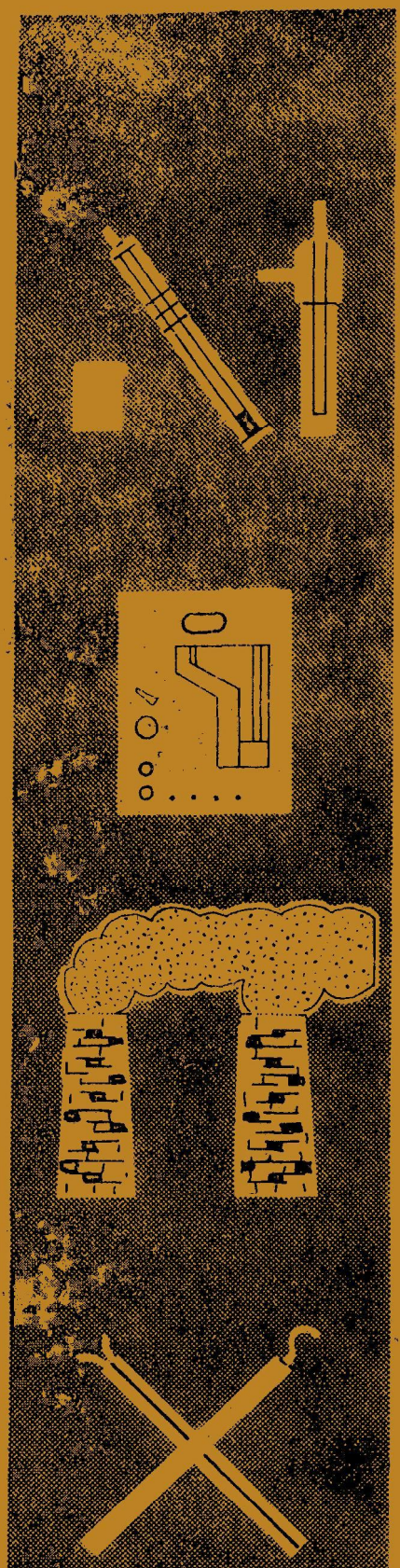
EMB Report No. 75SIN4



AIR POLLUTION EMISSION TEST

SINTER PLANT
GRANITE CITY STEEL DIVISION
NATIONAL STEEL CORPORATION
GRANITE CITY, ILLINOIS

NOVEMBER, 1975

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Emission Measurement Branch
Research Triangle Park, North Carolina

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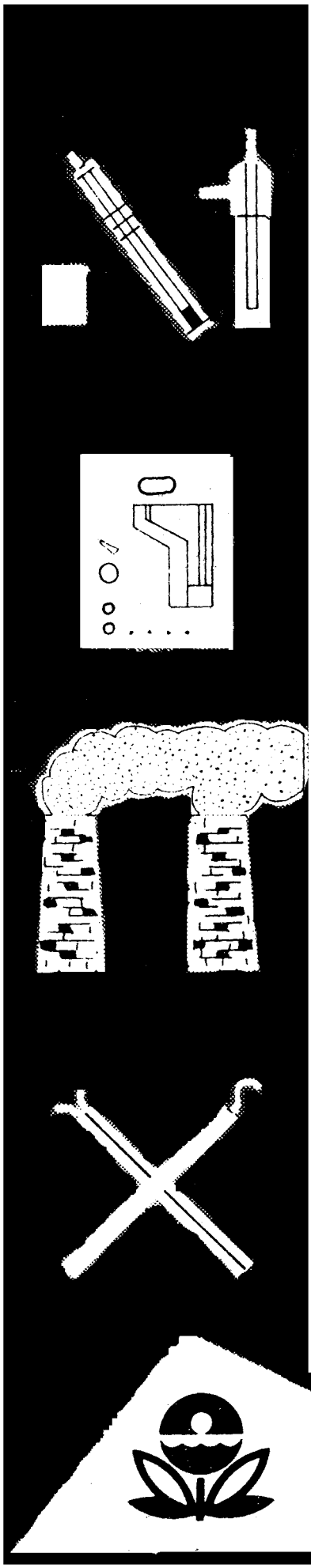

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Sinter Plant
Granite City Steel Division
National Steel Corporation
Granite City, Illinois

EMB Report No. 75SIN4

by

Thomas A. Loch, Ph.D., P.E.

Prepared for:

U.S. Environmental Protection Agency

Contract No. 68-02-1408

by

Clayton Environmental Consultants, Inc.
25711 Southfield Road
Southfield, Michigan 48075

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I. INTRODUCTION

In accordance with the Clean Air Act, the Environmental Protection Agency is charged with the establishment of performance standards for new or modified stationary sources. To establish a background data base useful in developing these standards, the Emission Measurement Branch of the Environmental Protection Agency (Emission Standards and Engineering Division) under Task 16 of Contract No. 68-02-1408, commissioned Clayton Environmental Consultants,Inc. to document the emissions from the Granite City Steel sintering facility at Granite City, Illinois.

The sintering process utilizes waste materials from other steelmaking processes. Materials including coke breeze, blast furnace dust, and ore fines are fused into a stable mass called sinter for use in subsequent blast furnace charging. The flue gases produced upon heating of the sinter mixture carry particulate, sulfur oxides, hydrocarbons, carbon monoxide, and fluorides. At Granite City Steel, the contaminants contained in the flue gases are abated using a two-stage control system comprised of a parallel bank of mechanical collectors and a high-energy venturi scrubber connected in series.

In this study, the efficiency of the high-energy venturi in controlling the aforementioned contaminant species was determined by simultaneous source testing at the outlet and inlet of the venturi scrubber. Process samples obtained from each of the individual sinter line feed hoppers and the sinter bed itself document the total process weight and the process input of sulfur and fluoride. Scrubber outlet and inlet water samples were collected to determine total dissolved and suspended solids in the scrubbing liquor as well as pH and fluoride content.

Process data and control system performance data were gathered during the week of May 19-23, 1975. Representatives from PEDCo Environmental Specialists, Cincinnati, Ohio, monitored the pertinent process parameters and documented process operation during the tests in the "Process Description and Operation" section of this report. Clayton Environmental Consultants was responsible for gathering process bulk samples and scrubber liquor samples. Additionally, Clayton Environmental Consultants, Southfield, Michigan, provided services and personnel necessary to conduct the source testing program and assemble this report. Representatives from York Research Corporation, Stamford, Connecticut, conducted particle size distribution tests at the scrubber outlet and inlet. The results of the particle size study are presented in a separate report. Environmental Protection Agency personnel supervised the source testing procedures and the acquisition of bulk samples. Project participants are delineated in Appendix L.

II. SUMMARY AND DISCUSSION OF RESULTS

Process Operation During Testing

The sinter plant operated two shifts per day from 7:00 A.M. to 11:00 P.M. during the week of testing. Since the strand (see Section III, Process Description and Operation, for terminology) was started cold each morning, the tests were not started until the process had reached normal conditions (about 1-1/2 hours).

Iron ore fines, iron-bearing wastes, dolomite,and coke breeze were blended with rerun sinter fines and water to form the sinter burden. Both coke oven gas and natural gas were burned at times to ignite the sinter. About 102 tons of sinter with a base-acid ratio of 1.44 were produced per hour of operation during the period of process monitoring. The average total strand burden was 261 tons/hour.

During the first particulate test, conducted on May 20, the venturi scrubber throat was in a fully-open configuration. Subsequently, on May 21, 22, and 23, the scrubber operated with approximately 26 inches of throat length blocked off by means of a movable plate installed during the evening of May 20. Further, during the first particulate test, a portion of the influent scrubbing water was blast furnace cooling water, while plant service water was supplied to the venturi during the second, third, and fourth particulate tests and the two fluoride tests. Because of these differences, the results obtained during the first particulate test are not included in any averages presented in this section.

Particulate Sampling Results

Tables I-1 through I-4 present the results of the particulate emission measurements made at the venturi scrubber outlet stack and inlet duct.

Table I-1 shows that the filterable particulate emissions at the outlet stack ranged from 29.3 to 42.5 pounds per hour with an average of 32.1 pounds per hour. Emission factors at the outlet ranged from 0.11 to 0.16 pounds of filterable particulate per ton of total strand burden with an average of 0.13 pound of filterable particulate per ton of total strand burden. Concentrations of filterable particulate at the outlet ranged from 0.017 to 0.025 grain per dry SCF with an average of 0.019 grain per dry SCF.

Table I-2 shows that the total particulate emission rate at the scrubber outlet stack ranged from 66.9 to 89.2 pounds per hour with an average of 72.3 pounds per hour. Emission factors at the outlet ranged from 0.27 to 0.34 pound of total particulate per ton of total strand burden with an average of 0.28 pound of total particulate per ton of total strand burden. Concentrations of total particulate at the outlet ranged from 0.039 to 0.053 grain per dry SCF with an average of 0.042 grain per dry SCF.

Table I-3 shows that the filterable particulate emissions at the scrubber inlet duct ranged from 501 pounds per hour to 546 pounds per hour with an average of 520 pounds per hour. Emission factors at the inlet ranged from 1.9 to 2.2 pounds of filterable particulate per ton of total strand burden with an average of 2.0 pounds of filterable particulate per ton of total strand burden. Corresponding concentrations of filterable particulate at the inlet ranged from 0.323 to 0.362 grain per dry SCF with an average of 0.338 grain per dry SCF.

Table I-4 shows that the total particulate emissions at the inlet duct ranged from 604 to 622 pounds per hour with an average of 619 pounds per hour. Emission factors at the inlet duct ranged from 2.3 to 2.5 pounds of total particulate per ton of total strand burden with an average of 2.4 pounds of total particulate per ton of total strand burden. Corresponding concentrations of total particulate at the inlet duct ranged from 0.392 to 0.409 grain per dry SCF with an average of 0.403 grain per dry SCF.

Scrubber efficiencies were calculated based upon filterable and total particulate emissions. As shown in Table II, the efficiency of the scrubber in removing filterable particulate emissions ranged from 91.8 to 94.3 percent with an average of 93.8 percent. The scrubber efficiencies in removing total particulate emissions ranged from 85.2 to 89.2 percent with an average of 88.3 percent.

The gas flowrate in the scrubber outlet stack ranged from 196,000 to 201,000 dry SCFM with an average of 199,000 dry SCFM. The average outlet stack gas temperature ranged from 145°F to 149°F with an average of 149°F. P rcent moisture in the stack gas, by volume, ranged from 10.6 to 14.7 percent with an average of 10.9 percent.

The gas flowrate measured at the scrubber inlet duct ranged from 174,000 to 185,000 dry SCFM with an average of 179,000 dry SCFM. The average temperature of the inlet exhaust gas ranged from 262°F to 289°F with an average of 272°F. Percent moisture in the inlet exhaust gas, by volume, ranged from 10.1 to 12.7 percent with an average of 11.5 percent.

The aforementioned averages exclude the first particulate test, P-1, due to abnormal scrubber feed water conditions.

All tests for particulate emissions were conducted within the required range of 90 percent and 110 percent of isokinetic.

The summary of chloroform-ether soluble particulate emissions is presented in the hydrocarbon sampling summary for filterable and condensible hydrocarbons. Appendix B contains the complete particulate, organic extraction results. Appendix C displays sample calculations used in developing the particulate emissions results. Appendix F contains auxiliary temperature data that document those temperatures existing in the sampling train used for particulate emissions measurements as shown in Figure 1.

TABLE I-1

SUMMARY OF FILTERABLE PARTICULATE EMISSIONS

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Source: Sinter Plant Scrubber Outlet Dimensions: 116"I.D.

Test Number			P-1*	P-2	P-3	P-4	Average
Date			5/20	5/21	5/22	5/23	—
Sampling Period	Start		09:31	09:50	09:15	09:02	—
	Stop		12:23	13:07	11:57	11:52	—
Sampled Volume	Am^3	(1)	3.08	2.91	2.74	2.71	—
	DNm^3	(2)	2.25	2.23	2.09	2.06	—
	ACF	(3)	108.7	102.8	96.7	95.8	—
	DSCF	(4)	79.3	78.6	73.8	72.8	—
Percent Moisture by Volume			14.7	10.6	11.0	11.2	10.9
Average Stack Temperature	°C		63	64	65	65	65
	°F		145	148	149	149	149
Stack Gas Flowrate	Am^3/min	(5)	7620	7360	7480	7360	7400
	DNm^3/min	(6)	5550	5640	5690	5610	5650
	$ACFM \times 10^{-3}$	(7)	269	260	264	260	261
	$DSCFM \times 10^{-3}$	(8)	196	199	201	198	199
Percent Isokinetic			106.1	104.0	96.3	96.8	—
Strand Burden	M tons/hr	(9)	239	233	242	225	233
	tons/hr		264	257	267	248	257
Sample Weight (mg)			130.0	107.1	81.3	86.4	—
Particulate Concentration	mg/Am^3		42.2	36.8	29.7	31.9	32.8
	mg/DNm^3		57.8	48.0	38.9	41.9	42.9
	gr/ACF		0.018	0.016	0.013	0.014	0.014
	gr/DSCF		0.025	0.021	0.017	0.018	0.019
Particulate Emission Rate	kg/hr		19.2	16.3	13.3	14.1	14.6
	kg/M ton of SB		0.08	0.07	0.05	0.06	0.06
	lb/hr		42.5	35.9	29.3	31.1	32.1
	lb/ton of SB		0.16	0.14	0.11	0.13	0.13

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

*Not included in averages

TABLE I-2

SUMMARY OF TOTAL PARTICULATE EMISSIONS

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Source: Sinter Plant Scrubber Outlet Dimensions: 116"I.D.

Test Number		P-1*	P-2	P-3	P-4	Average
Date		5/20	5/21	5/22	5/23	—
Sampling Period	Start	09:31	09:50	09:15	09:02	—
	Stop	12:23	13:07	11:57	11:52	—
Sampled Volume	Am^3 (1)	3.08	2.91	2.74	2.71	—
	DNm^3 (2)	2.25	2.23	2.09	2.06	—
	ACF (3)	108.7	102.8	96.7	95.8	—
	DSCF (4)	79.3	78.6	73.8	72.8	—
Percent Moisture by Volume		14.7	10.6	11.0	11.2	10.9
Average Stack Temperature	°C	63	64	65	65	65
	°F	145	148	149	149	149
Stack Gas Flowrate	Am^3/min (5)	7620	7360	7480	7360	7400
	DNm^3/min (6)	5550	5640	5690	5610	5650
	$ACFM \times 10^{-3}$ (7)	269	260	264	260	261
	$DSCFM \times 10^{-3}$ (8)	196	199	201	198	199
Percent Isokinetic		106.1	104.0	96.3	96.8	—
Strand Burden	M tons/hr (9)	239	233	242	225	233
	tons/hr	264	257	267	248	257
Sample Weight (mg)		272.9	226.3	205.7	186.1	—
Particulate Concentration	mg/Am^3	88.6	77.8	75.1	68.7	73.9
	mg/DNm^3	121	101	98.4	90.3	96.6
	gr/ACF	0.039	0.034	0.033	0.030	0.032
	gr/DSCF	0.053	0.044	0.043	0.039	0.042
Particulate Emission Rate	kg/hr	40.4	34.3	33.6	30.4	32.8
	kg/M ton of SB	0.17	0.15	0.14	0.14	0.14
	lb/hr	89.2	75.8	74.1	66.9	72.3
	lb/ton of SB	0.34	0.29	0.28	0.27	0.28

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

*Not included in averages

TABLE I-3
SUMMARY OF FILTERABLE PARTICULATE EMISSIONS

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Source: Sinter Plant Scrubber Inlet Dimensions: 106"x116"

Test Number		P-1*	P-2	P-3	P-4	Average
Date		5/20	5/21	5/22	5/23	—
Sampling Period	Start	09:15	09:50	09:15	09:02	—
	Stop	12:25	13:08	11:58	11:50	—
Sampled Volume	Am^3 (1)	5.41	4.96	5.17	4.87	—
	DNm^3 (2)	3.07	2.90	3.06	2.90	—
	ACF (3)	191.1	175.1	182.5	172.0	—
	DSCF (4)	108.3	102.5	108.2	102.3	—
Percent Moisture by Volume		12.4	11.7	12.7	10.1	11.5
Average Stack Temperature	°C	143	133	128	138	133
	°F	289	272	262	281	272
Stack Gas Flowrate	Am^3/min (5)	8700	8550	8840	8390	8590
	DNm^3/min (6)	4930	5000	5240	4990	5080
	ACFM x 10^{-3} (7)	307	302	312	296	303
	DSCFM x 10^{-3} (8)	174	177	185	176	179
Percent Isokinetic		106.6	99.5	100.3	99.5	—
Strand Burden	M tons/hr (9)	239	233	242	225	233
	tons/hr	264	257	267	248	257
Sample Weight (mg)		2445.6	2191.5	2263.9	2399.2	—
Particulate Concentration	mg/Am^3	452	442	438	493	458
	mg/DNm^3	797	756	740	827	774
	gr/ACF	0.197	0.193	0.191	0.215	0.200
	gr/DSCF	0.348	0.330	0.323	0.362	0.338
Particulate Emission Rate	kg/hr	236	227	233	248	236
	kg/M ton of SB	0.99	0.97	0.96	1.1	1.0
	lb/hr	520	501	512	546	520
	lb/ton of SB	2.0	1.9	1.9	2.2	2.0

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

*Not included in averages

TABLE I-4

SUMMARY OF TOTAL PARTICULATE EMISSIONS

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Source: Sinter Plant Scrubber Inlet Dimensions: 106" x 116"

Test Number		P-1*	P-2	P-3	P-4	Average
Date		5/20	5/21	5/22	5/23	—
Sampling Period	Start	09:15	09:50	09:15	09:02	—
	Stop	12:25	13:08	11:58	11:50	—
Sampled Volume	Am^3 (1)	5.41	4.96	5.17	4.87	—
	DNm^3 (2)	3.07	2.90	3.06	2.90	—
	ACF (3)	191.1	175.1	182.5	172.0	—
	DSCF (4)	108.3	102.5	108.2	102.3	—
Percent Moisture by Volume		12.4	11.7	12.7	10.1	11.5
Average Stack Temperature	°C	143	133	128	138	133
	°F	289	272	262	281	272
Stack Gas Flowrate	Am^3/min (5)	8700	8550	8840	8390	8590
	DNm^3/min (6)	4930	5000	5240	4990	5080
	$ACFM \times 10^{-3}$ (7)	307	302	312	296	303
	$DSCFM \times 10^{-3}$ (8)	174	177	185	176	179
Percent Isokinetic		106.6	99.5	100.3	99.5	—
Strand Burden	M tons/hr (9)	239	233	242	225	233
	tons/hr	264	257	267	248	257
Sample Weight (mg)		2842.6	2707.2	2749.5	2710.3	—
Particulate Concentration	mg/Am^3	525	546	532	557	545
	mg/DNm^3	926	934	899	935	923
	gr/ACF	0.230	0.239	0.232	0.243	0.238
	gr/DSCF	0.405	0.408	0.392	0.409	0.403
Particulate Emission Rate	kg/hr	274	280	282	280	281
	kg/M ton of SB	1.1	1.2	1.2	1.2	1.2
	lb/hr	604	618	622	617	619
	lb/ton of SB	2.3	2.4	2.3	2.5	2.4

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

*Not included in averages

TABLE II

SUMMARY OF SINTER PLANT SCRUBBER EFFICIENCIES
FOR PARTICULATE MATTER

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Contaminant	Test Number	Emission Rate, lb/hr		Percent Efficiency
		Scrubber Inlet	Scrubber Outlet	
Filterable Particulate	1*	520	42.5	91.8
	2	501	35.9	92.8
	3	512	29.3	94.3
	4	546	31.1	94.3
	Average	520	32.1	93.8
Total Particulate	1*	604	89.2	85.2
	2	618	75.8	87.7
	3	622	74.1	88.1
	4	617	66.9	89.2
	Average	619	72.3	88.3

*Not included in averages

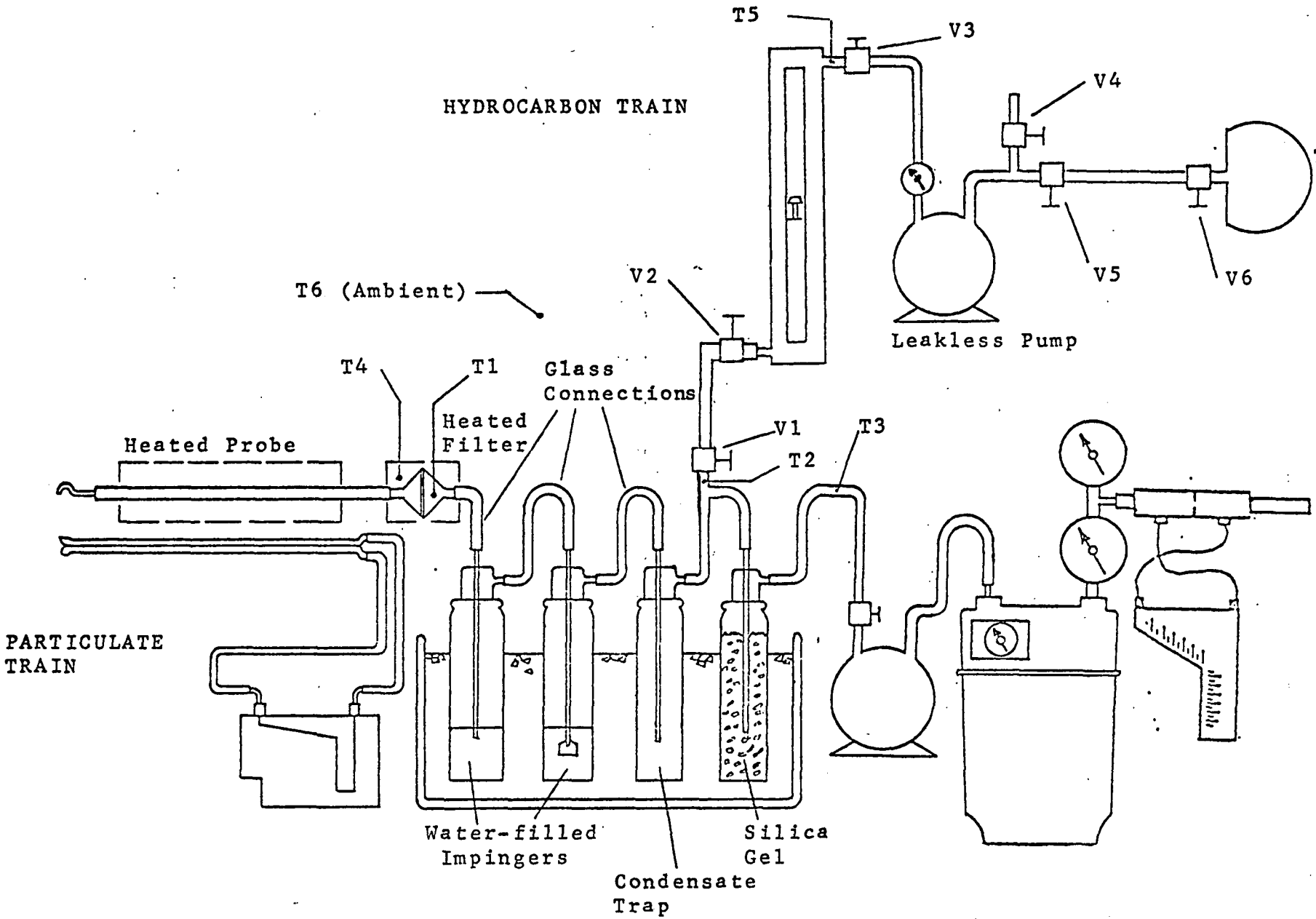

FIGURE 1

Gaseous Hydrocarbons - Particulate Train

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Fluoride Sampling Results

Tables III-1 and III-2 present the results of the fluoride emissions measurements at the scrubber outlet stack and inlet duct, respectively. Total fluoride emissions measured at the outlet stack ranged from 0.98 to 2.7 pounds per hour with an average of 1.8 pounds per hour. Emission factors ranged from 0.004 to 0.01 pound of fluoride per ton of total strand burden with an average of 0.007 pound of fluoride per ton of total strand burden. Corresponding total fluoride concentrations in the outlet stack gas ranged from 0.0006 to 0.002 grain per dry SCF with an average of 0.001 grain per dry SCF.

Total fluoride emissions measured in the inlet duct ranged from 11.8 to 12.6 pounds per hour with an average of 12.2 pounds per hour. Emission factors ranged from 0.04 to 0.05 pound of fluoride per ton of total strand burden with an average of 0.04 pound per ton of total strand burden. Corresponding total fluoride concentrations in the inlet exhaust gas were 0.008 grain per dry SCF for each of the two tests conducted.

As shown in Table IV, the scrubber efficiencies in removing total fluoride emissions ranged from 77.1 to 92.2 percent with an average of 84.6 percent.

The exhaust gas flowrates measured in the outlet stack ranged from 187,000 to 191,000 dry SCFM with an average of 189,000 dry SCFM. Stack gas temperatures ranged from 148°F to 152°F with an average of 150°F at the outlet. The gas flowrate measured in the inlet duct ranged from 176,000 to 177,000 dry SCFM with an average of 176,000 dry SCFM. The average exhaust gas temperature in the inlet duct ranged from 268°F to 288°F with an average of 278°F.

All tests were conducted within the range of 90 percent and 110 percent isokinetic.

TABLE III-1

SUMMARY OF FLUORIDE EMISSIONS

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Source: Sinter Plant Scrubber Outlet Dimensions: 116"I.D.

Test Number		F-1	F-2	Average
Date		5-21	5-22	-
Sampling Period	Start	15:43	14:23	-
	Stop	18:27	17:02	-
Sampled Volume	Am^3 (1)	2.85	2.62	-
	DNm^3 (2)	2.20	2.01	-
	ACF (3)	100.8	92.6	-
	DSCF (4)	77.6	70.9	-
Percent Moisture by Volume		9.9	10.2	10.0
Average Stack Temperature	°C	64	67	66
	°F	148	152	150
Stack Gas Flowrate	Am^3/min (5)	7020	6920	6970
	DNm^3/min (6)	5400	5300	5350
	ACFM (7)	248,000	244,000	246,000
	DSCFM (8)	191,000	187,000	189,000
Percent Isokinetic		106.9	99.5	-
Strand Burden	M tons/hr (9)	239	240	240
	tons/hr	264	265	264
Sample Weight (mg)		3.0	7.7	-
Total Fluoride Concentration	mg/Am^3	1.1	2.9	2.0
	mg/DNm^3	1.4	3.8	2.6
	gr/ACF	0.0005	0.001	0.0008
	gr/DSCF	0.0006	0.002	0.001
Total Fluoride Emission Rate	kg/hr	0.44	1.2	0.82
	kg/M ton of SB	0.002	0.005	0.004
	lb/hr	0.98	2.7	1.8
	lb/ton of SB	0.004	0.01	0.007

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

TABLE III-2
SUMMARY OF FLUORIDE EMISSIONS

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Source: Sinter Plant Scrubber Inlet Dimensions: 106"x116"

Test Number		F-1	F-2	Average
Date		5-21	5-22	-
Sampling Period	Start	15:44	14:25	-
	Stop	18:28	17:04	-
Sampled Volume	Am^3 (1)	2.81	2.88	-
	DNm^3 (2)	1.66	1.68	-
	ACF (3)	99.1	101.6	-
	DSCF (4)	58.7	59.4	-
Percent Moisture by Volume		11.1	10.8	11.0
Average Stack Temperature	°C	131	142	136
	°F	268	288	278
Stack Gas Flowrate	Am^3/min (5)	8450	8540	8500
	DNm^3/min (6)	5010	4990	5000
	ACFM (7)	299,000	301,000	300,000
	DSCFM (8)	177,000	176,000	176,000
Percent Isokinetic		102.5	104.1	-
Strand Burden	M tons/hr (9)	239	240	240
	tons/hr	264	265	264
Sample Weight (mg)		31.7	30.2	-
Total Fluoride Concentration	mg/Am^3	11.3	10.5	10.9
	mg/DNm^3	19.1	18.0	18.6
	gr/ACF	0.005	0.005	0.005
	gr/DSCF	0.008	0.008	0.008
Total Fluoride Emission Rate	kg/hr	5.7	5.4	5.6
	kg/M ton of SB	0.02	0.02	0.02
	lb/hr	12.6	11.8	12.2
	lb/ton of SB	0.05	0.04	0.04

(1) Actual cubic meters - stack conditions
(2) Dry normal cubic meters - 20°C, 760 mm Hg
(3) Actual cubic feet - stack conditions
(4) Dry standard cubic feet - 20°C, 760 mm Hg
(5) Actual cubic meters per minute - stack conditions
(6) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(7) Actual cubic feet per minute - stack conditions
(8) Dry standard cubic feet per minute - 20°C, 760 mm Hg
(9) Metric tons per hour (1 metric ton = 1000 kg)

TABLE IV

SUMMARY OF SINTER PLANT SCRUBBER EFFICIENCIES
FOR TOTAL FLUORIDE

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Test Number	Emission Rate, lb/hr		Percent Efficiency
	Scrubber Inlet	Scrubber Outlet	
1	12.6	0.98	92.2
2	11.8	2.7	77.1
Average	12.2	1.8	84.6

Hydrocarbon Sampling Results

For the purposes of this study, three classes of hydrocarbon emissions were defined and measured including (1) filterable, (2) condensible, and (3) non-condensible or gaseous. Filterable hydrocarbons are defined here as those hydrocarbons which are deposited prior to and on a filter maintained at 250°F ± 50°F*. Because these filterable hydrocarbons are inherently included as part of the total filterable particulate, a chloroform-ether extraction is performed to determine that portion of the filterable particulate matter which is soluble in chloroform-ether and therefore defined as hydrocarbons. Condensible hydrocarbons are defined here as those which pass through the heated filter and are collected in a chilled impinger train with an initial temperature of 250°F and a final temperature of 88°F. Particulate matter which is dissolved by chloroform-ether extractions performed on the residue resultant from analysis of the condensible (impinger) fraction is defined as condensible hydrocarbons. Non-condensible (gaseous) hydrocarbons are here defined as those which pass through the impinger train and are subsequently sampled from a portion of the particulate train impinger exhaust (see Figure 1).

An emissions summary for each of these three hydrocarbon sample fractions is presented in Tables V-1 through V-3. Complete results for non-condensible hydrocarbons and particulate organic extractions are presented in Appendices A and B, respectively.

Table V-1 summarizes the chloroform-ether soluble portion of the filterable particulate (CEFP) emissions measured in the outlet

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* Although, on several occasions, filter temperatures exceed 250 ± 50°F range, such temperatures are atypical since nearly 95% of all filter temperatures are within this range.

stack and inlet duct of the scrubber. The measurements were made by analysis of filterable particulate collected in Tests P-1 through P-4. The table shows that emission rate of CEFP at the outlet ranged from 3.4 to 9.1 pounds per hour with an average of 5.3 pounds per hour. The concentrations of CEFP in the outlet stack ranged from 0.002 to 0.005 grain per dry SCF with an average of 0.003 grain per dry SCF. At the inlet, the emission rate of CEFP ranged from 22.3 to 56.0 pounds per hour with an average of 40.5 pounds per hour. The concentration of CEFP ranged from 0.014 to 0.037 grain per dry SCF with an average of 0.027 grain per dry SCF in the inlet exhaust gas. Based upon mass emission rates, the scrubber efficiencies for CEFP ranged from 79.0 percent to 93.8 percent with an average of 85.9 percent as shown in Table VI.

Table V-2 summarizes the chloroform-ether soluble portion of the condensible particulate (CECP) emissions measured in the outlet stack and inlet duct of the scrubber. The measurements were made by analysis of the condensible particulate collected in tests P-1 through P-4. The table shows that the emission rate of CECP at the outlet ranged from 10.6 to 17.7 pounds per hour with an average of 14.4 pounds per hour. Correspondingly, concentrations of CECP ranged from 0.006 to 0.010 grain per dry SCF in the outlet stack gas. At the inlet, the emission rate of CECP ranged from 28.5 to 68.2 pounds per hour with an average of 47.6 pounds per hour. The concentration of CECP ranged from 0.019 to 0.043 grain per dry SCF with an average of 0.031 grain per dry SCF in the inlet exhaust gas. Based upon mass emission rates, the scrubber efficiencies for CECP ranged from 37.9 percent to 84.5 percent with an average of 63.4 percent as shown in Table VI.

Because the CEFP and the CECP are necessarily obtained from particulate test catch material, the results of CEFP and CECP as obtained from P-1 are not included in any of the above averages of emission rates or concentrations (since scrubber conditions were atypical).

Table V-3 summarizes the concentrations of non-condensible (gaseous) hydrocarbon emissions measured in the outlet stack and the inlet duct. Integrated gas samples collected from a portion of the particulate train (impinger) exhaust, were analyzed in the field by two methods: (1) by flame ionization detection (FID), and (2) by gas chromatography. The results are expressed in Table V-3 in parts per million (ppm), by volume, as methane. (Duplicate analyses were conducted in the laboratory on the same integrated samples to determine the magnitude of any losses and verify the results; complete field and laboratory measurement data for gaseous hydrocarbons are presented in Appendix A).

At the scrubber outlet stack, total non-condensible hydrocarbons (TNCH) as measured by FID, ranged from 300 to 3800 ppm with an average of 1480 ppm as methane. The TNCH, measured by gas chromatography, ranged from 362 ppm to 10,380 ppm with an average of 3550 ppm as methane at the outlet. Individual hydrocarbon species detected at the outlet included: methane, ranging from 150 ppm to 2170 ppm with an average of 950 ppm; ethane, ranging from 12 ppm to 65 ppm with an average of 39 ppm; ethylene, ranging from 17 ppm to 90 ppm with an average of 46 ppm; and acetone, ranging from 39 ppm to 9740 ppm with an average of 2310 ppm -- all expressed as methane.

At the scrubber inlet duct, TNCH, as measured by FID, ranged from 260 ppm to 2100 ppm with an average of 1120 ppm as methane. The TNCH, measured by gas chromatography, ranged from 1660 ppm to 1700 ppm with an average of 1680 ppm as methane at the inlet. Individual hydrocarbon species detected at the inlet included: methane, ranging from 140 ppm to 2460 ppm with an average of 880 ppm; ethane, ranging from 16 ppm to 57 ppm with an average of 38 ppm; ethylene, ranging from 17 ppm to 75 ppm with an average of 43 ppm; and acetone, ranging from 140 ppm to 3000 ppm with an average of 1210 ppm -- all expressed as methane.

Analysis for TNCH and the constituent species revealed that wide variation in measured concentrations, by either FID or gas chromatography, preclude scrubber efficiency determinations. Despite nearly simultaneous sampling, measured outlet concentrations are greater than measured inlet concentrations. As such, it is concluded that these measurements are useful in establishing the species of TNCH emissions and order of magnitude estimates of their concentrations. Consequently, mass emission rates are not calculated from these data.

Table V-3 indicates that methane and acetone are emitted in significant concentrations with traces of ethane and ethylene. Further, it appears from the data that the scrubber does not measurably abate these "gaseous" hydrocarbons.

The concentrations of acetone found in both the outlet and inlet exhaust gases may be attributable to contamination by acetone as it is used in standard clean-up procedures. The significantly greater outlet concentrations compared to inlet concentrations also tend to indicate that contamination is likely.

The measurements of average TNCH by FID and gas chromatography compare well when the concentrations of acetone (as methane) are deleted from the TNCH sum. At the outlet, the average TNCH as methane is 1480 ppm by FID and 1035 ppm by gas chromatography. excluding acetone*(3550 ppm with acetone included). At the inlet, the average TNCH as methane is 1120 ppm by FID and 961 ppm by gas chromatography excluding acetone*(1680 with acetone included). Therefore, it is concluded that the two independent measures of TNCH are in very good agreement if acetone is treated as a contaminant. If acetone is included, the two measures of TNCH are in, at least, order of magnitude agreement.

In all of the aforementioned hydrocarbon sampling results, outlet and inlet stack gas flowrates, temperatures, and moisture content are those measured during corresponding particulate tests. Since the gaseous hydrocarbon analyses were conducted on an integrated sample of gas which was saturated with respect to moisture content (at the particulate train impinger, average exit temperature of 88 °F), the concentrations are obtained on an "as analyzed" basis. Analyses conducted at about 75°F include inherently about 3-percent moisture by volume. Because the results of the analysis are expressed on a dry basis, a maximum possible error would be approximately negative 3 percent.

Complete sampling train temperature data are included in Appendix F.

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* TNCH excluding acetone, by gas chromatography, were computed by summing the averages of methane, ethane, and ethylene (all expressed as methane). The result is not numerically equal to the average sum of TNCH computed by summing all four species less the average acetone concentration. This occurs because sums of averages are not equal to averages of sums when the number of elements in each sum is different.

TABLE V-1

SUMMARY OF CHLOROFORM-ETHER SOLUBLE
FILTERABLE PARTICULATE EMISSIONS

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Test Number	1975 Date	Sampling Period	Scrubber Outlet			Scrubber Inlet		
			Concentration		Emission Rate (lbs/hr)	Concentration		Emission Rate (lbs/hr)
			gr/DSCF	mg/DNm^3		gr/DSCF	mg/DNm^3	
1*	5/20	09:15-12:25	0.005	11.7	8.6	0.029	66.6	43.5
2	5/21	09:50-13:08	0.005	12.2	9.1	0.029	65.3	43.3
3	5/22	09:15-11:58	0.002	4.5	3.4	0.014	32.2	22.3
4	5/23	09:02-11:52	0.002	4.7	3.5	0.037	84.8	56.0
A v e r a g e			0.003	7.1	5.3	0.027	60.8	40.5

*Not included in averages

Clayton Environmental Consultants, Inc.

TABLE V-2

SUMMARY OF CHLOROFORM-ETHER SOLUBLE
CONDENSIBLE PARTICULATE EMISSIONS

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Test Number	1975 Date	Sampling Period	Scrubber Outlet			Scrubber Inlet		
			Concentration		Emission Rate (lbs/hr)	Concentration		Emission Rate (lbs/hr)
			gr/DSCF	mg/DNm^3		gr/DSCF	mg/DNm^3	
1 *	5/20	09:15-12:25	0.008	17.7	13.0	0.026	58.3	38.0
2	5/21	09:50-13:08	0.010	23.7	17.7	0.019	43.1	28.5
3	5/22	09:15-11:58	0.006	14.1	10.6	0.043	98.6	68.2
4	5/23	09:02-11:52	0.009	20.0	14.8	0.030	69.7	46.0
A v e r a g e			0.008	19.3	14.4	0.031	70.5	47.6

*Not included in averages

TABLE V-3

SUMMARY OF GASEOUS HYDROCARBON EMISSIONS
DETERMINED BY FIELD ANALYSIS

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Sampling Station	Test No.	Date 1975	Sampling Period	Total Non-condensible Hydrocarbons By FID (ppm as CH_4)	Gas Chromatographic Results (ppm as CH_4)				
					Methane	Ethane	Ethylene	Acetone	Total Non-condensible Hydrocarbons
Sinter Plant Scrubber Outlet	1	5/20	11:00-11:06	400	264	23	31	58	376
	2	5/20	11:48-11:54	370	256	27	40	39	362
	3	5/21	12:14-12:20	1750	1610	60	60	—	—
	4	5/21	12:55-13:01	1600	2170	65	72	—	—
	5	5/22	11:03-11:09	3800	590	24	27	9740	10380
	6	5/22	11:46-11:52	3000	1990	64	90	3780	5920
	7	5/23	10:17-10:23	300	150	—	17	160	—
	8	5/23	11:38-11:44	640	580	12	28	70	690
Average				1480	950	39	46	2310	3550
Sinter Plant Scrubber Inlet	1	5/20	10:41-10:47	380	319	36	46	—	—
	2	5/20	12:15-12:22	470	320	26	34	—	—
	3	5/21	11:56-12:03	1800	2460	54	75	—	—
	4	5/21	12:36-12:44	1600	2010	57	66	—	—
	5	5/22	09:55-10:02	2100	280	—	29	3000	—
	6	5/22	11:24-11:31	1100	1330	38	52	280	1700
	7	5/23	09:21-09:32	1220	208	16	22	1410	1660
	8	5/23	10:57-11:20	260	140	—	17	140	—
Average				1120	880	38	43	1210	1680

Clayton Environmental Consultants, Inc.

TABLE VI

SUMMARY OF SINTER PLANT SCRUBBER EFFICIENCIES
FOR CHLOROFORM-ETHER SOLUBLE PARTICULATE MATTER

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Contaminant	Test Number	Emission Rate, lb/hr		Percent Efficiency
		Scrubber Inlet	Scrubber Outlet	
Chloroform-Ether Soluble Filterable Particulate	1*	43.5	8.6	80.2
	2	43.3	9.1	79.0
	3	22.3	3.4	84.8
	4	56.0	3.5	93.8
	Average	40.5	5.3	85.9
Chloroform-Ether Soluble Condensible Particulate	1*	38.0	13.0	65.8
	2	28.5	17.7	37.9
	3	68.2	10.6	84.5
	4	46.0	14.8	67.8
	Average	47.6	14.4	63.4

*Not included in averages

Sulfur Oxides Sampling Results

Table VII presents the emission rates and concentrations of sulfur oxides measured at the scrubber outlet. Sulfur oxides emissions at the scrubber outlet stack ranged from 136 to 213 pounds per hour with an average of 186 pounds per hour. These emission rates correspond to outlet stack gas concentrations ranging from 70.3 to 109 parts per million with the average of 95.4 parts per million by volume. Exhaust gas flowrates ranged from 194,000 to 195,000 dry SCFM at the outlet stack with an average of 195,000 dry SCFM. Outlet temperatures ranged from 148°F to 150°F with an average of 149°F.

While sampling was also conducted at the scrubber inlet duct, laboratory analyses and subsequent data processing indicate that results of sulfur oxides measurements at the inlet location must be invalidated. These results are not consistent with the outlet location sampling results, the expected emissions of sulfur oxides from this type of process, or the pH measurements made on the scrubber water. Investigation into the analytical procedure has not revealed any interference effects due to other contaminants present in the inlet gas stream capable of producing errors of sufficient order of magnitude with reference to the analytical procedure for sulfur oxides. Further, the triplicate measurements for sulfur oxides made on the inlet are in relatively good agreement among themselves. As such, it must be concluded that the inlet sampling results are invalid due to an experimental anomaly.

TABLE VII

SUMMARY OF SULFUR OXIDES EMISSIONS

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Source: Sinter Plant Scrubber Outlet Dimensions: 116" I.D.

Test Number		SO_x-1	SO_x-2	SO_x-3
Date		5-21	5-21	5-22
Sampling Period	Start	14:23	17:55	14:55
	Stop	14:53	18:25	15:25
Sampled Volume	DNm^3 (1)	0.0283	0.0285	0.0282
	DSCF (2)	0.999	1.01	0.996
Average Stack Temperature	°C	64	64	66
	°F	148	148	150
Stack Gas Flowrate	Am^3/min (3)	7190	7190	7200
	DNm^3/min (4)	5520	5520	5500
	ACFM (5)	254,000	254,000	254,000
	DSCFM (6)	195,000	195,000	194,000
Concentration	ppm	107	109	70.3
	mg/DNm^3	—	—	—
	gr/DSCF	—	—	—
Emission Rate	kg/hr	94.6	96.5	61.8
	lbs/hr	209	213	136

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

Carbon Monoxide Sampling Results

Tables VIII-1 through VIII-4 and Table IX present the results of carbon monoxide emissions measurements at the outlet and inlet of the scrubber. These tables list the results of gas chromatographic analyses of integrated gas samples acquired from the outlet and inlet streams directly as well as samples acquired from the particulate sampling train exhaust (see Hydrocarbon Sampling Results and Figure 1).

Table VIII-1 shows that, at the scrubber outlet, emission rates of carbon monoxide ranged from 5470 pounds per hour to 7810 pounds per hour with an average of 6610 pounds per hour using the gas chromatographic analysis of the samples acquired for subsequent Orsat analyees. Similarly, Table VIII-3 shows that analysis for carbon monoxide at the outlet, using integrated samples acquired from the particulate train impinger exhaust, yielded mass emission rates of carbon monoxide ranging from 4730 pounds per hour to 9160 pounds per hour with an average of 6410 pounds per hour. These data are in good agreement and indicate that the particulate sampling train does not remove measurable amounts of carbon monoxide.

Table VIII-2 shows that the total mass emission rate of carbon monoxide at the inlet ranges from 5080 pounds per hour to 7250 pounds per hour with an average of 5840 pounds per hour using the gas chromatographic analysis of the samples acquired for subsequent Orsat analyses. Similarly, Table VIII-4 shows that analysis for carbon monoxide at the scrubber inlet, using integrated samples acquired from the particulate train impinger exhaust, yielded mass emission rates ranging from 3180 pounds per hour to 8130 pounds per hour with an average of 5230 pounds per hour. These

data are in good agreement and also illustrate that the particulate sampling train does not remove significant amounts of carbon monoxide.

In general, the outlet and inlet mass emission rates, as measured by gas chromatographic analysis of samples acquired by two different methods, are equal within the limits of experimental accuracy. As such, it is concluded that the scrubber does not remove measurable amounts of carbon monoxide.

As an independent check of these measurements, an Orsat measurement of carbon dioxide, oxygen, carbon monoxide, and nitrogen was obtained for each of the four particulate tests (predominantly for the purpose of establishing molecular weight of the gas for the particulate tests). These data are tabulated in Table IX. The measurements indicate that percent carbon monoxide at the scrubber outlet ranges from 0.4 percent to 0.7 percent by volume with an average of 0.5 percent (5000 ppm). At the scrubber inlet the measurements also indicate that the carbon monoxide level ranges from 0.4 percent to 0.7 percent by volume with an average of 0.6 percent (6000 ppm). These results are in good agreement with results obtained from gas chromatographic analyses within the limits of experimental accuracy. These data also indicate that the scrubber does not remove significant amounts of carbon monoxide. As such, efficiency tabulations are not presented.

TABLE VIII-1

SUMMARY OF CARBON MONOXIDE EMISSIONS
MEASURED FROM ORSAT GAS SAMPLES BY GAS CHROMATOGRAPHY

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Source: Sinter Plant Scrubber Outlet Dimensions: 116" I.D.

Test Number		Orsat-1	Orsat-2	Orsat-3
Date		5-20	5-21	5-22
Sampling Period	Start	09:31	09:50	09:15
	Stop	12:23	13:07	11:57
Sampled Volume	DNm^3 (1)	—	—	—
	DSCF (2)	—	—	—
Average Stack Temperature	°C	63	64	65
	°F	145	148	149
Stack Gas Flowrate	Am^3/min (3)	7620	7360	7480
	DNm^3/min (4)	5550	5640	5690
	ACFM (5)	269,000	260,000	264,000
	DSCFM (6)	196,000	199,000	201,000
Concentration	ppm	9130	6300	7470
	mg/DNm^3	—	—	—
	gr/DSCF	—	—	—
Emission Rate	kg/hr	3540	2480	2970
	lbs/hr	7810	5470	6550

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

TABLE VIII-2

SUMMARY OF CARBON MONOXIDE EMISSIONS
MEASURED FROM ORSAT SAMPLES BY GAS CHROMATOGRAPHY

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Source: Sinter Plant Scrubber Inlet Dimensions: 106" x 116"

Test Number		Orsat-1	Orsat-2	Orsat-3
Date		5-20	5-21	5-22
Sampling Period	Start	09:15	09:50	09:15
	Stop	12:25	13:08	11:58
Sampled Volume	DNm^3 (1)	—	—	—
	DSCF (2)	—	—	—
Average Stack Temperature	°C	143	133	128
	°F	289	272	262
Stack Gas Flowrate	Am^3/min (3)	8700	8550	8840
	DNm^3/min (4)	4930	5000	5240
	ACFM (5)	307,000	302,000	312,000
	DSCFM (6)	174,000	177,000	185,000
Concentration	ppm	9550	6580	6440
	mg/DNm^3	—	—	—
	gr/DSCF	—	—	—
Emission Rate	kg/hr	3290	2310	2360
	lbs/hr	7250	5080	5200

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

TABLE VIII-3

SUMMARY OF CARBON MONOXIDE EMISSIONS
MEASURED FROM GASEOUS HYDROCARBON SAMPLES
BY GAS CHROMATOGRAPHY

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Source: Sinter Plant Scrubber Outlet Dimensions: 116" I.D.

Test Number		HC-1	HC-2	HC-3	HC-4	HC-5	HC-6	HC-7	HC-8
Date		5-20	5-20	5-21	5-21	5-22	5-22	5-23	5-23
Sampling Period	Start	11:00	11:48	12:14	12:55	11:03	11:46	10:17	11:38
	Stop	11:06	11:54	12:20	13:01	11:09	11:52	10:23	11:44
Sampled Volume	DNm^3 (1)	—	—	—	—	—	—	—	—
	DSCF (2)	—	—	—	—	—	—	—	—
Average Stack Temperature	°C	63	63	64	64	65	65	65	65
	°F	145	145	148	148	149	149	149	149
Stack Gas Flowrate	Am^3/min (3)	7620	7620	7360	7360	7480	7480	7360	7360
	DNm^3/min (4)	5550	5550	5640	5640	5690	5690	5610	5610
	ACFM x 10^{-3} (5)	269	269	260	260	264	264	260	260
	DSCFM x 10^{-3} (6)	196	196	199	199	201	201	198	198
Concentration	ppm	10700	9450	7730	5440	5590	5530	—	—
	mg/DNm^3	—	—	—	—	—	—	—	—
	gr/DSCF	—	—	—	—	—	—	—	—
Emission Rate	kg/hr	4150	3670	3050	2140	2230	2200	—	—
	lbs/hr	9160	8090	6720	4730	4910	4850	—	—

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

TABLE VIII-4

SUMMARY OF CARBON MONOXIDE EMISSIONS
MEASURED FROM GASEOUS HYDROCARBON SAMPLES
BY GAS CHROMATOGRAPHY

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Source: Sinter Plant Scrubber Inlet Dimensions: 106" x 116"

Test Number		HC-1	HC-2	HC-3	HC-4	HC-5	HC-6	HC-7	HC-8
Date		5-20	5-20	5-21	5-21	5-22	5-22	5-23	5-23
Sampling Period	Start	10:41	12:15	11:56	12:36	09:55	11:24	09:21	10:57
	Stop	10:47	12:22	12:03	12:44	10:02	11:31	09:32	11:20
Sampled Volume	DNm^3 (1)	—	—	—	—	—	—	—	—
	DSCF (2)	—	—	—	—	—	—	—	—
Average Stack Temperature	°C	143	143	133	133	128	128	138	138
	°F	289	289	272	272	262	262	281	281
Stack Gas Flowrate	Am^3/min (3)	8700	8700	8550	8550	8840	8840	8390	8390
	DNm^3/min (4)	4930	4930	5000	5000	5240	5240	4990	4990
	$ACFMx10^{-3}$ (5)	307	307	302	302	312	312	296	296
	$DSCFMx10^{-3}$ (6)	174	174	177	177	185	185	176	176
Concentration	ppm	7730	10700	6150	6080	5870	3940	—	—
	mg/DNm^3	—	—	—	—	—	—	—	—
	gr/DSCF	—	—	—	—	—	—	—	—
Emission Rate	kg/hr	2660	3690	2160	2130	2150	1440	—	—
	lbs/hr	5870	8130	4750	4700	4740	3180	—	—

(1) Dry normal cubic meters - 20°C, 760 mm Hg
(2) Dry standard cubic feet - 20°C, 760 mm Hg
(3) Actual cubic meters per minute - stack conditions
(4) Dry normal cubic meters per minute - 20°C, 760 mm Hg
(5) Actual cubic feet per minute - stack conditions
(6) Dry standard cubic feet per minute - 20°C, 760 mm Hg

TABLE IX

SUMMARY OF ORSAT DATA

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Sampling Location	Particulate Test Number	1975 Date	Orsat Run No.	Exhaust Gas Composition (percent, dry basis)			
				Carbon Dioxide	Oxygen	Carbon Monoxide	Nitrogen (By Difference)
Scrubber Inlet	1	5/20	1	5.4	15.6	0.6	78.4
			2	5.4	14.8	0.6	79.2
			3	5.4	15.0	0.6	79.0
			Avg.	5.4	15.1	0.6	78.9
	2	5/21	1	4.4	15.8	0.5	79.3
			2	4.8	15.8	0.4	79.0
			3	4.5	16.0	0.5	79.0
			Avg.	4.6	15.9	0.5	79.0
	3	5/22	1	5.5	15.6	0.5	78.4
			2	5.4	15.7	0.7	78.2
			3	5.6	15.6	0.7	78.1
			Avg.	5.5	15.6	0.6	78.3
	4	5/23	1	4.7	16.3	0.6	78.4
			2	4.6	16.1	0.5	78.8
			3	4.8	16.1	0.5	78.6
			Avg.	4.7	16.2	0.5	78.6
Scrubber Outlet	1	5/20	1	5.6	15.3	0.5	78.6
			2	5.5	15.3	0.6	78.6
			3	5.4	15.2	0.6	78.8
			Avg.	5.5	15.3	0.6	78.6
	2	5/21	1	5.0	15.8	0.5	78.7
			2	4.9	15.7	0.5	78.9
			3	4.9	15.8	0.4	78.9
			Avg.	4.9	15.8	0.5	78.8
	3	5/22	1	5.0	16.1	0.5	78.4
			2	4.8	16.0	0.4	78.8
			3	4.6	16.0	0.7	78.7
			Avg.	4.8	16.0	0.5	78.7
	4	5/23	1	4.6	15.9	0.4	79.1
			2	4.8	16.0	0.4	78.8
			3	5.0	16.0	0.5	78.5
			Avg.	4.8	16.0	0.4	78.8

Scrubber Water Sampling Results

Table X displays the total dissolved solids, total suspended solids, pH, fluoride content, and the measured sample temperature for the scrubber outlet and inlet water samples acquired during the four particulate tests and the two fluoride tests.

Total dissolved solids in the outlet scrubber liquor ranged from 0.492 to 0.777 gram/liter. Total dissolved solids in the inlet scrubber water ranged from 0.300 gram/liter to 0.566 gram/liter during the course of the tests.

At the scrubber outlet, total suspended solids ranged from 0.200 gram/liter to 0.371 gram/liter. Total suspended solids in the inlet scrubber water ranged from 0.039 gram/liter to 0.300 gram/liter.

The pH of the outlet scrubber water, as measured in the laboratory, ranged from 2.70 to 3.58. The inlet scrubber water pH ranged from 4.80 to 7.60. The inlet scrubber water was considerably more acidic during the first particulate test compared with the other three particulate tests and two fluoride tests (5.21 during P-1 versus 7.55 average pH of all other tests). As previously indicated, blast furnace cooling water was supplied to the scrubber during the first particulate test only, while plant service water was supplied during all other tests. These data indicate that acidification of the scrubber water is occurring either by the absorption of the acidic fluoride species or the absorption of sulfur dioxide. During acquisition of scrubber water samples throughout the study, a subtle but distinct odor of sulfur dioxide was noted at the scrubber water discharge point.

Fluoride content measured in the outlet scrubbing liquor ranged from 6.19 to 29.9 milligrams/liter. The inlet scrubber water ranged from 0.536 to 20.3 milligrams/liter of fluoride. In general, the data displayed in Table X indicate that in all cases, measurable increases in fluoride concentrations in the scrubbing liquor occur in passing through the venturi scrubber.

As noted in the delineation of process operations, throughout the first particulate test blast furnace cooling water was used in the venturi. This fact is obviated by the temperature measurements, taken in the field, of the scrubber water samples. In general, during the first particulate test, the inlet scrubbing liquor was at 98°F as compared to approximately 75° to 77°F for all other tests. Similarly, the outlet scrubbing liquor was 112° to 115°F during the course of the first particulate test and approximately 107° to 110°F during the remaining tests. Examination of the data in Table X shows that total dissolved solids, suspended solids, pH, and fluoride content in the scrubber water is measurably higher during the course of the first particulate test than during the course of the other three particulate tests and two fluoride tests.

The exact times of scrubber water sample acquisition are delineated in Appendix K.

TABLE X
SUMMARY OF SCRUBBER WATER ANALYSES

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Sampling Location	Test No.	1975 Date	Run No.	Time	Scrubber Water Data				
					Total Dissolved Solids (gm/l)	Total Suspended Solids (gm/l)	pH	Fluoride (mg/l)	Temp. (°F)
Scrubber Water Inlet	Particulate #1	5/20	1	09:23	0.517	0.265	5.28	20.3	—
			2	10:29	0.540	0.276	4.80	16.6	98
			3	11:30	0.566	0.300	5.55	18.0	98
	Particulate #2	5/21	Comp*	10:09, 11:29 & 12:35	0.325	0.039	7.60	0.536	75
	Fluoride #1	5/21	Comp*	15:38, 16:44 & 17:45	0.325	0.043	7.45	0.557	76
	Particulate #3	5/22	Comp*	09:15, 10:15 & 11:17	0.300	0.049	7.58	0.789	75
	Fluoride #2	5/22	Comp*	14:30, 15:25 & 16:34	0.331	0.048	7.58	0.666	77
	Particulate #4	5/23	Comp*	09:05, 10:05 & 11:05	0.330	0.040	7.52	0.556	76
Scrubber Water Outlet	Particulate #1	5/20	1	09:25	0.777	0.371	3.12	27.4	—
			2	10:32	0.723	0.340	3.00	15.5	115
			3	11:34	0.706	0.313	3.10	29.9	112
	Particulate #2	5/21	Comp*	10:14, 11:33 & 12:40	0.506	0.200	2.70	6.19	107
	Fluoride #1	5/21	Comp*	13:51, 16:50 & 17:47	0.492	0.220	2.78	13.3	107
	Particulate #3	5/22	Comp*	09:20, 10:18 & 11:22	0.550	0.245	3.58	9.11	110
	Fluoride #2	5/22	Comp*	14:35, 15:30 & 16:37	0.548	0.236	3.00	8.78	108
	Particulate #4	5/23	Comp*	09:11, 10:13 & 11:09	0.522	0.214	2.70	11.7	108
Hopper Drain	Particulate #4	5/23	1	12:05	0.749	3.312	6.60	43.2	115

* Composite of three samples. Indicated temperatures are averages.

Sinter Line Feed Sampling Results

Table XI summarizes the results of sulfur and fluoride content determinations of the sinter line feed materials which were sampled during the course of the particulate tests. Bulk samples were acquired from each of the nine hoppers and the sinter line strand at the beginning, in the middle, and at the end of each particulate and fluoride test. The three samples so acquired from each source of material were composited. From that composite, moisture content, sulfur, and fluoride weight percentages were determined.

Although samples were acquired for each particulate and fluoride test, only the results associated with samples acquired during the second particulate test were analyzed and included in Table XI. Additionally, in those instances where visual observation indicated a sudden abnormal condition in any of the feed materials, additional samples were analyzed and the results presented in Table XI. The weight percent determinations of sulfur and fluoride presented in Table XI are on a wet basis. In the Process Description section of this report, the mass flowrates of each feed were measured on a wet basis. As such, the data presented in Table XI can be used directly in conjunction with flowrate measurements of each feed material to determine total sulfur and fluoride input to the process from the nine raw material feed hoppers.

The nine hoppers feed raw materials to the conveyor belt, which supplies the strand, as follows (see Process Description section):

1. Rerun sinter fines,
2. Belmont ore fines,
3. Belmont ore fines,
4. Mill scale,
5. Fines from the open hearth furnace,

6. Blast furnace flue dust,
7. Track back (floor sweepings which fall off the back of the feed conveyor),
8. Dolomite fines, and
9. Coke breeze.

The following observations constituted the only known fluctuations in material feeds. As indicated, special analyses were conducted under those conditions and are included in the summary presented in Table XI.

During the first particulate test the sixth hopper was inoperative while the other eight hoppers were operational. During all other particulate and fluoride tests, all hoppers were operational except the seventh hopper (Track Back). As such, the analysis for this material, which is presented in Table XI, was acquired during test P-1.

During the third particulate test, the rerun sinter fines changed in color from a dry, black substance to a wet, brown substance. During the first third of the fourth particulate test, the rerun sinter fines were again brown in color but dry. During the second particulate test the rerun sinter fines became "fuming, very hot, and odorous." Therefore, Table XI presents the analytical results for this feed material as it was sampled during tests P-2, P-3, and P-4.

No other atypical feed material conditions were observed during the course of the sampling program. The strand mix was sampled during the beginning, at the middle, and at the end of each particulate and fluoride test. The samples were composited and the analytical results are displayed in Table XI. Because the strand

mix constitutes the sinter process feed, the results for all four particulate tests and two fluoride tests are presented in Table XI.

The data in Table XI indicate that the material contributing the largest percent of sulfur, on a weight basis, to the strand mix includes the open hearth furnace fines and the rerun fines. These and the other materials contribute sulfur to the extent that the sulfur content of the strand mix ranges from 0.0779 percent to 0.0953 percent with an average of 0.0914 percent on a wet basis. On a dry basis, sulfur content of the strand mix ranges from 0.084 percent to 0.104 percent with an average of 0.0996 percent by weight. The fraction of fluoride in the strand mix ranged from 0.0172 percent to 0.0458 percent with an average of 0.0288 percent on a wet basis. On a dry basis, the fluoride content of the strand mix ranged from 0.0187 to 0.0494 percent with an average of 0.0337 percent. Moisture content of the strand ranged from 7.25 percent to 9.24 percent with an average of 8.21 percent as measured during three of the four particulate tests and the two fluoride tests.

The mill scale feed from the fourth hopper was analyzed for chloroform-ether soluble material. A known weight of the thoroughly mixed sample was placed in a soxhlet (recirculating condenser-boiling flask apparatus) and extracted using chloroform for three hours. The sample was then extracted in a similar manner using ether. The resulting solutions were mixed and evaporated to dryness at room temperature to a constant weight. Results indicate that, on a wet basis, 0.0063 gram of chloroform-ether soluble material is found in one gram of the bulk sample (0.63% by weight) obtained during particulate test P-2.

The sample was not pre-crushed because it was felt that the "organic materials" present in the mill scale were deposited on the surface of the solids by the nature of the process from which mill scale is derived. Since the organic materials are those compounds soluble in chloroform-ether, the results are comparable to chloroform-ether soluble fractions of particulate matter as previously reported. The other hopper feed materials are expected to contribute negligible amounts of chloroform-ether soluble matter.

The exact times of bulk sample acquisition are delineated in Appendix K.

TABLE XI

SUMMARY OF SINTER LINE FEED ANALYSES FOR SULFUR AND FLUORIDE

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Hopper No.	Sample Acquired During Test	Material Designation	Weight Percent Sulfur (wet basis)*	Weight Percent Fluoride (wet basis)*	Weight Percent Moisture
1	P-2	Rerun Fines	0.0504	0.0191	3.06
	P-3	Rerun Fines	0.0508	0.0195	2.33
	P-4	Rerun Fines	0.0268	0.0175	4.29
2	P-2	Ore Fines	<0.001	0.0029	12.2
3	P-2	Ore Fines	<0.001	0.0025	12.4
4	P-2	Mill Scale	0.0193	0.0029	3.35
5	P-2	Open Hearth Furnace Fines	0.159	0.122	5.56
6	P-2	Blast Furnace Dust	0.0326	0.0369	18.6
7**	P-1	Track Back (Sweepings)	0.0334	0.0556	16.5
8	P-2	Dolomite	<0.001	0.0063	4.35
9	P-2	Coke Breeze	0.0230	0.0210	18.0
-	P-1	Strand Mix	0.0953	0.0344	8.40
-	P-2	Strand Mix	0.0944	0.0236	9.24
-	P-3	Strand Mix	0.0949	0.0172	7.82
-	P-4	Strand Mix	-	0.0181	-
-	F-1	Strand Mix	0.0944	0.0338	8.35
-	F-2	Strand Mix	0.0779	0.0458	7.25

* A wet basis is used to facilitate computations of mass flowrates of sulfur and fluoride from feed rate data (see Process Description, Table XV).

** Hopper No. 7 was in use only during Test P-1.

Summary of Visible Emission Results

Opacity measurements were made by certified opacity readers. Measurements of emissions opacity from the scrubber outlet stack and from the building were made every 15 seconds. Tables XII-1 to XII-16 list the summary of average opacities as they were calculated by averaging 24 consecutive readings made during a six-minute interval and reporting the average to the nearest tenth percent opacity (as requested). Each table contains 40 sets of average opacities corresponding to 24 readings in each set or 960 opacity readings from each source for each of two observers and conducted during each of the four particulate tests (except Observer No. 1 during P-4).

The two visible emissions observers were located east-southeast of both the stack and building visible emissions. A steam plume was occasionally observed masking the opacity of the stack. However, this masking was only observed occasionally and therefore when it occurred opacity readings were taken just above the stack outlet, just before the condensing of the steam plume. In general, the stack visible emissions were lofting towards the north. A complete schematic diagram showing the observers' position with respect to the stack and building visible emissions is provided in Figure 2. Emissions from the far end of the building (that is, building visible emissions) were generally black in color and intermittent in nature. These emissions are from the discharge hood, control system, and fugitive emissions from the cooler, screens, and sinter transfer points. The emissions designated as "building" had the machine discharge and sinter product handling system as their source. As such they are not strictly fugitive emissions, uncontrollable by a windbox, discharge, or pug mill control system. At the time of

testing and opacity observations, it was unclear as to what sources contributed to,and were to be included in, the emissions designated as "building." As such, these data reflect a conglomerate of sources.

In general,the emissions recorded as building are the higher of either the fugitive emissions from the discharge hood or the exhaust emissions from the control system used on various operations.

Tables XII-1 through XII-4 display the average opacities of the stack emissions as determined by observer No. 1. Tables XII-5 through XII-8 display the average opacities of the stack emissions as obtained by the second observer. Tables XII-9 through XII-12 display the average opacities of building emissions as determined by observer No. 1. Tables XII-13 through XII-16 display the average opacities of building emissions determined by observer No. 2.

In general, opacity readings obtained by the two observers are in relatively good agreement. Tables XII-1 through XII-16 include graphical plots of opacity as a function of time throughout each test. Tables XII-1 and XII-5 show that the opacity remained essentially constant between 30% and 35% throughout the first particulate test with a peak in opacity occurring at about the first half hour into the test. Similarly, Tables XII-2 and XII-6 show that both observers recorded a steady decrease in opacity during the first hour of the second particulate test followed by a sudden increase and a sinusoidal type variation in stack opacity thereafter. Tables XII-3 and XII-7 show that the average opacities during the course of the third particulate test ranged between 10 and 20% for the first half of the test as recorded by both observers and varied somewhat between 0 and 10% during the second half of the test. Tables XII-4 and XII-8 indicate that the opacity of stack emissions varied somewhat at about the 40% level for the first

half of the test and dropped suddenly varying at about the 15-20% level during the latter part of the test.

The opacity of building emissions as recorded by both observers are in relatively good agreement. Wide and rapid fluctuation of building emissions occurred throughout the first particulate test as indicated in Tables XII-9 and XII-13. Similarly, Tables XII-10 and XII-14 indicate that building emissions opacity increased markedly during the first half hour of the second particulate test then dropped off and oscillated for the remainder of the test. During the fourth particulate test building emissions opacity remained at a fairly constant and low level, near 10% opacity, as recorded by both observers and as shown in Tables XII-12 and XII-16.

Table XIII displays the overall averages of scrubber outlet stack opacity during each of the four particulate tests. Also displayed are the ranges of opacities recorded by each observer during the tests. The table shows clearly that the average opacities and ranges recorded by the two independent observers are in good agreement.

An attempt was made to correlate the average stack opacity and the measured outlet particulate concentrations for each test by conducting regression analyses. Two regression analyses were concucted wherein the degree of correlation was measured in considering: (1) average stack opacity to be a linear function of the measured total particulate concentration in the stack gas (actual, i.e., grains per actual cubic foot), or (2) the measured concentration of total particulate (actual) to be a linear function of the logarithm of the reciprocal stack gas transmittance. The two corresponding correlation coefficients are 0.297 and 0.316, respectively, using the four data points contained in Table XIII. Since a correlation

coefficient of unity represents an exact fit of the data to the proposed correlation (and 0.95 is regarded as a minimum correlation coefficient to characterize a meaningful correlation), it is concluded that neither of these"models" is adequate to demonstrate a correlation between stack gas opacity and total particulate concentration measured in the stack gas.

The correlation utilized concentrations expressed in actual stack gas volumes since this more closely approximates the physical conditions which determine the opacity of visible emissions from a gas density view point. Similarly, total particulate concentrations were utilized because plume cooling likely caused partial condensation of condensible particulate.

However, examination of the data in Table XIII shows that, qualitatively, "high" opacities generally correspond to high outlet stack gas total particulate concentrations except for the fourth test. The first test, for which the highest average opacity has been recorded by both observers, resulted in the highest measured total particulate concentration. The second and third tests, for which the lowest average opacities have been recorded by both observers, resulted in lower total particulate concentrations. However, the lowest concentration measured, which was obtained from the fourth particulate test, does not correspond to the lowest measured stack gas opacity.

A complicating factor in attempts to correlate average opacity with average total particulate concentration is the effect of condensible particulate. Since this portion of the emissions can have a significant impact on their visibility, attempts were made to include this factor in a correlation. Because the condensible

hydrocarbon concentration and the relative fraction of condensible total particulate varied from test to test, relationships between average opacity and condensible hydrocarbon concentration as well as between average opacity and the ratio "condensible concentration/total concentration" were considered. There was no general relationship found that adequately included all of the four data points available.

From these observations, it appears that a trend in opacity decrease occurs as measured total particulate concentrations decrease. However, with only four data points, a single "outlier" biases heavily any attempted correlation.

TABLE XII-1

SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/20/75
Type of Discharge: Stack
Height of Point of Discharge: 200 ft.
Wind Direction: South
Color of Plume: Reddish-gray
Observer No.: 1
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Partly cloudy
Wind Velocity: 703 fpm
Detached Plume: Yes
Duration of Observation: 4 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Gray, hazy

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0915	0921	760	31.7	21	1115	1121	825	34.4
2	0921	0927	740	30.8	22	1121	1127	840	35.0
3	0927	0933	760	31.7	23	1127	1133	825	34.4
4	0933	0939	860	35.8	24	1133	1139	730	30.4
5	0939	0945	945	39.4	25	1139	1145	830	34.6
6	0945	0951	845	35.2	26	1145	1151	815	34.0
7	0951	0957	840	35.0	27	1151	1157	830	34.6
8	0957	1003	850	35.4	28	1157	1203	825	34.4
9	1003	1009	850	35.4	29	1203	1209	795	33.1
10	1009	1015	710	29.6	30	1209	1215	825	34.4
11	1015	1021	815	34.0	31	1215	1221	840	35.0
12	1021	1027	815	34.0	32	1221	1227	835	34.8
13	1027	1033	840	35.0	33	1227	1233	840	35.0
14	1033	1039	740	30.8	34	1233	1239	835	34.8
15	1039	1045	635	26.5	35	1239	1245	840	35.0
16	1045	1051	865	36.0	36	1245	1251	825	34.4
17	1051	1057	800	33.3	37	1251	1257	830	34.6
18	1057	1103	800	33.3	38	1257	1303	840	35.0
19	1103	1109	805	33.5	39	1303	1309	845	35.2
20	1109	1115	775	32.3	40	1309	1315	830	34.6

Sketch Showing How Opacity Varied With Time:

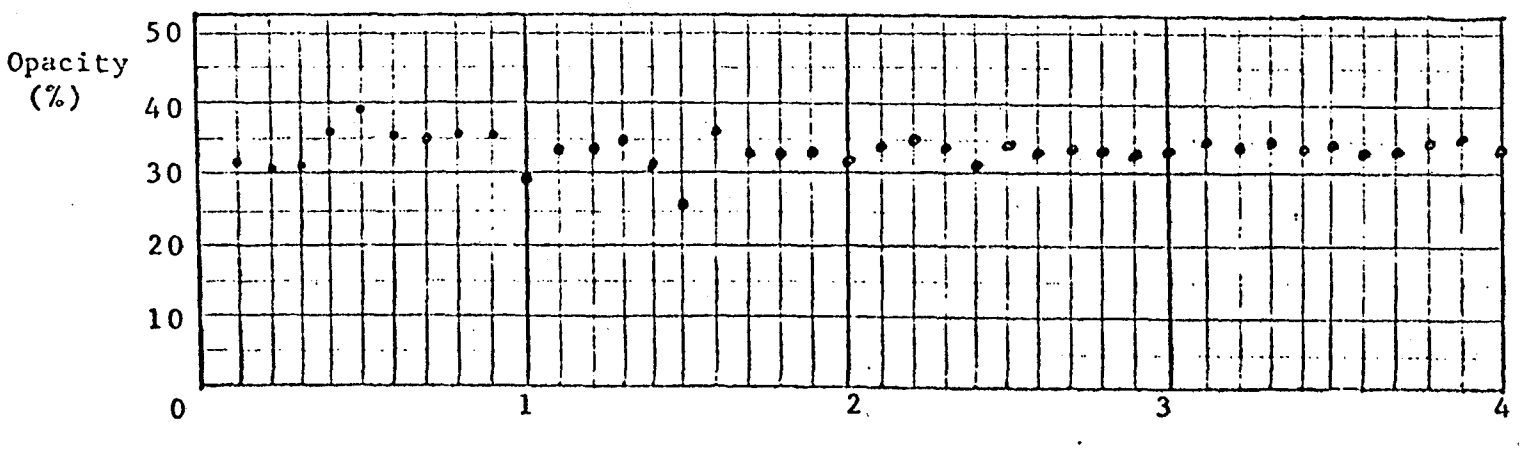


TABLE XII-2

SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/21/75
Type of Discharge: Stack
Height of Point of Discharge: 200 ft.
Wind Direction: SW
Color of Plume: Yellow
Observer No.: 1
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Clear to partly cloudy
Wind Velocity: 866 fpm
Detached Plume: No
Duration of Observation: 4 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Gray (haze) to light blue

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0910	0916	750	31.2	21	1110	1116	295	12.3
2	0916	0922	700	29.2	22	1116	1122	260	10.8
3	0922	0928	665	27.7	23	1122	1128	155	6.5
4	0928	0934	540	22.5	24	1128	1134	100	4.2
5	0934	0940	475	19.8	25	1134	1140	180	7.5
6	0940	0946	310	12.9	26	1140	1146	195	8.1
7	0946	0952	205	8.5	27	1146	1152	210	8.8
8	0952	0958	170	7.1	28	1152	1158	725	30.2
9	0958	1004	180	7.5	29	1158	1204	465	19.4
10	1004	1010	645	26.9	30	1204	1210	620	25.8
11	1010	1016	715	29.8	31	1210	1216	360	15.0
12	1016	1022	360	15.0	32	1216	1222	70	2.9
13	1022	1028	695	29.0	33	1222	1228	85	3.5
14	1028	1034	215	9.0	34	1228	1234	155	6.5
15	1034	1040	350	14.6	35	1234	1240	170	7.1
16	1040	1046	295	12.3	36	1240	1246	125	5.2
17	1046	1052	385	16.0	37	1246	1252	70	2.9
18	1052	1058	200	8.3	38	1252	1258	85	3.5
19	1058	1104	440	18.3	39	1258	1304	165	6.9
20	1104	1110	370	15.4	40	1304	1310	120	5.0

Sketch Showing How Opacity Varied With Time:

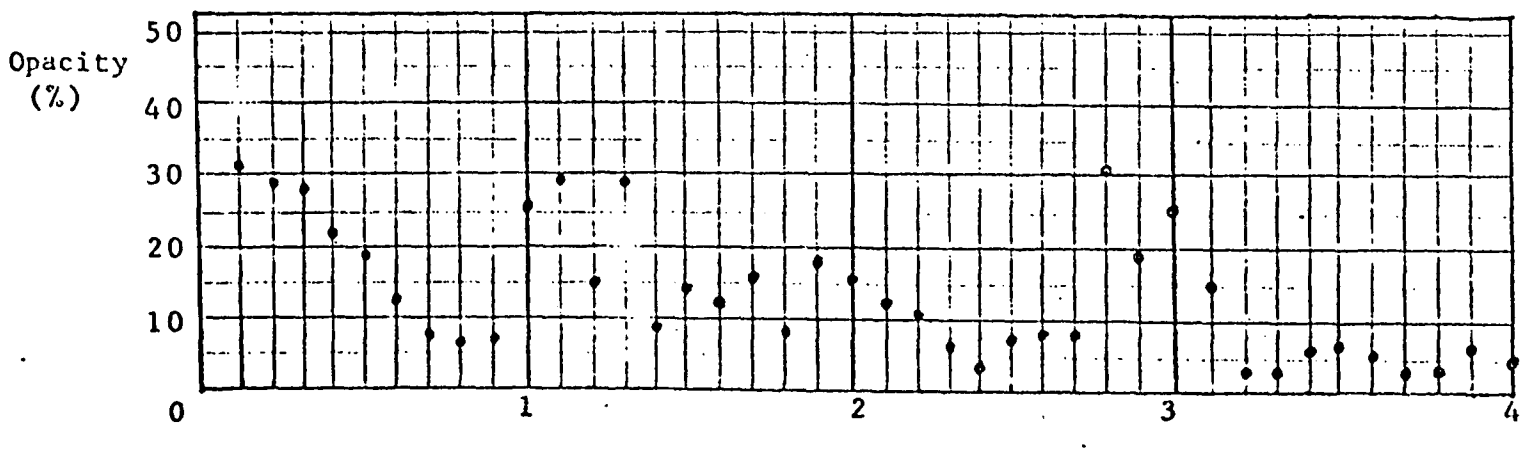


TABLE XII-3

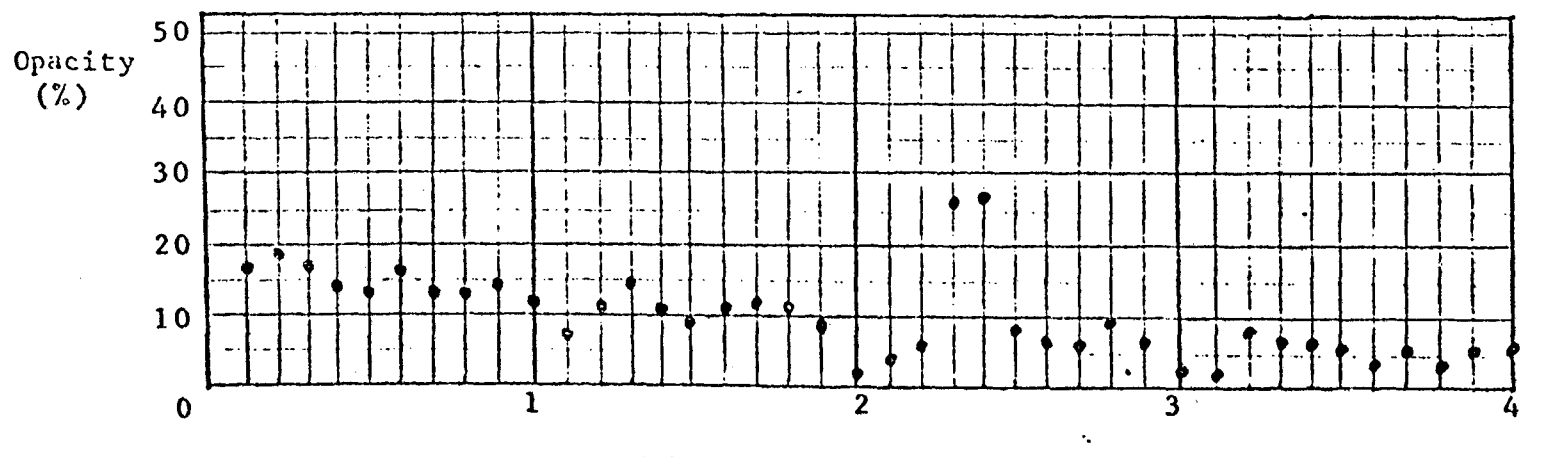
SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/22/75
Type of Discharge: Stack
Height of Point of Discharge: 200 ft.
Wind Direction: WNW
Color of Plume: Yellowish-white
Observer No.: 1
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Sunny
Wind Velocity: 450 fpm
Detached Plume: No
Duration of Observation: 4 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Light blue and hazy to sunny

SUMMARY OF AVERAGE OPACITY									
Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0910	0916	400	16.7	21	1110	1116	110	4.6
2	0916	0922	455	19.0	22	1116	1122	150	6.2
3	0922	0928	420	17.5	23	1122	1128	640	26.7
4	0928	0934	355	14.8	24	1128	1134	650	27.1
5	0934	0940	335	14.0	25	1134	1140	210	8.8
6	0940	0946	375	15.6	26	1140	1146	155	6.5
7	0946	0952	330	13.8	27	1146	1152	145	6.0
8	0952	0958	315	13.1	28	1152	1158	230	9.6
9	0958	1004	355	14.8	29	1158	1204	165	6.9
10	1004	1010	290	12.1	30	1204	1210	60	2.5
11	1010	1016	180	7.5	31	1210	1216	55	2.3
12	1016	1022	250	10.4	32	1216	1222	200	8.3
13	1022	1028	350	14.6	33	1222	1228	175	7.3
14	1028	1034	245	10.2	34	1228	1234	175	7.3
15	1034	1040	235	9.8	35	1234	1240	135	5.6
16	1040	1046	255	10.6	36	1240	1246	100	4.2
17	1046	1052	265	11.0	37	1246	1252	125	5.2
18	1052	1058	260	10.8	38	1252	1258	105	4.4
19	1058	1104	225	9.4	39	1258	1304	125	5.2
20	1104	1110	50	2.1	40	1304	1310	125	5.2

Sketch Showing How Opacity Varied With Time:



Time, hours

TABLE XII-4

SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/23/75
Type of Discharge: Stack
Height of Point of Discharge: 200 ft.
Wind Direction: SE
Color of Plume: Yellow-white
Observer No.: 1
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Hazy, sunny
Wind Velocity: 600 fpm
Detached Plume: No
Duration of Observation: 3 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Bluish-gray - No obstructions

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0900	0906	900	37.5	21	1100	1106	565	23.5
2	0906	0912	800	33.3	22	1106	1112	455	19.0
3	0912	0918	805	33.5	23	1112	1118	315	13.1
4	0918	0924	975	40.6	24	1118	1124	100	4.2
5	0924	0930	990	41.2	25	1124	1130	185	7.7
6	0930	0936	980	40.8	26	1130	1136	800	33.3
7	0936	0942	895	37.3	27	1136	1142	410	17.1
8	0942	0948	945	39.4	28	1142	1148	205	8.5
9	0948	0954	910	37.9	29	1148	1154	240	10.0
10	0954	1000	1000	41.7	30	1154	1200	265	11.0
11	1000	1006	980	40.8	31				
12	1006	1012	925	38.5	32				
13	1012	1018	890	37.1	33				
14	1018	1024	825	24.4	34				
15	1024	1030	865	36.0	35				
16	1030	1036	940	39.2	36				
17	1036	1042	965	40.2	37				
18	1042	1048	720	30.0	38				
19	1048	1054	460	19.2	39				
20	1054	1100	400	16.7	40				

Sketch Showing How Opacity Varied With Time:

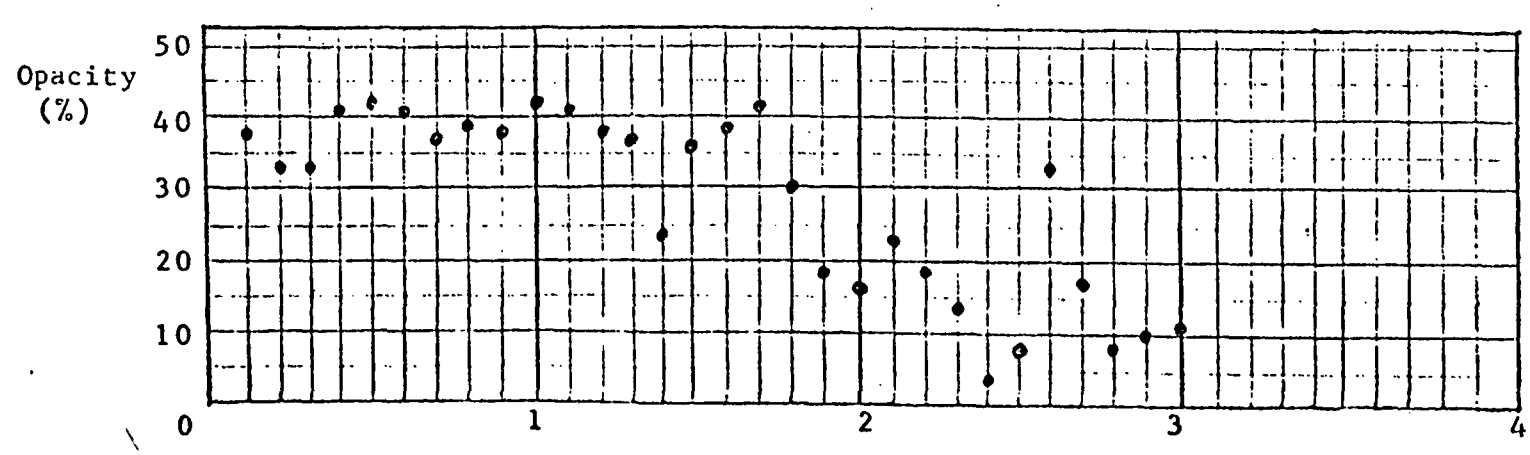


TABLE XII-5

SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/20/75
Type of Discharge: Stack
Height of Point of Discharge: 200 ft.
Wind Direction: South
Color of Plume: Reddish-gray
Observer No.: 2
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Partly cloudy
Wind Velocity: 703 fpm
Detached Plume: Yes
Duration of Observation: 4 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Gray, hazy

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0915	0921	700	29.2	21	1115	1121	840	35.0
2	0921	0927	745	31.0	22	1121	1127	840	35.0
3	0927	0933	780	32.5	23	1127	1133	840	35.0
4	0933	0939	840	35.0	24	1133	1139	770	32.1
5	0939	0945	990	41.2	25	1139	1145	840	35.0
6	0945	0951	820	34.2	26	1145	1151	765	31.9
7	0951	0957	810	33.8	27	1151	1157	840	35.0
8	0957	1003	825	34.4	28	1157	1203	825	34.4
9	1003	1009	835	34.8	29	1203	1209	810	33.8
10	1009	1015	840	35.0	30	1209	1215	840	35.0
11	1015	1021	850	35.4	31	1215	1221	840	35.0
12	1021	1027	855	35.6	32	1221	1227	840	35.0
13	1027	1033	865	36.0	33	1227	1233	840	35.0
14	1033	1039	805	33.5	34	1233	1239	840	35.0
15	1039	1045	735	30.6	35	1239	1245	840	35.0
16	1045	1051	835	34.8	36	1245	1251	840	35.0
17	1051	1057	785	32.7	37	1251	1257	840	35.0
18	1057	1103	820	34.2	38	1257	1303	840	35.0
19	1103	1109	860	35.8	39	1303	1309	840	35.0
20	1109	1115	840	35.0	40	1309	1315	840	35.0

Sketch Showing How Opacity Varied With Time:

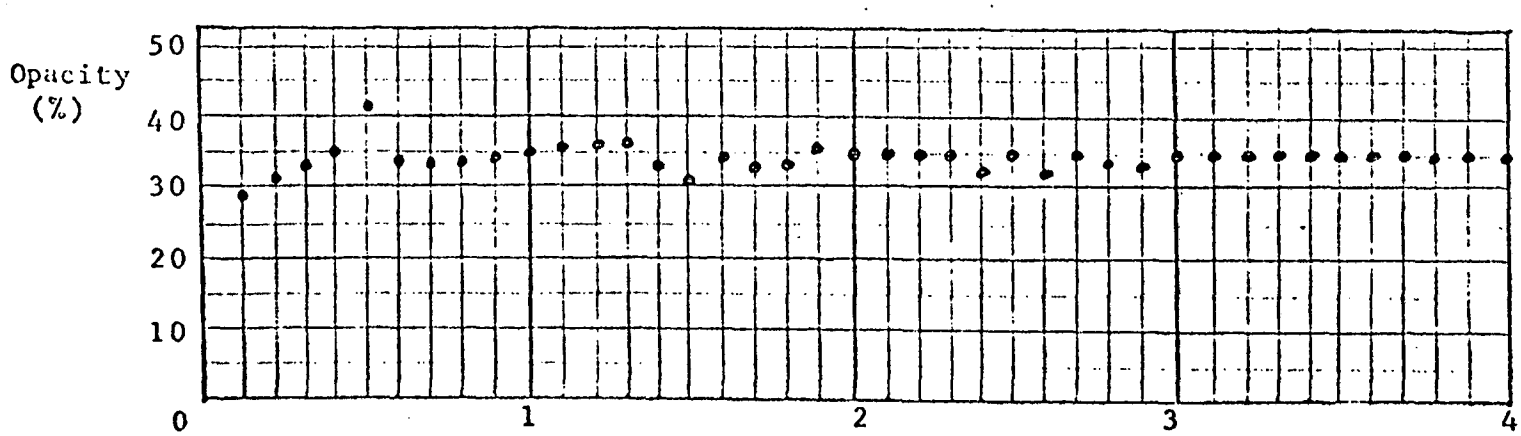


TABLE XII-6

SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/21/75
Type of Discharge: Stack
Height of Point of Discharge: 200 ft.
Wind Direction: SW
Color of Plume: Yellowish
Observer No.: 2
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Clear
Wind Velocity: 866 fpm
Detached Plume: No
Duration of Observation: 4 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Light blue sky with some haze

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0910	0916	720	30.0	21	1110	1116	165	6.9
2	0916	0922	720	30.0	22	1116	1122	180	7.5
3	0922	0928	650	27.1	23	1122	1128	80	3.3
4	0928	0934	505	21.0	24	1128	1134	70	2.9
5	0934	0940	445	18.5	25	1134	1140	85	3.5
6	0940	0946	370	15.4	26	1140	1146	225	9.4
7	0946	0952	315	13.1	27	1146	1152	80	3.3
8	0952	0958	310	12.9	28	1152	1158	350	14.6
9	0958	1004	310	12.9	29	1158	1204	230	9.6
10	1004	1010	800	33.3	30	1204	1210	225	9.4
11	1010	1016	520	21.7	31	1210	1216	135	5.6
12	1016	1022	410	17.1	32	1216	1222	110	4.6
13	1022	1028	475	19.8	33	1222	1228	120	5.0
14	1028	1034	115	4.8	34	1228	1234	245	10.2
15	1034	1040	340	14.2	35	1234	1240	210	8.8
16	1040	1046	180	7.5	36	1240	1246	310	12.9
17	1046	1052	240	10.0	37	1246	1252	280	11.7
18	1052	1058	350	14.6	38	1252	1258	230	9.6
19	1058	1104	355	14.8	39	1258	1304	125	5.2
20	1104	1110	295	12.3	40	1304	1310	120	5.0

Sketch Showing How Opacity Varied With Time:

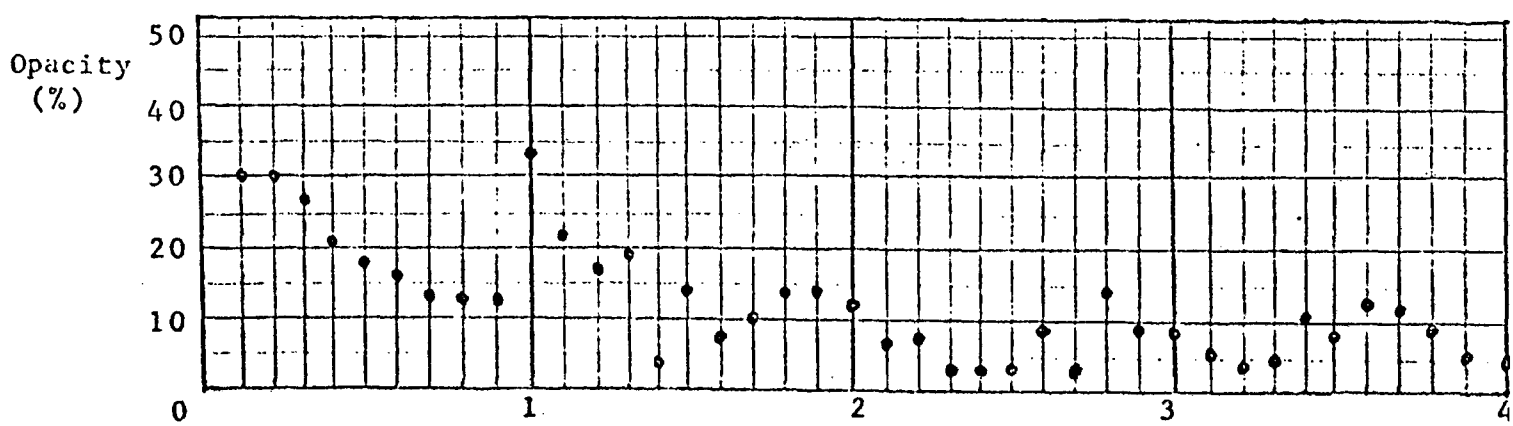


TABLE XII-7

SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/22/75
Type of Discharge: Stack
Height of Point of Discharge: 200 ft.
Wind Direction: WNW
Color of Plume: Yellowish-white
Observer No.: 2
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Clear
Wind Velocity: 450 fpm
Detached Plume: No
Duration of Observation: 4 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Light blue sky with haze

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0910	0916	250	10.4	21	1110	1116	95	4.0
2	0916	0922	260	10.8	22	1116	1122	60	2.5
3	0922	0928	280	11.7	23	1122	1128	345	14.4
4	0928	0934	275	11.5	24	1128	1134	340	14.2
5	0934	0940	250	10.4	25	1134	1140	135	5.6
6	0940	0946	240	10.0	26	1140	1146	15	0.6
7	0946	0952	255	10.6	27	1146	1152	185	7.7
8	0952	0958	325	13.5	28	1152	1158	250	10.4
9	0958	1004	345	14.4	29	1158	1204	180	7.5
10	1004	1010	260	10.8	30	1204	1210	105	4.4
11	1010	1016	145	6.0	31	1210	1216	135	5.6
12	1016	1022	250	10.4	32	1216	1222	265	11.0
13	1022	1028	370	15.4	33	1222	1228	175	7.3
14	1028	1034	280	11.7	34	1228	1234	140	5.8
15	1034	1040	305	12.7	35	1234	1240	100	4.2
16	1040	1046	275	11.5	36	1240	1246	45	1.9
17	1046	1052	270	11.2	37	1246	1252	165	6.9
18	1052	1058	300	12.5	38	1252	1258	135	5.6
19	1058	1104	270	11.2	39	1258	1304	110	4.6
20	1104	1110	130	5.4	40	1304	1310	130	5.4

Sketch Showing How Opacity Varied With Time:

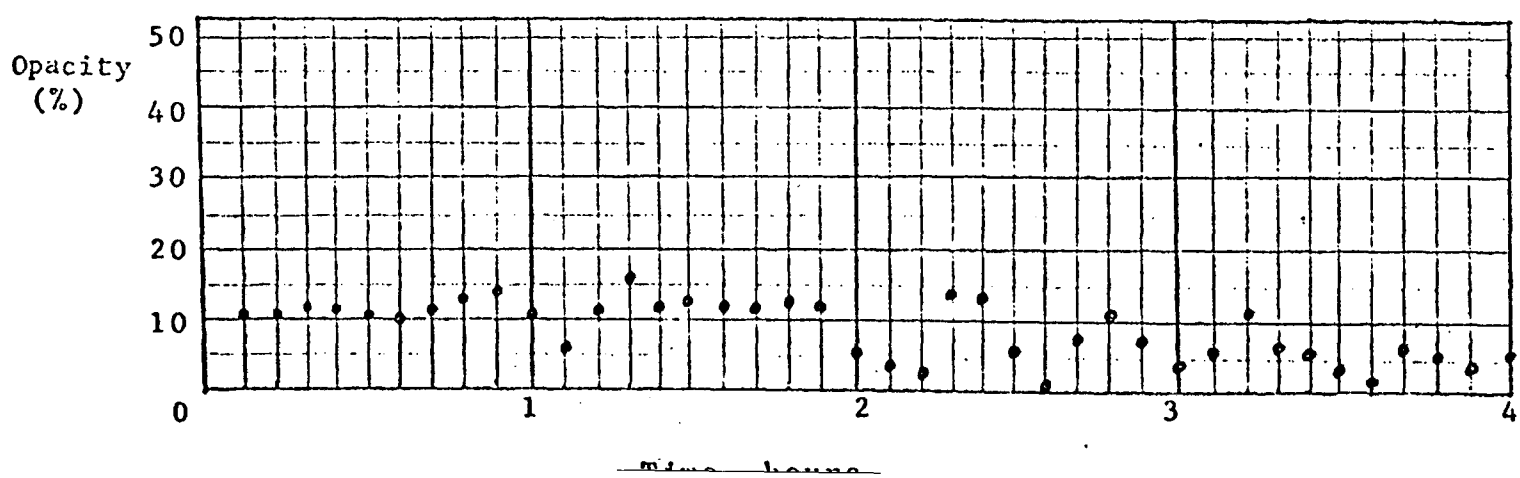


TABLE XII-8

SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/23/75
Type of Discharge: Stack
Height of Point of Discharge: 200 ft.
Wind Direction: SW
Color of Plume: Yellowish-white
Observer No.: 2
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Clear and hazy
Wind Velocity: 600 fpm
Detached Plume: No
Duration of Observation: 4 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Light blue sky with haze

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0900	0906	1030	42.9	21	1100	1106	815	34.0
2	0906	0912	980	40.8	22	1106	1112	950	39.6
3	0912	0918	810	33.8	23	1112	1118	815	34.0
4	0918	0924	670	27.9	24	1118	1124	360	15.0
5	0924	0930	890	37.1	25	1124	1130	380	15.8
6	0930	0936	1000	41.7	26	1130	1136	745	31.0
7	0936	0942	805	33.5	27	1136	1142	505	21.0
8	0942	0948	640	26.7	28	1142	1148	450	18.8
9	0948	0954	720	30.0	29	1148	1154	265	11.0
10	0954	1000	830	34.6	30	1154	1200	335	14.0
11	1000	1006	855	35.6	31	1200	1206	370	15.4
12	1006	1012	805	33.5	32	1206	1212	465	19.4
13	1012	1018	825	34.4	33	1212	1218	530	22.1
14	1018	1024	735	30.6	34	1218	1224	395	16.5
15	1024	1030	870	36.2	35	1224	1230	285	11.9
16	1030	1036	875	36.5	36	1230	1236	270	11.2
17	1036	1042	900	37.5	37	1236	1242	365	15.2
18	1042	1048	855	35.6	38	1242	1248	345	14.4
19	1048	1054	750	31.2	39	1248	1254	265	11.0
20	1054	1100	795	33.1	40	1254	1300	205	8.5

Sketch Showing How Opacity Varied With Time:

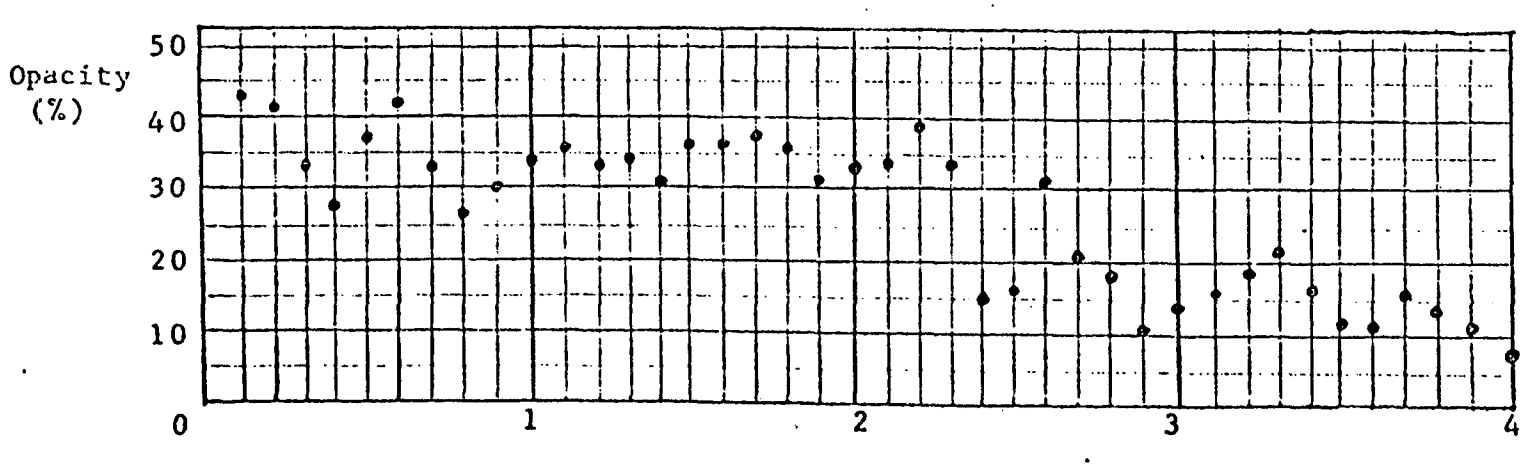


TABLE XII-9

SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/20/75
Type of Discharge: Building
Height of Point of Discharge: 50 ft.
Wind Direction: South
Color of Plume: Reddish-gray
Observer No.: 1
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Partly cloudy
Wind Velocity: 703 fpm
Detached Plume: Yes
Duration of Observation: 4 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Gray, hazy

SUMMARY OF AVERAGE OPACITY									
Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0915	0921	0	0	21	1115	1121	90	3.8
2	0921	0927	0	0	22	1121	1127	205	8.5
3	0927	0933	260	10.8	23	1127	1133	105	4.4
4	0933	0939	1080	45.0	24	1133	1139	70	2.9
5	0939	0945	1010	42.1	25	1139	1145	400	16.7
6	0945	0951	805	33.5	26	1145	1151	565	23.5
7	0951	0957	455	19.0	27	1151	1157	840	35.0
8	0957	1003	295	12.3	28	1157	1203	445	18.5
9	1003	1009	665	27.7	29	1203	1209	270	11.2
10	1009	1015	560	23.3	30	1209	1215	110	4.6
11	1015	1021	830	34.6	31	1215	1221	230	9.6
12	1021	1027	635	26.5	32	1221	1227	175	7.3
13	1027	1033	770	32.1	33	1227	1233	435	18.1
14	1033	1039	880	36.7	34	1233	1239	120	5.0
15	1039	1045	350	14.6	35	1239	1245	460	19.2
16	1045	1051	180	7.5	36	1245	1251	545	22.7
17	1051	1057	30	1.2	37	1251	1257	210	8.8
18	1057	1103	200	8.3	38	1257	1303	265	11.0
19	1103	1109	175	7.3	39	1303	1309	220	9.2
20	1109	1115	180	7.5	40	1309	1315	235	9.8

Sketch Showing How Opacity Varied With Time:

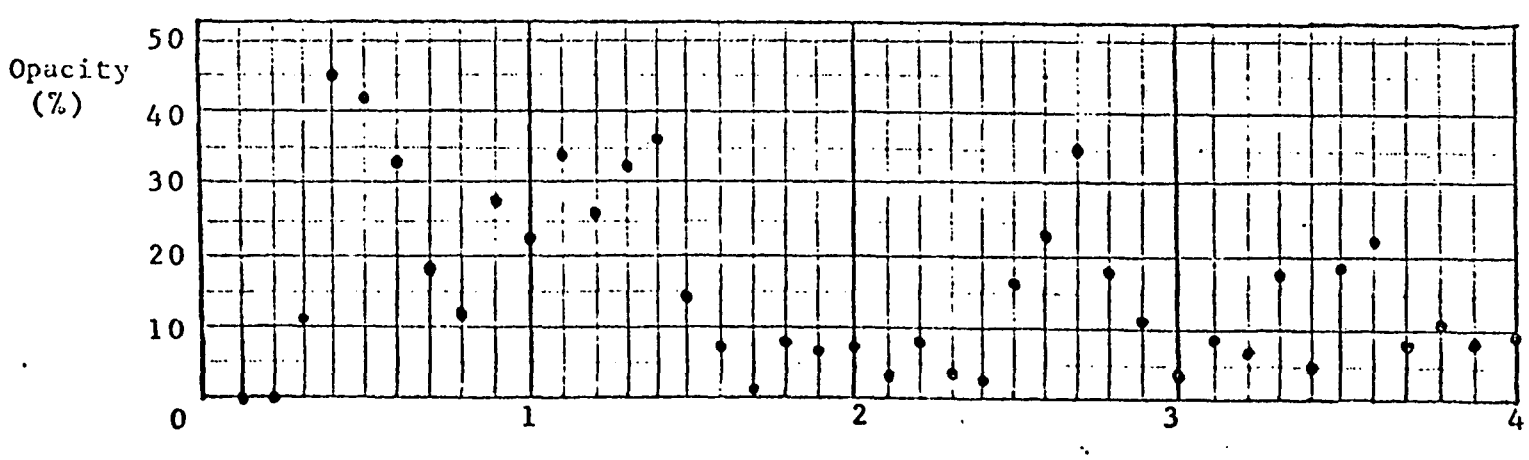


TABLE XII-10

SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/21/75
Type of Discharge: Building
Height of Point of Discharge: 200 ft.
Wind Direction: SW
Color of Plume: Yellow
Observer No.: 1
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Clear to partly cloudy
Wind Velocity: 866 fpm
Detached Plume: No
Duration of Observation: 4 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Gray (haze) to light blue

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0910	0916	320	13.3	21	1110	1116	775	32.3
2	0916	0922	445	18.5	22	1116	1122	665	27.7
3	0922	0928	770	32.1	23	1122	1128	410	17.1
4	0928	0934	1030	42.9	24	1128	1134	360	15.0
5	0934	0940	1200	50.0	25	1134	1140	390	16.2
6	0940	0946	1475	61.5	26	1140	1146	620	25.8
7	0946	0952	625	26.0	27	1146	1152	1505	62.7
8	0952	0958	630	26.2	28	1152	1158	1000	41.7
9	0958	1004	415	17.3	29	1158	1204	1375	57.3
10	1004	1010	360	15.0	30	1204	1210	1185	49.4
11	1010	1016	460	19.2	31	1210	1216	1080	45.0
12	1016	1022	1100	45.8	32	1216	1222	770	32.1
13	1022	1028	1580	65.8	33	1222	1228	185	7.7
14	1028	1034	1005	41.9	34	1228	1234	335	14.0
15	1034	1040	750	31.2	35	1234	1240	340	14.2
16	1040	1046	975	40.6	36	1240	1246	475	19.8
17	1046	1052	655	27.3	37	1246	1252	595	24.8
18	1052	1058	470	19.6	38	1252	1258	130	5.4
19	1058	1104	385	16.0	39	1258	1304	95	4.0
20	1104	1110	535	22.3	40	1304	1310	80	3.3

Sketch Showing How Opacity Varied With Time:

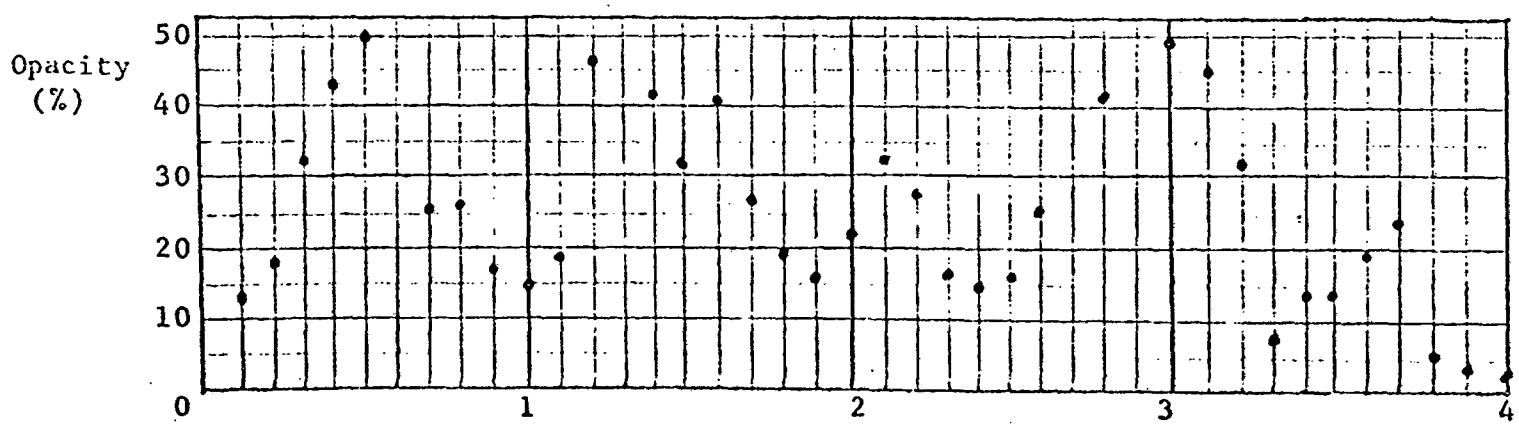


TABLE XII-11

SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/22/75
Type of Discharge: Building
Height of Point of Discharge: 50 ft.
Wind Direction: WNW
Color of Plume: Yellowish-white
Observer No.: 1
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Sunny
Wind Velocity: 450 fpm
Detached Plume: No
Duration of Observation: 4 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Light blue and hazy to sunny

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0910	0916	1020	42.5	21	1110	1116	200	8.3
2	0916	0922	470	19.6	22	1116	1122	250	10.4
3	0922	0928	370	15.4	23	1122	1128	850	35.4
4	0928	0934	385	16.0	24	1128	1134	920	38.3
5	0934	0940	1285	53.5	25	1134	1140	225	9.4
6	0940	0946	1175	49.0	26	1140	1146	190	7.9
7	0946	0952	825	34.4	27	1146	1152	940	39.2
8	0952	0958	800	33.3	28	1152	1158	275	11.5
9	0958	1004	730	30.4	29	1158	1204	285	11.9
10	1004	1010	565	23.5	30	1204	1210	240	10.0
11	1010	1016	580	24.2	31	1210	1216	465	19.4
12	1016	1022	585	24.4	32	1216	1222	310	12.9
13	1022	1028	290	12.1	33	1222	1228	205	8.5
14	1028	1034	210	8.8	34	1228	1234	320	13.3
15	1034	1040	255	10.6	35	1234	1240	210	8.8
16	1040	1046	240	10.0	36	1240	1246	235	9.8
17	1046	1052	235	9.8	37	1246	1252	180	7.5
18	1052	1058	250	10.4	38	1252	1258	150	6.2
19	1058	1104	85	3.5	39	1258	1304	250	10.4
20	1104	1110	40	1.7	40	1304	1310	195	8.1

Sketch Showing How Opacity Varied With Time:

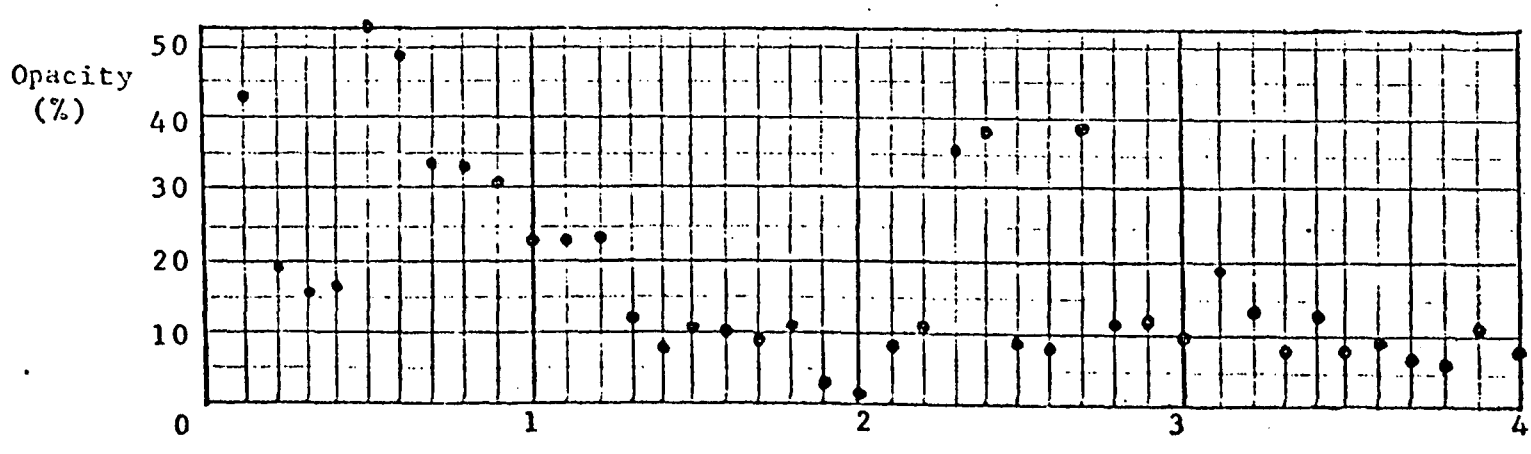


TABLE XII-12

SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/23/75
Type of Discharge: Building
Height of Point of Discharge: 50 ft.
Wind Direction: SE
Color of Plume: Yellow-white
Observer No.: 1
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Hazy, sunny
Wind Velocity: 600 fpm
Detached Plume: No
Duration of Observation: 3 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Bluish gray - No obstruction

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0900	0906	305	12.7	21	1100	1106	55	2.3
2	0906	0912	345	14.4	22	1106	1112	65	2.7
3	0912	0918	185	7.7	23	1112	1118	690	28.8
4	0918	0924	160	6.7	24	1118	1124	30	1.2
5	0924	0930	135	5.6	25	1124	1130	35	1.5
6	0930	0936	90	3.8	26	1130	1136	120	5.0
7	0936	0942	95	4.0	27	1136	1142	155	6.5
8	0942	0948	215	9.0	28	1142	1148	315	13.1
9	0948	0954	295	12.3	29	1148	1154	65	2.7
10	0954	1000	215	9.0	30	1154	1200	65	2.7
11	1000	1006	235	9.8	31				
12	1006	1012	390	16.2	32				
13	1012	1018	240	10.0	33				
14	1018	1024	185	7.7	34				
15	1024	1030	160	6.7	35				
16	1030	1036	115	4.8	36				
17	1036	1042	150	6.2	37				
18	1042	1048	120	5.0	38				
19	1048	1054	125	5.2	39				
20	1054	1100	75	3.1	40				

Sketch Showing How Opacity Varied With Time:

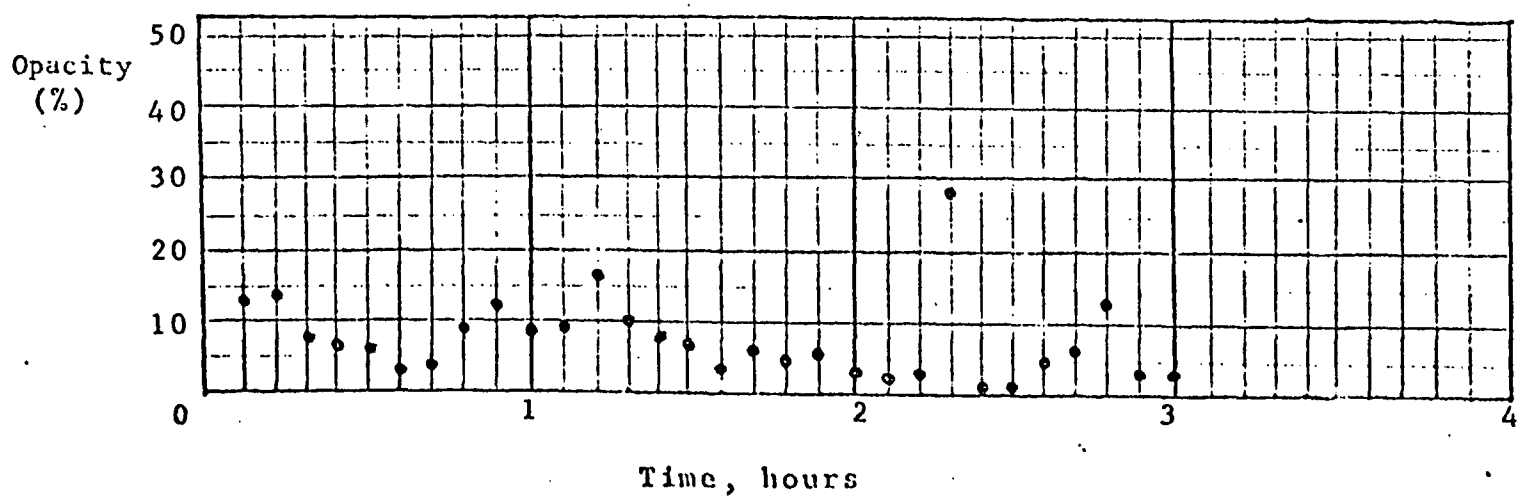


TABLE XII-13

SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/20/75
Type of Discharge: Building
Height of Point of Discharge: 50 ft.
Wind Direction: South
Color of Plume: Reddish-gray
Observer No.: 2
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Partly cloudy
Wind Velocity: 703 fpm
Detached Plume: Yes
Duration of Observation: 4 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Gray, hazy

SUMMARY OF AVERAGE OPACITY									
Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0915	0921	0	0	21	1115	1121	230	9.6
2	0921	0927	0	0	22	1121	1127	290	12.1
3	0927	0933	295	12.3	23	1127	1133	60	2.5
4	0933	0939	1130	47.1	24	1133	1139	215	9.0
5	0939	0945	1070	44.6	25	1139	1145	495	20.6
6	0945	0951	1020	42.5	26	1145	1151	590	24.6
7	0951	0957	500	20.8	27	1151	1157	860	35.8
8	0957	1003	310	12.9	28	1157	1203	415	17.3
9	1003	1009	665	27.7	29	1203	1209	315	13.1
10	1009	1015	690	28.8	30	1209	1215	275	11.5
11	1015	1021	930	38.8	31	1215	1221	245	10.2
12	1021	1027	720	30.0	32	1221	1227	250	10.4
13	1027	1033	565	23.5	33	1227	1233	425	17.7
14	1033	1039	910	37.9	34	1233	1239	220	9.2
15	1039	1045	625	26.0	35	1239	1245	560	23.3
16	1045	1051	390	16.2	36	1245	1251	645	26.9
17	1051	1057	215	9.0	37	1251	1257	275	11.5
18	1057	1103	375	15.6	38	1257	1303	240	10.0
19	1103	1109	245	10.2	39	1303	1309	240	10.0
20	1109	1115	75	3.1	40	1309	1315	240	10.0

Sketch Showing How Opacity Varied With Time:

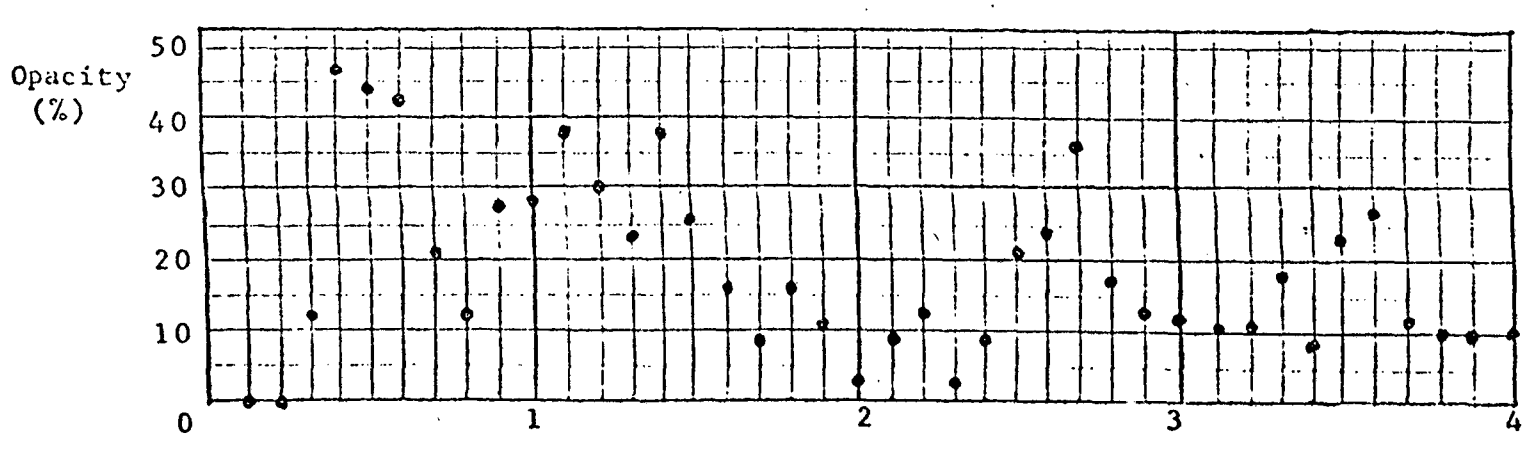


TABLE XII-14
SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/21/75
Type of Discharge: Building
Height of Point of Discharge: 50 ft.
Wind Direction: SW
Color of Plume: Yellowish
Observer No.: 2
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Clear
Wind Velocity: 866 fpm
Detached Plume: No
Duration of Observation: 4 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Light blue sky with some haze

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0910	0916	370	15.4	21	1110	1116	865	36.0
2	0916	0922	430	17.9	22	1116	1122	655	27.3
3	0922	0928	750	31.2	23	1122	1128	390	16.2
4	0928	0934	1035	43.1	24	1128	1134	310	12.9
5	0934	0940	1350	56.2	25	1134	1140	220	9.2
6	0940	0946	1070	44.6	26	1140	1146	510	21.2
7	0946	0952	710	29.6	27	1146	1152	690	28.8
8	0952	0958	780	32.5	28	1152	1158	520	21.7
9	0958	1004	495	20.6	29	1158	1204	615	25.6
10	1004	1010	480	20.0	30	1204	1210	420	17.5
11	1010	1016	405	16.9	31	1210	1216	475	19.8
12	1016	1022	1020	42.5	32	1216	1222	335	14.0
13	1022	1028	1335	55.6	33	1222	1228	400	16.7
14	1028	1034	1025	42.7	34	1228	1234	550	22.9
15	1034	1040	660	27.5	35	1234	1240	525	21.9
16	1040	1046	1275	53.1	36	1240	1246	775	32.3
17	1046	1052	650	27.1	37	1246	1252	720	30.0
18	1052	1058	630	26.2	38	1252	1258	545	22.7
19	1058	1104	715	29.8	39	1258	1304	315	13.1
20	1104	1110	835	34.8	40	1304	1310	290	12.1

Sketch Showing How Opacity Varied With Time:

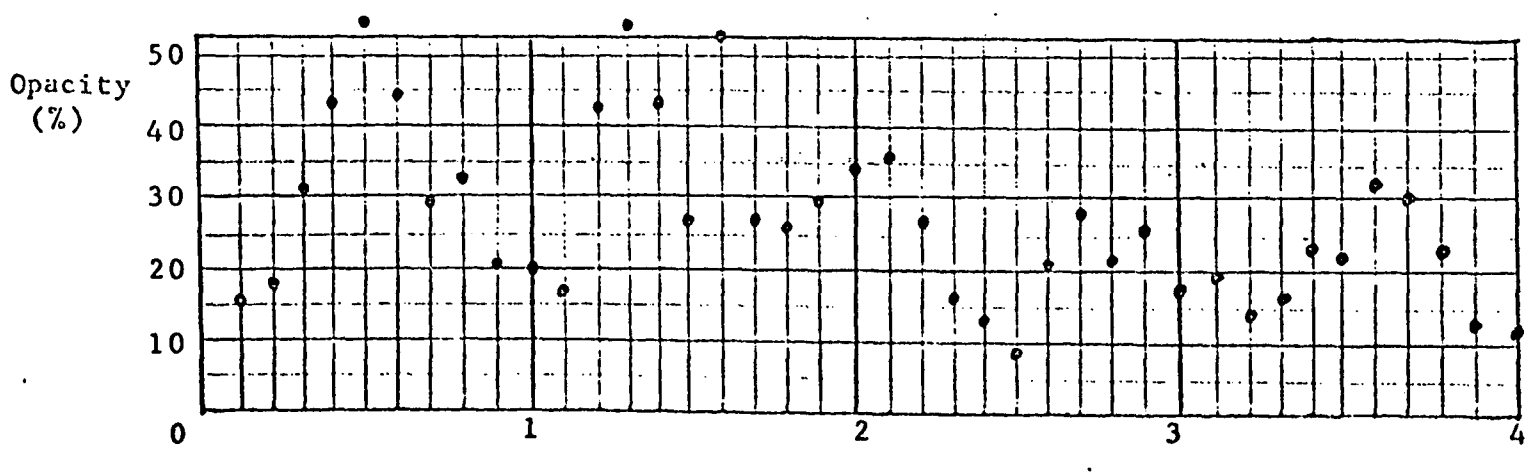


TABLE XII-15

SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/22/75
Type of Discharge: Building
Height of Point of Discharge: 50 ft.
Wind Direction: WNW
Color of Plume: Yellowish-white
Observer No.: 2
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Clear
Wind Velocity: 450 fpm
Detached Plume: No
Duration of Observation: 4 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Light blue sky with haze

SUMMARY OF AVERAGE OPACITY									
Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0910	0916	800	33.3	21	1110	1116	215	9.0
2	0916	0922	370	15.4	22	1116	1122	200	8.3
3	0922	0928	410	17.1	23	1122	1128	785	32.7
4	0928	0934	365	15.2	24	1128	1134	680	28.3
5	0934	0940	1320	55.0	25	1134	1140	410	17.1
6	0940	0946	995	41.5	26	1140	1146	325	13.5
7	0946	0952	785	32.7	27	1146	1152	660	27.5
8	0952	0958	1020	42.5	28	1152	1158	465	19.4
9	0958	1004	995	41.5	29	1158	1204	435	18.1
10	1004	1010	710	29.6	30	1204	1210	310	12.9
11	1010	1016	675	28.1	31	1210	1216	485	20.2
12	1016	1022	505	21.0	32	1216	1222	330	13.8
13	1022	1028	325	13.5	33	1222	1228	250	10.4
14	1028	1034	345	14.4	34	1228	1234	230	9.6
15	1034	1040	320	13.3	35	1234	1240	295	12.3
16	1040	1046	285	11.9	36	1240	1246	255	10.6
17	1046	1052	260	10.8	37	1246	1252	220	9.2
18	1052	1058	320	13.3	38	1252	1258	165	6.9
19	1058	1104	245	10.2	39	1258	1304	150	6.2
20	1104	1110	195	8.1	40	1304	1310	190	7.9

Sketch Showing How Opacity Varied With Time:

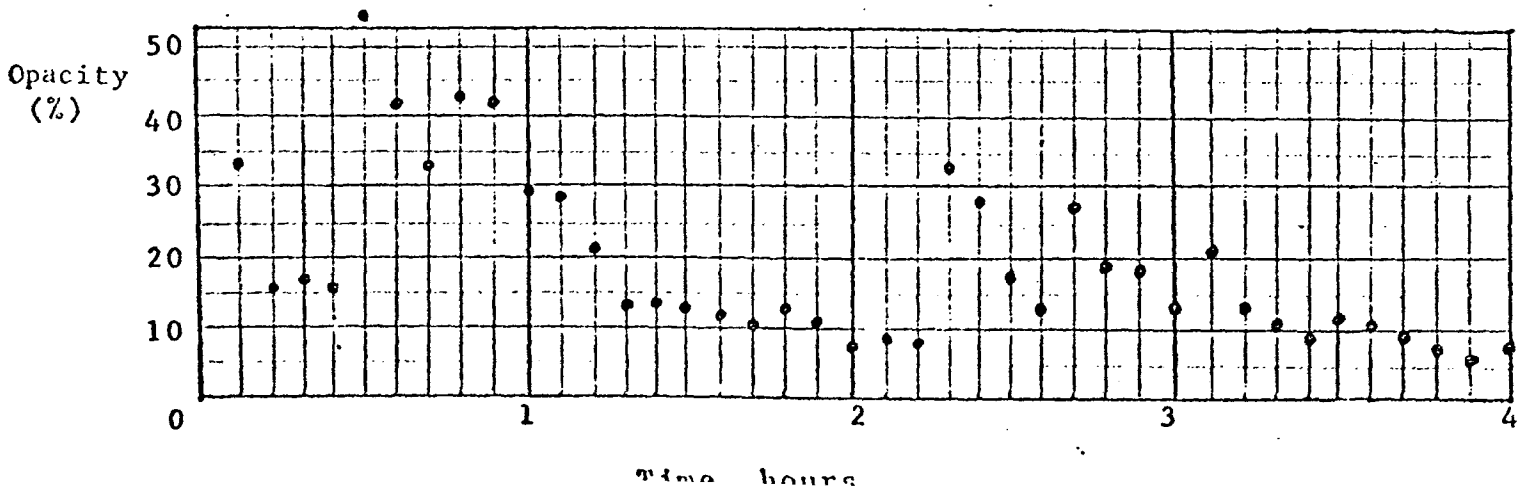


TABLE XII-16

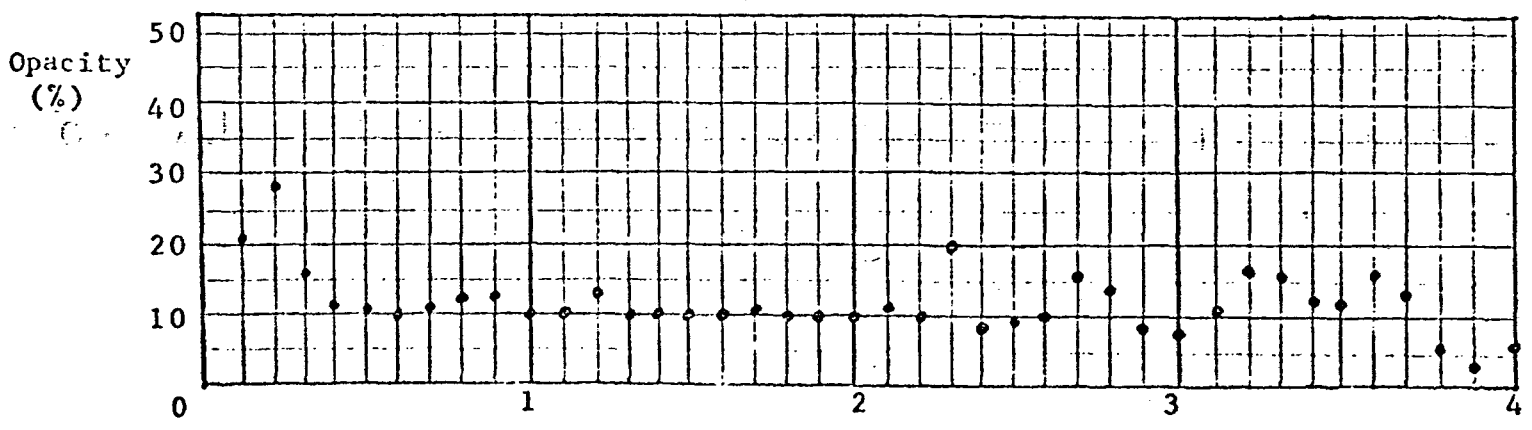
SUMMARY OF VISIBLE EMISSIONS

Granite City Steel
Granite City, Illinois

Date: 5/23/75
Type of Discharge: Building
Height of Point of Discharge: 50 ft.
Wind Direction: SW
Color of Plume: Yellowish-white
Observer No.: 2
Type of Plant: Sintering
Location of Discharge: WNW of observer
Description of Sky: Clear and hazy
Wind Velocity: 600 fpm
Detached Plume: No
Duration of Observation: 4 hours
Distance from Observer to Discharge Point: 1/4 mile
Direction of Observer from Discharge Point: ESE
Height of Observation Point: 60 ft.
Description of Background: Light blue sky with haze

SUMMARY OF AVERAGE OPACITY								
Set Number	Time		Opacity		Set Number	Time		Opacity	
	Start	End	Sum	Average		Start	End	Sum	Average
1	0900	0906	505	21.0	21	1100	1106	265	11.0
2	0906	0912	665	27.7	22	1106	1112	240	10.0
3	0912	0918	385	16.0	23	1112	1118	480	20.0
4	0918	0924	270	11.2	24	1118	1124	210	8.8
5	0924	0930	245	10.2	25	1124	1130	230	9.6
6	0930	0936	240	10.0	26	1130	1136	240	10.0
7	0936	0942	250	10.4	27	1136	1142	370	15.4
8	0942	0948	295	12.3	28	1142	1148	345	14.4
9	0948	0954	300	12.5	29	1148	1154	210	8.8
10	0954	1000	240	10.0	30	1154	1200	170	7.1
11	1000	1006	240	10.0	31	1200	1206	265	11.0
12	1006	1012	305	12.7	32	1206	1212	410	17.1
13	1012	1018	240	10.0	33	1212	1218	370	15.4
14	1018	1024	240	10.0	34	1218	1224	295	12.3
15	1024	1030	240	10.0	35	1224	1230	290	12.1
16	1030	1036	240	10.0	36	1230	1236	390	16.2
17	1036	1042	245	10.2	37	1236	1242	345	14.4
18	1042	1048	240	10.0	38	1242	1248	125	5.2
19	1048	1054	240	10.0	39	1248	1254	115	4.8
20	1054	1100	240	10.0	40	1254	1300	130	5.4

Sketch Showing How Opacity Varied With Time:



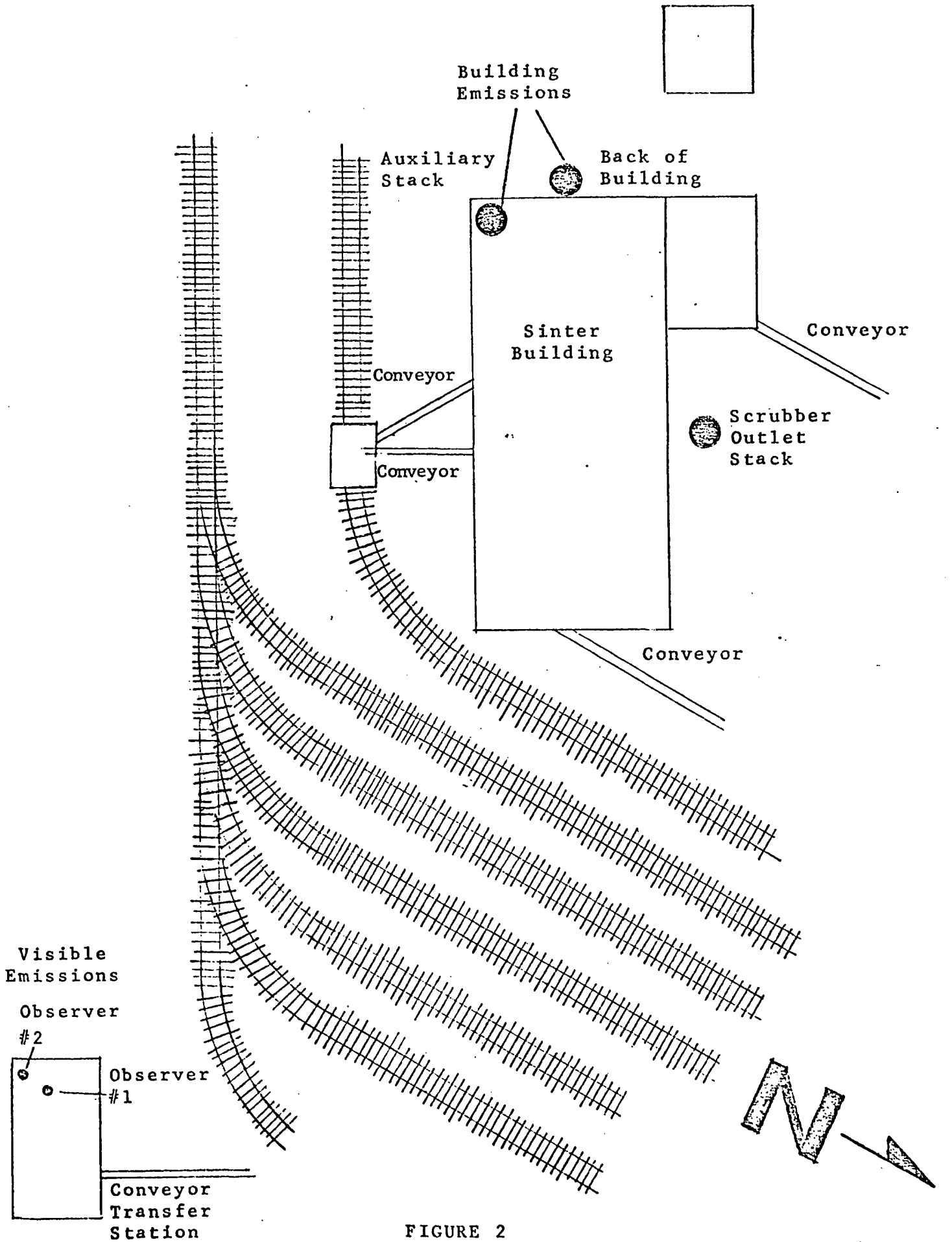


FIGURE 2

SCHEMATIC DIAGRAM OF VISIBLE EMISSIONS OBSERVATION LOCATIONS
Granite City Steel
Granite City, Illinois

TABLE XIII

AVERAGE OUTLET STACK VISIBLE EMISSIONS
DURING PARTICULATE TESTS

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Particulate Test Number	Date	Sampling Period	Average Opacity		Range of Opacities		Measured Outlet Total Particulate Concentrations			
			Observer No. 1	Observer No. 2	Observer No. 1	Observer No. 2	mg/Am^3	mg/DNM^3	gr/ACF	gr/DSCF
1	5/20	09:31 - 12:23	34.1	34.8	10 - 45	15 - 45	88.6	121	0.039	0.053
2	5/21	09:50 - 13:07	12.4	10.8	0 - 40	0 - 35	77.8	101	0.034	0.044
3	5/22	09:15 - 11:57	12.6	10.2	0 - 35	0 - 20	75.1	98.4	0.033	0.043
4	5/23	09:02 - 11:52	29.0	31.2	0 - 50	5 - 50	68.7	90.3	0.030	0.039

III. PROCESS DESCRIPTION AND OPERATION

The sintering process converts the charge material into an agglomerated product that is suitable for blast furnace feed material. The charge consists of iron ore fines and iron-bearing wastes (such as blast furnace flue dust, mill scale, and miscellaneous fines), flux (limestone, dolomite, or both), coke breeze or coal, and water. The charge is thoroughly mixed and placed on the sinter strand (a continuous moving grate), and combustion air is drawn through the top of the bed over its active length. The sinter bed is approximately 12 inches thick. The top surface of the material is ignited in a gas-fired or oil-fired combustion furnace. Once the coke breeze is ignited, the combustion is self-supporting to the end of the sinter bed — the flame front moving down through the bed. The combustion temperature range is 2400 to 2700°F. Typical heat input to the combustion furnace is approximately 150,000 Btu per ton of sinter produced. In order to provide a uniform distribution of combustion air, the sections under the bed are separated into a number of compartments known as windboxes. After the combustion is complete, the sinter cake is often crushed and screened. The undersize is collected in the hot return fines bin for recycling on the strand and the balance is fed to a cooler. Fines from the cooler and the cold screening operation are also recycled. Figure 3 shows a simplified schematic diagram of a sintering process.

Process Description

Granite City Steel has a typical traveling grate single strand machine that was built in 1958. It normally operates 24 hours per

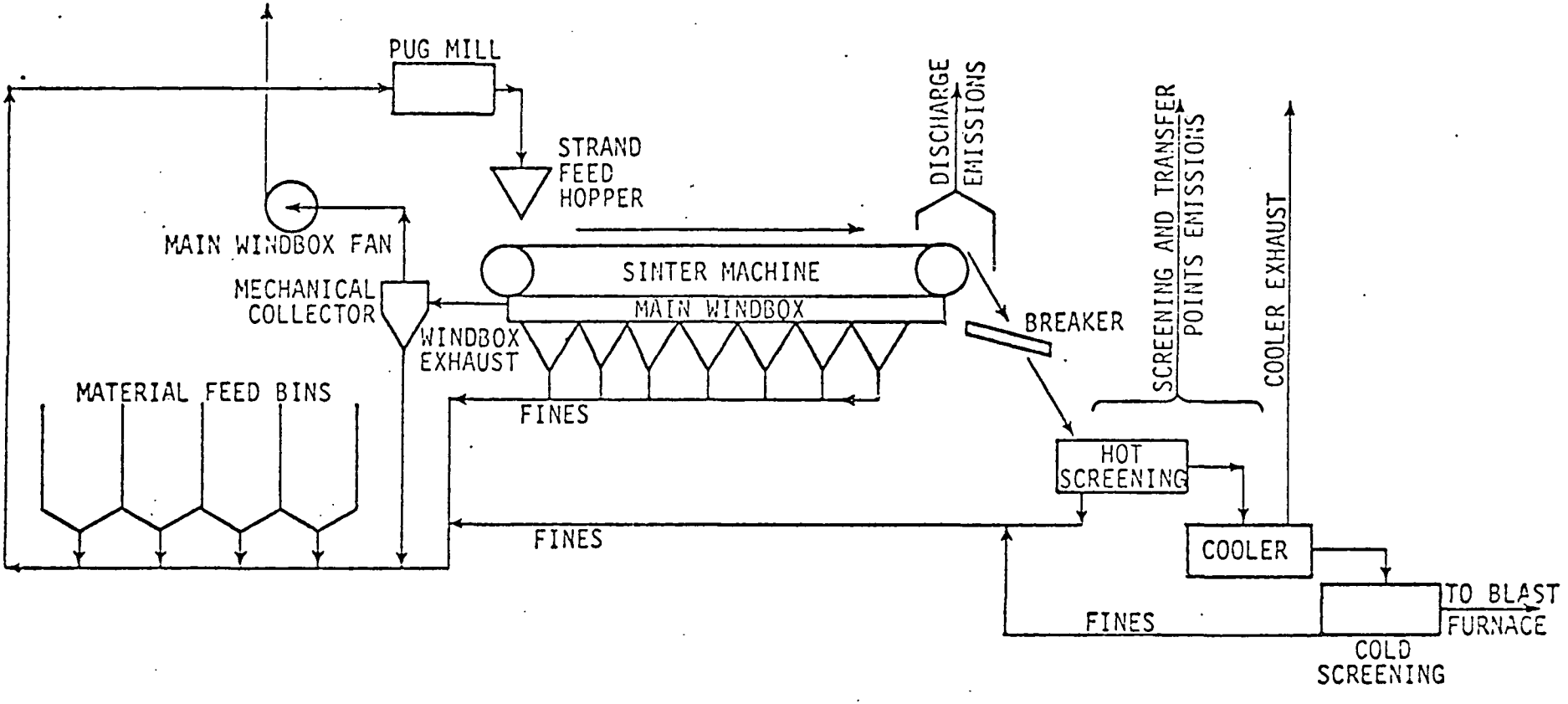


Figure 3. Simplified schematic diagram of a sintering process.

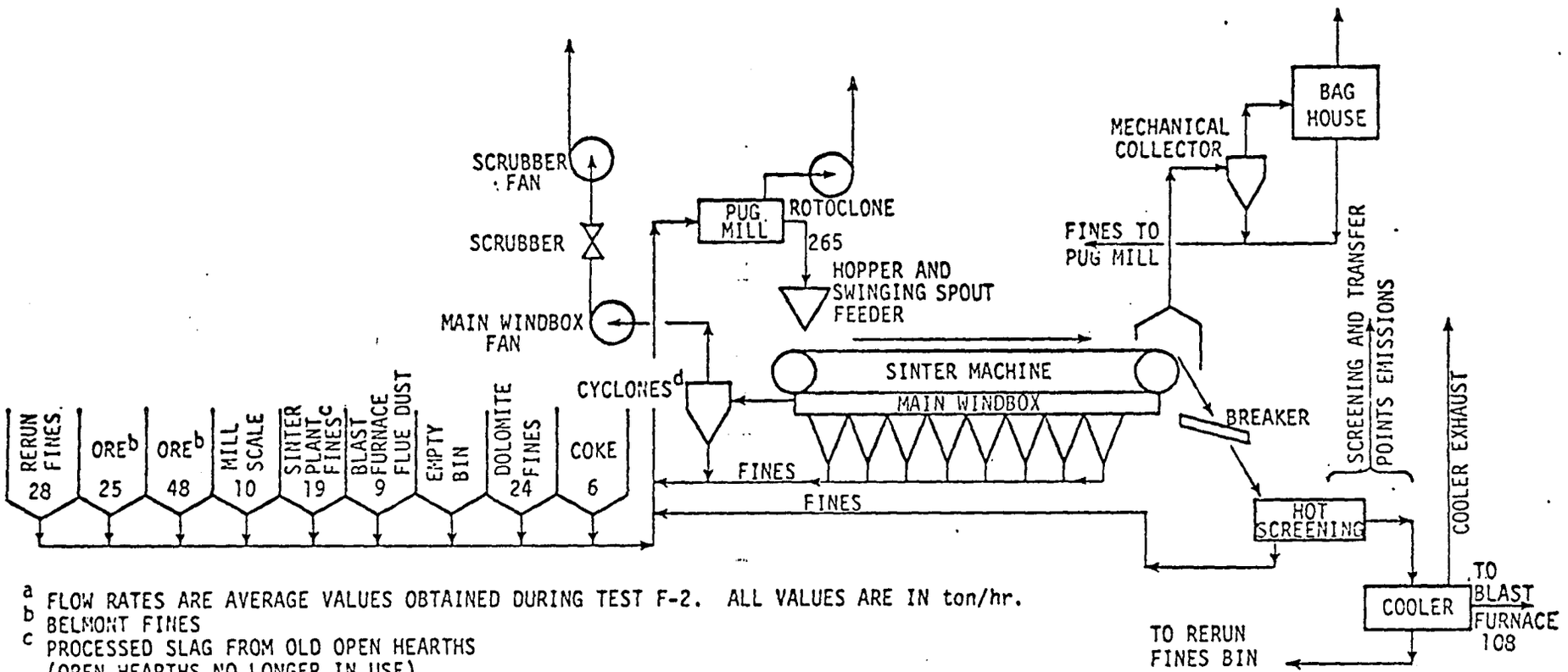
Granite City Steel
Granite City, Illinois

day. The charge material comes from nine storage bins that feed onto a common belt conveyor. Material from these bins plus returns from the hot screens are sent to a pug mill for proper mixing. Water is added to the mixture in the pug mill to achieve the proper moisture content. From the pug mill, the feed is placed on the strand by a swinging spout feeder. The strand is eight feet wide and the layer of charge material is 14 inches deep. Each pallet is 42 inches long. Either natural gas or coke oven gas is burned in the ignition hood. As the sinter product is discharged from the strand it is crushed, screened, and sent to a rotary cooler. A process flow diagram of Granite City Steel is shown in Figure 4.

The strand drive and the material feed turn tables are controlled by rheostats. A gauge records the strand speed and another keeps a running count of the traveling-grate pallets. There are also temperature gauges for each windbox. A belt scale measures the total feed except hot returns and water. However, plant personnel report that the gauges and scales are very inaccurate, therefore, readings from these could not be relied upon.

The design production of the strand is 130 tons/hour. The maximum production is 150 tons/hour and the normal production is 120 tons/hour. Typical burden characteristics are as follows:

Constituents	Percent
Ore	43
Reclaim	
Oily (mill scale)	20
Nonoily (BOF fines)	8
Coke breeze	7
Limestone	10
Dolomite	12



[a] FLOW RATES ARE AVERAGE VALUES OBTAINED DURING TEST F-2. ALL VALUES ARE IN ton/hr.
[b] BELMONT FINES
[c] PROCESSED SLAG FROM OLD OPEN HEARTHS (OPEN HEARTHS NO LONGER IN USE).
[d] FOUR CYCLONES IN PARALLEL.

Figure 4. Process flow diagram.

Granite City Steel
Granite City, Illinois

This produces a sinter that is between self-fluxing and superfluxing. That is, the base-to-acid ratio is greater than one. The normal strand speed is approximately 70 to 80 inches/minute.

The windbox emissions are controlled by cyclones and a venturi scrubber. The pug mill is controlled by a rotoclone and the discharge is controlled by a baghouse. Four Buell cyclones, model 15, type FAC, in parallel comprise primary windbox controls. The dimensions of each cyclone are as follows: core height - 66-1/2 inches; body height - 65 inches; body diameter - 50 inches; inlet dimensions- 14-1/4 inches x 31-3/4 inches; and outlet diameter - 26-3/4 inches. An American Air Filter venturi scrubber (model AAF L76) was installed in September, 1973. The unrestricted throat size is 10 inches x 176 inches or 12.2 ft^2. A plate can be inserted in one end of the throat to restrict the size to 10 inches x 150 inches or 10.4 ft^2. Restricting the throat size increases the pressure drop. The design pressure drop is 55 inches W.G. Two water pumps, each with a capacity of 1300 gpm, feed the scrubber through 44 water sprays. Design water flow to the scrubber is 2500 gpm. The scrubber inlet design is 180,000 scfm (dry), 300°F, and 0 inches W.G. Outlet design conditions from the mist eliminator are 289,700 acfm,118°F, and -55 inches W.G.

Process Operation

Only eight of the nine feed bins were used during the week of testing. There were separate bins for rerun fines (from the cooler), two bins of ore (Belmont fines), mill scale, sinter plant fines (process slag from old open hearths that are no longer in use), blast furnace flue dust, dolomite fines, and coke breeze. Pan tests for each bin were made to determine the hourly feed rates at the approximate start, middle, and end of each test. In addition the strand speed and feed density were measured at the same

intervals. In the pan test, a sample was taken by allowing a pan of known weight and length to pass under the feed table of each component at a known conveyor speed. After collecting each component, the pan and its contents were weighed. Component feed rates were then calculated as follows:

$$r = 0.03\ c \times s \div p \qquad (1)$$

where:

r = component feed rate, ton/hr.

c = collected sample weight, lb

s = conveyor speed, ft/min

p = pan length, ft.

For all tests except P-1, the pan was passed under the feed table twice. This effectively doubled the actual pan length. The reason for this was to increase precision since some of the samples collected in test P-1 were as small as one pound.

The strand speed was determined by measuring the elapsed time required for the strand to travel a known distance. The feed density was determined by taking a sample of the material as it is placed on the strand. This was placed in a container of known volume and weighed.

Total feed to the strand was calculated using strand speed, bed depth and width, and feed density. The average feed density for each test was used in these calculations. The equation used is as follows:

$$F = 2.083 \times 10^{-4} \times S \times B \times W \times \rho \qquad (2)$$

where:

F = total feed, ton/hr

S = strand speed, in./min.

B = bed depth, in.

W = strand width, ft.

ρ = feed density, lb/ft^3

There is no system for measuring the facility's production rate. Approximate production was calculated by a formula derived by the plant personnel for inventory purposes. The formula is as follows:

$$P = \left[(S \times 60 \div L) \times C - R\right] \times K \qquad (3)$$

where:

P = production (to blast furnace), ton/hr

C = 1.4, empirical constant

S = strand speed, in./min.

K = 0.76, empirical constant

L = pallet length, 42 in.

R = rerun fines from bin No. 1, ton/hr

During the test week, (May 19-23, 1975), the strand ignition fuel alternated between coke oven gas and natural gas. Coke oven gas was used exclusively on May 20. Natural gas was used from 11:00 a.m. to 4:30 p.m. on May 21 with coke oven gas burned at all other times that day. On May 22, coke oven gas was used until 11:30 a.m. then natural gas was used until 10:00 a.m. on May 23. Coke oven gas was then burned until the end of testing.

The basicity (base-to-acid ratio) of the sinter was measured each shift by plant personnel. The results for the shifts during which tests were made are given in Table XIV.

TABLE XIV

BASICITY OF THE SINTER

Shift	Date, 1975			
	5/20	5/21	5/22	5/23
7a.m.- 3p.m.	1.48	1.36	1.40	1.51
3p.m.-11p.m.	1.39	1.41	1.49	No Test

A gauge to measure pressure drop across the throat of the scrubber, located on the strand main floor, was not operating. Therefore, for the purposes of the tests, the company installed a manometer at the scrubber throat. Also, prior to the tests the scrubber inlet water flow meter was removed since it was not functioning. At the end of the first day of testing, however, the plant personnel attached a differential pressure gauge to the existing flange taps across the 8.526-inch diameter knife-edge orifice in the 12-inch water inlet pipe. Readings of the manometer and the differential pressure gauge were recorded approximately every half hour during the tests.

Water inlet flow was calculated by two methods. One method was by the equation used by Granite City Steel personnel to calculate flow as follows:

$$Q = 1000\sqrt{h} \qquad (4)$$

where:

Q = flow rate, gpm

h = pressure drop across the orifice, ft. W.G.

An alternate method was also used to calculate water flow through the orifice. This was by using equations from Perry's Chemical Engineer's Handbook, Fourth Edition, as follows:

$$w = KA\sqrt{(2\ g_c\ (p_1-p_2)+ 2\ g\rho\ (z_1-z_2))\ \rho} \qquad (5)$$

where:

w = weight rate of discharge, lb/sec.

$K = C/\sqrt{1-\beta^4} = 0.807$

$C = 0.697$ (from "Fluid Mechanics" by A.G. Hansen)

$\beta = d_2/d_1 = 0.7105$

$A = 0.396\ ft^2$

$g_c = 32.2\ lb_m\text{-}ft/lb_f\text{-}sec^2$

Δp = pressure drop across orifice, lb/ft^2

$g = 32.2\ ft/sec^2$

$\rho = 62.4\ lb/ft^3$

Δz = vertical distance between pressure taps $= 0.167$ ft.[2]

Equation 4 yields flow rates 12 percent lower than Equation 5.

The scrubber water supply came from the Mississippi River. There was no water recirculation during the testing. All of the scrubber effluent went to a settling pond.

Process Operation During Tests

Table XV lists process material rates during the tests. Raw field data are presented in Appendix I. In the table, the sum of the rerun fines plus the total raw feed does not equal the strand burden because fines from the hot screens, the discharge control system, and the mechanical collectors on the windbox exhaust are charged directly into the pug mill (see Figure 4).

The sintering process is normally a 24-hour per day operation. However, during the week of testing it was only operating two shifts per day because there was a reduced sinter demand by the blast

TABLE XV

PROCESS MATERIAL RATES SUMMARY (tons/hr)

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Material	Hopper Number	Test Number and 1975 Date					
		P-1 5/20	P-2 5/21	F-1 5/21	P-3 5/22	F-2 5/22	P-4 5/23
Ore[a]	2&3	87	73	71	69	73	78
Reclaim[a]	—						
Mill scale	4	16	14	11	13	10	9.2
Sinter plant fines[b]	5	16	16	15	17	19	15
Blast furnace flue dust	6&7	11	8.8	4.9	8.9	9.4	8.3
Coke breeze[a]	9	4.2	7.2	6.0	5.8	5.5	4.1
Dolomite[a]	8	27	20	19	25	24	24
Total raw feed[c]		161	139	127	139	141	139
Rerun fines[a,d]		26	51	52	39	28	26
Strand burden[e]		264	257	264	267	265	248
Production[f]		108	93	92	104	108	105

[a] Calculated by pan test method (including moisture, see Table XI)

[b] Processed slag from old open hearths (open hearths no longer in use).

[c] All feed bins except rerun fines.

[d] Feed bin No. 1 (cold returns from cooler).

[e] Material actually put on the strand, calculated using strand speed and feed density.

[f] Calculated using formula provided by Granite City Steel

furnace shop. Since the strand was started up cold each morning, the tests were not started until the process had reached normal conditions. Reliable readings of the windbox temperatures were not available, therefore they could not be used as a guideline. The sinter plant operator's judgment was used to determine when the process had reached normality. They felt that two revolutions of the strand gate (approximately 1-1/2 hours) would be needed to bring the system up to temperature. At least two hours was allowed between start-up and testing to ensure the system was at equilibrium. Therefore, the test results should not be affected by start-up.

Normal operation includes stopping the strand occasionally for five minutes or less. There are various reasons for this, including the cleaning of plugging in the pug mill. These brief stops are typical for all sinter plants. Thus the test results for periods when the brief stops occurred are representative of normal operation.

The strand speed was normal, generally between 80 and 90 in./min. The total raw strand burden remained approximately the same (about 260 ton/hr) throughout all tests. Production for all tests, except tests P-2 and F-1, also remained relatively constant at about 105 ton/hr. Since production stayed at this level throughout most of the test week, and within the normal production range, representative test results should be obtained. Production during tests P-2 and F-1 decreased to approximately 92 ton/hr. This was because the increase in rerun fines that occurred during these tests decreased production (when calculated using the equation provided by Granite City Steel). However, increase in reruns may not be indicative of a decrease in production. This is because of the lag time in transferring rerun fines from the cooler to the bin. The fact that the total strand feed remained approximately equal

throughout all tests indicates that production levels were also about the same for all tests. Production levels for all tests should represent typical operation.

For the test week, the basicity ranged from 1.36 to 1.51. This is indicative of a sinter that is between self- and super-fluxed, which is the normal product at the facility.

In summary, the process operated normally during all tests. The strand was bedded to full depth and strand speed was within the normal range.

Control System Operation During Tests

The control equipment data are listed in Tables XVI-1 through XVI-4. The design pressure drop across the venturi is 55 in. W.G. The average pressure drop observed during the first test (test P-1) was approximately 44 in. W.G. This was below the design of 55 in. W.G. but was representative of the normal operation prior to the test series. Records of the usual pressure drop were not available since the monitor in the control room was not functioning and the manometer at the venturi throat was not installed until just before the tests.

After the first day of testing, the company inserted a plate in the throat of the venturi to restrict the flow and raise the pressure drop. This was done without prior knowledge by EPA or the project contractors.

With the plate inserted in the scrubber throat, the pressure drop increased to approximately 51 in. W.G. This is close to the design conditions so the test results should be representative of good operation.

The pressure drop across the venturi was observed to be less than usual prior to testing on May 23 (test P-4). The plant personnel

TABLE XVI-1

VENTURI PARAMETERS

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Test Number		P-1						
Date, 1975		5/20						
Time		09:20	09:55	10:28	11:00	11:30	12:10	12:43
Venturi pressure drop, in. W.G.		43	43	43.5	43	43.5	44	44
Water pipe orifice pressure drop, in. W.G.		—[c]	—	—	—	—	—	—
Calculated water flow, gpm	Method 1[a]	—	—	—	—	—	—	—
	Method 2[b]	—	—	—	—	—	—	—

[a] Method used by Granite City Steel..

[b] Calculated using formula in Perry's Chemical Engineer's Handbook.

[c] Differential pressure gauge not yet installed.

TABLE XVI-2

VENTURI PARAMETERS

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Test Number		P-2							F-1					
Date, 1975		5/21							5/21					
Time		09:35	10:08	10:45	11:18	11:48	12:20	13:00	15:38	16:19	16:48	17:24	17:45	18:20
Venturi pressure drop, in. W.G.		51	52	51	51	51	51	51	51	51	51	51	51	51.5
Water pipe orifice pressure drop, in. W.G.		53	53	49	49	49.5	54	53	52	54	52	53	52	53
Calculated water flow, gpm	Method 1[a]	2100	2100	2020	2020	2030	2120	2100	2080	2120	2080	2100	2080	2100
	Method 2[b]	2380	2380	2290	2290	2300	2410	2380	2360	2410	2360	2380	2360	2380

[a] Method used by Granite City Steel.

[b] Calculated using formula in Perry's Chemical Engineer's Handbook.

TABLE XVI-3

VENTURI PARAMETERS

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Test Number		P-3						F-2					
Date, 1975		5/22						5/22					
Time		09:15	09:52	10:15	10:53	11:20	12:00	14:29	15:06	15:27	15:59	16:33	17:08
Venturi pressure drop, in. W.G.		51.5	52	52	52	51	51	51	52	50.5	51.5	51	51
Water pipe orifice pressure drop, in. W.G.		53	52.5	52	52	42	53	53	52.5	52.5	53	52.5	52.5
Calculated water flow, gpm	Method 1[a]	2100	2090	2080	2080	1870	2100	2100	2090	2090	2100	2090	2090
	Method 2[b]	2380	2370	2360	2360	2110	2380	2380	2370	2370	2380	2370	2370

[a] Method used by Granite City Steel.

[b] Calculated using formula in Perry's Chemical Engineer's Handbook.

TABLE XVI-4

VENTURI PARAMETERS

Granite City Steel
Granite City, Illinois
May 20-23, 1975

Test Number		P-4					
Date, 1975		5/23					
Time		09:07	09:43	10:06	10:43	11:05	11:45
Venturi pressure drop, in.W.G.		49	51	51	51	51	50.5
Water pipe orifice pressure drop, in. W.G.		53	53	53.5	53	53	53
Calculated water flow, gpm	Method 1[a]	2100	2100	2110	2100	2100	2100
	Method 2[b]	2380	2380	2400	2380	2380	2380

[a] Method used by Granite City Steel.

[b] Calculated using formula in Perry's Chemical Engineer's Handbook.

were informed and the situation corrected (pressure drop back to normal) within the first ten minutes of the test.

Data showing the normal rate of water flow to the scrubber was unavailable since the flow meter was inoperative. The design flow is 2500 gpm. After a differential pressure gauge was installed, the flow was calculated to be 2100 gpm to 2400 gpm (depending on the calculation method used). Plant personnel reported that to the best of their knowledge, the water supply system was "wide open" but that it was possible that the pumps were not receiving all the water they are capable of pumping. Since the calculated water flow is approximately at design level, and the water supply system was reported to be operated as usual, the flow rates are representative of normal operation.

One of the water pumps was down from approximately 10:00 a.m. to 11:30 a.m. on May 21 (during test P-2). Plant personnel did not inform EPA or project contractor of the shut down until after the test was completed. No unusual decrease in pressure drop across the water inlet orifice was recorded during the period that the pump was out of service. Plant personnel felt that the reason a large decrease in pressure drop was not observed may be that the pumps starve for water when operating concurrently, so when one pump was down, the other was capable of handling almost all of the supply. Since there was not a large variation in pressure drop across the orifice and calculated water flow, the test results for P-2 should not be seriously affected.

IV. LOCATION OF SAMPLING POINTS

The exhaust gases, after passing through the venturi scrubber, a mist eliminator, and a second fan, passed into a round stack which exhausts to the atmosphere as shown in Figure 5. The outlet sampling location, located on the 116-inch diameter stack, is shown in Figure 5. Four ports, located at right angles, were used to access the 24 sampling points in the outlet sampling cross section as shown in Figure 7. The points, 12 on a diameter, comprised 24 equal quadrant-annular areas. This number of points is consistent with the minimum requirement specified in Method 1 (FR V.36, n.247 December 23, 1971).

The inlet air sampling was conducted in the rectangular duct leading from the bank of cyclone collectors to the first fan, as shown in Figure 5. This duct, measuring 106 inches by 116 inches in cross section, was divided into 48 equal areas, as shown in Figure 7. Eight, bottom sampling ports were used to access these 48 sampling points at the inlet. The inlet sampling cross section was positioned less than two equivalent diameters downstream of a flow disturbance. Therefore, the 48 sampling points utilized were inconsistent with the minimum requirements specified in Method 1 but are adequate for the determination of inlet particulate loading to the scrubber.

For particulate tests, sampling was conducted for three minutes at each of the 48 sampling points at the inlet. Similarly, sampling was conducted for six minutes at each of the 24 outlet sampling points. To fulfill the requirement of simultaneous inlet and outlet particulate sampling with respect to both the sampling period and the sampling time, and to ensure that the impinger contents did not back up into the filter (because of high negative pressure in the duct), the inlet sampling station did not shut down during port changes except when the outlet station changed ports. Two

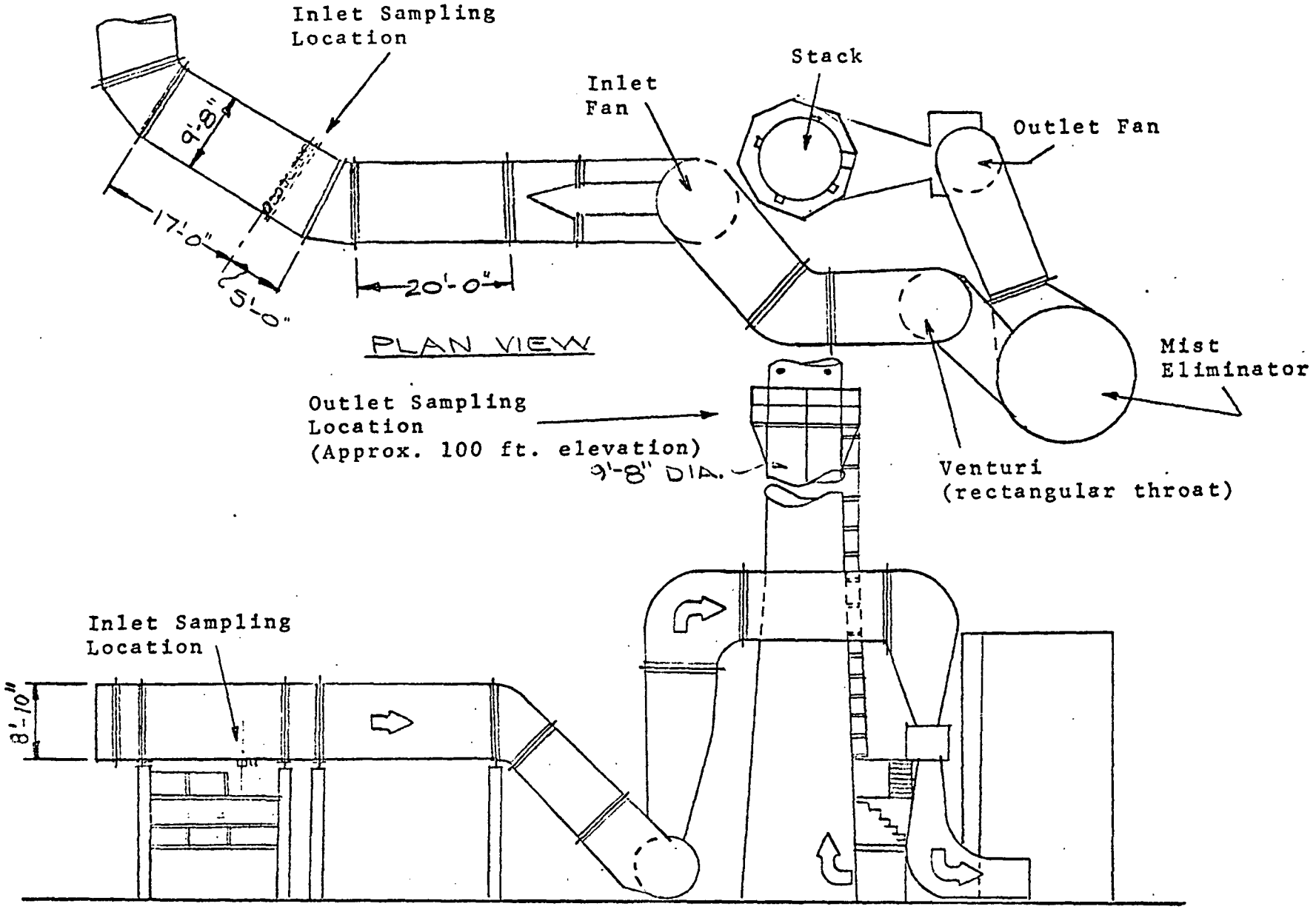


FIGURE 5

Schematic of Venturi Scrubber System and Sampling Locations

Granite City Steel
Granite City, Illinois
May 20-23, 1975

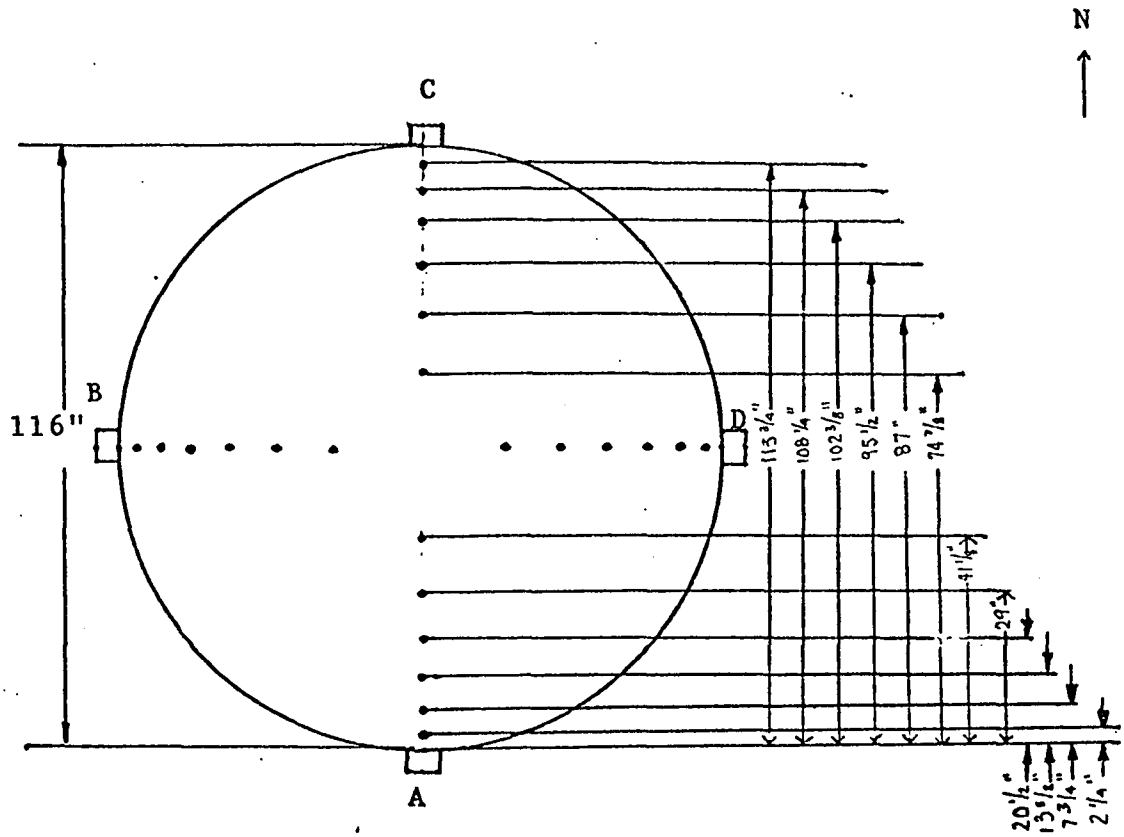


FIGURE 6

Location of Sampling Points in the Outlet Stack

Granite City Steel
Granite City, Illinois
May 20-23, 1975

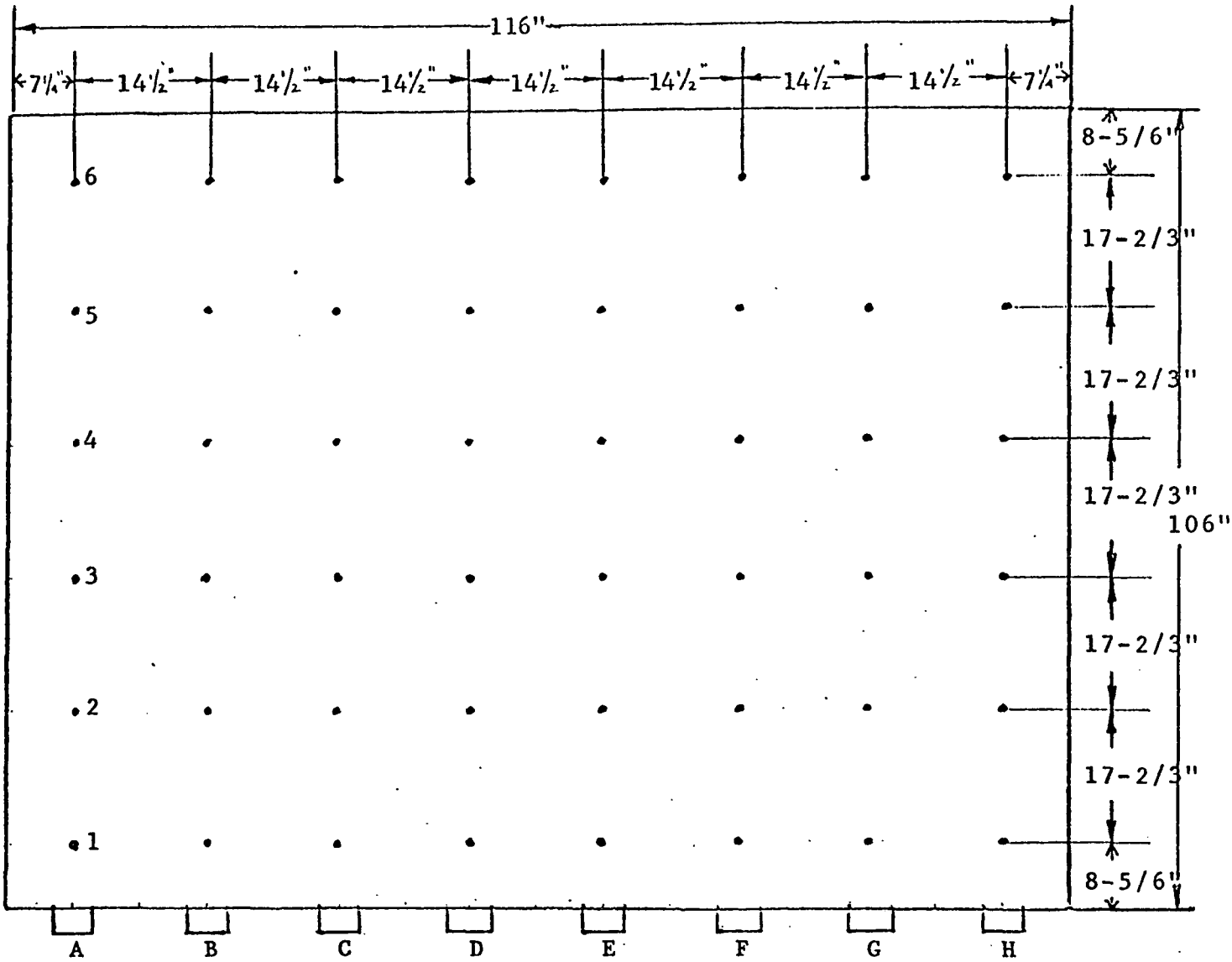


FIGURE 7

Location of Sampling Points in the Inlet Duct

Granite City Steel
Granite City, Illinois
May 20-23, 1975

port changes were required at the inlet for every port change required at the outlet. Due to the rapid and efficient method of port change at the inlet station, this contributed an insignificant error into the measurement of the inlet particulate concentration.

Ten sampling points were used to gather process samples. These included the nine raw material hopper feeds and the main conveyor, or strand (see Process Description). Samples collected from these sources constituted all those process samples necessary to characterize the feed materials as they affect the contaminants influent to the scrubber.

Inlet scrubber water samples were obtained from the spray manifold adjacent to the venturi throat section. The tapline on this manifold is less than one foot long and about two inches in diameter. Consequently, precipitated solids or scale in the tapline were minimal. Nonetheless, the tap was allowed to run free for a sufficient time to purge the line of any residual materials that might render the sample non-representative of the actual feed water.

The outlet scrubbing liquor was sampled in the concrete-lined drainage ditch which conducts all scrubber draining to the settling pond. Scrubbing liquor samples were obtained by immersing a sample bottle immediately below the exit of the pipe which exhausts scrubbing liquor into the ditch before the scrubbing liquor was able to mix with the stream in the ditch. Scrubbing liquor effluent comprised the majority of all flow passing through the drainage ditch. Other effluents which are subsequently mixed with the scrubbing liquor effluent included scrubber feed water pump overflow, and drainage from the settling hopper (normally closed during scrubber operation).

As indicated in the summary of visible emissions results, the two observers who recorded opacities of stack and building emissions were located as shown in Figure 2. These "sampling locations" provided an unobstructed view of all visible emissions.

V. SAMPLING AND ANALYTICAL PROCEDURES

Particulate Sampling and Analysis

Particulate sampling at the scrubber inlet duct and outlet stack was conducted in accordance with the principles outlined in EPA Method 5 (Federal Register, December 23, 1971, V. 36, No. 247. Deviations from this method are noted below:

1. A glass cyclone was placed in the heated filter box to remove some particulate material prior to filtration.

2. Calculation of the average stack gas velocity included an averaging of the square roots of the product (rather than the products of the square roots of the averages) of velocity pressure and absolute stack temperature at each of the traverse points.

3. Teflon bottles were used for acetone and distilled water washes used to clean the probe and sampling trains.

4. For both particulate tests and fluoride tests, the heated probe used for sampling at the outlet stack was glass-lined, however, the heated probe used for sampling at the inlet duct was 316 stainless steel (due to the required probe length).

5. The configuration was modified so that hydrocarbon samples could be taken (see Figure 1). Volume of gas removed for the hydrocarbon sample was added to the volume measured on the dry gas meter to obtain the total stack gas sampled.

6. Additional thermocouples were added to record train operation temperatures(see Figure 1).

The analytical method for the determination of particulate in accordance with Method 5 is expanded to include the determination of aqueous and organic soluble fractions. Special precautions are taken to prevent the settling of the particulate which is insoluble in the chloroform-ether extract layer (more dense than the aqueous fraction) during analysis so that it will not be included in the organic-soluble fraction catch weight. The details of this portion of the analytical method are included in Appendix D.

Fluoride Sampling and Analysis

Gaseous and particulate fluoride sampling and analysis at the scrubber inlet duct and outlet stack was conducted in accordance with the principles outlined in the proposed EPA Method 13B (Federal Register, October 23, 1974, V. 39, No. 206) entitled "Determination of Total Fluoride Emissions From Stationary Sources Specific Ion Electrode Method." Deviations from this method are noted below:

1. The absorbing reagent in the impingers was 0.1N sodium hydroxide, instead of distilled water.

2. A heated probe and cyclone were used in the train in conjunction with a Whatman #1 filter. The filter was positioned between the probe and the first impinger.

3. The train was modified to include a modified Greenburg-Smith impinger with 100 ml of 0.1N sodium hydroxide, a standard Greenburg-Smith impinger with 100 ml of 0.1N sodium hydroxide, a modified Greenburg-Smith impinger as a dry trap, a glass wool plug in the adjacent U-connector, and a modified Greenburg-Smith impinger containing silica gel.

Gaseous Hydrocarbon Sampling and Analysis

Integrated samples of the gases in the scrubber inlet duct and the outlet stack were obtained in accordance with the "Gaseous Hydrocarbon Test Procedure" delineated in Appendix D. In brief, non-condensible hydrocarbons were sampled from the particulate sampling train using a leakless pump which exhausted into a Tedlar bag (see Figure 1).

The integrated gaseous hydrocarbon samples were analyzed in the field. A total gaseous hydrocarbon analysis was conducted from the integrated bag sample using a flame ionization detector. All hydrocarbons not condensed in the particulate train's impingers were analyzed and reported as methane. In conjunction with this, a gas chromatographic technique was employed to identify those hydrocarbons (in the same integrated sample) within the range of C_1 through C_6. Detailed analytical procedures, utilized in the field and in the laboratory, are included in Appendix D.

Sulfur Oxides Sampling and Analysis

Sulfur dioxide sampling at the scrubber inlet duct and outlet stack was conducted in accordance with the principles outlined in EPA Method 6 (Federal Register, December 23, 1971, V. 36, No. 247.

Sulfur dioxide samples were analyzed by EPA Method 6 with the modification of passing an aliquot of the sample through an ion-exchange column prior to titration to remove interfering cations which may cause erroneously low results. The eluate from the column was quantitatively transferred to a 125-ml Erlenmeyer flask and isopropanol was added to yield a final solution of 80% isopropanol for analysis.

Carbon Monoxide Sampling and Analysis

Integrated samples of the gases in the scrubber inlet duct and the outlet stack were acquired in accordance with EPA Method 3 (Federal Register, December 23, 1971, V. 36, No. 247). The percent of carbon dioxide, oxygen, and carbon monoxide in the gas were determined prior to each particulate and fluoride test to determine the molecular weight of the gas.

The grab samples were analyzed for carbon monoxide using the standard procedure for Orsat operation. The second analytical technique utilized a Fisher-Hamilton gas partitioner, Model 29 of the molecular sieve type. The unit is calibrated with Matheson certified gas standards of the following concentrations of carbon monoxide in N_2:

540 ppm CO in N_2,

5,042 ppm CO in N_2.

The gas partitioner utilized a 6-1/2-ft. x 1/2-inch column packed with 42/60 molecular sieve 13X to separate the carbon monoxide from other gaseous components. Th carbon monoxide was then detected with a thermal conductivity detector kept at 70°F. Five-milliliter injections were made using a gas-tight syringe (Hamilton #1005 LT). The instrument was recalibrated every morning by injecting a standard at least three times; standards were also injected between samples to ensure that the instrument was operating correctly.

The carbon monoxide peak heights of the samples were compared to the average peak height of the carbon monoxide standards to determine the concentration of carbon monoxide in the sample:

$$\frac{\text{Sample's peak height}}{\text{Standard's peak height}} \times (\text{Concentration of Standard}) = \text{Concentration of Sample}$$

Scrubber Water Sampling and Analysis

Scrubber water samples were acquired at the sampling locations specified previously in accordance with the document "Methods for Analysis of Material Samples from Sintering Facilities," issued by the Emission Measurement Branch of EPA to Clayton Environmental Consultants prior to the beginning of this study. This document is included in Appendix D.

Scrubber water samples were analyzed for pH, total suspended solids, total dissolved solids, and fluoride content. The analytical method for determination of pH was a glass electrode pH meter. The device was linearized for a range of pH of 4 to 7 for acidic samples and linearized separately for alkaline samples of a pH of 7 to 10 using the appropriate buffer. The pH measurements were made in the laboratory.

The analytical procedure for the analysis of fluoride content is identical to that employed in EPA Method 13B.

Process Material Sampling and Analysis

Bulk samples of process feed materials were acquired at the sampling locations specified previously in accordance with the document "Methods of Analysis of Material Samples from Sintering Facilities," issued by the Emissions Measurement Branch of EPA to Clayton Environmental Consultants prior to the beginning of this study. This document is included in Appendix D.

As specified in the "Methods for Analysis of Material Samples from Sintering Facilities," two methods were utilized for the process bulk samples. These included ASTM Method D-271-70 for the analysis of sulfur content in coke (this method requires determination of moisture) and ASTM Method D-395-70 for the determination of sulfur in iron ore. Those process samples which were not entirely composed of coke or coal were analyzed for sulfur utilizing ASTM Method D-395-70.

Bulk samples were analyzed for fluoride content using the analytical procedure delineated with EPA Method 13B.