLECULAR WT-STACK GAS	27.95	27.95

PB	BAROMETRIC PRESSURE	29.79	IN-HG	756.67	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.70	IN-HG	754.42	MM-HG
TS	AVERAGE STACK TEMP	455.	F	235.	C
VS	AVG STACK GAS VELOCITY	16.3	FPS	5.0	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1552508.	SCFH	43962.	SCMH
QS	ACTUAL STACK FLOW RATE	3065894.	ACFH	86817.	ACMH
ISO	PERCENT ISOKINETIC	103.5		103.5	
MN		.0000		.0000	
	MG. EPA 5				
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR		.00000	LB/HR	.000	KG/HR
	EMISSION RATE				

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D6-1

COKE OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 52.010 * 1.003 * (29.79 + .577 / 13.6)}{(40. + 460.)} = 54.917 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 153. = 7.20 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.20}{54.917 + 7.20} = 11.59 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.6}{100.} = .884$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (5.10*44/100) + (11.0*32/100) + ((83.9+ .0) * 28/100 = 29.26

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.26* (1. -(11.59/100)) + 18. * (11.59/100) = 27.95

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 78.681 / (SQRT(27.95 * 29.70) * 12. = 16.34 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 16.34 * 7505. 3600/144 = 3065894. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3065894. * 29.70 * (1. - (11.59/100))}{(455. + 460.)} = 1552508.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(455.+460.))*((0.002669* 153.)+(52.010*1.003*(29.79+(.577/13.6))/(40.+460.)))}{120. * 16.34 * 29.70 * .404 * .404} = 103.55\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 54.917 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1552508. / (15.43 * 453.6) = .00000

Run No. D6.1

Sample volume = 1.56 m^3, 54.92 scf

Example calculations

CS (Part) = 12.2 / 1.56 = 7.8 mg/m^3

CS (Part) = 0.001 x 12.2 x 15.43/ 54.92 = 0.003 gr/dscf

CS (SO_2) = 118.3/ 1.56 = 75.8 mg/m^3

= 75.8 x 24.06/ 64 = 28 ppm

= 0.001 x 118.3 x 15.43/54.92 = 0.033 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at: Ambient 2-h at 350°F 4-h at 350°F 2-h at 400°F 4-h at 400°F 2-h at 600°F	12.2	7.8	0.003	
Acid sulfates As H_2SO_4 As $H_2SO_4 \cdot 2H_2O$	0.0 0.0	0.0 0.0	0.000 0.000	
Water soluble sulfates As $SO_4^=$	0.0	0.0	0.000	
Sulfur dioxide	118.3	75.8	0.033	28
Sulfuric acid mist As H_2SO_4	13.2	8.5	0.004	2
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/13/81
SAMPLING LOCATION	COKE OUTLET	RUN NUMBER	D6-2
SAMPLE TYPE	PART	PROBE LENGTH & TYPE	4 FT GLASS
OPERATOR	ARMSTRONG	NOZZLE : I.D.	.400
AMBIENT TEMP.(DEG.F)	32.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.79	SAMPLE BOX NUMBER	8
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F87
FILTER NUMBER(S)		METER HEAD DIFF.	1.71
STACK INSIDE DIM.(IN)	97.75 .00	C FACTOR	.76
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.002 CFM @ 4.0 IN.HG	REFERENCE PRESS. DIFF.	.15
METER CALIB. FACTOR	1.004		
READ & RECORD DATA EVERY 10.0 MINUTES			

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	947	655.605									
	10.0	957	660.140	.050	.62	.62	455.	40.	38.	1.2	270.	41.
	20.0	1007	664.425	.046	.56	.56	463.	42.	38.	1.5	267.	37.
	30.0	1017	668.850	.048	.59	.59	465.	47.	38.	1.5	264.	40.
	40.0	1027	673.140	.045	.55	.55	443.	51.	40.	1.5	240.	41.
	50.0	1037	677.450	.046	.56	.56	456.	53.	40.	1.5	258.	42.
	60.0	1047	681.980	.050	.62	.62	463.	55.	42.	1.5	244.	43.
	70.0	1057	686.350	.047	.58	.58	447.	56.	43.	1.5	232.	43.
	80.0	1107	690.700	.045	.55	.55	460.	57.	44.	1.5	246.	44.
	90.0	1117	695.000	.047	.58	.58	460.	58.	44.	1.5	245.	50.
	100.0	1127	699.430	.045	.55	.55	460.	58.	46.	1.5	224.	51.
	110.0	1137	704.020	.050	.62	.62	448.	58.	46.	1.5	226.	49.
	120.0	1147	708.370	.045	.55	.55	461.	58.	47.	1.5	260.	55.
TOTALS	120.0		52.765									
AVERAGE					.58	.58	457.	53.	42.	1.5	248.	45.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — ARMSTRONG

TEST 06-2 COKE OUTLET

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/13/81	12/13/81
TB	TIME-START	947	947
TF	TIME-FINISH	1147	1147
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.004	1.004
DN	SAMPLING NOZZLE DIAMETER	.400 IN	10.2 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.58 IN-H2O	14.7 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	52.765 CU-FT	1.494 CU-M
TM	AVERAGE GAS METER TEMP	47.5 F	8.6 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	54.959 SCF	1.556 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	171.0	171.0
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.049 SCF	.228 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.77	12.77
FMO	MOLE FRACTION DRY GAS	.872	.872
PCO2	PERCENT CO2 BY VOL., DRY	5.10	5.10
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	83.90	83.90
MD	MOLECULAR WT-DRY STACK GAS	29.26	29.26
MWS	MOLECULAR WT-STACK GAS	27.82	27.82

PB	BAROMETRIC PRESSURE	29.79	IN-HG	756.67	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.70	IN-HG	754.42	MM-HG
TS	AVERAGE STACK TEMP	457.	F	236.	C
VS	AVG STACK GAS VELOCITY	16.4	FPS	5.0	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1534002.	SCFH	43438.	SCMH
QS	ACTUAL STACK FLOW RATE	3075958.	ACFH	87102.	ACMH
ISO	PERCENT ISOKINETIC	107.0		107.0	
MN		.0000		.0000	
	MG, EPA 5				
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR		.00000	LB/HR	.000	KG/HR
	EMISSION RATE				

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D6-2

COKE OUTLET

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 52.765 * 1.004 * (29.79 + .577 / 13.6)}{(47. + 460.)} = 54.959 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 171. = 8.05 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 8.05}{54.959 + 8.05} = 12.77 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.8}{100.} = .872$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (5.10*44/100) + (11.0*32/100) + ((83.9+ .0) * 28/100 = 29.26

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.26* (1. -(12.77/100)) + 18. * (12.77/100) = 27.82

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 78.751 / (SQRT(27.82 * 29.70) * 12. = 16.40 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 16.40 * 7505. 3600/144 = 3075958. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3075958. * 29.70 * (1. - (12.77/100))}{(457. + 460.)} = 1534002.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*ON*DN)

$$ISO = \frac{(305.58*(457.+460.))*((0.002669* 171.)+(52.765*1.004*(29.79+(.577/13.6))/(47.+460.)))}{120. * 16.40 * 29.70 * .400 * .400} = 106.99\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 54.959 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1534002. / (15.43 * 453.6) = .00000

Run No. D6.2

Sample volume = 1.56 m^3, 54.96 scf

Example calculations

CS (Part) = 21.1 / 1.56 = 13.5 mg/m^3

CS (Part) = 0.001 x 21.1 x 15.43/54.96 = 0.006 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	21.1	13.5	0.006	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F	5.4	3.5	0.001	
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Water soluble sulfates				
As $SO_4^=$	0.0	0.0	0.000	
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
Inorganic condensibles	55.2	35.4	0.015	
Organic condensibles	2.4	1.5	0.0007	
TOC (Condensible)	403	258	0.113	IPA contaminated

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIO	DATE	12/13/81
SAMPLING LOCATION	STACK OUTLET #1 BATTERY	RUN NUMBER	D6-3
SAMPLE TYPE	PART/H2SO4/SO2	PROBE LENGTH & TYPE	4 FOOT GLASS
OPERATOR	DAN FITZGERALD	NOZZLE : I.D.	.404
AMBIENT TEMP.(DEG.F)	32.	ASSUMED MOISTURE	13.2
BAR.PRESS.(IN.HG)	29.79	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F88
FILTER NUMBER(S)	3530059	METER HEAD DIFF.	1.91
STACK INSIDE DIM.(IN)	97.75 .00		
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	400.
THERM. NO.	133	HEATER BOX SETTING	400.
LEAKAGE	.002 CFM @ 5.0 IN.HG		
METER CALIB. FACTOR	.982	K FACTOR	11628.3
READ & RECORD DATA EVERY 10.0 MINUTES			

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	945	911.168									
	10.0	955	915.480	.050	.64	.64	455.	34.	32.	2.5	407.	40.
	20.0	1005	919.560	.046	.58	.58	463.	38.	33.	2.5	401.	44.
	30.0	1015	923.675	.048	.60	.60	465.	43.	35.	2.5	401.	42.
	40.0	1025	927.765	.045	.58	.58	443.	48.	37.	2.5	399.	42.
	50.0	1035	931.700	.046	.58	.58	455.	50.	40.	3.0	404.	43.
	60.0	1045	936.000	.050	.63	.63	463.	52.	42.	4.5	407.	41.
	70.0	1055	940.205	.047	.60	.60	447.	54.	44.	4.5	406.	49.
	80.0	1105	944.290	.045	.57	.57	460.	54.	45.	4.5	402.	49.
	90.0	1115	948.480	.047	.59	.59	460.	55.	46.	5.0	397.	57.
	100.0	1125	952.700	.045	.58	.58	440.	55.	47.	5.0	391.	60.
	110.0	1135	957.105	.050	.64	.64	448.	56.	48.	5.0	387.	60.
	120.0	1145	961.260	.045	.57	.57	461.	56.	48.	5.0	387.	55.
TOTALS	120.0		50.092									
AVERAGE					.60	.60	455.	50.	41.	3.9	399.	49.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO — DAN FITZGERALD

TEST 06-3 STACK OUTLET #1 BATTERY

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/13/81	12/13/81
TB	TIME-START	945	945
TF	TIME-FINISH	1145	1145
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.982	.982
DN	SAMPLING NOZZLE DIAMETER	.404 IN	10.3 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.60 IN-H2O	15.2 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	50.092 CU-FT	1.418 CU-M
TM	AVERAGE GAS METER TEMP	45.5 F	7.5 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	51.232 SCF	1.451 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL, ML.	147.1	147.1
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	6.924 SCF	.196 SCM
BWO	PERCENT MOISTURE BY VOLUME	11.91	11.91
FMD	MOLE FRACTION DRY GAS	.881	.881
PCO2	PERCENT CO2 BY VOL., DRY	5.10	5.10
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	83.90	83.90
MD	MOLECULAR WT-DRY STACK GAS	29.26	29.26
MWS	MOLECULAR WT-STACK GAS	27.92	27.92

PB	BAROMETRIC PRESSURE	29.79	IN-HG	756.67	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.70	IN-HG	754.42	MM-HG
TS	AVERAGE STACK TEMP	455.	F	235.	C
VS	AVG STACK GAS VELOCITY	16.4	FPS	5.0	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1548066.	SCFH	43837.	SCMH
QS	ACTUAL STACK FLOW RATE	3067686.	ACFH	86868.	ACMH
ISO	PERCENT ISOKINETIC	96.9		96.9	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D6-3

STACK OUTLET #1 BATTERY

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 50.092 * .982 * (29.79 + .597 / 13.6)}{(46. + 460.)} = 51.232 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 147. = 6.92 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 6.92}{51.232 + 6.92} = 11.91 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 11.9}{100.} = .881$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (5.10*44/100) + (11.0*32/100) + ((83.9+ .0) * 28/100 = 29.26

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.26* (1. -(11.91/100)) + 18. * (11.91/100) = 27.92

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 78.678 / (SQRT(27.92 * 29.70) * 12. = 16.35 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 16.35 * 7505. 3600/144 = 3067686. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3067686. * 29.70 * (1. - (11.91/100))}{(455. + 460.)} = 1548066.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(455.+460.))*((0.002669*147.)+(50.092*.982*(29.79+(.597/13.6))/(46.+460.)))}{120. * 16.35 * 29.70 * .404 * .404} = 96.88\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 51.232 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1548066. / (15.43 * 453.6) = .00000

Run No. D6.3

Sample volume = 1.45 m^3, 51.23 scf

Example calculations

CS (Part) = 15.6/1.45 = 10.8 mg/m^3

CS (Part) = 0.001 x 15.6 x 15.43/51.23 = 0.005 gr/dscf

CS (SO_2) = 113.3/1.45 = 78.1 mg/m^3

= 78.1 x 24.06/64 = 29 ppm

= 0.001 x 113.3 x 15.43/51.23 = 0.034 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	15.6	10.8	0.005	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	1.0	0.7	0.0003	
As $H_2SO_4 \cdot 2H_2O$	1.4	1.0	0.0004	
Water soluble sulfates				
As $SO_4^=$	0.0	0.0	0.000	
Sulfur dioxide	113.3	78.1	0.034	29
Sulfuric acid mist				
As H_2SO_4	7.5	5.2	0.002	1
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND OHIO	DATE	12/13/81
SAMPLING LOCATION	STACK OUTLET #1 BATTERY	RUN NUMBER	D6-4
SAMPLE TYPE	PARTICULATE	PROBE LENGTH & TYPE	5 FOOT GLASS
OPERATOR	DAN FITZGERALD	NOZZLE : I.D.	.404
AMBIENT TEMP.(DEG.F)	13.	ASSUMED MOISTURE	13.7
BAR.PRESS.(IN.HG)	29.79	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F84
FILTER NUMBER(S)	3530411	METER HEAD DIFF.	1.88
STACK INSIDE DIM.(IN)	97.75 .00		
PITOT TUBE COEFF.	.84	PROBE HEATER SETTING	400.
THERM. NO.	133	HEATER BOX SETTING	400.
LEAKAGE	.002 CFM @ 3.0 IN.HG		
METER CALIB. FACTOR	1.033	K FACTOR	11628.3
READ & RECORD DATA EVERY	10.0 MINUTES		

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	947	467.502									
	10.0	957	471.750	.050	.64	.64	455.	38.	38.	2.0	403.	42.
	20.0	1007	475.770	.046	.58	.58	463.	43.	40.	1.5	444.	48.
	30.0	1017	479.860	.048	.60	.60	465.	49.	42.	2.0	443.	42.
	40.0	1027	483.890	.045	.58	.58	443.	55.	45.	2.0	440.	45.
	50.0	1037	487.955	.046	.58	.58	455.	59.	48.	2.0	426.	41.
	60.0	1047	492.270	.050	.63	.63	463.	62.	52.	2.0	433.	46.
	70.0	1057	496.395	.047	.60	.60	447.	64.	54.	2.0	429.	48.
	80.0	1107	500.485	.045	.57	.57	460.	65.	55.	2.0	438.	52.
	90.0	1117	504.635	.047	.59	.59	460.	66.	57.	2.0	431.	52.
	100.0	1127	508.755	.045	.58	.58	440.	67.	58.	2.0	425.	55.
	110.0	1137	513.195	.050	.64	.64	448.	68.	60.	2.5	422.	57.
	120.0	1147	517.299	.045	.57	.57	389.	68.	60.	2.0	387.	55.
TOTALS	120.0		49.797									
AVERAGE					.60	.60	449.	59.	51.	2.0	427.	49.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND OHIO — DAN FITZGERALD

TEST D6-4 STACK OUTLET #1 BATTERY

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/13/81	12/13/81
TB	TIME-START	947	947
TF	TIME-FINISH	1147	1147
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	1.033	1.033
DN	SAMPLING NOZZLE DIAMETER	.404 IN	10.3 MM
CP	PITOT TUBE COEFFICIENT	.84	.84
PM	AVERAGE ORIFICE PRESSURE DROP	.60 IN-H2O	15.2 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	49.797 CU-FT	1.410 CU-M
TM	AVERAGE GAS METER TEMP	54.7 F	12.6 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	52.617 SCF	1.490 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	161.7	161.7
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.611 SCF	.216 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.64	12.64
FMD	MOLE FRACTION DRY GAS	.874	.874
PCO2	PERCENT CO2 BY VOL., DRY	5.10	5.10
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	83.90	83.90
MD	MOLECULAR WT-DRY STACK GAS	29.26	29.26
MWS	MOLECULAR WT-STACK GAS	27.83	27.83

PB	BAROMETRIC PRESSURE	29.79	IN-HG	756.67	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.70	IN-HG	754.42	MM-HG
TS	AVERAGE STACK TEMP	449.	F	232.	C
VS	AVG STACK GAS VELOCITY	16.3	FPS	5.0	MPS
AS	STACK AREA	7505.	SQ-IN	4.842	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1542579.	SCFH	43681.	SCMH
QS	ACTUAL STACK FLOW RATE	3062194.	ACFH	86712.	ACMH
ISO	PERCENT ISOKINETIC	99.9		99.9	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D6-4

STACK OUTLET #1 BATTERY

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 49.797 * 1.033 * (29.79 + .597 / 13.6)}{(55. + 460.)} = 52.617 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 162. = 7.61 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.61}{52.617 + 7.61} = 12.64 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.6}{100.} = .874$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (5.10*44/100) + (11.0*32/100) + ((83.9+ .0) * 28/100 = 29.26

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.26* (1. -(12.64/100)) + 18. * (12.64/100) = 27.83

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .84 * 78.421 / (SQRT(27.83 * 29.70) * 12. = 16.32 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 16.32 * 7505. 3600/144 = 3062194. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3062194. * 29.70 * (1. - (12.64/100))}{(449. + 460.)} = 1542579.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(449.+460.))*((0.002669*162.)+(49.797*1.033*(29.79+(.597/13.6))/(55.+460.)))}{120. * 16.32 * 29.70 * .404 * .404} = 99.85\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 52.617 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1542579. / (15.43 * 453.6) = .00000

Run No. D6.4

Sample volume = 1.49 m^3, 52.62 scf

Example calculations

CS (Part) = 12.0 / 1.49 = 8.0 mg/m^3

CS (Part) = 0.001 x 12.0 x 15.43/ 52.62 = 0.004 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	12.0	8.0	0.004	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Water soluble sulfates				
As $SO_4^=$	0.0	0.0	0.000	
Sulfur dioxide				
Sulfuric acid mist				
As H_2SO_4				
Inorganic condensibles	144.2	96.8	0.042	
Organic condensibles	2.8	1.9	0.0008	
TOC (Condensible)	77	51.7	0.022[a]	

[a] IPA contaminated.

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/13/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	D6-5
SAMPLE TYPE	M5-250	PROBE LENGTH & TYPE	6' GLASS
OPERATOR	DD	NOZZLE : I.D.	.431
AMBIENT TEMP.(DEG.F)	32.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.79	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	F81
FILTER NUMBER(S)		METER HEAD DIFF.	1.87
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.86
PITOT TUBE COEFF.	.83	PROBE HEATER SETTING	250.
THERM. NO.		HEATER BOX SETTING	250.
LEAKAGE	.000 CFM @ 3.0 IN.HG	REFERENCE PRESS. DIFF.	.10
METER CALIB. FACTOR	.992		

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	945	191.991									
	10.0	955	197.190	.050	.89	.89	455.	37.	33.	2.1	271.	42.
	20.0	1005	202.330	.050	.89	.89	463.	41.	33.	2.1	251.	42.
	30.0	1015	207.560	.050	.89	.89	465.	49.	35.	2.2	289.	43.
	40.0	1025	212.780	.050	.89	.89	443.	55.	37.	2.2	275.	44.
	50.0	1035	218.010	.050	.89	.89	455.	59.	40.	2.2	267.	44.
	60.0	1045	223.260	.050	.89	.89	463.	62.	43.	2.2	273.	44.
	70.0	1055	228.510	.050	.89	.89	447.	63.	45.	2.2	258.	46.
	80.0	1105	233.810	.050	.89	.89	460.	65.	46.	2.3	267.	47.
	90.0	1115	239.120	.050	.89	.89	460.	65.	48.	2.2	266.	48.
	100.0	1125	244.430	.050	.89	.89	440.	66.	48.	2.2	265.	48.
	110.0	1135	249.750	.050	.89	.89	448.	67.	49.	2.2	264.	48.
	120.0	1145	255.077	.050	.89	.89	461.	67.	50.	2.2	263.	50.
TOTALS	120.0		63.086									
AVERAGE					.89	.89	455.	58.	42.	2.2	267.	46.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — DO

TEST D6-5 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/13/81	12/13/81
TB	TIME-START	945	945
TF	TIME-FINISH	1145	1145
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.992	.992
DN	SAMPLING NOZZLE DIAMETER	.431 IN	10.9 MM
CP	PITOT TUBE COEFFICIENT	.83	.83
PM	AVERAGE ORIFICE PRESSURE DROP	.89 IN-H2O	22.6 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	63.086 CU-FT	1.786 CU-M
TM	AVERAGE GAS METER TEMP	50.1 F	10.1 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	64.634 SCF	1.830 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	191.1	191.1
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	8.995 SCF	.255 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.22	12.22
FMD	MOLE FRACTION DRY GAS	.878	.878
PCO2	PERCENT CO2 BY VOL., DRY	5.10	5.10
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	83.90	83.90
MD	MOLECULAR WT-DRY STACK GAS	29.26	29.26
MWS	MOLECULAR WT-STACK GAS	27.88	27.88

PB	BAROMETRIC PRESSURE	29.79	IN-HG	756.67	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.70	IN-HG	754.42	MM-HG
TS	AVERAGE STACK TEMP	455.	F	235.	C
VS	AVG STACK GAS VELOCITY	16.7	FPS	5.1	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1565391.	SCFH	44327.	SCMH
QS	ACTUAL STACK FLOW RATE	3112999.	ACFH	88151.	ACMH
ISO	PERCENT ISOKINETIC	105.7		105.7	
MN		.0000		.0000	
	MG. EPA 5				
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR		.00000	LB/HR	.000	KG/HR
	EMISSION RATE				

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D6-5

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 63.086 * .992 * (29.79 + .890 / 13.6)}{(50. + 460.)} = 64.634 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 191. = 9.00 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 9.00}{64.634 + 9.00} = 12.22 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.2}{100.} = .878$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (5.10*44/100) + (11.0*32/100) + ((83.9+ .0) * 28/100 = 29.26

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.26* (1. -(12.22/100)) + 18. * (12.22/100) = 27.88

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .83 * 81.166 / (SQRT(27.88 * 29.70) * 12. = 16.68 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 16.68 * 7466. 3600/144 = 3112999. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3112999. * 29.70 * (1. - (12.22/100))}{(455. + 460.)} = 1565391.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(455.+460.))*((0.002669*191.)+(63.086*.992*(29.79+(.890/13.6))/(50.+460.)))}{120. * 16.68 * 29.70 * .431 * .431} = 105.66\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 64.634 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1565391. / (15.43 * 453.6) = .00000

Run No. D6.5

Sample volume = 1.83 m^3, 64.63 scf

Example calculations

CS (Part) = 19.9 / 1.83 = 10.9 mg/m^3

CS (Part) = 0.001 x 19.9 x 15.43/ 64.63 = 0.005 gr/dscf

CS (SO_2) = ____ / ____ = ____ mg/m^3

= ____ x 24.06/____ = ____ ppm

= 0.001 x ____ x 15.43/____ = ____ gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	19.9	10.9	0.005	
2-h at 350°F	13.6	7.4	0.003	
4-h at 350°F	12.8	7.0	0.003	
2-h at 400°F	11.5	6.3	0.003	
4-h at 400°F	11.3	6.2	0.003	
2-h at 600°F	4.4	2.4	0.001	
Acid sulfates				
As H_2SO_4	0.0	0.0	0.000	
As $H_2SO_4 \cdot 2H_2O$	0.0	0.0	0.000	
Water soluble sulfates				
As $SO_4^=$	0.0	0.0	0.000	
Sulfur dioxide				
Sulfuric acid mist As H_2SO_4				
Inorganic condensibles	10.0	5.5	0.002	
Organic condensibles	2.4	1.3	0.0006	
TOC (Condensible)	8.0	4.4	0.002	

FIELD DATA

PLANT	REPUBLIC STEEL CLEVELAND	DATE	12/13/81
SAMPLING LOCATION	COKE STACK	RUN NUMBER	D6-6
SAMPLE TYPE	M8-600	PROBE LENGTH & TYPE	4' GLASS
OPERATOR	DO	NOZZLE : I.D.	.378
AMBIENT TEMP.(DEG.F)	32.	ASSUMED MOISTURE	11.0
BAR.PRESS.(IN.HG)	29.79	SAMPLE BOX NUMBER	
STATIC PRESS.(IN.H2O)	-1.20	METER BOX NUMBER	FB6
FILTER NUMBER(S)		METER HEAD DIFF.	1.51
STACK INSIDE DIM.(IN)	97.50 .00	C FACTOR	.70
PITOT TUBE COEFF.	.83	PROBE HEATER SETTING	600.
THERM. NO.		HEATER BOX SETTING	600.
LEAKAGE	.000 CFM @ 7.0 IN.HG	REFERENCE PRESS. DIFF.	.21
METER CALIB. FACTOR	.967		

READ & RECORD DATA EVERY 10.0 MINUTES

TRAVERSE POINT NO.	SAMPLE TIME (MIN.)	CLOCK TIME (24-HR CLOCK)	GAS METER READING (CU.FT.)	VELOCITY HEAD (IN.H2O)	ORIFICE PRESSURE DIFFERENTIAL (IN.H2O)		STACK TEMP (DEG.F)	DRY GAS METER TEMP (DEG.F)		PUMP VACUUM (IN.HG)	SAMPLE BOX TEMP (DEG.F)	IMPINGER TEMP (DEG.F)
					DESIRED	ACTUAL		INLET	OUTLET			
INIT	0	946	938.892									
	10.0	956	943.070	.050	.43	.43	455.	33.	35.	3.5	568.	40.
	20.0	1006	947.250	.050	.43	.43	463.	35.	35.	3.8	598.	40.
	30.0	1016	951.440	.050	.43	.43	465.	40.	35.	3.9	622.	41.
	40.0	1026	955.650	.050	.43	.43	443.	44.	36.	3.8	612.	41.
	50.0	1036	959.810	.050	.43	.43	455.	47.	37.	4.0	610.	42.
	60.0	1046	964.000	.050	.43	.43	463.	48.	38.	4.9	611.	42.
	70.0	1056	968.220	.050	.43	.43	447.	49.	39.	5.4	613.	43.
	80.0	1106	972.420	.050	.43	.43	460.	50.	40.	5.6	615.	44.
	90.0	1116	976.620	.050	.43	.43	460.	50.	40.	5.7	613.	46.
	100.0	1126	980.820	.050	.43	.43	440.	51.	41.	5.8	613.	46.
	110.0	1136	985.060	.050	.43	.43	448.	51.	41.	6.5	606.	48.
	120.0	1146	989.293	.050	.43	.43	461.	51.	41.	6.8	605.	51.
TOTALS	120.0		50.401									
AVERAGE					.43	.43	455.	46.	38.	5.0	607.	44.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT- NAME AND ADDRESS — TEST TEAM LEADER

REPUBLIC STEEL CLEVELAND — DD

TEST 06-6 COKE STACK

		ENGLISH UNITS	METRIC UNITS
TEST DATE		12/13/81	12/13/81
TB	TIME-START	946	946
TF	TIME-FINISH	1146	1146
TT	NET TIME OF TEST, MIN.	120.0	120.0
NP	NET SAMPLING POINTS	12	12
Y	METER CALIBRATION FACTOR	.967	.967
DN	SAMPLING NOZZLE DIAMETER	.378 IN	9.6 MM
CP	PITOT TUBE COEFFICIENT	.83	.83
PM	AVERAGE ORIFICE PRESSURE DROP	.43 IN-H2O	10.9 MM-H2O
VM	VOLUME OF DRY GAS SAMPLED AT METER CONDITIONS	50.401 CU-FT	1.427 CU-M
TM	AVERAGE GAS METER TEMP	42.0 F	5.5 C
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*	51.098 SCF	1.447 SCM
VLC	TOTAL H20 COLLECTED IN IMPINGERS AND SILICA GEL,ML.	149.2	149.2
VWC	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*	7.023 SCF	.199 SCM
BWO	PERCENT MOISTURE BY VOLUME	12.08	12.08
FMD	MOLE FRACTION DRY GAS	.879	.879
PCO2	PERCENT CO2 BY VOL., DRY	5.10	5.10
PO2	PERCENT O2 BY VOL., DRY	11.00	11.00
PCO	PERCENT CO BY VOL., DRY	.00	.00
PN2	PERCENT N2 BY VOL., DRY	83.90	83.90
MD	MOLECULAR WT-DRY STACK GAS	29.26	29.26
MWS	MOLECULAR WT-STACK GAS	27.90	27.90

PB	BAROMETRIC PRESSURE	29.79	IN-HG	756.67	MM-HG
PSI	STATIC PRES OF STACK GAS	-1.20	IN-H2O	-30.48	MM-H2O
PS	STACK PRES, ABS.	29.70	IN-HG	754.42	MM-HG
TS	AVERAGE STACK TEMP	455.	F	235.	C
VS	AVG STACK GAS VELOCITY	16.7	FPS	5.1	MPS
AS	STACK AREA	7466.	SQ-IN	4.817	SQ-M
QSSTD	STACK FLOW RATE, DRY*	1567349.	SCFH	44383.	SCMH
QS	ACTUAL STACK FLOW RATE	3112161.	ACFH	88127.	ACMH
ISO	PERCENT ISOKINETIC	108.5		108.5	
MN	MG. EPA 5	.0000		.0000	
CS		.00000	GR/DSCF*	.0000	MG/DSCM
PMR	EMISSION RATE	.00000	LB/HR	.000	KG/HR

* 68 DEG F, 29.92 IN.HG.

EXAMPLE PARTICULATE CALCULATIONS TEST NO. D6-6

COKE STACK

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

VMSTD = (17.647 * VM * Y * (PB + PM / 13.6)) / (TM + 460.)

$$VMSTD = \frac{17.647 * 50.401 * .967 * (29.79 + .430 / 13.6)}{(42. + 460.)} = 51.098 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWC = .04707 * VLC

VWC = .04707 * 149. = 7.02 SCF

PERCENT MOISTURE IN STACK GAS

BWO = (100. * VWC) / (VMSTD + VWC)

$$BWO = \frac{100. * 7.02}{51.098 + 7.02} = 12.08 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

FMD = (100. - BWO) / 100.

$$FMD = \frac{100. - 12.1}{100.} = .879$$

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MD = (PCO2 * .44) + (PO2 * .32) + (PN2 + PCO) * .28

MD = (5.10*44/100) + (11.0*32/100) + ((83.9+ .0) * 28/100 = 29.26

MOLECULAR WEIGHT OF STACK GAS

MWS = MD * (1. - (BWO/100)) + 18. * (BWO/100)

MWS = 29.26* (1. -(12.08/100)) + 18. * (12.08/100) = 27.90

STACK GAS VELOCITY AT STACK CONDITIONS

DELP = SUM. OF THE SQRT(VH * (TS + 460.))

VS = 85.49 * CP * DELP / (SQRT(MWS * PS) * PNTS)

VS = 85.49 * .83 * 81.166 / (SQRT(27.90 * 29.70) * 12. = 16.67 FPS

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

QS = VS * AS * 3600/144

QS = 16.67 * 7466. 3600/144 = 3112161. ACFH

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

QSSTD = 17.647 * QS * PS * (1. - (BWO/100)) / (TS + 460.)

$$QSSTD = \frac{17.647 * 3112161. * 29.70 * (1. - (12.08/100))}{(455. + 460.)} = 1567349.\ SCFH$$

PERCENT ISOKINETIC

ISO = (305.58*(TS+460.))*((0.002669*VLC)+(VM*Y*(PB+(PM/13.6))/(TM+460.)))/(TT*VS*PS*DN*DN)

$$ISO = \frac{(305.58*(455.+460.))*((0.002669*\ 149.)+(\ 50.401*\ .967*(\ 29.79+(\ .430/13.6))/(\ 42.+460.)))}{120. * 16.67 * 29.70 * .378 * .378} = 108.46\ PERCENT$$

PARTICULATE LOADING -- EPA METHOD 5 (AT STANDARD CONDITIONS)

CS = 0.001 * MN * 15.43 / VMSTD

CS = 0.001 * .0000 * 15.43 / 51.098 = .00000 GR/DSCF

PARTICULATE LBS/HR -- EPA METHOD 5

PMR = CS * QSSTD / (15.43 * 453.6)

PMR = .00000 * 1567349. / (15.43 * 453.6) = .00000

Run No. D6.6

Sample volume = 1.45 m^3, 51.10 scf

Example calculations

CS (Part) = 9.2 / 1.45 = 6.3 mg/m^3

CS (Part) = 0.001 x 9.2 x 15.43/51.10 = 0.003 gr/dscf

CS (SO_2) = 110.1/1.45 = 75.9 mg/m^3

= 75.9 x 24.06/64 = 28 ppm

= 0.001 x 110.1x 15.43/51.0 = 0.033 gr/dscf

Parameter	Catch weight, mg	Concentration, mg/m^3	Concentration, gr/dscf	Concentration, ppm
Particulate following conditioning at:				
Ambient	9.2	6.3	0.003	
2-h at 350°F				
4-h at 350°F				
2-h at 400°F				
4-h at 400°F				
2-h at 600°F				
Acid sulfates				
As H_2SO_4	0.2	0.1	0.0001	
As $H_2SO_4 \cdot 2H_2O$	0.3	0.2	0.0001	
Water soluble sulfates				
As $SO_4^=$	0.0	0.0	0.000	
Sulfur dioxide	110.1	75.9	0.033	28
Sulfuric acid mist				
As H_2SO_4	11.4	7.9	0.003	2
Inorganic condensibles				
Organic condensibles				
TOC (Condensible)				