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AP-42 Section 12.2
Reference
Report Sect. 4
Reference 45

ROUGE STEEL COMPANY
"C" COKE OVEN COMBUSTION STACK
PARTICULATE COMPLIANCE SURVEY

July 1, 1986

Conducted by

STATIONARY SOURCE ENVIRONMENTAL CONTROL OFFICE
Survey & Compliance Assurance

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ROUGE STEEL COMPANY
"C" COKE OVEN COMBUSTION STACK
PARTICULATE COMPLIANCE SURVEY

Table of Contents

	<u>Subjects</u>	<u>Page</u>
I.	INTRODUCTION.....	1
II.	PROCESS DESCRIPTION.....	2
III.	SUMMARY.....	4
IV.	RESULTS.....	5
V.	DISCUSSION.....	9

List of Appendices

A.	Location of Sampling Ports and Points.....	10
B.	Sampling Procedures.....	14
C.	Analytical Procedures.....	19
D.	Field Data Sheets.....	22
E.	Process Operating Parameters Data Sheets.....	38
F.	Laboratory Data Sheets.....	50
G.	Sample Calculations.....	53
H.	Equipment Calibration.....	62
I.	Opacity Data Sheets.....	68

List of Tables

I.	Summary of Results - Particulate/Flow Data.....	4
II.	Stack Gas Velocity and Flow Results.....	6
III.	Particulate Sampling Results.....	7
IV.	Individual Test Averages - Heater Room Data.....	8

List of Figures

1.	Schematic of Koppers Coking Oven.....	3
2.	Sampling Port Location.....	12
3.	Sampling Point Location.....	13
4.	Particulate Sampling Train.....	16

I. INTRODUCTION

Three tests for particulate emissions and opacity were performed at the "C" Coke Oven Combustion Stack on July 1, 1986. The survey was conducted to fulfill requirements of operating condition 2d of Installation Permit No. C-6562 issued to Rouge Steel Company on December 10, 1984. Results of the test program are included herein.

The survey was performed by the Ford Motor Company Stationary Source Environmental Control Office. Opacity readings were made by Mr. D. O'Connor of Rouge Steel. The test was witnessed by Messrs. S. Drielick, M. Farrell, and R. Niemi from the Wayne County APCD.

All testing was performed during active periods when ovens in the battery were being pushed and charged. Included with the report are operating data pertaining to each test and analysis of the enriched blast furnace gas used to heat the ovens.

II. PROCESS DESCRIPTION

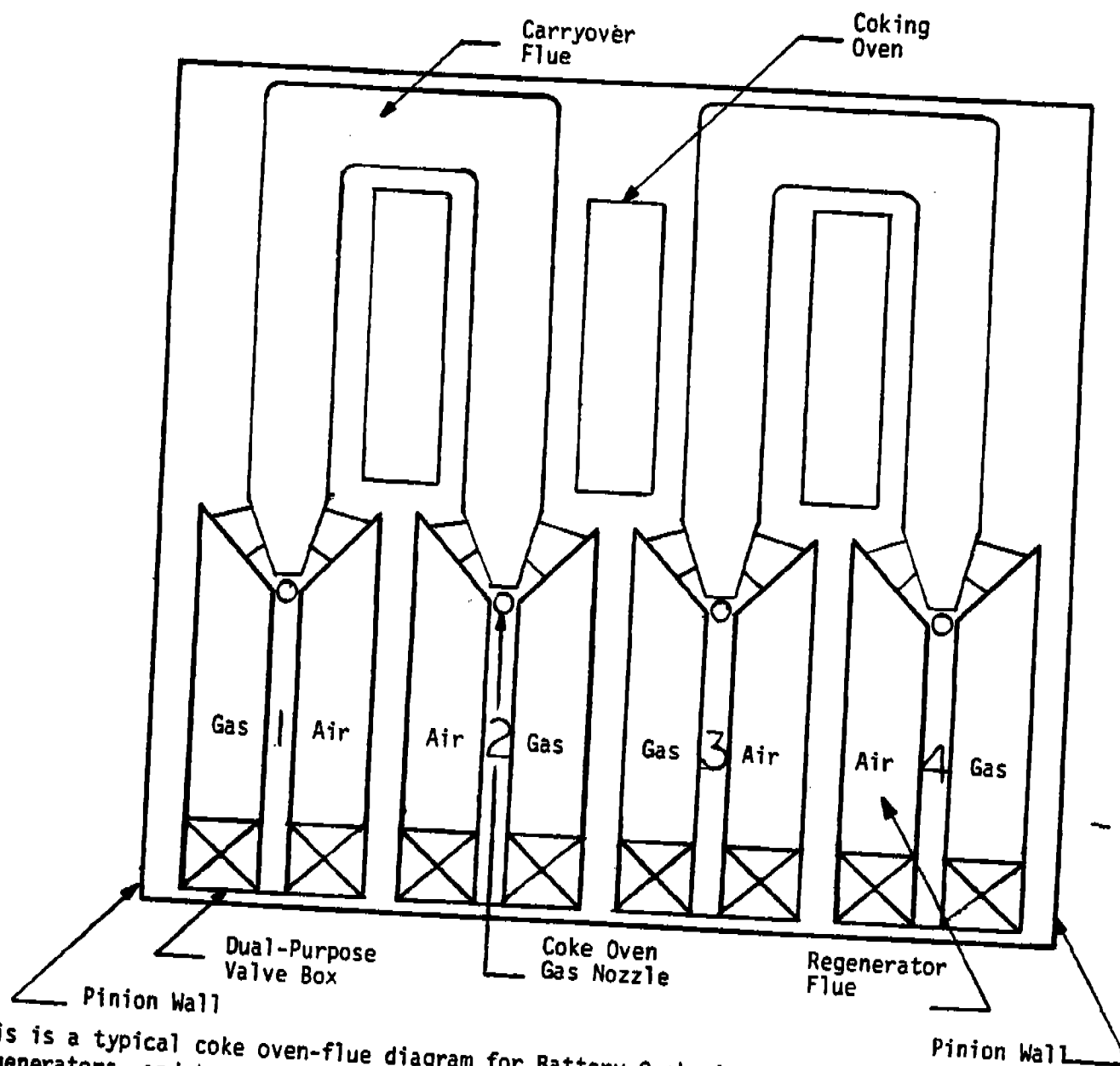
Coking is a process by which coal is destructively distilled in a reducing atmosphere to produce a relatively nonvolatile coke residue and a volatile gas byproduct. The Rouge Steel Company coking operation utilizes a Koppers combination gun-flue type byproduct coke oven battery.

On each side of a byproduct oven wall is a gas flue. Fuel gas is fired on one side of the wall at a time. The other side is used to direct exhaust flue gas into a regenerator. The regenerator acts to preheat both combustion air and fuel gas. Every half hour the direction of fuel gas and combustion air flows reverses over the entire battery. As a result, the opposite flue contains the burning fuel gas. Refer to Figure 1 for a schematic illustration of a typical Kopper's Coking Oven.

The volatile byproduct from the coking chamber is drawn through an ascension pipe into a collecting main. It is then transported to the byproduct plant for processing and distribution. The waste flue gas from both the coke and the pusher sides is directed through a 225-foot tall combustion stack.

"C" Battery includes 63 coking chambers. During the survey all 63 ovens were in operation and functioning normally. Enriched blast furnace gas is used as fuel for firing the battery.

FIGURE 1
SCHEMATIC OF TYPICAL KOPPERS COKING OVEN
COKE OVEN BATTERY C
FORD MOTOR COMPANY



This is a typical coke oven-flue diagram for Battery C showing three coking ovens, four regenerators, and two pinion walls. Blast furnace gas and air are fed into their labeled regenerators on a #1-#4-#5, #2-#3 sequence or reversal. The opposite flue is used for transport of waste flue gas through the dual-purpose valve box and into the waste gas flue and exhausted through an electrostatic precipitator and finally a 225-foot stack.

III. SUMMARY

Results from this survey are summarized below in Table I. The table includes stack emission results and operating data obtained during test periods.

TABLE I
SUMMARY OF RESULTS
"C" COKE OVEN COMBUSTION STACK
PARTICULATE COMPLIANCE SURVEY
JULY 1, 1986

PARTICULATE EMISSIONS	VALUE	UNITS
Mass Flow rate	4.6	Lb/Hr
Concentration		
-Stack Conditions	.007	GR/ACF
-Std. Conditions	.012	GR/DSCF
EXHAUST GAS	VALUE	UNITS
Flow rate		
-Stack Conditions	77,600	ACFM
-Std. Conditions	44,400	DSCFM
Temperature	347	°F
Moisture	10.4	%
Excess Air	48.6	%
OPERATING DATA	VALUE	UNITS
En. Blast Furnace Gas		
-Integrator Flow	1,279,000	CFH
-Recorder Flow	1,285,000	CFH
-BTU Content	116	BTU/CF
Ovens Pushed/Charged per Test	5	

IV. RESULTS

The individual test results from this survey are presented in the tables which follow. The tables are listed below by title.

<u>TABLE NO.</u>	<u>TITLE</u>
II	Stack Gas Velocity and Flow Results
III	Particulate Sampling Results
IV	Individual Test Avg. - Heater Room Data

Table II
"C" COMBUSTION STACK-COMPLIANCE TESTS
STACK GAS VELOCITY AND FLOW RESULTS

PHYSICAL DATA	UNITS	TEST NUMBER			AVERAGE
		1	2	3	
DATE OF TEST		7-1-86	7-1-86	7-1-86	
TIME OF TEST	START	0908	1222	1425	
	FINISH	1043	1333	1531	
NUMBER OF TRAVERSE POINTS		12	12	12	
PITOT TUBE COEFFICIENT		0.78	0.79	0.78	
MEASURED DATA					
BAROMETRIC PRESSURE	INCHES HG	29.25	29.23	29.18	
STACK DIAMETER	INCHES	132.8	132.0	132.0	
STACK STATIC PRESSURE	INCHES H2O	-0.58	-0.58	-0.58	
STACK GAS TEMPERATURE	DEG F	343.	347.	351.	347.
VOLUME % CO2	DRY BASIS	18.2	18.4	19.0	18.5
VOLUME % O2	DRY BASIS	4.6	4.8	4.0	4.5
VOLUME % CO	DRY BASIS	0.0	0.0	0.0	0.0
VOLUME % N2	DRY BASIS	77.2	76.8	77.0	77.8
CALCULATED DATA					
STACK GAS PRESSURE	INCHES HG	29.21	29.19	29.14	
MOISTURE	VOLUME %	10.1	10.4	10.7	10.4
EXCESS AIR	%	50.4	53.2	42.3	48.6
DRY MOLECULAR WEIGHT	LB/LB-MOLE	31.10	31.14	31.20	31.14
WET MOLECULAR WEIGHT	LB/LB-MOLE	29.77	29.77	29.78	29.78
AVERAGE SQ. ROOT OF VELOCITY PRESSURE	IN. H2O**5	0.221	0.199	0.214	0.211
STACK CROSS SECTIONAL AREA	SQ. FT.	95.83	95.03	95.83	
STACK GAS VELOCITY - STACK COND.	FT/MIN	848.	777.	826.	817.
STACK GAS VELOCITY - STD. COND.	FT/MIN	544.	496.	524.	521.
STACK GAS FLOW - STACK COND.	ACFM	88600.	73800.	78500.	77600.
STACK GAS FLOW - DRY STD. COND.	DSCFM	46500.	42200.	44400.	44400.
STACK GAS FLOW - WET STD. COND.	WSCFM	51700.	47100.	49800.	49500.

STANDARD CONDITIONS: 68 DEG F AND 29.92 IN. HG

Table III

"C" COMBUSTION STACK-COMPLIANCE TESTS
PARTICULATE SAMPLING RESULTS

PHYSICAL DATA	UNITS	TEST NUMBER			AVERAGE
		1	2	3	
DATE OF TEST		7-1-86	7-1-86	7-1-86	
TIME OF TEST	START	0908	1222	1425	
	FINISH	1043	1333	1531	
NOZZLE DIAMETER	INCHES	0.5000	0.5000	0.5000	
MEASURED DATA					
METERED SAMPLE VOLUME	CU. FT.	39.800	36.269	38.760	
AVERAGE METER TEMPERATURE	DEG F	66.0	71.6	77.3	
METER CORRECTION FACTOR		1.0020	1.0020	1.0020	
AVERAGE ORIFICE PRESSURE DROP	INCHES H2O	1.59	1.29	1.48	
VOLUME OF H2O CONDENSATE	ML	78.8	74.0	83.0	
WEIGHT OF H2O ADSORBED	GRAMS	15.6	12.8	12.1	
TOTAL SAMPLE TIME	MINUTES	60.0	60.0	60.0	
PROBE WASH WEIGHT	GRAMS	0.0274	0.0275	0.0109	
WEIGHT, FILTER CATCH	GRAMS	0.0076	0.0099	0.0052	
CALCULATED DATA					
METERED SAMPLE VOLUME - STD. COND.	CU. FT.	39.288	35.375	37.361	
TOTAL SAMPLE CORR. VOL. - STD. COND.	CU. FT.	43.786	39.472	41.849	
TOTAL PARTICULATE WEIGHT	GRAMS	0.0350	0.0374	0.0161	
PARTICULATE CONC. - STACK COND.	GR/ACF	0.00793	0.00933	0.00377	0.00701
PARTICULATE CONC. - DRY STD. COND.	GR/SCF	0.0137	0.0163	0.00645	0.0122
PARTICULATE CONC. - WET STD. COND.	GR/WSCF	0.0124	0.0146	0.00594	0.0110
PARTICULATE FLOW RATE	LB/HR	5.47	5.89	2.53	4.63
NOZZLE AREA	SQ. FT.	0.001364	0.001364	0.001364	
ISOKINETIC RATIO	%	98.2	97.3	97.7	97.7

STANDARD CONDITIONS: 68 DEG F AND 29.92 IN. HG

TABLE IV
INDIVIDUAL TEST AVERAGES
"C" COKE OVEN HEATER ROOM DATA
JULY 1, 1986

OPERATING PARAMETERS	UNITS	T-1	T-2	T-3
Number of Ovens Pushed		4	6	5
Number of Ovens Charged		5	6	5
Avg. Weight of Coal Charge	lb?	35,200	35,300	35,300
En. Blast Furnace Gas				
-Integrator Flow	CFH	1,279,000	1,278,000	1,280,000
-Recorder Flow	CFH	1,308,000	1,264,000	1,284,000
-BTU Content	BTU/CF	116	116	116
Waste Heat Flue-Pusher Side				
-Temperature	°F	370	375	370
-Oxygen	%	2.0	2.7	2.2
-Pressure	mm H ₂ O	-17.8	-17.7	-17.9
Waste Heat Flue-Coke Side				
-Temperature	°F	357	363	360
-Oxygen	%	2.8	3.2	3.1
-Pressure	mm H ₂ O	-16.3	-15.9	-16.2

V. DISCUSSION

Three particulate tests were performed on the "C" Combustion Stack on July 1, 1986. Emission results varied from 2.5 to 5.9 lb/hr, or .007-.016 grains/DSCF. Approximately 27 percent of the particulate was captured on the filter, and the remaining 73 percent was from the nozzle and probe wash. Residue from the evaporation of the nozzle/probe wash consisted of a brownish-yellow liquid in the bottom of the evaporating dish.

In an attempt to determine the composition of the residue, distilled water was added to the evaporating dish, and the water - soluble portion of the remains was analyzed by ion chromatography. As expected, SO_4 was a major component of the residue. It was not possible to accurately quantify results from the water rinse and IC analysis, so no attempt was made to determine the sulfate contribution to the overall nozzle/probe wash weight gain.

Opacity readings obtained during the three tests seldom varied from zero. During one-minute reversal periods each half hour (when the direction of fuel gas and combustion air is reversed over the length of the battery), the opacity registered 5-10 percent.

Emission testing was performed without incident. At least 30 cubic feet of exhaust gas was sampled during each test, all sampling train leak-checks were within the 0.02 cfm allowable limit, and isokinetic sampling ratios were all within the allowable range of 90 to 110 percent.

APPENDIX A

LOCATION OF SAMPLING PORTS AND POINTS

APPENDIX A

LOCATION OF SAMPLING PORTS AND POINTS

Figures 2 and 3 which follow show the locations of the sampling ports and points for the "C" Combustion Stack. This location is more than eight duct diameters upstream and more than two diameters downstream from the nearest flow disturbances as shown in Figure 2.

Figure 3 shows the relative location of the twelve sampling points used for this survey. Twelve points equals the number required for a sampling location of this configuration according to the September 30, 1983 Federal Register.

Figure 2
Location of Sampling Ports
"C" Coke Oven Combustion Stack
Rouge Steel Company

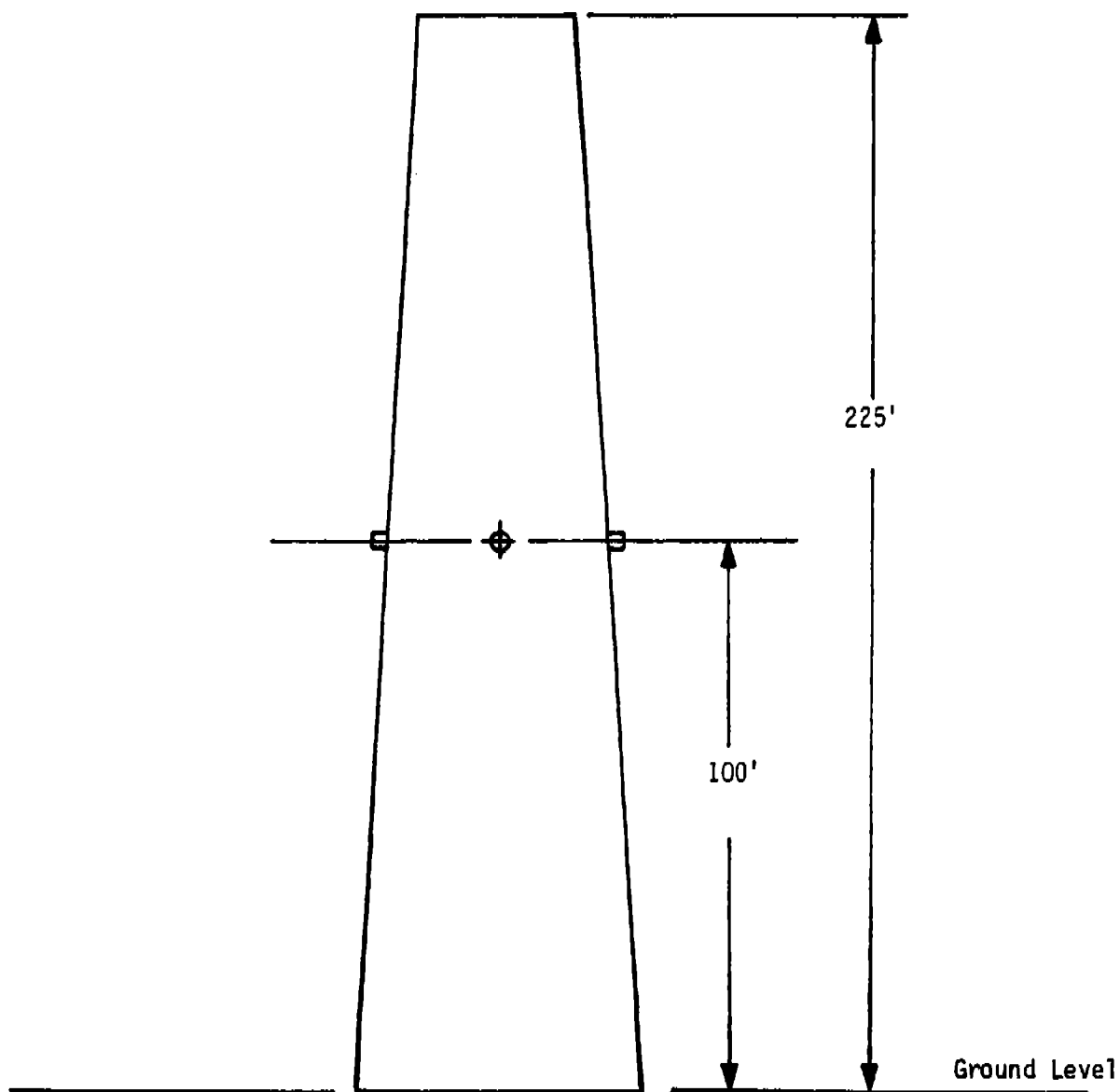
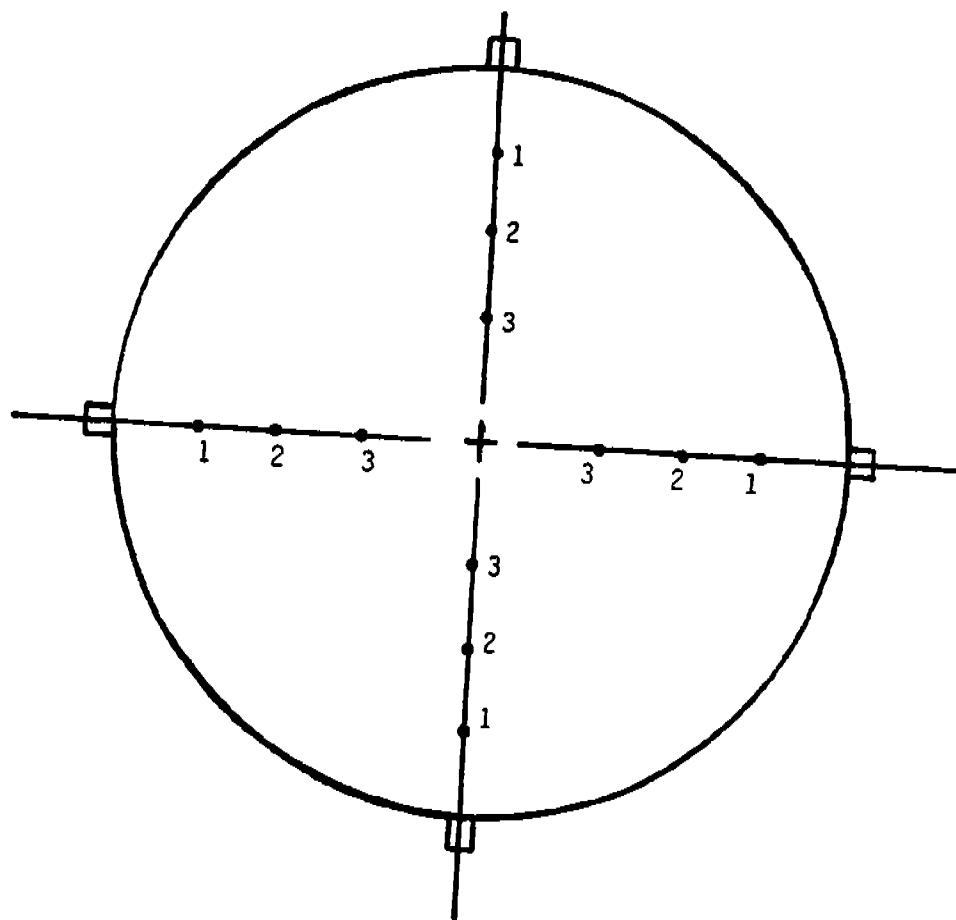


Figure 3
 Location of Sampling Points
 "C" Coke Oven Combustion Stack
 Rouge Steel Company



Sample
Point No.

1
2
3

Distance from
Stack Wall (In.)

5-3/4
19-1/4
39-1/8

APPENDIX B
SAMPLING PROCEDURES

APPENDIX B

SAMPLING PROCEDURES

Three complete tests are run over an eight-hour period. During each test the following parameters are measured:

- o Exhaust gas velocity and flow
- o Exhaust gas temperature
- o Moisture content of exhaust gas
- o Particulate flowrate
- o Exhaust gas composition

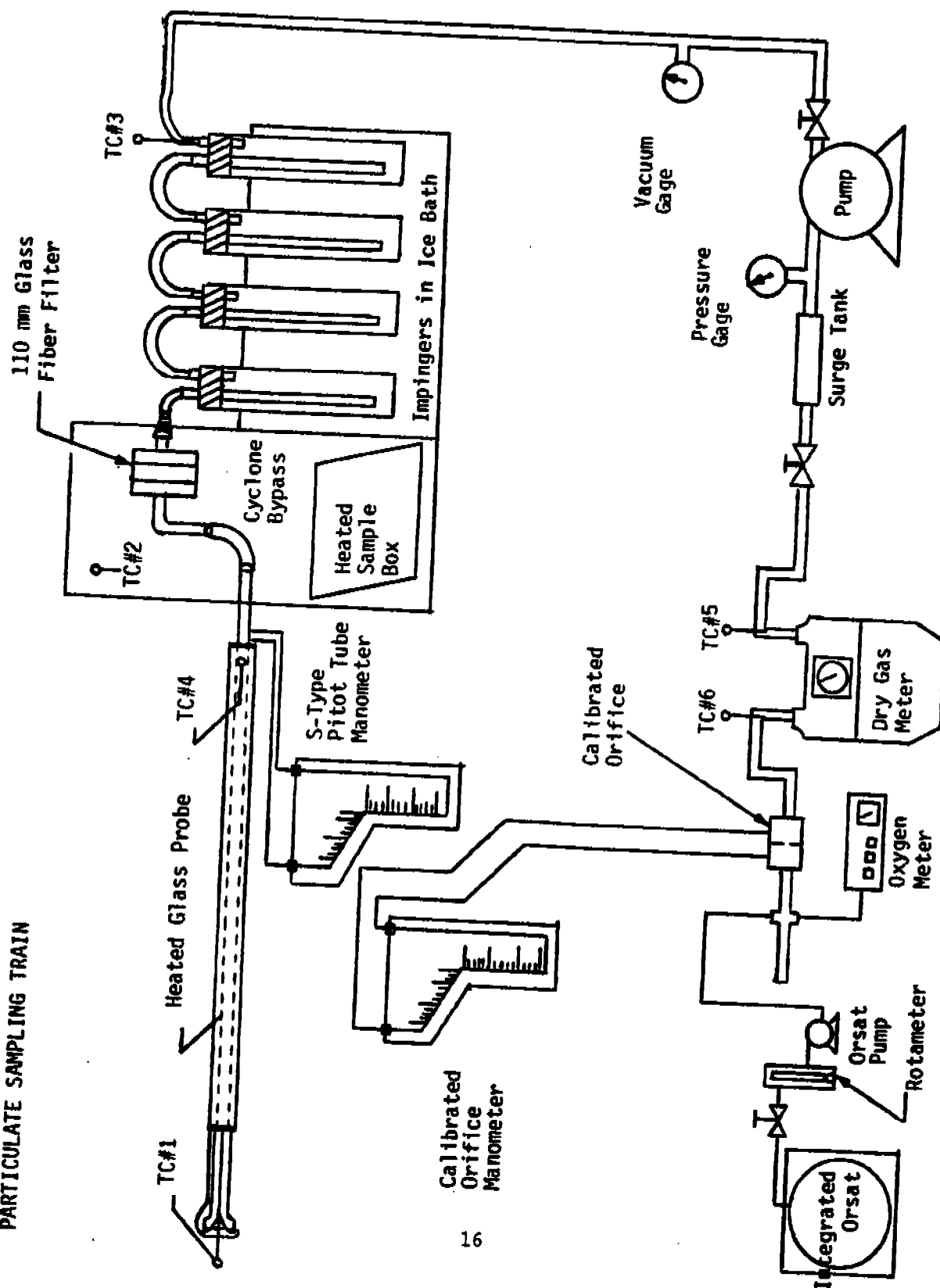
The sampling procedures used to measure the exhaust gas velocity and particulate concentrations are consistent with EPA Test Methods 1, 2, and 5.* Integrated Orsat measurements to determine excess air and dry molecular weight of the stack gases are taken in accordance with EPA Test Method 4.*

A. Sampling Train

The sampling train used in this survey appears in Figure 4. As shown, the front half consists of a stainless steel nozzle, glass probe liner, cyclone bypass, and a 110mm glass fiber filter. This portion of the train is heated to a maximum temperature of $250^{\circ}\text{F} \pm 25^{\circ}\text{F}$.

The condenser portion of the train consists of four plastic "impingers", connected in series with Tygon tubing, placed in an ice

FIGURE 4
PARTICULATE SAMPLING TRAIN



bath. The first two contain 150 ml distilled water, the third is empty and the fourth contains approximately 200 grams of preweighed silica gel.

The dry, filtered exhaust gas exits the condenser section and goes to the metering portion of the sampling train. This consists of a leakless vacuum pump, dry gas meter and orifice. After exiting the orifice, the sample gas is split into two streams. One portion of the gas goes to a previously evacuated bag to be analyzed at the end of the test as an integrated Orsat sample. The second stream is analyzed instantaneously on a Sybron/Taylor Model OA 570 portable oxygen meter. Oxygen readings are recorded at each sampling point.

Six thermocouples are located throughout the sampling train as shown in Figure 4. They are connected to a multipoint potentiometer with digital readout, mounted on the face of the meter box. Also on the face of the box is a twin-tube manometer which is used in measuring stack velocity pressures and orifice pressure differentials.

B. Particulate Sampling Procedures

1. Stack Gas Velocity and Flow

Stack gas velocity is measured with a calibrated S-type pitot tube on the probe assembly. The stack temperature is monitored using a thermocouple at the tip of the probe.

2. Particulate concentration

Particulate from the exhaust stream is captured in the front half of the sampling train and the net gain of material is measured gravimetrically after following a routine clean-up and evaporation procedure.

3. Moisture Content

The moisture content of the exhaust gas is determined by measuring the volume of the condensate in the first three "impingers" and the weight gain of silica gel in the fourth. Results are calculated based on condensate and gas volumes measured during the test.

4. Exhaust Gas Composition

The exhaust gas composition is determined by one of two methods:
a) a continuous sample of exhaust gas from the orifice discharge is collected in a pre-evacuated bag for later analysis using a Hays Orsat, and b) a continuous sample of exhaust gas from the orifice discharge is routed to a Sybron/Taylor oxygen meter and readings are taken at each sample point. The integrated Orsat results are incorporated into the gas density and heat input calculations for this survey.

APPENDIX C
ANALYTICAL PROCEDURES

APPENDIX C

ANALYTICAL PROCEDURES

A. Field Procedures

At the completion of each test the nozzle and probe liner are washed with known quantities of acetone into a clean, appropriately labeled sample bottle. The filter holder, cyclone bypass and flask from each test are capped with rubber stoppers in the field and placed in a protective glassware box for shipment to our laboratory.

All impinger liquids are measured for total volume after each test and then discarded. Silica gel is removed from the fourth impinger and placed in its original container for transport.

A blank acetone sample is collected at the site and returned to the laboratory for processing with survey samples.

B. Laboratory Procedures

1. Particulate Concentration

In the laboratory, the acetone rinse from the sampling train nozzle and probe wash is placed in a tared evaporating dish. Added to this are acetone rinses from the corresponding cyclone bypass and front filter half from the train.

Dish contents are evaporated to dryness over a water bath maintained at 130°F, desiccated to constant weight at room temperature, and weighed on a Torbal analytical balance with a sensitivity of 0.1 mg.

The glass fiber filter from each test is removed from its holder and transferred to its original aluminum foil envelope. The filter is oven-dried for two hours at 105°C, placed in a desiccator overnight and weighed on a Torbal balance.

The weight gains of the acetone rinse and filter are added and reported as particulate catch.

2. Moisture Content

The silica gel from the fourth impinger is weighed on an analytical balance having a sensitivity of 0.1 gram. The resulting weight gain is converted to volume and added to the volumes of water condensate measured in the impingers after each test in order to determine the moisture content of the exhaust gas.

3. Exhaust Gas Composition

Carbon dioxide, carbon monoxide and oxygen percentages in exhaust gas are determined using a standard Orsat procedure. Then, assuming the exhaust gas contains only four major constituents, nitrogen can be determined by difference.

APPENDIX D
FIELD DATA SHEETS

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL CONTROL OFFICE

SOURCE Comb stack-c
PLANT Range
DATE 6/30/86
INITIALS DSW-TAD
TEST NO. 1

"C" COMBUSTION STACK

RCC 247

NOTES

NOZZLE SIZE STACK TEMP ~ 340 °F
.500 }
.499 } .500
.500 }

ORIFICE COEFFICIENT CHECK						
	SAMPLE TIME (Min.)	P _{bar} (In Hg)	Orifice Δh (In H ₂ O)	Meter Reading (ft ³)	Meter Inlet Temp. (°F)	Meter Outlet Temp. (°F)
FINISH	319.0	29.31	1.0	137.154	66/66	64/64
START	309.0	29.31	1.0	131.558	65/66	65/64
AVG/NET	10.0	29.31	1.0	5.596	65.75	64.25

$$\Delta H = \frac{(0.03175) (\Delta h) (P_{bar})}{(T_{m-out} + 460)}$$

$$\Delta H = \frac{(0.03175)(1.0)(29.31)}{524.25}$$

$$\Delta H = 1.80 / 1.76$$

$$\left[\frac{(T_{m-avg} + 460) \theta}{(V_m) (P_{bar} + \Delta h / 13.6)} \right]^2$$

$$\left[\frac{(525)^{1.0}}{(5.596)(29.31 + 1.0 / 13.6)} \right]^2$$

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL
CONTROL OFFICE

Source: Comb Stack C
Plant: Rouge
Date: 7/1/86
Initials: DSW - TAD

Test No.: 1

Sampling Train Information					
Filter Type	115 mm A/E	Sample Box No.	1	Nozzle Diameter	1.500
Filter No.	14	Probe No.	1	Nozzle Material	SS
Cyclone & Flask No.	1	Probe Material	PYREX	Meter Box No.	2
Silica Gel No.	1	Probe Length	7'	Meter Box ΔH	1.76

Leak Test Data						
	Prelim. Reading	Time Date	Initial Reading	Time	Final Reading	Time
Meter and Orifice	OK 7.5" H ₂ O OK 20" Hg	6/30/86	OK	7/1/86	OK	7/1/86
Pump and Surge Tank	OK 20 PSIG	6/30/86	OK	7/1/86	OK	7/1/86
Meter Box, Cord, Sample Box, Probe	2.005 CFM @ 15" Hg	6/30/86	2.005 CFM @ 15" Hg	7/1/86	2.005 CFM @ 15" Hg	7/1/86
Pitot Tube Total Pressure Line	OK 6.3" H ₂ O	6/30/86	OK 7.1" H ₂ O	7/1/86	OK	7/1/86
Pitot Tube Static Pressure Line	OK 5.2" H ₂ O	6/30/86	OK 4.4" H ₂ O	7/1/86	OK	7/1/86

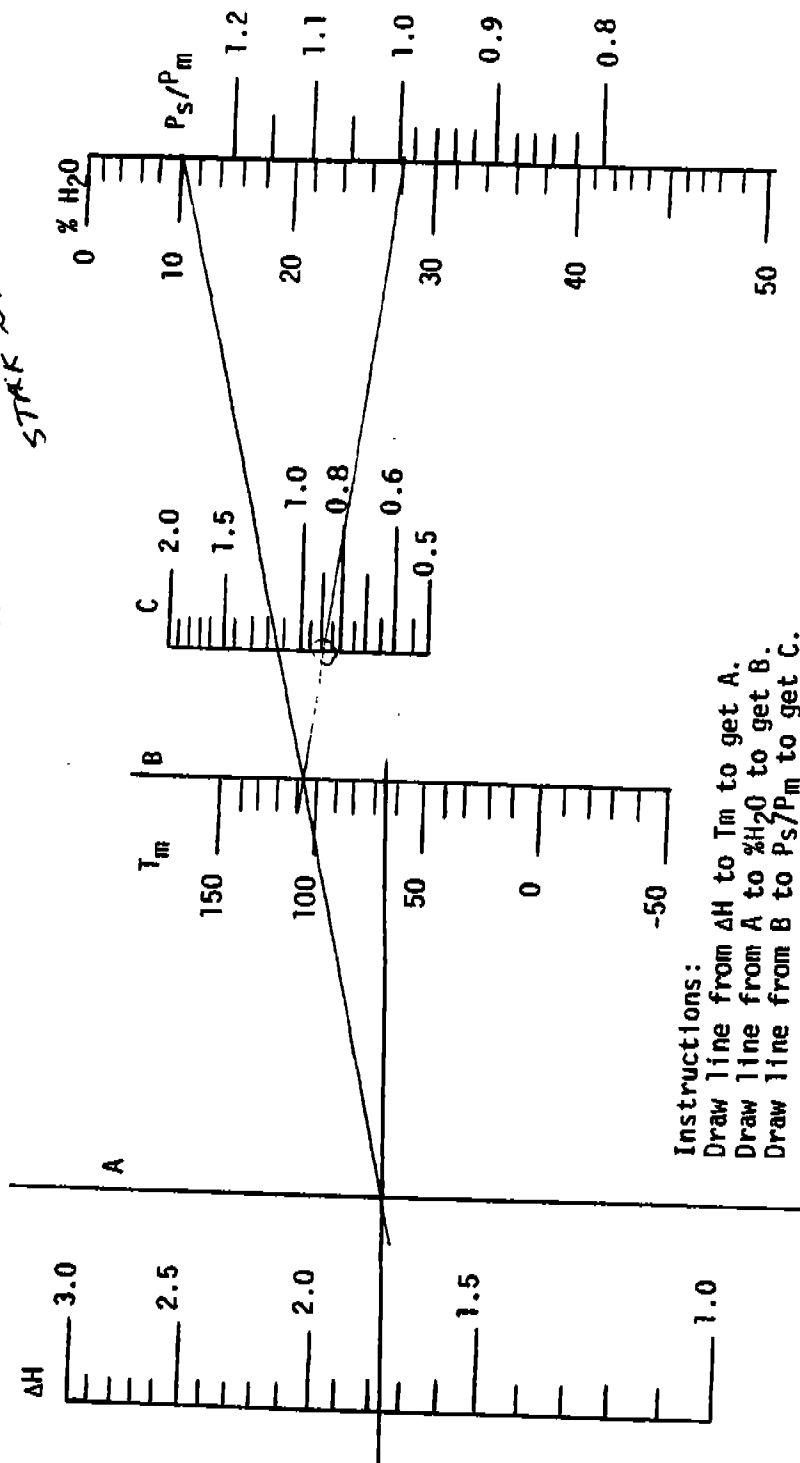
Impinger Data				
Impinger Number	1	2	3	4
Impinger Contents	H ₂ O	H ₂ O	—	Silica Gel
Final Volume (ml)	192	180	6	240.5
Initial Volume (ml)	150	150	0	224.9
Volume Collected (ml)	42	30	6	15.6
	24			
	Total			93.6

$$78 + 15.6 = 93.6$$

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL CONTROL OFFICE

NOMOGRAPH C FACTOR DETERMINATION

$\% H_2O = 10$
 $T_m \sim 65^\circ F$
 $STACK \sim 340^\circ F$



Instructions:
Draw line from ΔH to T_m to get A.
Draw line from A to $\% H_2O$ to get B.
Draw line from B to P_s/P_m to get C.

SOURCE Comb stack C
PLANT Roy
DATE 7/1/86
INITIALS PSM - TMD
TEST NO. 1
METER BOX NO. 2
ΔH ORIFICE 1.76

AMBIENT TEMPERATURE
BAROMETRIC PRESSURE (Pbar) 29.25
STATIC PRESSURE (Psp) $-158/13.6 = .04$
 $P_s = P_{bar} + P_{sp} = 29.25 + .04 = 29.29$
(Assumed Δh) $.5$ Δh/13.6 = .01
 $P_m = P_{bar} + \Delta h/13.6 = 29.25 + .01 = 29.26$
 $P_s/P_m = 29.29 / 29.26 = .998$

C FACTOR .89
PITOT TUBE Cp .78
CORRECTED C FACTOR, $(C_c) =$
 $(C)(Cp/.85)^2 = .09 (78/.85)^2$
 $C_c = .749 = .75$

ICE Comb Stock C
IT Royce
7/17/06

TEST NO.	MIN/PNT	INITIALS
1	10	10
2	10	10
3	10	10
4	10	10
5	10	10
6	10	10
7	10	10
8	10	10
9	10	10
10	10	10
11	10	10
12	10	10
13	10	10
14	10	10
15	10	10
16	10	10
17	10	10
18	10	10
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86	10	10
87	10	10
88	10	10
89	10	10
90	10	10
91	10	10
92	10	10
93	10	10
94	10	10
95	10	10
96	10	10
97	10	10
98	10	10
99	10	10
100	10	10

13
DSW-TND

CORR. C FACTOR
NOM. SET POINT

950.05
56.

$P_{\text{Bar}} = 29.25$

MCF 1.00020

[illegible]

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL CONTROL OFFICE

FIELD ORSAT DATA

SOURCE Comb STACK - C
PLANT Rouge
DATE 7/1/86
INITIALS DSW-TAD

TEST NO. 1

ORSAT TEST NO.	TIME	READING	PERCENT BY VOLUME DRY BASIS			TYPE OF SAMPLE - REMARKS
			CO ₂	O ₂	CO	
1		FINAL	18.2	22.6	22.6	
		INITIAL	0	18.2	22.6	
		DIFFERENCE	18.2	4.4	0	
2		FINAL	18.6	23.0	23.0	
		INITIAL	0.4	18.2	23.0	
		DIFFERENCE	18.2	4.8	0	
3		FINAL				
		INITIAL				
		DIFFERENCE				
4		FINAL				
		INITIAL				
		DIFFERENCE				
5		FINAL				
		INITIAL				
		DIFFERENCE				
AVERAGE			18.2	4.6	0	

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL CONTROL OFFICE

SOURCE Comb Stack C
PLANT Rouge
DATE 7/1/86
INITIALS DSW-TAD
TEST NO. 2

NOTES

Nozzle size

.500
.499 } .500
.500

STACK Temp ~ 345 °F

ORIFICE COEFFICIENT CHECK						
	SAMPLE TIME (Min.)	P _{bar} (In Hg)	Orifice Δh (In H ₂ O)	Meter Reading (ft ³)	Meter Inlet Temp. (°F)	Meter Outlet Temp. (°F)
FINISH						
START						
AVG/NET						

$$\Delta H = \frac{(0.03175) (\Delta h) (P_{bar})}{(T_{m-out} + 460)}$$

$$\Delta H = (0.03175)$$

$$\Delta H = 1.80/1.76$$

$$\left[\frac{(T_{m-avg} + 460) \theta}{(V_m) (P_{bar} + \Delta h/13.6)} \right]^2$$

28

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL
CONTROL OFFICE

Source: Comb Stack C

Plant: Rouge

Date: 7-1-86

Initials: DSW-TAD

Test No.: 2

Sampling Train Information					
Filter Type	115 mm A/E	Sample Box No.	2	Nozzle Diameter	.500
Filter No.	15	Probe No.	2	Nozzle Material	SS
Cyclone & Flask No.	2	Probe Material	PYREX	Meter Box No.	2
Silica Gel No.	2	Probe Length	7'	Meter Box ΔH	1.76

Leak Test Data						
	Prelim. Reading	Time Date	Initial Reading	Time	Final Reading	Time
Meter and Orifice			OK	7/1/86	OK	7/1/86
Pump and Surge Tank			OK	7/1/86	OK	7/1/86
Meter Box, Cord, Sample Box, Probe			2.005 CFM @ 17" H ₂ O	7/1/86	2.005 CFM @ 15" H ₂ O	7/1/86
Pitot Tube Total Pressure Line			OK 4.9" H ₂ O	7/1/86	OK	7/1/86
Pitot Tube Static Pressure Line			OK 5.1" H ₂ O	7/1/86	OK	7/1/86

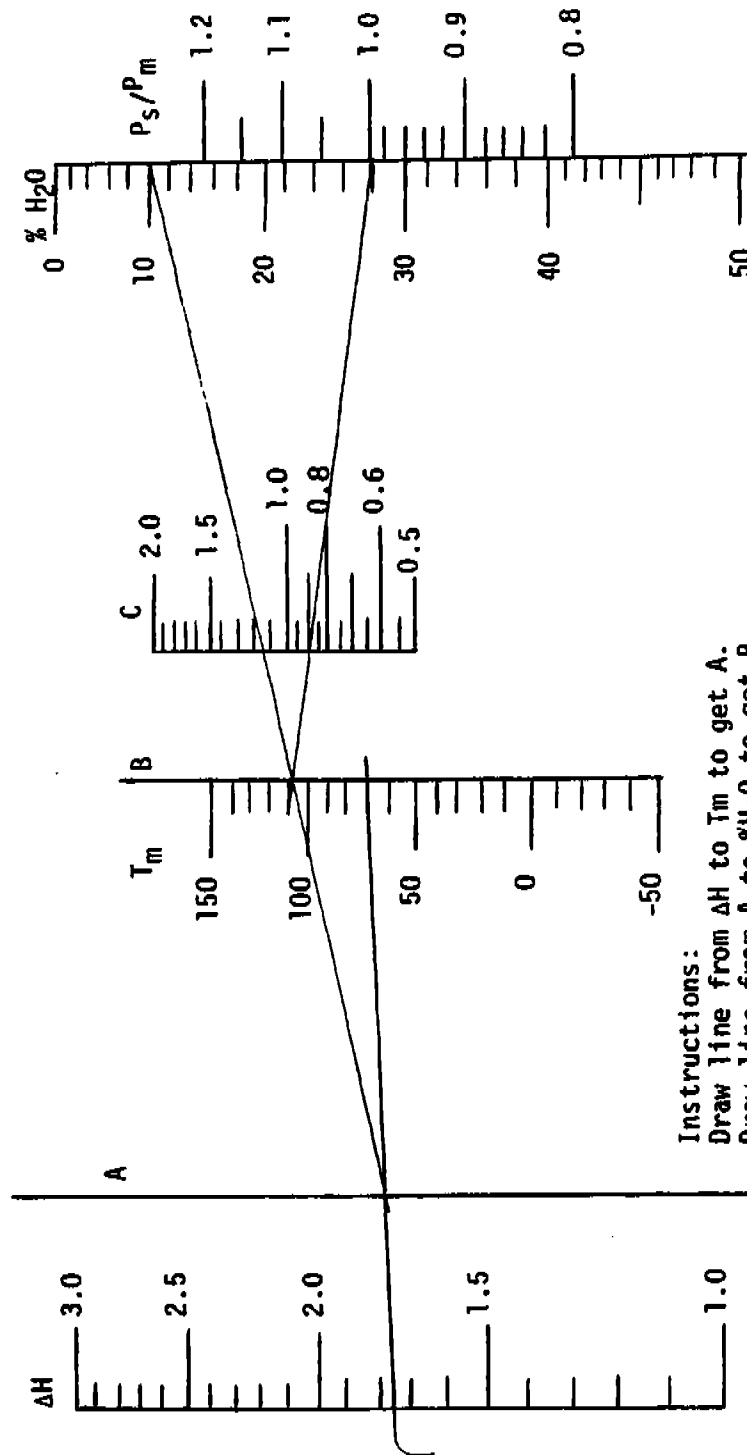
Impinger Data				
Impinger Number	1	2	3	4
Impinger Contents	H ₂ O	H ₂ O	—	Silica Gel
Final Volume (ml)	190	179	5	241.9
Initial Volume (ml)	150	150	—	220.5 229.1
Volume Collected(ml)	40	29	5	12.8
			Total	

$$74 + 12.8 = 86.8 \text{ g}$$

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL CONTROL OFFICE

$57^{\circ}\text{A}^{\circ}\text{K} = 345^{\circ}\text{F}$
 $T_m = 70^{\circ}\text{F}$
 $\% \text{H}_2\text{O} = 10$

NOMOGRAPH C FACTOR DETERMINATION



30

SOURCE Comb Stack C
PLANT Rouge
DATE 7/1/86
INITIALS DSW - TAD
TEST NO. 2
METER BOX NO. 2
 ΔH ORIFICE 1.16

AMBIENT TEMPERATURE
BAROMETRIC PRESSURE (Pbar) 29.23
STATIC PRESSURE (Psp) 58/13.6 = .04
 $P_s = P_{\text{bar}} + P_{\text{sp}} = 29.23 + .04 = 29.27$
(Assumed Δh) 1.5 $\Delta h/13.6 = .11$
 $P_m = P_{\text{bar}} + \Delta h/13.6 = 29.23 + .11 = 29.34$
 $P_s/P_m = 29.27/29.34 = .9978 \approx .998$

C FACTOR .89
PITOT TUBE Cp .77
CORRECTED C FACTOR, $(C_c) =$
 $(C)(C_p/.85)^2 = .89 (.77/.85)^2$
 $C_c = .767 \approx .77$

**FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL CONTROL OFFICE**

IRCE Comb Stack C TEST NO. 2

WT Rev 4 MIN/PNT

E 7/1/86 INITIALS DSW-TAD

CORR. C FACTOR .77
NOM. SET POINT .036

P_{Bar} = 29.23 MCF 1.0020

056																	
INITIALS 2250-14 D NOM. SEI POINT																	
Point Number	Clock Time	Meter Box Clock Time	Percent O ₂ at Sample Point	Velocity Head, ΔP	In. H ₂ O	VAP	Nomograph ΔH Orifice	Meter Reading	In Hg	Selector Switch Number						Gas Temperature at Meter	
										1	2	3	4	5	6		
	Actual	Min	%	In. H ₂ O	In. H ₂ O ^{1/2}	Ft ³				Stack Temperature °F	Sample Box Temperature °F	Gas Temp. Leaving Last Impinger °F	Probe Temperature °F	Inlet °F	Outlet °F		
1	1222	385.0	4.3	.03			.96	178.193	1.0	341	248	69	252	69	69		
2	1227	398.0	3.9	.04			1.27	181.470	2.0	342	247	66	246	69	68		
3	1232	395.0	3.8	.05			1.61	184.445	3.0	359	240	63	244	70	68		
1	1237	400.0		.03			.96	187.834	2.0	339	248	68	251	70	69		
2	1242	405.0		.04			1.29	190.450	3.0	337	244	67	246	71	69		
3	1247	410.0		.05			1.61	192.470	4.0	344	242	65	244	73	69		
1	1300	415.0		.03			.96	196.869	2.0	351	248	70	253	72	72		
2	1305	420.0		.04			1.29	199.500	3.0	353	257	68	251	74	73		
3	1310	425.0		.05			1.61	202.555	4.0	341	261	68	254	75	73		
1	1318	430.0		.03			.96	205.943	3.0	347	261	69	257	74	74		
2	1323	435.0		.04			1.29	208.620	3.5	349	258	68	255	75	73		
3	1328	440.0		.05			1.61	211.650	4.5	360	253	63	249	76	74		
	1333	445.0						215.062									

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL CONTROL OFFICE

FIELD ORSAT DATA

SOURCE Comb STACK - C
PLANT Rouge
DATE 7/1/86
INITIALS DSW-TAD

TEST NO. 2

ORSAT TEST NO.	TIME	READING	PERCENT BY VOLUME DRY BASIS			TYPE OF SAMPLE - REMARKS
			CO ₂	O ₂	CO	
1		FINAL	18.3	23.1	23.1	
		INITIAL	0	18.3	23.1	
		DIFFERENCE	18.3	4.8	Ø	
2		FINAL	18.4	23.2	23.2	
		INITIAL	0	18.4	23.2	
		DIFFERENCE	18.4	4.8	Ø	
3		FINAL				
		INITIAL				
		DIFFERENCE				
4		FINAL				
		INITIAL				
		DIFFERENCE				
5		FINAL				
		INITIAL				
		DIFFERENCE				
AVERAGE			18.4	4.8	Ø	

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL CONTROL OFFICE

SOURCE Comb stack C
PLANT Range
DATE 7/1/86
INITIALS DSW-TAD
TEST NO. 3

NOTES

NOZZLE SIZE

.500
.500 } .500
.499

STACK Temp in deg

ORIFICE COEFFICIENT CHECK						
	SAMPLE TIME (Min.)	P _{bar} (In Hg)	Orifice Δh (In H ₂ O)	Meter Reading (ft ³)	Meter Inlet Temp. (°F)	Meter Outlet Temp. (°F)
FINISH						
START						
AVG/NET						

$$\Delta H = \frac{(0.03175) (\Delta h) (P_{\text{bar}})}{(T_{\text{m-out}} + 460)}$$

$$\Delta H = (0.03175)$$

$$\Delta H = 1.80/1.76$$

$$\left[\frac{(T_{\text{m-avg}} + 460) q}{(V_{\text{m}}) (P_{\text{bar}} + \Delta h/13.6)} \right]^2$$

33

$$\left[\right]^2$$

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL
CONTROL OFFICE

Source: Comb STACK - C

Plant: Rouge

Date: 7/1/86

Initials: DSW - TAD

Test No.: 3

Sampling Train Information					
Filter Type	115MM A/E	Sample Box No.	1	Nozzle Diameter	.500
Filter No.	C	Probe No.	1	Nozzle Material	SS
Cyclone & Flask No.	BIPAS	Probe Material	Pyrex	Meter Box No.	2
Silica Gel No.	3	Probe Length	7'	Meter Box ΔH	1.76

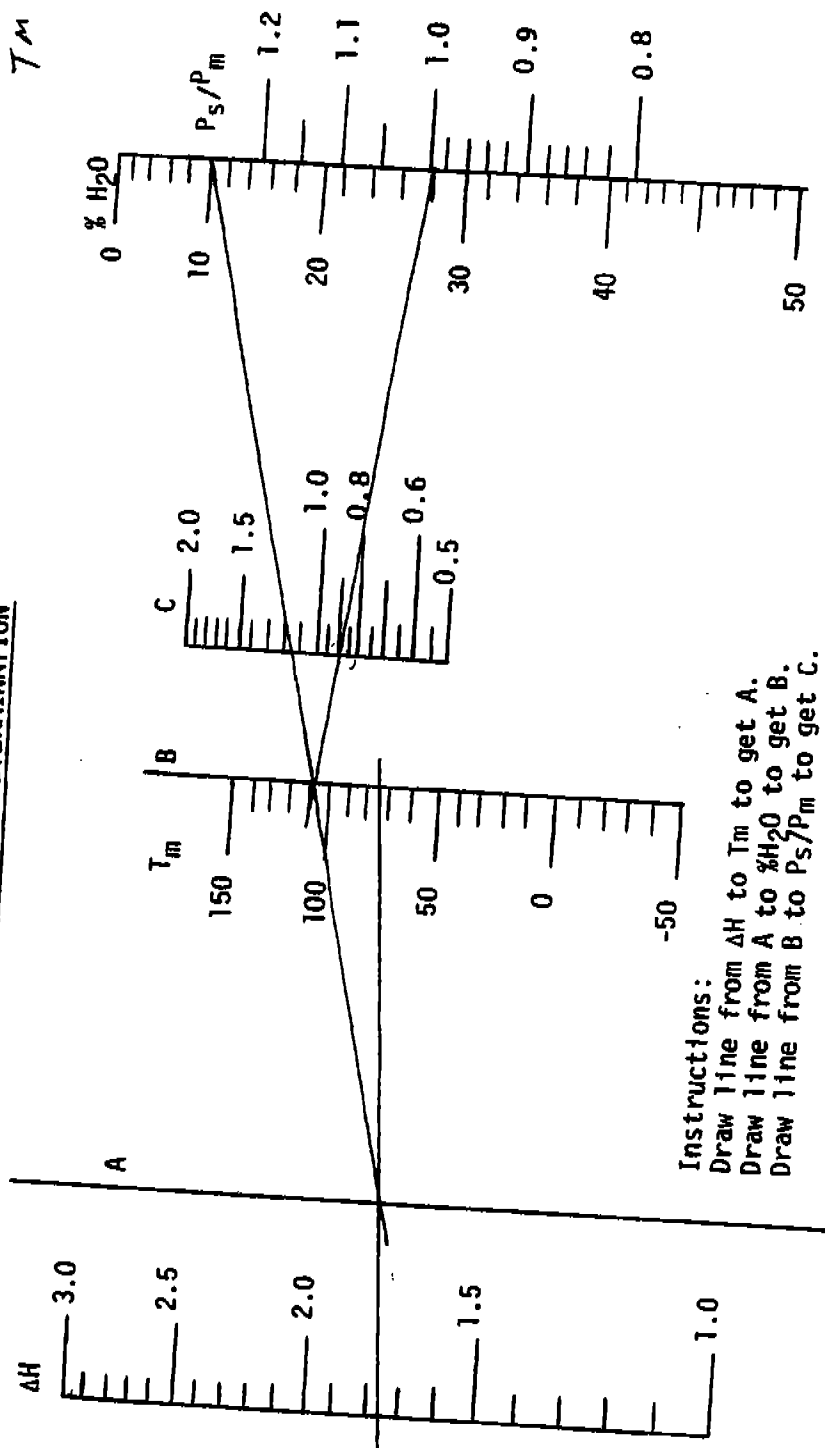
Leak Test Data						
	Prelim. Reading	Time Date	Initial Reading	Time	Final Reading	Time
Meter and Orifice			OK	7/1/86	OK	7/1/86
Pump and Surge Tank			OK	7/1/86	OK	7/1/86
Meter Box, Cord, Sample Box, Probe			< 1.005 CFM @ 17" H ₂ O	7/1/86	< 1.005 CFM @ 15" H ₂ O	7/1/86
Pitot Tube Total Pressure Line			OK 6.3" H ₂ O	7/1/86	OK	7/1/86
Pitot Tube Static Pressure Line			OK 7.1" H ₂ O	7/1/86	OK	7/1/86

Impinger Data				
Impinger Number	1	2	3	4
Impinger Contents	H ₂ O	H ₂ O	—	Silica Gel
Final Volume (ml)	197	176	10	245.6
Initial Volume (ml)	150	150	10 0	233.5
Volume Collected (ml)	47	26	10	12.1
			Total	

$$83 + 12.1 = 95.1$$

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL CONTROL OFFICE

NOMOGRAPH C FACTOR DETERMINATION



Instructions:
Draw line from ΔH to T_m to get A.
Draw line from A to $\%H_2O$ to get B.
Draw line from B to P_s/P_m to get C.

$T_m =$
STACK $\sim 345^\circ F$
 $H_2O \sim 10\%$
 $T_m = 75$

SOURCE Comb Stack - C
PLANT Rawls
DATE 7/1/84
INITIALS JSW
TEST NO. 3
METER BOX NO. 2
 ΔH ORIFICE 1.10

AMBIENT TEMPERATURE 29.18
BAROMETRIC PRESSURE (Pbar) 29.18
STATIC PRESSURE (Psp) $-0.58/15.6 = .04$
 $P_s = P_{bar} + P_{sp} = 29.18 + .04 = 29.22$
(Assumed Δh) 1.5 $\Delta h/13.6 = .11$
 $P_m = P_{bar} + \Delta h/13.6 = 29.18 + .11 = 29.29$
 $P_s/P_m = 29.22 / 29.29 = .998$

C FACTOR $.89$
PITOT TUBE Cp $.75$
CORRECTED C FACTOR, $(C_c) =$
 $(C)(Cp/.85)^2 = .89 (.75/.85)^2$
 $C_c = .749 = .75$

FORD MOTOR COMPANY

rage

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL CONTROL OFFICE

FIELD ORSAT DATA

SOURCE Comb Stack - C
PLANT Rouge
DATE 7/1/86
INITIALS DSW - TAD

TEST NO. 3

ORSAT TEST NO.	TIME	READING	PERCENT BY VOLUME DRY BASIS			TYPE OF SAMPLE - REMARKS
			CO ₂	O ₂	CO	
1	7/1/86	FINAL	18.9	22.8	23.0	
		INITIAL	0	18.9	23.0	
		DIFFERENCE	18.9	3.9	0	
2	7/1/86	FINAL	19.0	23.0	23.0	
		INITIAL	0	19.0	23.0	
		DIFFERENCE	19.0	4.0	0	
3		FINAL				
		INITIAL				
		DIFFERENCE				
4		FINAL				
		INITIAL				
		DIFFERENCE				
5		FINAL				
		INITIAL				
		DIFFERENCE				
AVERAGE			19.0	4.0	0	

APPENDIX E

PROCESS OPERATING PARAMETERS DATA SHEETS

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL CONTROL OFFICE
ROUGE STEEL COMPANY
'C' COKE OVEN METER ROOM DATA

TEST NO. : 1+2
PAGE NO. : 1

DATE: 7/1/86
INITIALS: DKR

CLOCK TIME	WOBBE INDEX	FUEL GAS HEATER TEMP.		PRESSURE OF ENRICHED B.F. GAS		COLLECTING MAIN		WASTE HEAT FLUE		PUSHER MACHINE	WOBBE INDEX
		BEFORE	AFTER	M. PUSHER SIDE	N. COKE SIDE	PRESSURE	TEMPERATURE	TEMPERATURE	OXYGEN	AMPERAGE	
		DEG. F	DEG. F	IN. H2O	IN. H2O	MM H2O	DEG. F	DEG. F	%	MM H2O	
0905	—	71.4	97.7	2.4	2.4	11.7	197	369	2.4	—	90
0930	—	71.1	97.8	2.3	2.4	11.8	188	380	1.8	—	83
1020	—	71.2	97.6	2.3	2.4	11.8	189	367	1.9	—	102
1040	—	71.4	97.7	2.2	2.3	11.8	180	362	2.0	—	102
1228	—	72.1	98.4	2.4	2.4	11.3	181	380	2.6	—	97
1250	—	72.2	98.6	2.4	2.5	11.8	179	366	2.3	—	100
1305	—	72.3	99.1	2.3	2.3	11.9	184	381	3.6	—	99
1323	—	72.5	99.0	2.3	2.4	11.8	185	373	2.1	—	102

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL CONTROL OFFICE
ROUGE STEEL COMPANY
'C' COKE OVEN METER ROOM DATA

TEST NO. : 1+2
PAGE NO. : 2

DATE: 7/1/86
INITIALS: DKR

CLOCK TIME	PUSHER SIDE	COKE SIDE	ENRICHED B.F. GAS	COLLECTING MAIN COKE PUSHER SIDE	WASTE HEAT FLUE COKE SIDE	STACK SMOKE DENSITY	FLOW-COKE OVEN GAS ENRICHMENT
	PUSHER SIDE	COKE SIDE	ENRICHED B.F. GAS	COLLECTING MAIN COKE PUSHER SIDE	WASTE HEAT FLUE COKE SIDE	STACK SMOKE DENSITY	FLOW-COKE OVEN GAS ENRICHMENT
	1M. H2O	1M. H2O	1M. H2O	1M. H2O	1M. H2O	1M. H2O	1M. H2O
0910	—	—	2.4	12.0	3.0	5	116
0930	—	2.3	2.4	11.8	2.7	8	116
1020	—	2.3	2.4	11.8	2.7	6	125
1044	—	2.4	2.5	11.8	2.7	7	118
1229	—	2.4	2.4	11.3	3.3	9	116
1251	—	2.4	2.4	12.5	3.0	9	116
1306	—	2.2	2.2	11.7	3.7	7	116
1325	—	2.3	2.3	11.7	2.9	9	116

FORD MOTOR COMPANY

STATIONARY SOURCE ENVIRONMENTAL CONTROL OFFICE

'C' COKE OVEN METER ROOM DATA

TEST NO. : 1+2

PAGE NO. : 3

DATE: 7/1/86

INITIALS: DKR

CLOCK TIME	LEVEL C.O. GAS HOLDER	FLOW-C.O. GAS TO BAT.	ENRICHED 8.F. GAS - NORTH		ENRICHED 8.F. GAS - SOUTH		TOTAL FLOW ENR. B.F. GAS	TEMP. OFF- TAKE MAIN
			FLOW SCFH	TEMPERATURE DEG. F	FLOW SCFH	TEMPERATURE DEG. F		
0913	1165	0	668	—	642	42	1302	—
0931	1157	0	655	—	645	91	1327	—
1021	1160	0	662	—	638	90.6	1304	—
1045	1165	0	672	—	618	89.5	1299	—
1231	1242	0	661	—	630	91.7	1260	—
1253	1273	0	678	—	590	91.3	1234	—
1308	1269	0	662	—	650	91.4	1282	—
1326	1252	0	665	—	620	91.4	1280	—

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL CONTROL OFFICE
ROUGE STEEL COMPANY
'C' COKE OVEN METER ROOM DATA

TEST NO. : 1+2
PAGE NO. : 4

DATE: 7/1/86
INITIALS: DKR

TOTALIZER DISPLAYS						
CLOCK TIME	C.O. GAS TO BATTERY X1000 SCFH	ENR. B.F. GAS TO BATTERY-N. X1000 SCFH	ENR. B.F. GAS TO BATTERY-S. X1000 SCFH	TOTAL ENR. B.F. GAS TO BATTERY X1000 SCFH	TOTAL STM. TO BATTERY X100 LBS.	C.O. GAS ENRICHMENT X1000 SCFH
0915	9566	5209	4646	4145	4149	6477
0932	9566	5394	4826	4506	4152	6509
1022	9566	5956	5339	5574	4162	6605
1046	9566	6225	5583	6085	4166	6651
		1016	607	1440		
				1277		
1227	9566	7362	6627	8255	4182	6849
1254	—	7663	6894	8819	4187	6900
1309	—	7829	7045	9134	4191	6929
1327	—	8036	7239	9533	4196	6965
				1277		

TEST NO. : 3
PAGE NO. : 1

DATE: 7/1/86
INITIALS: DKR

[illegible]

DATE: 7/1/86
INITIALS: DKR

TEST NO. : 3
PAGE NO. : 2

[illegible]

COKE OVEN METER ROOM DATA

DATE: 7/1/86

INITIALS: DKR45

'C' COKE OVEN METER ROOM DATA

INITIALS: D&R

CLOCK TIME	TOTALIZER DISPLAYS					
	C.O. GAS TO BATTERY	ENR. B.F. GAS TO BATTERY-H.	ENR. B.F. GAS TO BATTERY-S.	TOTAL ENR. B.F. GAS TO BATTERY	TOTAL SIM. TO BATTERY	C.O. GAS ENRICHMENT
	X1000 SCFH	X1000 SCFH	X1000 SCFH	X1000 SCFH	X1000 LBS.	X1000 SCFH
1429	—	8734	7871	90,858	4207	7086
1446	—	8923	8038	91,211	4210	7119
1503	—	9122	8213	91,583	4214	7155
1523	—	9342	8423	92,010	4217	7197
				157. 1260		

COKE OVENS REPORT OF BY-PRODUCTS

DATE: July 1, 1986 Tue

LABORATORY NUMBER 070186-37

[illegible]

COKE OVENS REPORT OF BY-PRODUCTS

DATE: JULY 2, 1956 WEC

LABORATORY NUMBER 070256 - JE

[illegible]

COKE OVENS REPORT OF BY-PRODUCTS

DATE: JULY 3, 1986 -LMB

LABORATORY NUMBER 67CJEG-39

[illegible]

S I G N E D

APPENDIX F

LABORATORY DATA SHEETS

ROUGE STEEL COMPANY

243

"C" COMBUSTION STACK
PARTICULATE COMPLIANCE TEST
JULY 1, 1986

TEST NO	FILTER DISC NO	SAMPLE ID	INITIAL WEIGHT (Gm)			FINAL WEIGHT (Gm)			NET GAIN (Gms)
			1	2	AVG.	1	2	AVG.	
1	14	F	2.0532	2.0532	2.0532	2.0608	2.0608	2.0608	.0076
2	15	F	2.0350	2.0350	2.0350	2.0449	2.0449	2.0449	.0099
3	C	R	1.9765	1.9766	1.9766	1.9818	1.9818	1.9818	.0052
1	39	TELENOX	122.1044	122.1046	122.1045	122.1328	122.1328	122.1328	.0283
2	6	TELENOX	139.9672	139.9672	139.9672	139.9955	139.9957	139.9956	.0284
3	17	TELENOX	124.1842	124.1844	124.1843	124.1957	124.1959	124.1958	.0115
3	32	RE-TONE	116.8089	116.8089	116.8089	116.8074	116.8076	116.8075	.0006
1	39		122.1267	122.1269	122.1268				.0223
2	6		139.9917	139.9917	139.9917				.0245
3	17		124.1937	124.1939	124.1938				.0095
1	D	6	22.8804	22.8804	22.8804	22.8804	22.8805	22.8805	.0001
2	E	6	22.5406	22.5406	22.5406	22.5406	22.5407	22.5407	.0001
3	F	6	21.0787	21.0788	21.0788	21.0789	21.0790	21.0790	.0002

LABORATORY ANALYSIS

FORD SSECO

SAMPLES: Two 250 ml samples of quench tower water from
Rouge Steel Company "C" Coke Oven Battery

DATE OF SAMPLE: July 1, 1986

ANALYSIS REQUIRED: Total dissolved solids

METHOD OF ANALYSIS: Filterable Residue, Method 160.1,
Storet No. 70300

RESULTS: Sample 1 - 205 mg/l Sample 2 - 207 mg/l

ANALYST: A. W. Haga
A. W. Haga

APPENDIX C

SAMPLE CALCULATIONS

SAMPLE CALCULATIONS

=====

GAS FLOW ANALYSIS

SOURCE - "C" COMBUSTION STACK-COMPLIANCE TESTS

TEST - 1

MEASURED DATA

STACK DIAMETER	DS	132.0	IN.
STACK GAS TEMPERATURE	TS	343.	DEG F
STACK STATIC PRESSURE	PSP	-0.58	INCHES H2O
BAROMETRIC PRESSURE	PBAR	29.25	INCHES HG
PITOT TUBE COEFFICIENT	CP	0.78	
AVERAGE SQ. ROOT OF VELOCITY PRESSURE	DELPV	0.221	IN.H2O**.5
VOLUME % CO2 (DRY BASIS)	%CO2	18.2	%
VOLUME % O2 (DRY BASIS)	%O2	4.6	%
VOLUME % CO (DRY BASIS)	%CO	0.0	%
VOLUME % N2 (DRY BASIS)	%N2	77.2	%

SAMPLE CALCULATIONS

=====

GAS FLOW ANALYSIS

SOURCE - "C" COMBUSTION STACK-COMPLIANCE TESTS

TEST - 1

MEASURED DATA

STACK DIAMETER	DS	132.0	IN.
STACK GAS TEMPERATURE	TS	343.	DEG F
STACK STATIC PRESSURE	PSP	-0.58	INCHES H2O
BAROMETRIC PRESSURE	PBAR	29.25	INCHES HG
PITOT TUBE COEFFICIENT	CP	0.78	
AVERAGE SQ. ROOT OF VELOCITY PRESSURE	DELPV	0.221	IN.H2O**0.5
VOLUME % CO2 (DRY BASIS)	XCO2	18.2	%
VOLUME % O2 (DRY BASIS)	XO2	4.6	%
VOLUME % CO (DRY BASIS)	XCO	0.0	%
VOLUME % N2 (DRY BASIS)	XN2	77.2	%

SAMPLE CALCULATIONS

MOLECULAR WEIGHT OF DRY EXHAUST GAS

MWD

$$MWD = 0.44 * X_{CO2} + 0.28 * (X_{CO} + X_{N2}) + 0.32 * X_{O2}$$

$$MWD = 0.44 * 18.20 + 0.28 * (18. + 77.20) + 0.32 * 4.600$$

$$MWD = 31.10 \text{ LB/LB-MOLE}$$

MOLECULAR WEIGHT OF WET EXHAUST GAS

MWW

$$MWW = (MWD / 100.) * (100. - X_M) + 0.18 * X_M$$

$$MWW = (31.10 / 100.) * (100. - 10.11) + 0.18 * 10.11$$

$$MWW = 29.77 \text{ LB/LB-MOLE}$$

STACK GAS PRESSURE

PS

$$PS = P_{BAR} + (PSP / 13.6)$$

$$PS = 29.25 + (-0.5800 / 13.6)$$

$$PS = 29.21 \text{ IN. HG.}$$

STACK GAS VELOCITY AT STACK CONDITIONS

VS

$$VS = 5128.8 * CP * DELPU * \text{SQRT}((TS + 460.) / (PS * MWW))$$

$$VS = 5128.8 * 0.7800 * 0.2206 * \text{SQRT}((343.2 + 460.) / (29.21 * 29.77))$$

$$VS = 848.0 \text{ FT./MIN.}$$

STACK GAS VELOCITY AT STANDARD CONDITIONS

VSTD

$$VSTD = 17.647 * VS * PS / (TS + 460.)$$

$$VSTD = 17.647 * 848.0 * 29.21 / (343.2 + 460.)$$

$$VSTD = 544.2 \text{ FT./MIN.}$$

SAMPLE CALCULATIONS

STACK AREA - ROUND

AS

$$AS = PI * (DS **2) / 4. / 12.**2$$

$$AS = 3.142 * (132.0 **2) / 4. / 12.**2$$

$$AS = 95.03 \text{ SQ. FT.}$$

STACK GAS FLOW

QS

$$QS = VS * AS$$

$$QS = 848.0 * 95.03$$

$$QS = 80580. \text{ ACFM}$$

STACK GAS FLOW AT WET STANDARD CONDITIONS

QWSTD

$$QWSTD = VSTD * AS$$

$$QWSTD = 544.2 * 95.03$$

$$QWSTD = 51710. \text{ WSCFM}$$

STACK GAS FLOW AT DRY STANDARD CONDITIONS

QDSTD

$$QDSTD = QWSTD * (1. -(XM / 100.))$$

$$QDSTD = 51710. * (1. -(10.11 / 100.))$$

$$QDSTD = 46490. \text{ DSCFM}$$

SAMPLE CALCULATIONS
=====

PARTICULATE ANALYSIS

SOURCE - "C" COMBUSTION STACK-COMPLIANCE TESTS

TEST - 1

MEASURED DATA

METERED SAMPLE VOLUME	VM	39.800	ACT. CU. FT.
METER CORRECTION FACTOR	DGMCF	1.0020	
AVERAGE METER TEMPERATURE	TM	66.	DEG F
AVERAGE ORIFICE PRESSURE DROP	DELH	1.59	INCHES H2O
VOLUME OF H2O CONDENSATE	VI	78.0	ML
WEIGHT OF H2O ADSORBED	VSG	15.6	GRAMS
NOZZLE DIAMETER	DN	0.5000	INCHES
TOTAL SAMPLE TIME	THETA	60.	MINUTES
WEIGHT OF PROBE CATCH	WPROBE	0.0274	GRAMS
WEIGHT OF FILTER CATCH	WF	0.0076	GRAMS

58

VTSTD = 43.71 CU. FT.

PERCENT MOISTURE IN EXHAUST GAS

ZM

ZM = 100. * VMSTD / VTSTD

ZM = 100. * 4.418 / 43.71

ZM = 10.11 %

NOZZLE AREA

AN

AN = PI * (DN **2) / 4. / 12.**2

AN = 3.142 * (0.5000 **2) / 4. / 12.**2

AN = 0.00136 SQ. FT.

59

SAMPLE CALCULATIONS

ISOKINETIC RATIO

I

$$I = 100. * VTSTD / (THETA * AN * VSTD)$$

$$I = 100. * 43.71 / (60.00 * 0.00136 * 544.2)$$

$$I = 98.17 \%$$

TOTAL WEIGHT OF PARTICULATE MATTER COLLECTED

WPT

$$WPT = WPROBE + WF$$

$$WPT = 0.02740 + 0.00760$$

$$WPT = 0.03500 \text{ GRAMS}$$

PARTICULATE CONCENTRATION AT STACK CONDITIONS

CSTK

$$CSTK = 15.43 * 17.647 * PS * WPT / (VTSTD * (TS + 460.))$$

$$CSTK = 15.43 * 17.647 * 29.21 * 0.03500 / (43.71 * (343.2 + 460.))$$

$$CSTK = 0.00793 \text{ GR/ACF}$$

PARTICULATE CONCENTRATION AT DRY STANDARD CONDITIONS

CDSTD

$$CDSTD = 15.43 * WPT / VMSTD$$

$$CDSTD = 15.43 * 0.03500 / 39.29$$

$$CDSTD = 0.01375 \text{ GR/DSCF}$$

PARTICULATE CONCENTRATION AT WET STANDARD CONDITIONS

WCSTD

$$WCSTD = 15.43 * WPT / VTSTD$$

$$WCSTD = 15.43 * 0.03500 / 43.71$$

$$WCSTD = 0.01236 \text{ GR/WSCF}$$

PARTICULATE FLOW RATE

WR

$$WR = 0.132 * WPT * WCSTD / VTSTD$$

$$WR = 0.132 * 0.03500 * 51710. / 43.71$$

$$WR = 5.467 \text{ LB/HR}$$

"C" COKE OVEN COMBUSTION STACK

EXCESS AIR DETERMINATION

CALCULATION BASED UPON THEORETICAL COMBUSTION REACTIONS

COMPOSITION DATA YIELD:

NAME OF TEST:	1	2	3
DATE OF TEST:	7/1/86	7/1/86	7/1/86
PERCENT EXCESS AIR:	50.39	53.23	42.27
PERCENT CO ₂ :	18.20	18.40	19.00
PERCENT O ₂ :	4.60	4.80	4.00
PERCENT CO:	0.00	0.00	0.00

BASIS FOR EXCESS AIR DETERMINATION -- EXAMPLE : TEST NAME -- 1

COMPOSITION OF COMBUSTION GAS IS: 0.00 % COKE OVEN GAS; 100.00 % BLAST FURNACE GAS; 0.00 % NATURAL GAS

REACTIONS OF COMBUSTION/COMPONENT BALANCES			COMBUSTION COMPONENT QUANTITY SUPPLIED			
COMPONENT NAME	COMBUSTION REACTION EQUATION	PRODUCTS OF COMBUSTION	COKE OVEN GAS	BLAST FURNACE GAS	NATURAL GAS	COAL
H ₂	H ₂ + 0.5*O ₂	H ₂ O	0.00	9.05	0.00	0.00
O ₂	-1.0*O ₂	NONE	0.00	0.17	0.00	0.00
N ₂	NONE -- INERT	N ₂	0.00	48.00	0.00	0.00
CO	CO + 0.5*O ₂	CO ₂	0.00	20.26	0.00	0.00
CH ₄	CH ₄ + 2.0*O ₂	CO ₂ , H ₂ O	0.00	1.68	0.00	0.00
CO ₂	NONE -- INERT	CO ₂	0.00	17.32	0.00	0.00
C ₂ H ₄	C ₂ H ₄ + 3.0*O ₂	2.0*CO ₂ , 2.0*H ₂ O	0.00	0.00	0.00	0.00
C ₂ H ₄	C ₂ H ₄ + 3.0*O ₂	2.0*CO ₂ , 2.0*H ₂ O	0.00			
C ₂ H ₆	C ₂ H ₆ + 3.5*O ₂	2.0*CO ₂ , 3.0*H ₂ O	0.00	0.00	0.00	0.00
C ₃ H ₈	C ₃ H ₈ + 5.0*O ₂	3.0*CO ₂ , 4.0*H ₂ O	0.00	0.00	0.00	0.00
BTU	VALUE SUPPLIED FROM FUEL ANALYSIS		0.00	116.00	0.00	0.
S	S + 1.0*O ₂	SO ₂	0.00	0.00	0.00	0.00
C	C + 1.0*O ₂	CO ₂	0.00	0.00	0.00	0.00

APPENDIX H
EQUIPMENT CALIBRATION

SSFCU METER BOX NO. 2 CALIBRATION DATA

DATE: 6-4-86
INITIALS: DAW
BAR. PRESS.: 29.42

STD. METER NO.: 916592
BOX-METER NO.: 716581
NO. OF TRIALS: 9

TRIAL TIME		STANDARD METER DATA (CORR. FACTOR 1.0035)						
NO.	MIN.	TEMP DEG F	DFL P IN. H2O	START CU. FT.	FINISH CU. FT.	NET CU. FT.	VOL. STP SCF	CORR. VOL SCF
1	16.0	76.0	-0.230	502.362	508.762	6.400	6.196	6.217
2	14.0	76.0	-0.240	508.762	515.610	6.848	6.629	6.652
3	15.0	76.0	-0.270	515.610	524.128	8.518	8.245	8.274
4	15.0	76.0	-0.300	524.128	533.418	9.290	8.942	9.023
5	10.0	76.0	-0.330	533.418	540.220	6.802	6.583	6.606
6	10.0	76.0	-0.350	540.220	547.616	7.396	7.158	7.183
7	10.0	76.0	-0.380	547.616	555.523	7.907	7.652	7.678
8	5.0	76.0	-0.440	555.523	559.955	4.432	4.288	4.303
9	5.0	76.0	-0.510	559.955	564.782	4.827	4.670	4.686

TRIAL		METER BOX DATA						
NO.	T-IN DEG F	T-OUT DEG F	DEL. P IN. H2O	START CU. FT.	FINISH CU. FT.	STP VOL. SCF	DELTA H	CORR. DEL. H
1	78.3	76.3	0.500	42.373	48.804	6.224	1.79	1.80
2	83.7	80.7	0.750	48.804	55.747	6.664	1.78	1.79
3	88.0	83.0	1.000	55.747	64.412	8.274	1.76	1.76
4	91.7	86.0	1.250	64.412	73.914	9.024	1.84	1.84
5	93.3	88.0	1.500	73.914	80.871	6.590	1.84	1.83
6	94.0	89.7	1.750	80.871	88.437	7.157	1.81	1.80
7	95.0	89.0	2.000	88.437	96.524	7.653	1.81	1.80
8	96.0	90.0	2.500	96.524	101.043	4.276	1.81	1.79
9	96.3	90.7	3.000	101.043	105.965	4.660	1.83	1.81

AVERAGE METER CORRECTION FACTOR: 1.0020
AVERAGE CORRECTED CALIBRATION CONSTANT (DELTA H): 1.80

CALIBRATION EQUATIONS:

CORRECTED METER VOLUME (SCF) =
(CU. FT.) * (528 / (METER TEMP + 460)) * ((PBAR * (DELTA P / 13.6)) / 29.92)

CALIBRATION CONSTANT (DELTA H) =
0.03175 * DELTA P * PBAR / (METER TEMP OUT + 460) *
(((METER TEMP AVE + 460) * TIME) / (CU. FT. * (PBAR + DELTA P / 13.6))) * 2.0

***FOOTNOTE: STANDARD CONDITIONS (STP):
29.92 IN. HG. AND 528 DEGREES RANKINE.***

6-3-86
OK DSN

ASTM °F	Done Box #1 Probe #1 °F	Done Box #2 Probe #2 °F
308.0	308	308
295.5	296	296
279.0	279	279
270.0	270	270
251.0	251	251
244.0	245	244
234.5	235	235
222.5	223	223
205.8	206	205
174.0	175	174
163.6	164	164
152.2	153	152
146.2	147	146
138.0	139	138
131.2	132	130
126.2	127	125
117.4	118	117
109.2	110	109
101.2	102	100
91.1	92	90
78.8	79	77
65.8	66	64
51.0	51	50
40.6	40	38
33.2	33	31

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL CONTROL
FORD WIND TUNNEL - PITOT TUBE CALIBRATION

INITIALS DPS/PM PROBE ID. 7' #1 Probe DATE 5-28-86

FAN SPEED	STG. PITOT		NOZZLE SIZE		$C_p = \frac{\sqrt{\Delta P_{stg}}}{\sqrt{\Delta P_{nozzle}}}$	REMARKS
	ΔP	$\sqrt{\Delta P}$	ΔP	$\sqrt{\Delta P}$		
LOW	.20	.447	3/16"	.335	.579	.77
	.205	.453	3/16"	.34	.583	.78
	.205	.453	3/16"	.33	.574	.79
	.205	.453	1/4"	.345	.587	.77
	.20	.447	1/4"	.35	.592	.76
	.195	.442	1/4"	.33	.574	.77
	.21	.458	5/16"	.36	.600	.76
	.20	.447	5/16"	.36	.600	.75
	.195	.442	5/16"	.345	.587	.75
	.37	.608	3/16"	.60	.775	.78
MEDIUM	.37	.608	3/16"	.59	.768	.79
	.37	.608	3/16"	.60	.775	.78
	.36	.600	1/4"	.60	.775	.77
	.37	.608	1/4"	.61	.781	.79
	.37	.608	1/4"	.60	.775	.78
	.36	.600	5/16"	.62	.787	.76
	.37	.608	5/16"	.62	.787	.77
	.37	.608	5/16"	.63	.794	.77
	.55	.742	3/16"	.88	.938	.79
	.545	.738	3/16"	.895	.946	.78
HIGH	.56	.748	3/16"	.90	.949	.79
	.565	.752	1/4"	.92	.959	.78
	.565	.752	1/4"	.915	.957	.79
	.57	.755	1/4"	.89	.943	.80
	.565	.752	5/16"	.90	.949	.79
	.57	.755	5/16"	.94	.970	.78
	.555	.745	5/16"	.92	.959	.78

	C_p			COMPOSITE C_p
FAN SPEED	NOZZLE SIZE			
	3/16"	1/4"	5/16"	
LOW	.78	.77	.75	
MEDIUM	.78	.78	.77	
HIGH	.79	.79	.78	
AVERAGE	.78	.78	.77	.78

FORD MOTOR COMPANY
STATIONARY SOURCE ENVIRONMENTAL CONTROL
FORD WIND TUNNEL - PITOT TUBE CALIBRATION

INITIALS jm/DS PROBE ID. 2' PROBE #2 DATE 5/28/86

FAN SPEED	STD PITOT		S-TYPE PITOT		CP = $\frac{\sqrt{\Delta P_{std}}}{\sqrt{\Delta P_{s-t}}}$	REMARKS
	ΔP	$\sqrt{\Delta P}$	NOZZLE SIZE	ΔP	$\sqrt{\Delta P}$	
LOW	.21	.458	3/16	.33	.574	.80
	.21	.458	3/16	.34	.583	.79
	.21	.458	3/16	.33	.574	.80
	.21	.458	1/4	.33	.574	.80
	.215	.464	1/4	.34	.583	.80
	.21	.458	1/4	.35	.591	.77
	.21	.458	5/16	.33	.574	.80
	.21	.458	5/16	.33	.574	.80
	.21	.458	5/16	.33	.574	.80
	.21	.458	5/16	.33	.574	.80
MEDIUM	.375	.612	3/16	.605	.778	.79
	.375	.612	3/16	.61	.781	.78
	.375	.612	3/16	.59	.768	.80
	.37	.608	1/4	.60	.775	.78
	.375	.612	1/4	.60	.775	.79
	.365	.604	1/4	.59	.768	.79
	.37	.608	5/16	.60	.775	.78
	.37	.608	5/16	.60	.775	.78
	.37	.608	5/16	.58	.762	.80
	.55	.742	3/16	.90	.949	.78
HIGH	.57	.755	3/16	.90	.949	.80
	.56	.748	3/16	.93	.964	.78
	.555	.745	1/4	.90	.949	.79
	.55	.742	1/4	.90	.949	.78
	.56	.748	1/4	.895	.946	.79
	.56	.748	5/16	.88	.938	.80
	.58	.762	5/16	.89	.943	.81
	.58	.762	5/16	.89	.943	.81

FAN SPEED	C _p			COMPOSITE C _p
	NOZZLE SIZE			
	3/16	1/4	5/16	
LOW	.80	.79	.80	.79
MEDIUM	.79	.79	.79	
HIGH	.79	.79	.81	
AVERAGE	.79	.79	.80	.79

Visible Emissions Evaluation Form

(USEPA REGION V)

W.C.A.P.C.D. OF-OPERATION TEST

CERTIFICATE OF COMPLIANCE

RECEIVED STATIONARY SOURCE

JUL 2 10 31 AM '86 OF 6

FACILITY: "C" COKE BATTERY

DATE: 7-1-86

OBSERVER: D.A. O'CONNOR

START: 9:07 am X pm

FINISH: 10:06 am X pm

Source: COMBUSTION STACK

Observation Point: NW OF DIX ROAD BRIDGE

distance from: 190 m

direction from: SW

source height: _____

wind direction SE

wind speed 5-10 MPH

sky condition OVERCAST

background SKY

amb. temp. °F 60

rel. hum. % _____

color of emissions _____

other: _____

Remarks: _____

Observers Signature William O'Connor

Last Cert. Date 4-86

MIN	0	15	30	45	REMARKS	MIN	0	15	30	45	REMARKS
0	0	0	0	0		30	0	0	0	0	
1	0	0	0	0		31	0	0	0	0	
2	0	0	0	0		32	0	0	0	0	
3	0	0	0	0		33	0	0	0	0	
4	0	0	0	0		34	0	0	0	0	
5	0	0	0	0		35	0	0	0	0	
6	0	0	5	5	END	36	0	0	0	0	
7	5	5	0	0	START	37	5	10	5	0	
8	0	0	0	0		38	5	10	5	5	
9	0	0	0	0		39	0	0	0	0	
10	0	0	0	0		40	0	0	0	0	
11	0	0	0	0		41	0	0	0	0	
12	0	0	0	0		42	0	0	0	0	
13	0	0	0	0		43	-	-	0	0	OBSERVED
14	0	0	0	0		44	0	0			LOST
15	0	0	0	0		45					POWER
16	0	0	5	0		46					TO
17	0	0	0	0		47					SAMPLING
18	0	0	0	0		48					EQUIP.
19	0	0	0	0		49					
20	0	0	0	0		50					
21	0	0	0	0		51					
22	0	0	0	0		52					
23	0				LOST	53					
24					POWER	54					
25					TO	55					
26	0	0	0	0	SAMPLING	56					
27	0	0	0	0	EQUIP.	57					
28	0	0	0	0		58	0	0	0	0	
29	0	0	0	0		59	0	0	0	0	

Visible Emissions Evaluation Form

(USEPA REGION V)

2 OF 6

FACILITY: "C" COKE BATTERY

DATE: 7-1-86

START: 10:07 am ☒ pm

OBSERVER: P.A. O'CONNOR

FINISH: 10:42 am ☒ pm

Source: COMBUSTION STACK

Observation Point: NW OF DIX ROAD BRIDGE

distance from; 190 m

direction from; SW

source height; _____

wind direction SE

wind speed 5-10 MPH

sky condition CLOUDY-OVERCAST

background SKY

amb. temp. °F 60°

rel. hum. % _____

color of emissions _____

other; _____

Remarks; _____

Observers Signature P.A. O'Connor

Last Cert. Date 7-86

MIN.	0	15	30	45	REMARKS	MIN.	0	15	30	45	REMARKS
0						30	0	0	0	0	
1						31	0	0	0	0	
2						32	0	0	0	0	
3						33	0	0	0	0	
4						34	0	0	0	0	
5						35	0	0	0	5	
6					END	36	5	5	0	0	
7	0	5	10	5	START	37	0	10	5	5	
8	0	0	0	0		38	0	0	0	0	
9	0	0	0	0		39	0	0	0	0	
10	0	0	0	0		40	0	0	0	0	
11	0	0	0	0		41	0	0	0	0	
12	0	0	0	0		42	0	0	0	0	END OF
13	0	0	0	0		43					TEST
14	0	0	0	0		44					
15	0	0	0	0		45					
16	0	0	0	0		46					
17	0	0	0	0		47					
18	0	0	0	0		48					
19	0	0	0	0		49					
20	0	0	0	0		50					
21	0	0	0	0		51					
22	0	0	0	0		52					
23	0	0	0	0		53					
24	0	0	0	0		54					
25	0	0	0	0		55					
26	0	0	0	0		56					
27	0	0	0	0		57					
28	0	0	0	0		58					
29	0	0	0	0		59					

Visible Emissions Evaluation Form

(USEPA REGION V)

3 OF 6

FACILITY: "C" COKE OVEN

DATE: 7-1-86

OBSERVER: D.A. O'CONNOR

START: 12:22 am/pm X

FINISH: 1:21 am/pm X

Source: COMBUSTION STACK

Observation Point: NW OF
DIX ROAD BRIDGE

distance from: 190 m

direction from: SW

source height: _____

wind direction SE

wind speed 5-10 MPH

sky condition OVERCAST

background SKY

amb. temp. °F 70

rel. hum. % _____

color of emissions _____

other: _____

Remarks: 1. OBSCURED BY
QUEEN STEAM.

Observers Signature _____

Last Cert. Date 7-86

MIN	0	15	30	45	REMARKS	MIN	0	15	30	45	REMARKS
0	0	0	0	0		30	0	0	0	0	
1	0	0	0	0		31	0	0	0	0	
2	0	0	0	0		32	0	0	0	0	
3	0	0	0	0		33	0	0	0	0	
4	0	0	0	0		34	0	0	0	0	
5	0	0	0	0		35	0	0	0	0	
6	0	0	0	0		36	0	0	0	0	
7	5	5	5	0		37	0	5	5	0	
8	5	10	5	0		38	5	5	0	0	
9	0	0	0	0		39	0	0	0	0	
10	0	0	0	0		40	0	0	0	0	
11	0	0	0	0		41	0	0	0	0	
12	0	0	0	0		42	0	0	0	0	
13	0	0	0	0		43	0	0	0	0	
14	0	0	0	0		44	0	0	0	0	
15	0	0	0	0		45	0	0	0	0	
16	0	0	0	0		46	0	0	0	0	
17	0	0	0	0		47	0	0	0	0	
18	0	0	0	0		48	0	0	0	0	
19	0	0	0	0		49	0	0	0	0	
20	-	-	0	0	1	50	0	0	0	0	
21	0	0	0	0	END	51	0	0	0	0	
22	0	0	0	0	START	52	0	0	0	0	
23	0	0	0	0		53	0	0	0	0	
24	0	0	0	0		54	0	0	0	0	
25	0	0	0	0		55	0	0	0	0	
26	0	0	0	0		56	0	0	0	0	
27	0	0	0	0		57	0	0	0	0	
28	0	0	0	0		58	0	0	0	0	
29	0	0	0	0		59	0	0	0	0	

Visible Emissions Evaluation Form

(USEPA REGION V)

4 of 6

FACILITY: "C" COKE BATTERY

DATE: 7-1-86

OBSERVER: D.A. O'CONNOR

START: 1:22 am/pm X

FINISH: 1:42 am/pm X

Source: COMBUSTION STACK

Observation Point: NW OF
DIX ROAD BRIDGE

distance from: 190 M

direction from: SW

source height: _____

wind direction SE

wind speed 5-10 MPH

sky condition CLOUDY

background SKY

amb. temp. °F 71

rel. hum. % _____

color of emissions _____

other: _____

Remarks: _____

Observers Signature: D.A. O'Connor Last Cert. Date 4-86

MIN	0	15	30	45	REMARKS	MIN	0	15	30	45	REMARKS
0						30	0	0	0	0	
1						31	0	0	0	0	
2						32	0	0	0	0	
3						33	0	0	0	0	
4						34	0	0	0	0	
5						35	0	5	0	0	
6						36	0	0	0	0	STOP
7						37	5	10	5	0	TEST
8						38	5	10	5	0	
9						39	0	0	0	0	
10						40	0	0	0	0	
11						41	0	0	0	0	
12						42	0	0			
13						43					
14						44					
15						45					
16						46					
17						47					
18						48					
19						49					
20						50					
21						51					
22	0	0	0	0	START	52					
23	0	0	0	0		53					
24	0	0	0	0		54					
25	0	0	0	0		55					
26	0	0	0	0		56					
27	0	0	0	0		57					
28	0	0	0	0		58					
29	0	0	0	0		59					

Visible Emissions Evaluation Form

(USEPA REGION V)

5 of 6

FACILITY: "C" COKE BATTERY

DATE: 7-1-86

OBSERVER: D.A. O'CONNOR

START: 2:13 am pm X

FINISH: 3:12 am pm X

Source: COMBUSTION STACK

Observation Point NW OF DIX RD.
BRIDGE

distance from; 190 m

direction from; SW

source height; _____

wind direction SE

wind speed 5-10 MPH

sky condition OVERCAST

background SKY

amb. temp. °F 73°

rel. hum. % _____

color of emissions _____

other; _____

Remarks: 1. OBSCURED BY

"AX" PUSH

MIN	0	15	30	45	REMARKS	MIN	0	15	30	45	REMARKS
0	0	0	0	0		30	-	-	-	0	
1	0	0	0	0		31	0	0	0	0	
2	0	0	0	0		32	0	0	0	0	
3	0	0	0	0		33	0	0	0	0	
4	0	0	0	0		34	0	0	0	0	
5	0	0	0	5		35	0	0	0	0	
6	10	5	5	-	1	36	0	5	5	5	
7	-	5	5	0		37	0	5	5	0	
8	0	0	0	0		38	0	0	0	0	
9	0	0	0	0		39	0	0	0	0	
10	0	0	0	0		40	0	0	5	5	
11	0	0	0	0		41	0	0	0	0	
12	0	0	0	0	END	42	0	0	0	0	
13			0	0	START	43	0	0	0	0	
14	0	0	0	0	READING	44	0	0	0	0	
15	0	0	0	0		45	0	0	0	0	
16	0	0	0	0		46	0	0	0	0	
17	0	0	0	0		47	0	0	0	0	
18	0	0	0	0		48	0	0	0	0	
19	0	0	0	0		49	0	0	0	0	
20	0	0	0	0	START	50	0	5	0	0	
21	0	0	0	0	TEST	51	0	0	0	0	
22	0	0	0	0		52	0	0	0	0	
23	0	0	0	0		53	0	0	0	0	
24	0	0	0	0		54	0	0	0	0	
25	0	0	0	0		55	0	0	0	0	
26	0	0	0	0		56	0	0	0	0	
27	0	0	0	0		57	0	0	0	0	
28	0	0	0	0		58	0	0	0	0	
29	0	-	0	0	1	59	0	0	0	0	

Observers Signature William D. O'Grady Test Cert. Date 7-86

Visible Emissions Evaluation Form

(USEPA REGION V)

6 OF 6

FACILITY: "C" COKE BATTERY

DATE: 7-1-86

OBSERVER: D. A. O'CONNOR

START: 3:13 am/pm X

FINISH: 3:33 am/pm X

Source: COMBUSTION STACK

Observation Point: NW OF
DIX RD. BRIDGE

distance from: 190 m

direction from: SW

source height: _____

wind direction: SE

wind speed: 5-10 MPH

sky condition: OVERCAST

background: SKY

amb. temp. °F: 73°

rel. hum. %: _____

color of emissions: _____

other: _____

Remarks: _____

Observers Signature: D. A. O'CONNOR Last Cert. Date: 4-86

MIN.	0	15	30	45	REMARKS	MIN.	0	15	30	45	REMARKS
0						30	0	0	0	0	
1						31	0	0	0	0	
2						32	0	0	0	0	
3						33	0	0	0	0	END
4						34					PEST
5						35					
6						36					
7						37					
8						38					
9						39					
10						40					
11						41					
12						42					
13	0	0	0	0	START	43					
14	0	0	0	0		44					
15	0	0	0	0		45					
16	0	0	0	0		46					
17	0	0	0	0		47					
18	0	0	0	0		48					
19	0	0	0	0		49					
20	0	0	0	0		50					
21	0	0	0	0		51					
22	0	0	0	0		52					
23	0	0	0	0		53					
24	0	0	0	0		54					
25	0	0	0	0		55					
26	0	0	0	0		56					
27	0	0	0	0		57					
28	0	0	0	0		58					
29	0	0	0	0		59					