Note: This is a reference cited in *AP 42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

AP42 Section:	12.2
Reference:	93
Title:	Republic Steel Corporation, Warren, Ohio, Particulate Emission Evaluation of the No. 1 Envirotech/Chemico One Spot Quench Car at the Coke Oven Battery, Betz, Converse, Murdoch, Inc., Pittsburgh, PA,
	January 1982.

PROPOSAL

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AP-42 Section <u>12.2</u> Reference Report Sect. <u>4</u> Reference <u>91</u>

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REPUBLIC STEEL CORPORATION MAHONING VALLEY DISTRICT 1040 PINE AVENUE, S.E. WARREN, OHIO 44481

FOR

Pertoin No.1

A SOURCE EMISSION TESTING OF THE ENVIROTECH/CHEMICO ENCLOSED QUENCH CAR SYSTEMS AT THE WARREN AND YOUNGSTOWN MILLS OF REPUBLIC STEEL CORPORATION

BCM PROJECT NO. 00-4683-02

JANUARY 29, 1981

PREPARED BY:

PETER R. CHARRINGTON, P.E. ASSISTANT VICE PRESIDENT, AIR QUALITY

BETZ-CONVERSE-MURDOCH-INC. ONE PLYMOUTH MEETING MALL PLYMOUTH MEETING, PENNSYLVANIA 19462

SOTDAT/STEEL LIBRARY SYSTEM

Envirote Report Title: Source Em مقآ of the chemico Enclosed Zmench Car scyotema et the ation: and Youngrown Mills of Republic Steel Cosp. Plant and Location: Republic stal, Warren, OH SCC: 30300303 Testing Date(s): 10/12-16/8/

By Whom: BCM

Stack Test Review Attached: No

Reviewed By:

Problems Seen by Reviewer:

Confidentiality Status: $N \mathcal{P}$

If status is confidential, list confidential pages or sections:

Source of Determination of the Confidentiality Status:

Report Encoded By:

Date Encoded:

Form Numbers:

Comments:

Betz - Converse - Murdoch - Inc. REPUBLIC. STEEL CORPORATION

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TECHNICAL SCOPE

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It is the desire of Republic Steel Corporation (Republic) to have the emissions from the ENVIROTECH/CHEMICO Enclosed Quench Car Systems located at the Warren and Youngstown plants of the Republic Steel Corporation evaluated and quantified. The intent of this proposal is to present Betz+Converse+Murdoch+Inc.'s (BCM) approach to fulfilling Republic's request for determining the above information.

The project will involve emission sampling from the outlet of three Quench Car Systems in order to generate compliance data for submission to the Ohio Environmental Protection Agency (EPA). A maximum of three runs will be performed during a four-day period at each location. The project is subdivided as noted below.

For ease of discussion and mutual understanding of the BCM services to be provided, the suggested scope is subdivided into the steps as noted below.

1.0 PROJECT PLANNING

Upon acceptance of the proposal, the Section Manager of the Air Quality Section or the Field Project Engineer will meet with Republic Steel to ••••a=,5•. المربعة المعرفة المعرفة accomplish the following:

- Establish lines of communication for the testing
- Discuss the project scope to ensure Republic and BCM are in agreement
- Ensure that the sampling site is prepared for testing (see Client Responsibility Section)

2.0 SAMPLING AND ANALYSIS

2.1 Test Procedures

All particulate testing procedures to be followed during the three 24 push tests for each car are those prescribed by the Environmental Protection Agency (EPA) and the Ohio EPA. The procedures to be followed during testing are outlined below:

- Use an out-of-stack glass fiber filter, followed by a full impinger train (which consists of two distilled water filled . impingers), followed by an empty impinger, and then a silica gel-filled final impinger. A glass lined probe heated to 250°F \pm 25°F will be used for the testing.
 - Sample point location and velocity traverses will consist of four six-point sampling traverses.

REPUBLIC STEEL CORPORATION

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JANUARY 29, 1981

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- EPA Method 5 sampling procedures will be followed for the particulate sampling with the following exceptions:
 - A sample rate of approximately 0.3 scfm will by used for each test
 - (2) A back half particulate loading will be generated by evaporating all water washes at $105^{\circ}C \pm 5^{\circ}C$, and the residue weight determined

2.2 Parameters

The following parameters will be evaluated and reported for each of three test runs for each Quench Car.

- Gas flow ACFM ACFM and SCFM
- Gas temperature -°F
- Gas molecular weight Orsat analysis (CO₂, O₂, CO and N₂ by difference) - X by volume
- Moisture content % by volume
- Particulate concentration -gr/dscf (front-half and back-half of sampling train reported separately)
- Particulate emission rate lbs/hr (front-half and back-half of sampling train reported separately)
- Visible emissions % opaque (optional)
- 2.3 For each car, BCM will provide two men on-site for four days with the necessary sampling equipment to complete the testing. If visible emissions are required, BCM will provide three men during the program.

3.0 ANALYTICAL

All samples will be returned to our laboratory in Pittsburgh, PA for analysis.

4.0 REPORT

Five copies of the reports (one report for each car) will be submitted within 30 working days of field testing completion. Preliminary data should be available within 15 working days of the completion of the sampling. The reports will include all field data sheets, analytical reports, and sampling methodologies from the testing of the cars.

REPUBLIC STEEL CORPORATION

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JANUARY 29, 1981

BUSINESS SCOPE

COMPENSATION

It is proposed that the outlined project scope be performed on a Lump Sum basis. This fee is firm and cannot be changed unless it is mutually agreed that the scope of the work has changed from what is outlined in this project. Costs are based on 10 hour field days and hours in excess of 10 are considered as overtime.

LUMP SUM COSTS

Mobilization(1) Report Preparation Each 24-push test Opacity Observer/10-hour day Each Delay/OT Hour per 2-man crew Each Delay/OT Hour per 3-man crew

(1)Include Pre-test Meeting, completion of Intent to test forms,

DELAYS/OVERTIME

Delays caused by conditions beyond BCM's control, such as partial or complete process shutdowns or irregularities, strikes, floods or fires which delay the project's completion, constitute a Change-of-Scope. Also, unfavorable weather conditions which BCM's Field Project Engineer considers a threat to crew safety and/or sample quality, constitute a Change-of-Scope and will be charged at the delay/overtime rate. In addition, the field work is based on a 10-hour day (excluding travel). Any hours necessary for the successful completion of the project in excess of 10 per day will be charged at the delay/overtime rate described in the compensation section. Any expenses incurred as a result of project delays/ overtime will be billed at cost plus 10%. The BCM Field Project Engineer will notify you of such Changes of Scope. At your request, BCM will outline the type of shelter, as required, to minimize weather delays. If the project is postponed within 72 hours of the scheduled start date, you may be charged a fee (not to exceed the mobilization charge).

WORK SCHEDULE

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Work on this project can be started within 10 calendar days of your authorization to proceed and can be completed within 30 working days of completion of the field work. This schedule is our best estimate based on our anticipated laboratory and engineering workload. At the time of Betz · Converse · Murdoch · Inc. REPUBLIC STEEL CORPORATION

JANUARY 29, 1981

your authorization to proceed, it may be possible to improve this schedule if necessary. On the other hand, an unexpected increase in our laboratory and engineering workload may cause a few days' delay in starting the project.

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INVOICES

Invoices will be submitted monthly for work completed, with terms net thirty (30) days with past-due balances subject to interest at the rate of one and one-quarter percent (1-1/4%) per month, effective forty-five (45) days after date of invoice. This represents an annual interest charge of fifteen percent (15%).

VALIDITY

This proposal is valid for 60 days. Subsequent to that date, BCM may review the basis of payment to allow for changing costs and adjust starting and completion dates to conform to our workload.

INSURANCE

BCM will maintain insurance coverage in the following amounts and, upon request of the client, will provide a Certificate of Insurance so indicating:

Type of Policy

- (a) Standard Worker's Compensation and Employer's Liability
- (b) General Liability Bodily Injury

Property Damage

Limits of Liability

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Statutory

\$500,000 Each Occurrence and Aggregate

\$500,000 Each Occurrence and Aggregate

(c) Automobile Liability Combined Single Limit \$1,000,000 Each Occurrence (Bodily Injury and Property Damage)

SAFETY

BCM personnel always endeavor to conduct field activities in such a manner as to protect themselves and others from accidents and injury. When special safety equipment is required, the client should so specify. BCM personnel use their own safety equipment (hard hats, goggles) unless otherwise instructed.

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PROJECT MANAGEMENT

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BCM will assign key personnel who are fully qualified and experienced with similar studies. Their duties are briefly described below.

Section Manager - Air Quality

Mr. P. R. Charrington, P.E., will be responsible for all field studies and analytical determinations. Mr. Charrington has been involved in over four-hundred source emission programs.

Project Engineer - Air Quality

Mr. D. E. Seely will be assigned as the project engineer for the field sampling project. He will be responsible for the data evaluation and sampling system design. Mr. Seely has been involved in the J&L Pittsburgh Works Quench Car testing and several Bethlehem Steel Quench Car programs.

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REPUBLIC STEEL CORPORATION

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CLIENT RESPONSIBILITY

To successfully complete the field testing, it shall be the responsibility of Republic Steel to provide the following:

- 1. A plant liaison for the BCM field testing team during the field testing
- 2. Access to the sampling location
- 3. Electric power (110V and 20 amp service) to within 50' of the sampling location
- 4. All operating data of the coke oven battery during field testing

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JANUARY 29, 1981

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QUALIFICATIONS

BCM has performed over 40 tests on the ENVIROTECH/CHEMICO Quench Car during the past two years. Provided below are the locations of the projects with plant contacts and phone numbers which Republic should feel free to contact.

Jones and Laughlin Steel Corporation - Pittsburgh Works

May - July, 1978 August - September, 1979 Mr. S. W. Kretz - (412) 378-5447

Bethlehem Steel Corporation - Bethlehem, PA

February - March, 1979 Mr. Ed Rekai and Mr. Robert Alpago - (215) 694-3878

Bethlehem Steel Corporation - Sparrows Point, MD

October, 1980 Bill Bogart - (301) 477-7886

Bethlehem Steel Corporation - Lackawanna, NY

April, 1981 - Tentative Schedule Ron Riefler - (716) 821-2504

Jones and Laughlin Steel Corporation - Indiana Harbor Works²

November, 1980 Andrew Wichlinski - (219) 391-2818

APPENDIX 2 FIELD SAMPLING PROGRAM

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APPENDIX 2

FIELD SAMPLING PROGRAM

1.0 SAMPLING PROCEDURES

1.1 Test Station and Traverse Locations

The locations of the sampling stations and traverse points are critical to the performance of the project. A description of the sampling location follows. The outlet duct of the scrubber measured 72 by 64 inches. Four test ports each contained 6 test points, for a total of 24 points.

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1.2 Gas Flow and Gas Temperature Determinations

The gas flow rate and temperature profiles were measured by conducting a simultaneous velocity and temperature traverse in conjunction with the particulate testing program. Gas velocity heads were measured with a calibrated "S"-type Pitot tube which was connected to an inclined manometer. A Chromel-Alumel thermocouple connected to a potentiometer was used to determine the gas temperature.

1.3 Moisture Content

Sampling was conducted concurrently with particulate sampling using the ³ principles presented in EPA Method Four. The following parameters were evaluated in order to determine the gas stream's moisture content: sample gas volume, sample gas temperature, sample gas pressure, impinger moisture gain, and silica gel moisture gain. Some minor modifications were made to the Method Four train to allow simultaneous particulate and moisture content sampling. These modifications did not deviate from established sampling principles.

The substitution of a glass fiber filter for Pyrex wool as a filtering medium and the substitution of a calibrated orifice for a rotameter as a flow metering device were the primary modifications.

1.4 Particulate Sampling

The sampling procedures and sampling equipment used are outlined in Method Five of the Federal Register, Volume 42, Number 160, August 18, 1977...

The size of the nozzle required to maintain isokinetic sampling was calculated from the results of a previously completed velocity and temperature traverse. The sampling train used a glass-lined probe, which was heated

to 250° F by an internal heating element. A nozzle of the calculated size was attached to the end of the probe which was inserted into the stack. A calibrated "S"-type Pitot tube and a Chromel-Alumel thermocouple were attached to the probe and used to monitor the velocity head and the temperature at the traverse points during the sampling period. Sampled gas passed through the nozzle and the probe to a glass fiber filter for the removal of the suspended particulates. The filter was housed in a heated chamber whose temperature was maintained at 248°F ±25 degrees. From the filter, the stack gas passed to the impinger train. The first two impingers each contained 150 ml of deionized water. The third impinger contained no reagents and acted as a knockout impinger. The fourth impinger contained approximately 200 grams of coarse silica gel which collected any moisture and/or vapors which had not been captured in the preceding impingers.

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The second impinger was a 500 ml Greenburg-Smith inpinger, while the first, third and fourth were 500 ml impingers of the Greenburg-Smith design, modified by replacing the tip with a 1/2-inch ID glass tube. Note that the impinger train was immersed in an ice bath for the entire test period so that the exist gas temperature would not exceed $68^{\circ}F$.

The sampling train was subjected to a leak check prior to and after each sample run. The inlet of the nozzle was plugged and the pump vacuum was held at the highest vacuum attained during that period of testing. In all cases, the leakage rate was minimal and did not exceed the maximum allowable leakage rate of 0.02 cfm.

Upon completion of a test, the soiled glass fiber filter was removed from its filter holder and placed in a petri dish which was subsequently sealed. The probe and nozzle were washed internally with acetone; the particulate matter remaining in the probe was removed with a nylon brush attached to a polyethylene line. The front half of the glass filter holder was also rinsed with acetone and the washings obtained were added to those collected from the nozzle and the probe. All washings were stored in sealed polyethylene sample bottles for transfer to the laboratory. The silica gel used in the fourth impinger was removed and stored in a sealed sample bottle. The contents of the first, second and third impingers were combined and measured volumetrically.

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1.5 Field Data Sheets

The flue gas velocity head, the flue gas temperature, the inlet and outlet dry gas meter temperatures, the orifice pressure differential, the sample volume, the sampling time, the pump vacuum, the filter temperature, and the impinger train outlet gas temperature were recorded during the sampling program. The field data sheets generated during the program follow.

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NOMOGRAPH DATA

PLANT Republic STEEL WARREN DATE 9-28-81 SAMPLING LOCATION Q-CAR #1

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STATIC PRESSURE IN STACK, in. Hg -		
(Pm±0.073 x STACK GAUGE PRESSURE in in. H2O)	P _s · .	-ú ₁
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MAXIMUM VELOCITY HEAD, in. H20	Δp _{max.}	1.4
C FACTOR		>
CALCULATED NOZZLE DIAMETER, in.	. 250	>
ACTUAL NOZZLE DIAMETER, in.	. 203	}
REFERENCE Δp , in. H ₂ O	1.6	

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C	onsulting	Engineers, P	lanners and Arct	nitects			
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Comments: SUN IN EVES White READING SMEKE FLOM PUCKING OF COKE WIND CFITUP OF CULLS BLOWING IN TOWARD Q:: AC

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بو .درو به دد:	16.	B-23	0 % ~ 25 %	18.44séc		25 40	
1:3:44	17	C-23	0"/ r= 26 %	10.745ec		300%	
2:474 2:48 2:48	18	A-25	04/0 + 2305/0	19.08 Sec.	· .	2040 4	Scaubock nict Tura Chill TIME
3 54,54	14	B-25	046 ru 204	7.615 ec.		2040	
3: 10 28	20	C-25	246 70 20 4	13.40 SEC			
5-23-44	ລ.່_	A-27	C1/070 2010			10.90	B.25 cuer smean
3:5594 1:35-05 1:3	22	8-27	0% TO 25%			2000	CAUSE Scine PRUBLES
14110		C-27		· .			REPUBLIC START+STU AUT FULL CAP.CAT
13:55-0 3:57-21		A-29	240 TO 2500	15.2250		2540	

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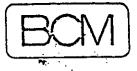
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Date <u>to</u>	· ·		Locati <u>Rojav</u> Addres		EPUBLIC	STE EL	WARKEN, OHIO
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				ght <u>3e'</u>		BLUE SK	155 CALLING FRE
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			· · ·	TEST 2			
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8:5071	1	C-27	C46 TO 1000			10%	
B: 51.92 700 -T	a	re fi	CYCTLISTC			1540	A-27 BATTERY SOUR COLLO CAUSE Higher RUADINGS
9-11.22 9-11.22	3	8-24	USETE 15-16			15%	
4112.66 4152.40	i.	A-2	0.0% To 10 40				
9:33.0 9:-5+5 9:47.42	5	B-2	0%072224	3,64sec.		€0 4°	A - 24 BATTELY SINCE CL.LD. CAUSE doy ARR READ-MYS.
4.26.17	6	د-۲	0% TO 2040	€ 10'Y Sec		2040	
10; C9.47 FC 31 (1)	7	A-4	046 TC 15-6		· ·		I with Felding FA
10: 200 10: 200	8	B-4	!			25%	
10:36.36	9	C-4	00/070 25:40				
11:19 442 11:19 442 11.15 31 11:25 02	10	A-6 B6	0 0/0 TO 200k			20010	INTERECANCE WHALESMORIA TO TOP OF BAN

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Comments: SUN COMING OF RIGHT BEHIND CORECUEN BATTERIES Discover For OBSPERS

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Time of Uench	Push	Oven	Seconds مرجر Opacity Per Push	Seconds ≩⊋0.% Opacity Per Push *	Seconds ≥40% Opacity Per Push	Maximum Opacity	Remarks
1-3-1.25	17	C-6	0% TO 30 40	4.cisec		20 9%	-
1:51.35	13	A-8	0°10 To 25=10	G.Stsec		25%	
1:08-25	14	8-8	096 70 20 46	7.83 SEC		20%	
12.16.54	15	C-8	0 % TU 10%			10%	
12:27.26 2:25.17 2:36.25	16	.A -10	0 0 16 TO 20 1/6	6.02 sec		20%	SMCKE FROM WHARF
2:37.10	17	8-10	·	—			INTER FRACALE
2:45.00	. 18	C-10	04000 30%			300%	PITZ SAID CULOSPOT
2.5822	19	A -12	0°/0 TO 30%	20.64542		30%	
13:10 il 13:0848	20	B-12					SMURE FROM WHAR INTERFERENCE
تدور در الدرون در	-	C-12	0% 12 25%	14.27 sec		2540	HARO PUSH SICURA
13:31 59 13:31 59	22	A - 14	·	·			A'13 OCCR LIAK
15 10 54		B-14	0°10 TO 200%	2.50540			Reading INTERTON
13.51 m 13:	24	C-14	U°10 TO 35°40	15,755 vc		3540	HARD PUSH SCR BER ON NUCLORE FO BOSEC THEN FUSHU
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		gan <u>9'3</u> 1ation			· · ·		
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8-3524 8-3651	}	·C-14	0967020%	5. J25ec		2040	17 4 3 16 5
3:45:00	2	A-16	0% To 10%	,		100.0	
85553 3.56.50	3	B-16	0%705%			5%	
حدى: 4 15.20 9	4	C-16	0% To 5%			· 5%.	
9:14.40 9:1536	5	A-18	0% To 5%	- -	•	5%	INT CRACLEUR E FLOR STEAM S MORE FLOR
9:25.06	6	B-18					WHARE
9:34.21 9:35.00	7	C-18	0%70.254	5.71 sec	÷	25%	
9:14.45 4:15.10	8 .	A-20	040 To 1540			- J U	
9:5424	9	6-30	0% To 26%	3.00 SEC		20%	
10 - 285	10	C- 20	C% TC 20%	7.12 586		200%	
الا (ل : ن) ۲ لا (: ن)	, 11	בג-א	ct/c.Tc 3C %	7-6155c		21%	
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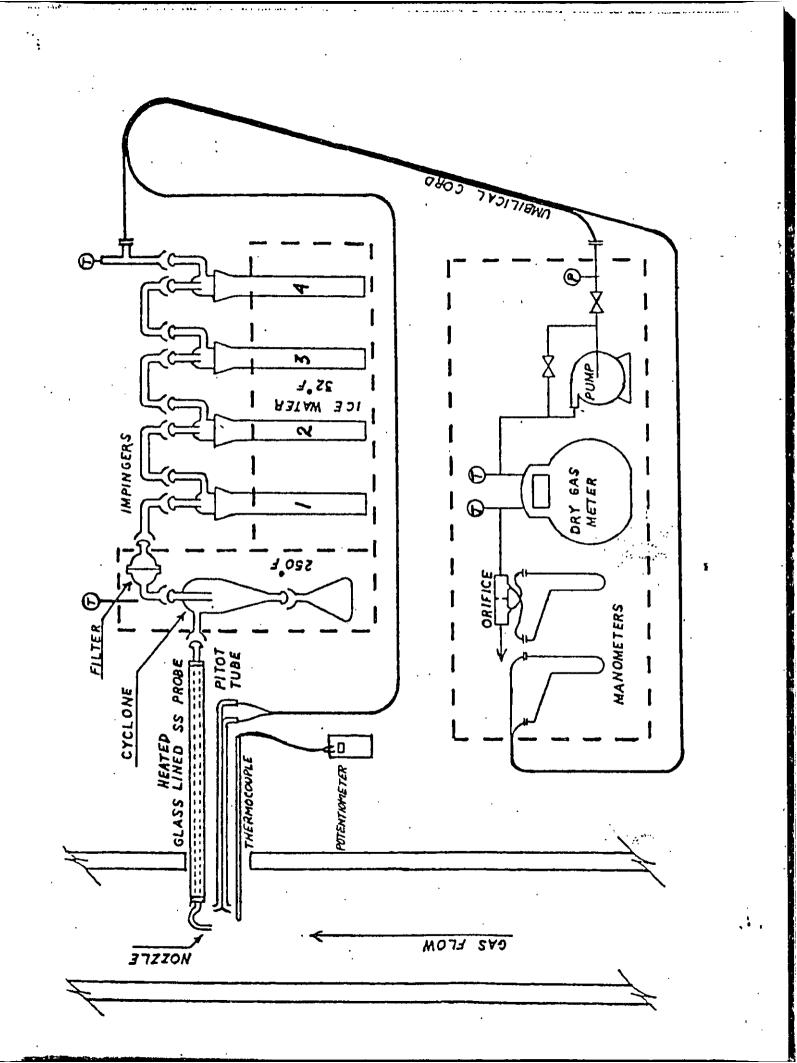
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Time of	D 1		Seconds 0 ≥ 30 % Opacity	Seconds ≥ % Opacity	Seconds ≥ % Opacity	Maximum	Demonto
uench	Push	Oven	Per Push	î	Per Push	Opacity	Remarks
108 31	17	B-93	09670-2646	. 7.215EC		20%	· ·
۶. 25, ۱۱	13	C-22	0% TE 2540	14.12555		25%	or holor th
11:31.30		A				 .	INTERFORMUS» FRO SMOLE FROM WHARF
11.12.35	14	A-24 B-24					INTERGERANE FROM SMOKEFROM WARRI
11: 12.38	15 16	C-24	0% To 500		•	1540	
1:53.50			· · ·				INTERFERENCE FREE SOUCE FROM WHARE
12:01:31 H;/3:48 4:1-53	17	A-26	0°10 TO 20%	2.36 <i>54</i> 6.		20%	14
12.2454	18 19	B-26	046To 15 46			15%	
12:35-2		A-28	0%TO 20%	3.265EC		20%	And the second
12:36.00 12:40:57 12:44:57		B-28	0°/2 TU 10 40			10%	
11544	21	A-1.	0% 70 20 40	- 4.165EC	• •	20%	· · · ·
15,11.35	22	B-1	04070154	₹ <i>1</i>		15%	
BIIM	23 24	с-1	0% TC15.46		•	15%	
1522.03	• - ·						
.:. - -							
	-						
Commen	ts:	· · · · · · · · · · · · · · · · · · ·	······	· · · · · · · · · · · · · · · · · · ·			
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APPENDIX 3

LABORATORY ANALYSIS AND DATA REDUCTION

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APPENDIX 3

LABORATORY ANALYSIS AND DATA REDUCTION

1.0 ANALYTICAL METHODS

All samples generated during the test program were analyzed at the BCM Laboratory in Norristown, Pennsylvania. The following discussions describe the analytical methods employed.

1.1 Particulate Samples

All glass fiber filters used in the sampling program had been tare-weighed following a 24-hour desiccation period prior to their use in the field. Upon their return to the laboratory, they were desiccated and reweighed. The weight difference was the amount of sample collected.

Nozzle, probe, and filter holder acetone washings were evaporated to dryness in separate tared beakers. The residue was desiccated and the beakers were reweighed to a constant weight. The weight difference was the amount of particulate matter collected at these locations in the sampling train.

Acetone blanks were evaporated to dryness in tared beakers, and were desiccated and reweighed. Any residue which remained was a contaminant, in the reagent and was considered a blank weight used as a correction factor in subsequent calculations. The laboratory results of the particulate sampling program are listed in Table 3-1.

1.2 Moisture Content

Silica gel had been tare-weighed prior to its use in the field. Upon its return to the laboratory, the silica gel was reweighed. The entire weight gain was due to water vapor. The total volume of the impinger solutions, minus the original volume of water in the impingers, plus the volume of moisture and/or vapors collected by the silica gel, equaled the total moisture gain of the sampling train. This volume was used as the basis for percent moisture by volume calculations.

2.0 COMPUTER INPUT SHEET

The reduced data calculated from the field data sheets were combined with the laboratory results on the computer input data sheet to facilitate programming. The computer input data sheet follows Table 3-1.

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3.0 EQUATIONS FOR THE CALCULATIONS OF TEST RESULTS

The equations following the data input sheet were programmed into the computer to facilitate the calculation of the test program results. The equations were prescribed in Methods 2, 3 and 5 of the Federal Register, Volume 42, Number 160, August 8, 1977, appropriately amended, and used to calculate the results of particulate testing and flow, temperature, and static pressure testing.

4.0 PARTICULATE TEST RESULTS

The complete results of the computer analyses of the data generated from the particulate test program are presented on the computer printout at the end of this appendix.

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TABLE 3-1

LABORATORY RESULTS*

Particulate Results P&C** Filter Total Catch Run Number (mg) (mg) (mg) 1 34.8 35.9 70.7 7.3 2 13.5 20.8 3 7.2 23.5 16.3

* Blank corrected

**	P&C	=	probe	and	cyclone;	includes	acetone	wash	of	nozzle,	probe,
	cycl	one	, and	front	-half of	filter hold	der			-	

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	1 Heading 2 Number of Lests		7	Erucic		N-CAK	ι	WARKEN		
	J Test type		1.19	1.57.0	1. 1. 1.	1.11				Ĭ
	4 Test identification		1-1-5	001-2	6-1-20	מכדו				
·	5 Stack area, in ²		3076	4036	4108	1076	-+			Ì
	<u>ت</u>	of	129	139	136	133				
	7 Sample volume, ft ³		Ja 265	30.728	\$205	73.04				
	8 Meter temperature, ⁰ F	 Le	دد. ير	68	20	81				
	9 Orlfice (Δ H), in H ₂ O	0	1.236	1.194	1228	1.56				j
	10 Kozzle diameter, in		203	502	52	202				
	11 Duration of test, min.		50.1	51.92	53,53	2.2.S				Ī
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EQUATIONS FOR PARTICULATE, MOISTURE AND FLOW CALCULATIONS (Based on Standard Conditions of 68°F and 29.92 inches Hg)

 $= 0.0471 V_{WC}$ 1. $V_{w(std)}$ = 17.64 $V_{m} \left[\frac{P_{bar} + (.07355 \Delta H)}{T_{m} + 460} \right]_{\gamma}$ 2. V_{m(std)} Bwo $= \frac{V_{w(std)}}{V_{m(std)} + V_{w(std)}}$ 3. $= 0.44(\%CO_2) + 0.28(\%CO) + 0.32(\%O_2) + 0.28(\%N_2)$ 4. M_d $= M_{d} (1 - B_{wo}) + 18 B_{wo}$ 5. M $= \frac{(\$0_2) - 0.5(\$C0)}{0.264(\$N_2) - (\$0_2) + 0.5(\$C0)}$ б. EA 100 = $(85.49)(60)(C_p)^{-1}\sqrt{\Delta P} - \sqrt{\frac{T_s + 460}{(P_s)(M_s)}}$ 7. V Q_s 8. $= \frac{(V_s)(A_s)}{144}$

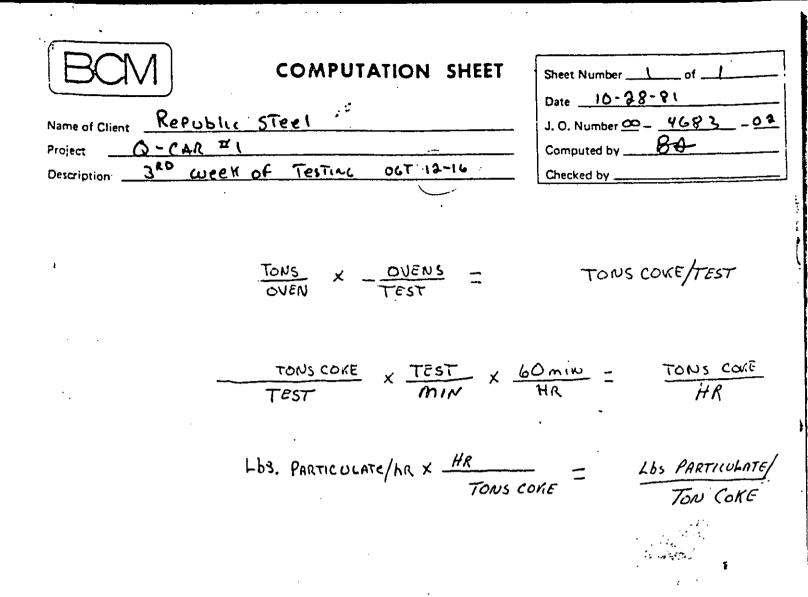
LEGEND	
An	= Area of nozzle, ft ²
A _s	≖ Area of stack, in ²
B _{WO}	Moisture content of gas stream, dimensionless
C _p	Pitot correction factor, dimensionless
C'a ·	Particulate concentration (stack conditions), gr/ft ³
C'c	= Particulate concentration at 12% CO _S (dry), gr/dscf
C's	Particulate concentration (dry), gr/dscf
C'w	= Particulate concentration (wet), gr/scf
Dn	= Diameter of nozzle, inches
Ε	= Particulate emission rate, lb/hr
EA	= Excess air, percent
۵H	= Orifice pressure drop, in. H ₂ O
I	Isokinetic ratio, percent
Md	= Dry molecular weight of stack gas, lb/lb-mole
Ms	Molecular weight of stack gas, lb/lb-mole
Pbar	= Barometric pressure, in. Hg
Ps	⇒ Stack pressure (absolute), in. Hg
VΔP	Average of square roots of Pitot pressure differential, in. H ₂ O
Qs	= Stack gas flow, acfm
Qs(std)	= Stack gas flow, scfm
T _m	≖ Average dry gas meter temperature, °F
Ts	= Average stack temperature, °F

V _m	= Dry sample volume (meter conditions), ft ³
V _{m(std)}	= Dry sample volume (standard conditions), ft ³
٧ _s	= Stack velocity, ft/min
V _{WC}	= Volume of liquid collected in impingers and silica gel, ml
V _{w(std)}	= Volume of liquid collected, ft ³
Wt	= Total weight of particulates collected, mg
θ	= Duration of test, minutes

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	2	12.65	24	303.6	51.92	350.8	28יר	.0206
	З	12.65	24	303.6	53.53	340.3	8.56	.0252

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APPENDIX 4

EQUIPMENT CALIBRATION

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PITOT CALIBRATION

The Pitot tubes were calibrated by measuring the velocity head in a duct with both an "S" type Pitot and a standard Pitot with a known coefficient. This calibration was performed at several different velocities. The Pitot tube coefficient can be calculated as follows:

$$C_{p(test)} = C_{p(std)} - \sqrt{\frac{\Delta P_{std}}{\Delta P_{test}}}$$

where:

C _{p(test)}	Pitot tube coefficient of "S" type Pitot.
-C _p (std)	= Pitot tube coefficient of standard Pitot
^{AP} test	= Velocity head measured by "S" type Pitot
^{∆P} std	= Velocity head measured by standard Pitot

Coefficients were determined for each leg of the "S" type Pitot. No C_p may deviate more than ± 0.01 from the average C_p , and the difference between the average C_p for each leg must be ≤ 0.01 .

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Betz: Converse - Murdoch - Inc.

DRY GAS METER AND ORIFICE METER

The dry gas meter and orifice were calibrated using a wet test meter. Gases were moved through the dry gas meter at orifice pressure differentials (Δ H) of 0.5, 1.0, and 2.0 inches of water. With the information obtained, γ , the ratio of the accuracy of the wet test meter to dry test meter, and Δ HQ, the orifice pressure differential yielding 0.75 cfm of air at 68°F and 29.92 inches of mercury, were calculated. The γ has a tolerance of 1.00 ±0.01, and the Δ HQ has a tolerance of 1.84 + 0.26 - 0.24. The γ and Δ HQ are determined as follows:

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$$r = \frac{V_w P_b (t_d + 460)}{V_d [P_b + .07353(\Delta H)] (t_w + 460)}$$

$$\Delta H_{\varrho} = \frac{0.0317 (\Delta H)}{P_{b} (t_{d} + 460)} \left(\frac{(T_{w} + 460)^{\theta}}{V_{w}} \right)^{2}$$

where:

 $\Delta H = Orifice pressure differential, in H₂O$

 $P_b \approx Barometric pressure, in Hg$

td = Average temperature of dry gas meter, °F

 t_w = Average temperature of wet test meter, °F

 θ = Duration of test, minutes

 V_d = Dry gas meter volume, ft³

$$V_W$$
 = Wet test meter volume, ft³

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9.
$$Q_{s(std)} = Q_{s}(1 - B_{wo}) 17.64 \frac{P_{s}}{T_{s} + 460}$$

10. C's = 0.0154
$$\frac{W_{t}}{V_{m(std)}}$$

11.
$$C'_{W} = 0.0154 \frac{W_{t}}{V_{m(std)} + V_{w(std)}}$$

12. $C'_{C} = 12 C'_{S} \frac{12 C'_{S}}{1200} \frac{12}{2}$

13.
$$C'_{a} = W_{W} \frac{(T_{s} + 460)(29.92)}{(528)(P_{s})}$$

14. E =
$$0.00857 \text{ Q}_{s(std)} \text{ C's}$$

15.
$$A_n = \frac{(\pi)(D_n)^2}{(144)(4)}$$

16. I =
$$\frac{(60)(1.667)(T_s + 460)(0.00267 V_{wc} + V_{m(std)}/17.64)}{(e)(V_s)(P_s)(A_n)}$$

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Time Dry Gas Notor O/S Voluma 285. Zer serial 33.6 7009 Leak Check - Max. Vacuum 2 6 in. Hg touk fate 2003 Ci M Pump 0/C Dilchurge "ick CHALLE Pump Serial No. 72-227261 unich connects OK Vacuen Gage OK Valves OK R. (8 Amphenol OK Lights OK Switchus OK Wirling OK Thereases on the 26 Nove 26 Nove 28 - 1 - 22 -Mancasters OF Rushe OK Oil OF Tubing OK ((1):+ 22)(1:10 + 20 (1.2) (2306)(2223 + 0.0737)(228 + 22) (1); + J772) (3328) (J77) (19.000) (29.52) (869 + 150) (2) + 4 4 (2 × 1) (2 × 3 × 1) (3):+ +)((22,52) (80 + 160) $(cr_{d})(P_{b} + \Delta H/13.6)(T_{w}^{4}, 60)$ P__Inspactor___ (CF_W)(P_b)(T_d+460) $0.99 \leq 7 \leq 1.01$ Date 8-15-11 Don 110. Renarks_ <u>_</u> 0.90 0.98 0.87 8.89 699 13 03 (0.0317)(0.5) · [(<u>2, 5,</u> + 460)(<u>12, 5 8</u>)]² (0.0317)(1.0) $|(\frac{9}{2}+460)(\frac{8}{2}+9)|^2$ 849 (0, 0317)(2.0) |(.92 + 460)(.2.0)20 , METER BOX CALIBRATION SHEET $(0.0317)(\Delta H) \left[(T_{v'}^{+460})(\theta) \right]^2$ (10.000). (4.915) i X 81. 5 (<u>38.51</u>) (<u>81.5</u> + 460) . (<u>57.51</u>). . 01. 96 (CF_W) 1.6≤∆11₈≤2.1 94.8 88.3 11, 81 (bⁱ⁾)(01⁴+460) (134 + JS) (223) (0)++ (0) 21.5 5.000 5.20L 71.8 10.00 / 10.05 / 72 .₹ 79815.174 цр С Jolerances: C,⊀ 1.89 Orifice 1.99 11 1.81 1.0 Δн_@ rian. 2.0 0.5

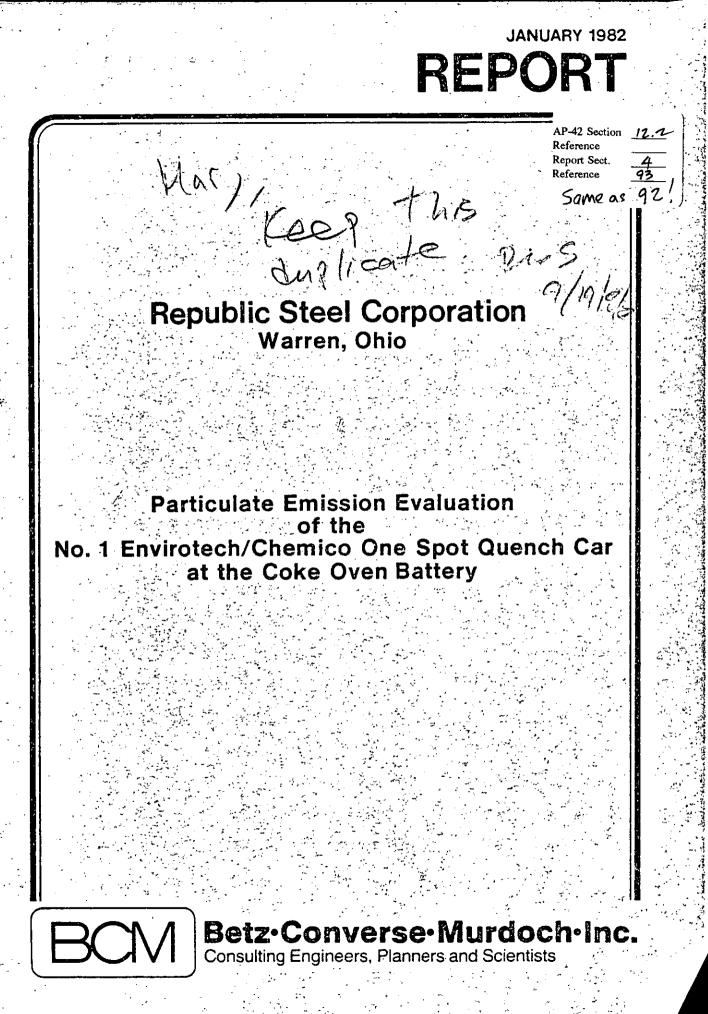
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 $c_p = 0.99 \sqrt{\frac{\Delta^{P_{51d}}}{\Delta^{P_{51d}}}}$

 $\frac{DCV.}{DEV.} = \frac{C_p}{C_p} - \frac{\overline{C_p}}{C_p}$

• DIF. = $\overline{C_{p(\lambda)}} - \overline{C_{p(D)}}$ DIF. \$ 0.01



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PARTICULATE EMISSION EVALUATION OF THE NO. 1 ENVIROTECH/CHEMICO ONE SPOT QUENCH CAR

AT THE

COKE OVEN BATTERY OF REPUBLIC STEEL CORPORATION WARREN, OHIO

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JANUARY 1982

BCM PROJECT NO. 00-4683-02

PREPARED BY

CAENTIST II

APPROVED BY

PETER R. CHARRINGTON, P.E. ASSISTANT VICE PRESIDENT PETER R. CHA

BETZ • CONVERSE • MURDOCH • INC. 5777 BAUM BOULEVARD PITTSBURGH, PENNSYLVANIA 15206

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		bum proposal
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		Laboratory Analysis & Data Reduction
Appendix	4	Equipment Calibration

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TABLES

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Table 1 Particulate Emissions Results

Table 2 Visible Emissions Results

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1.0 INTRODUCTION

Republic Steel Corporation (RSC) retained Betz.Converse.Murdoch.Inc. (BCM) to evaluate its No. 1 Envirotech/Chemico one spot quench car installed at the new Coke Oven Battery at their Warren, Ohio facility. The emission data were evaluated in accordance with the Envirotech/Chemico specifications, and testing was performed as per the procedures established by the Environmental Protection Agency (EPA) and the State of Ohio. Three 24 push tests, incorporating push and travel modes, were performed by BCM. In addition, opacity observations were noted for each oven that was pushed during the particulate testing program. The rounded average of the results of the three runs comprising the test demonstrates compliance with the allowable particulate emission rate of 0.03 pounds per ton of coke pushed.

2.0 SCOPE AND OBJECTIVES

The scope of the project was outlined in the BCM confirming Proposal of January 29, 1981, which is contained in Appendix 1. The following parameters were determined for each test:

- Gas flow ACFM and SCFM
- Gas temperature °F
- Moisture % by volume
- Flue gas analysis % by volume CO₂, O₂, CO and N₂ (by difference)
- Particulate emissions grains/dry standard cubic foot (g/dscf), lbs/hr and lbs/ton of coke pushed
- Opacity % Opaque

3.0 PROCEDURES

3.1 Field Work

Field testing was conducted October 12 through October 15, 1981. The sampling team consisted of the following BCM personnel:

- Robert Alfred Scientist II
- Edward W. Blanar Engineer I
- Dan Petrovay Technician III

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Mr. Tom Kachur of Republic Steel acted as liaison between BCM and Republic Steel, and Mr. Bill Weiss of Chemico ensured that the scrubber car was operating normally during the test periods. Mr. Joe Bryant of Chemico observed the testing performed on the test car. The Ohio EPA was present during the testing of the No. 1 Quench Car.

The following methods of sampling were employed in the test program:

- 1. Sampling and traverse locations were determined per agreement with the Ohio EPA.
- 2. Gas flow, gas temperature and static pressure measurements were made per Method Two of the Federal Register, Volume 42, Number 160, August 18, 1977; the methodology is outlined in Appendix 2.
- 3. Particulate testing was conducted per a modified Method Five of the Federal Register, Volume 42, Number 160, August 18, 1977. These procedures are outlined in Appendix 2.
- 4. Fyrite oxygen (0₂) and carbon dioxide (CO₂) indicators (manufactured by the Bacharach Instrument Company) were used to determine the molecular weight of the flue gas. The Fyrite directly determines percent carbon dioxide and oxygen. The volume percent CO plus nitrogen was determined by difference. All of these parameters were used to calculate the molecular weight of the dry flue gas.
- 5. Moisture content sampling was conducted per Method Four of the Federal Register, Volume 42, Number 160, August 18, 1977; the methodology is outlined in Appendix 2.

3.2 Equipment Calibration

In accordance with the accepted procedures published by the EPA, all gas velocity measuring equipment, volume metering equipment, temperature measuring equipment, and flow rate metering equipment had been calibrated within 60 days of the actual test date. Calibration data are contained in Appendix 4.

3.3 Analytical Methods

All samples generated during the sampling program were returned to the BCM Laboratory in Norristown, Pennsylvania. Laboratory data are contained in Appendix 3, Table 3-1.

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3.4 <u>Calculations</u>

All particulate concentrations, moisture content, gas flow, and molecular weight calculations were accomplished through the use of a computer. Raw data generated from the field sampling program and the results of the laboratory analyses were introduced into equations presented in Methods Two, Three, Four, and Five of the Federal Register, Volume 42, No. 160, August 18, 1977. Computer input and all other data appear in Appendix 3.

4.0 SUMMARY

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4.1 Particulate Emissions Results

The parameters evaluated using the EPA and State of Ohio testing methods are contained in the computer printout at the end of Appendix 3. Test results are listed in Table 1.

TABLE 1

Run Number	Concentration (Grains/DSCF)	Emission Rate (Pounds/Hour)	Lbs/Ton of Coke Pushed*
1 2	.0302 .0106 .0122	21.3 7.22 8.55	.0586 .0206
J	.0122	6.55	.0252 ,0348 lbs/+ zue
* Based c	on 303.6 tons of coke p	ushed for each 24 oven	test 21e

PARTICULATE EMISSIONS RESULTS

4.2 Visible Emissions

The opacity observations were performed in accordance with methodology approved by Chemico and the EPA. The readings are contained in Appendix 2.

5.0 DISCUSSION

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5.1 Particulate Testing Results

The particulate emission testing for the No. 1 Quench Car was performed with minimal field difficulties. Testing on October 13, 1981 was delayed for a total of 59 seconds during two pushes and on October 14, a delay of 65 seconds was incurred. These delays occurred because of the hot coke "sticking" in the ovens and not being able to be pushed out. The operator of the Quench Car who initiated the scrubbing cycle was not aware of the problem. After learning of the ensuing problem, the scrubber system was then shut off. As the scrubber was only scrubbing clean air, the cubic feet of gas sampled and the sampling time for the pushes were subtracted from the appropriate totals. If these were to be included in the calculations, the isokinetics would rise approximately one percent and the emission concentration would be artifically depressed.

The final testing results indicate compliance with the allowable emission rate of 0.03 lb/ton of coke pushed.

5.2 Visible Emissions Procedures

The opacity for the No. 1 Quench Car was observed during all three testing programs. All observations were recorded in accordance with guidelines established in EPA Reference Method Nine of the Federal Register, with the exception of the guideline that the sun be located 140° to the observer's back. This guideline could not be met as the location of the observer with respect to the coke ovens precluded this. All observations were recorded by an EPA Certified Emission Observer.

Opacity readings were taken above the coke car with blue sky as background. Observations began at the start of the push cycle of the quench car and continued until the quench car cycle completed its run, which lasted about two minutes. There were 24 pushes per test, each push occurring approximately 10 to 12 minutes apart.

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APPENDIX 1

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BCM PROPOSAL

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PROPOSAL

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TO

REPUBLIC STEEL CORPORATION MAHONING VALLEY DISTRICT 1040 PINE AVENUE, S.E. WARREN, OHIO 44481

FOR

A SOURCE EMISSION TESTING OF THE ENVIROTECH/CHEMICO ENCLOSED QUENCH CAR SYSTEMS AT THE WARREN AND YOUNGSTOWN MILLS OF REPUBLIC STEEL CORPORATION

BCM PROJECT NO. 00-4683-02

JANUARY 29, 1981

PREPARED BY:

PETER R. CHARRINGTON, P.E. ASSISTANT VICE PRESIDENT, AIR QUALITY

BETZ-CONVERSE-MURDOCH-INC. ONE PLYMOUTH MEETING MALL PLYMOUTH MEETING, PENNSYLVANIA 19462 Betz · Converse · Murdoch · Inc. REPUBLIC STEEL CORPORATION

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JANUARY 29, 1981

TECHNICAL SCOPE

It is the desire of Republic Steel Corporation (Republic) to have the emissions from the ENVIROTECH/CHEMICO Enclosed Quench Car Systems located at the Warren and Youngstown plants of the Republic Steel Corporation evaluated and quantified. The intent of this proposal is to present Betz-Converse-Murdoch-Inc.'s (BCM) approach to fulfilling Republic's request for determining the above information.

The project will involve emission sampling from the outlet of three Quench Car Systems in order to generate compliance data for submission to the Ohio Environmental Protection Agency (EPA). A maximum of three runs will be performed during a four-day period at each location. The project is subdivided as noted below.

For ease of discussion and mutual understanding of the BCM services to be provided, the suggested scope is subdivided into the steps as noted below.

1.0 PROJECT PLANNING

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Upon acceptance of the proposal, the Section Manager of the Air Quality Section or the Field Project Engineer will meet with Republic Steel to accomplish the following:

- Establish lines of communication for the testing
- Discuss the project scope to ensure Republic and BCM are in agreement
- Ensure that the sampling site is prepared for testing (see Client Responsibility Section)

2.0 SAMPLING AND ANALYSIS

2.1 Test Procedures

All particulate testing procedures to be followed during the three 24 push tests for each car are those prescribed by the Environmental Protection Agency (EPA) and the Ohio EPA. The procedures to be followed during testing are outlined below:

- Use an out-of-stack glass fiber filter, followed by a full impinger train (which consists of two distilled water filled impingers), followed by an empty impinger, and then a silica gel-filled final impinger. A glass lined probe heated to 250°F ± 25°F will be used for the testing.
 - Sample point location and velocity traverses will consist of four six-point sampling traverses.

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JANUARY 29, 1981

- EPA Method 5 sampling procedures will be followed for the particulate sampling with the following exceptions:
 - A sample rate of approximately 0.3 scfm will by used for each test
 - (2) A back half particulate loading will be generated by evaporating all water washes at $105^{\circ}C \pm 5^{\circ}C$, and the residue weight determined

2.2 Parameters

The following parameters will be evaluated and reported for each of three test runs for each Quench Car.

- Gas flow ACFM ACFM and SCFM
- Gas temperature -°F
- Gas molecular weight Orsat analysis (CO_2, O_2, CO) and N₂ by difference) % by volume
- Moisture content % by volume
- Particulate concentration -gr/dscf (front-half and back-half of sampling train reported separately)
- Particulate emission rate lbs/hr (front-half and back-half of sampling train reported separately)
- Visible emissions % opaque (optional)
- 2.3 For each car, BCM will provide two men on-site for four days with the necessary sampling equipment to complete the testing. If visible emissions are required, BCM will provide three men during the program.

3.0 ANALYTICAL

All samples will be returned to our laboratory in Pittsburgh, PA for analysis.

4.0 REPORT

Five copies of the reports (one report for each car) will be submitted within 30 working days of field testing completion. Preliminary data should be available within 15 working days of the completion of the sampling. The reports will include all field data sheets, analytical reports, and sampling methodologies from the testing of the cars.

REPUBLIC STEEL CORPORATION

-3-

JANUARY 29, 1981

BUSINESS SCOPE

COMPENSATION

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4 1. - It is proposed that the outlined project scope be performed on a Lump Sum basis. This fee is firm and cannot be changed unless it is mutually agreed that the scope of the work has changed from what is outlined in this project. Costs are based on 10 hour field days and hours in excess of 10 are considered as overtime.

LUMP SUM COSTS

Mobilization(1) Report Preparation Each 24-push test Opacity Observer/10-hour day Each Delay/OT Hour per 2-man crew Each Delay/OT Hour per 3-man crew

(1)Include Pre-test Meeting, completion of Intent to test forms.

DELAYS/OVERTIME

Delays caused by conditions beyond BCM's control, such as partial or complete process shutdowns or irregularities, strikes, floods or fires which delay the project's completion, constitute a Change-of-Scope. Also, unfavorable weather conditions which BCM's Field Project Engineer considers a threat to crew safety and/or sample quality, constitute a Change-of-Scope and will be charged at the delay/overtime rate. In addition, the field work is based on a 10-hour day (excluding travel). Any hours necessary for the successful completion of the project in excess of 10 per day will be charged at the delay/overtime rate described in the compensation section. Any expenses incurred as a result of project delays/ overtime will be billed at cost plus 10%. The BCM Field Project Engineer will notify you of such Changes of Scope. At your request, BCM will outline the type of shelter, as required, to minimize weather delays. If the project is postponed within 72 hours of the scheduled start date, you may be charged a fee (not to exceed the mobilization charge).

WORK SCHEDULE

Work on this project can be started within 10 calendar days of your authorization to proceed and can be completed within 30 working days of completion of the field work. This schedule is our best estimate based on our anticipated laboratory and engineering workload. At the time of

REPUBLIC STEEL CORPORATION

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your authorization to proceed, it may be possible to improve this schedule if necessary. On the other hand, an unexpected increase in our laboratory and engineering workload may cause a few days' delay in starting the project.

INVOICES

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Invoices will be submitted monthly for work completed, with terms net thirty (30) days with past-due balances subject to interest at the rate of one and one-quarter percent (1-1/4%) per month, effective forty-five (45) days after date of invoice. This represents an annual interest charge of fifteen percent (15%).

VALIDITY

This proposal is valid for 60 days. Subsequent to that date, BCM may review the basis of payment to allow for changing costs and adjust starting and completion dates to conform to our workload.

INSURANCE

BCM will maintain insurance coverage in the following amounts and, upon request of the client, will provide a Certificate of Insurance so indicating:

Type of Policy

- (a) Standard Worker's Compensation and Employer's Liability
- (b) General Liability Bodily Injury

Property Damage

Limits of Liability

Statutory

\$500,000 Each Occurrence and Aggregate

\$500,000 Each Occurrence and Aggregate

(c) Automobile Liability Combined Single Limit \$1,000,000 Each Occurrence (Bodily Injury and Property Damage)

SAFETY

BCM personnel always endeavor to conduct field activities in such a manner as to protect themselves and others from accidents and injury. When special safety equipment is required, the client should so specify. BCM personnel use their own safety equipment (hard hats, goggles) unless otherwise instructed.

REPUBLIC STEEL CORPORATION

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JANUARY 29, 1981

PROJECT MANAGEMENT

BCM will assign key personnel who are fully qualified and experienced with similar studies. Their duties are briefly described below.

Section Manager - Air Quality

Mr. P. R. Charrington, P.E., will be responsible for all field studies and analytical determinations. Mr. Charrington has been involved in over four-hundred source emission programs.

Project Engineer - Air Quality

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Mr. D. E. Seely will be assigned as the project engineer for the field sampling project. He will be responsible for the data evaluation and sampling system design. Mr. Seely has been involved in the J&L Pittsburgh Works Quench Car testing and several Bethlehem Steel Quench Car programs.

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REPUBLIC STEEL CORPORATION

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CLIENT RESPONSIBILITY

To successfully complete the field testing, it shall be the responsibility of Republic Steel to provide the following:

- 1. A plant liaison for the BCM field testing team during the field testing
- 2. Access to the sampling location
- 3. Electric power (110V and 20 amp service) to within 50' of the sampling location
- 4. All operating data of the coke oven battery during field testing

verse · Murdoch · Inc.

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JANUARY 29, 1981

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QUALIFICATIONS

is performed over 40 tests on the ENVIROTECH/CHEMICO Quench Car g the past two years. Provided below are the locations of the cts with plant contacts and phone numbers which Republic should feel to contact.

-7-

ones and Laughlin Steel Corporation - Pittsburgh Works

ay - July, 1978 .ugust - September, 1979 r. S. W. Kretz - (412) 378-5447

sethlehem Steel Corporation - Bethlehem, PA

'ebruary - March, 1979 1r. Ed Rekaj and Mr. Robert Alpago - (215) 694-3878

Sethlehem Steel Corporation - Sparrows Point, MD

)ctober, 1980
3ill Bogart - (301) 477-7886

Bethlehem Steel Corporation - Lackawanna, NY

April, 1981 - Tentative Schedule Ron Riefler - (716) 821-2504

Jones and Laughlin Steel Corporation - Indiana Harbor Works

November, 1980 Andrew Wichlinski - (219) 391-2818

nverse • Murdoch • Inc.

APPENDIX 2

FIELD SAMPLING PROGRAM

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Converse Murdoch Inc.

APPENDIX 2

FIELD SAMPLING PROGRAM

.0 SAMPLING PROCEDURES

.1 Test Station and Traverse Locations

he locations of the sampling stations and traverse points are critical o the performance of the project. A description of the sampling location ollows. The outlet duct of the scrubber measured 72 by 64 inches. Four est ports each contained 6 test points, for a total of 24 points.

.2 Gas Flow and Gas Temperature Determinations

The gas flow rate and temperature profiles were measured by conducting a simultaneous velocity and temperature traverse in conjunction with the particulate testing program. Gas velocity heads were measured with a calibrated "S"-type Pitot tube which was connected to an inclined manoneter. A Chromel-Alumel thermocouple connected to a potentiometer was used to determine the gas temperature.

1.3 Moisture Content

Sampling was conducted concurrently with particulate sampling using the principles presented in EPA Method Four. The following parameters were evaluated in order to determine the gas stream's moisture content: sample gas volume, sample gas temperature, sample gas pressure, impinger moisture gain, and silica gel moisture gain. Some minor modifications were made to the Method Four train to allow simultaneous particulate and moisture content sampling. These modifications did not deviate from established sampling principles.

The substitution of a glass fiber filter for Pyrex wool as a filtering medium and the substitution of a calibrated orifice for a rotameter as a flow metering device were the primary modifications.

1.4 Particulate Sampling

The sampling procedures and sampling equipment used are outlined in Method Five of the Federal Register, Volume 42, Number 160, August 18, 1977.

The size of the nozzle required to maintain isokinetic sampling was calculated from the results of a previously completed velocity and temperature traverse. The sampling train used a glass-lined probe, which was heated

to $250^{\circ}F$ by an internal heating element. A nozzle of the calculated size was attached to the end of the probe which was inserted into the stack. A calibrated "S"-type Pitot tube and a Chromel-Alumel thermocouple were attached to the probe and used to monitor the velocity head and the temperature at the traverse points during the sampling period. Sampled gas passed through the nozzle and the probe to a glass fiber filter for the removal of the suspended particulates. The filter was housed in a heated chamber whose temperature was maintained at 248°F ±25 degrees. From the filter, the stack gas passed to the impinger train. The first two impingers each contained 150 ml of deionized water. The third impinger contained no reagents and acted as a knockout impinger. The fourth impinger contained approximately 200 grams of coarse silica gel which collected any moisture and/or vapors which had not been captured in the preceding impingers.

The second impinger was a 500 ml Greenburg-Smith inpinger, while the first, third and fourth were 500 ml impingers of the Greenburg-Smith design, modified by replacing the tip with a 1/2-inch ID glass tube. Note that the impinger train was immersed in an ice bath for the entire test period so that the exist gas temperature would not exceed $68^{\circ}F$.

From the impinger train, the gas was conducted through an umbilical cord to the control console, a Model 2343 RAC Stak Samplr, which contained the following pieces of equipment (listed in the order in which sampled gas passed through them): a main valve; a by-pass valve for flow adjustment; an airtight vacuum pump; a dry gas meter; and a calibrated orifice. The orifice was equipped with pressure taps which were connected across the inclined manometer used to ensure that isokinetic conditions were maintained. A schematic diagram of the sampling train is presented at the end of this appendix.

The sampling train was subjected to a leak check prior to and after each sample run. The inlet of the nozzle was plugged and the pump vacuum was held at the highest vacuum attained during that period of testing. In all cases, the leakage rate was minimal and did not exceed the maximum allowable leakage rate of 0.02 cfm.

Upon completion of a test, the soiled glass fiber filter was removed from its filter holder and placed in a petri dish which was subsequently sealed. The probe and nozzle were washed internally with acetone; the particulate matter remaining in the probe was removed with a nylon brush attached to a polyethylene line. The front half of the glass filter holder was also rinsed with acetone and the washings obtained were added to those collected from the nozzle and the probe. All washings were stored in sealed polyethylene sample bottles for transfer to the laboratory. The silica gel used in the fourth impinger was removed and stored in a sealed sample bottle. The contents of the first, second and third impingers were combined and measured volumetrically.

1.5 Field Data Sheets

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The flue gas velocity head, the flue gas temperature, the inlet and outlet dry gas meter temperatures, the orifice pressure differential, the sample volume, the sampling time, the pump vacuum, the filter temperature, and the impinger train outlet gas temperature were recorded during the sampling program. The field data sheets generated during the program follow.



NOMOGRAPH DATA

PLANT Republic STEEL WARREN DATE 9-28-81 SAMPLING LOCATION _____

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CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H ₂ O	ΔH _@	1:75
AVERAGE METER TEMPERATURE (AMBIENT + 20 °F), °F	ī _{m avg.}	\$D
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B _{wo}	80
BAROMETRIC PRESSURE AT METER, in. Hg	Pm	
STATIC PRESSURE IN STACK, in. Hg		
($P_m \pm 0.073 \text{ x}$ STACK GAUGE PRESSURE in in. H ₂ 0)	P _s	
RATIO OF STATIC PRESSURE TO METER PRESSURE	P _{s/Pm}	
AVERAGE STACK TEMPERATURE, °F	T _{savg.}	150
AVERAGE VELOCITY HEAD, in. H20	^{∆p} avg.	.7
MAXIMUM VELOCITY HEAD, in. H ₂ O	۵ p _{max.}	1,4
C FACTOR	. 7	
CALCULATED NOZZLE DIAMETER, in.	, 250	
ACTUAL NOZZLE DIAMETER, in.	, 203	
REFERENCE Ap. in. H ₂ O	1.6	

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		IMPINCER TEMPERATURE; °F	, 70	72	72	73	μL		
<i>LL</i>	REFERENCE DP 1.1	SAMPLE BOX TEMPERATURE. °F	245	2.55	255	260	265	520	245
1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1	S'O Refere	PUMP VACUUM. in. H g	32	24	7 7	3 / 2	3	4 2	7.
MIREO MITE 10' A 55 CLAS 8) 24	RATURE	DRY GAS METER TEMPERATURE LLET in ¹ .°F (T _{m out}).°F	59	10	17	19	le 2	8 9	<i>ę §</i>
	ASSUMED METER TEMPERATURE C FACTOR 	DRY GAS METER TEMPERATURE INLET OUTLI (Tm out	58	· •	6.0	60	6.0	وو	lob
	ASSUMED ME C FACTOR MINUTES	STACK TEMPERATURE (T _s),"F	131	134	133	136	137	137	134
	- ATA EVERY -	DRIFICE PRESSURE DIFFERENTIAL (ΔH), in. H ₂ O) DESIRED ACTUAL	-St .2	16	1.1	1.2		2.2 7.2	7.5
FIELD DATA	CO C	DRIFICE DIFFER (AH), i	12			1.2	1.1	2.2	31
	HEAD AND RE	VELOCITY HEAO (ΔP ₅), in. H ₂ O	120	.15	1.0	1.1	30	<u>- 2</u>	
2164	PLATE NUMBER	CAS METER READING IV _{II} I, II ³ G Q Z Z O S	992.87	993.69	994.62	1995, 53	996.57	691.835	998, 77
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101 D. 15. 15. 15. 15. 15. 15. 15. 15. 15. 15		N III	51 12	52. 93	53	52	<u>н</u> 9.5	51 82	52 6 6
PLANT REPURATION DATE OCTTON SAMPLE TYPE P RUN NUMBER TYPE PRESSUN FILTER NUMBER(S) GEL NUMBER(S)	THIMBLE NUMBER H ₂ O PICKUP (ml)	TRAVERSE POINT NUMBER	A.L	A-5	F -A	R-A	A-2	H-H	B-6

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	IMPINGER TEMPERATURE	76	78	. 81	× v v	76	74	70	70	70	72	<u>+7</u>	
•	SAMPLE BOX TEMPERATURE °F	245	270	010	750	255	260	265	255	255	255	255	255
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	DRY GAS ME LER TEMPERATURE (LET OUTLET 1.ºF (TT 1.ºF	۲۵۰ (* ۶۶	63	69	72	68	48	69	11	71	12	72	78
	DRY GA TEMPEI INLET (Tm. 1, °F		18	9	01	89	801	69	10	10	<u>1</u> 2	16	113
	51ACK 51ACK 1EMPERATURE 1T ₅ 1."F	137	125	135	241	134	1351	136	137	137	139	135	138
	ORIFICE PRESSURE DIFFERENTIAL (2H), In. H ₂ O) ISSURED ACTUAL	1. 1. 1.	25	3.0	2.5	× 0 ×	13. 18.	4 7 4	3,5	<u> </u>	6.7	<u></u>	بر 4 کار
	ORIFICE DIFFEF (M), (1.5	3.5 689	3.0	2.7 2.5	5.0.1	58. BL	705.	3.5	3.9	49	<u>4</u> 3 1.2	54
NURBER	VELLGATY HEAD 13P51 III H ₂ U	5-1-5-	4 4	2 F 7	374	21	18. 74	33	3.3	3.7	4.1	4.0	.52
RUN NUR	(.AS ME I LR HE ADING IV _m ¹ II ³	999.955	215.100	ζης	004 26	000.01	006.89	068.445	010.08	21.110	27(.619	015.65	016.37
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	SAMPLING TRRE TH	50		53	51 -	50	59 76	51	52 20	54	0.8 8 0	57	5L 64
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	SAMPLE BOX Temperature. "F		755		210		250		250		250															
-	PUMP VACUUA in Mg	_	3	7	2	2	7	7	Ţ	7	4										/					
	DRY GAS METER TEMPERATURE	0UTLET IT _{m oul}).°F	80		7.8		52		28		82		4	00												
		INLET 17 _{m in}).°F	19		80		80		50		%															
	STACK TEMPERATURE (1, "F		135		141		138	-	136		135		126	111		•		¥.	,							
:	ORIFICE PRESSURE DIFFERENTIAL IJHI, IA. H ₂ 01	ACTUAI.	1.2	2h.	2	57	<u>ג</u>	ic.	<u>و</u> 	.50	ч. Ч	qt.		0					•		· .					
	ORIFICE DIFFER	DESIRED	1.2	47	7 1	is 1	22	11.	و ا	ر م.	 ~	70		117												-
NUMBER	VELUGHTY HEAD 13P2. n H50	ç.	i , I	40	1.1	.55	a.I	· 1 9	5,1	75	ا. ۴	89		166			2 1/4 5	С								
RUN NUR	(;AS ML I LA READING (,AS ML I LA READING	016.37	011.50		018,765		020.020		021.5L		222.765		IFOR PHEAK < 0	34 (10	2		2.01 CFM AT /	*							· ·	
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			54 bar		<u>م</u>	90	Z F	<u>i</u> 4)	53 8-4	82	52 P	53	2117				6006	-								-
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9 69 42	,						
9:17:4	2	C -13	1540			15%	
	3	A-15		• 		1546	
9:30-50			OVCTUS 42				
9 30.50 9.42-		0.5	04. 701040			1040	
9.4023	4	B-15				·	
9 17-	5	C-15	040702042	7.IOSEC		20%	
218					- · ·		NO KEADING THIS
4 39.7 10.00 st	6	A-17			,		re CAN EFRUS WAY
10 10 3		B·17	0-10 70.5%			15-12	
10:11.21	7		04% TU 20°%	18+14-5EC		2040	MIL WITH UTACITY
10 25 25	8	C-17				-	
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11.02.10	Ÿ	1		6.42 SEC	х. ^т	20 %	

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OMMENTS: SUN IN EVERS WHILE READING SMEKE FROM PUSHING OF COKE WIND CFITUP OF CUENS BLUNNIG IN TOWARD GOAR

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TEST 1

Consulting Engineers, Planners and Architects

1.0/13/51

Time of	Duch	0.000	Seconds ◦ ≥ 2¢ % Opacity	Seconds ≱ ∡c % Opacity	Seconds ≥ 40 % Opacity	Maximum	Derter	
luence	Push	Oven	Per Push	Per Push	Per Push	Opacity	Remarks	
11:27.45		c-19	09072 30 000	15-235ec		2040		
1124.05		A-21	096 TC 20 4C	<i>4.0 ≤</i> ह€	-	2040		
11 -49-46		B-21	09% 72 2040	12 2ISES		2040		
11 50.46			04072 = 5-10	8.61sec		25-10		
12:332	17	c-21 - A-23		-			Nic READing FERENCE FR Emmissions	LLIPER - C.M. WMARE
12:12 44 44 51:21 74:20:24			· · ·	18.445EC		25.010		•
2:23 09	16	B-23	0%~25%	10.745ec		200%		
2:33.29 12:47.41	17	C-23	0 % 70 26 %	19.08 500.		3040		
12: 48 22	19	A-25	04/0 FC 304/0 04/0 F0 204	T , GI SEC.		2000 +	SCRUBBER : CNIN TIM	~ CT 7,54
13:040		B-25		· · ·		20 %o		
13: 10 28	20	C-25	6% TO 20 %	13.70340	· .			
13 23 34	21	A-27	C+10 To 20+10			20%	8	
13:5594 3:35.05	22	B-27	00%0 TC 25%0	11.035EC 29.0550C		2040	B-25 CULA CAUSE Scine Kenanas	· · · · · · · · · · · · · · · · · · ·
13.46.46	· ~ ~	C-27	: 40 TO 45:6			45010	READING. SECULUMAR PREPERIN ST	ict crick
13:56 0		A-29	24/0 80 25-10	15.22500		250%	NOT FULL	CAPCATY
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Commen	ts•					•	· · · ·	
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		egan <u>;; g:5-c</u>	Ended_				
Type of	Insta	llation					
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of }uench	Push	Oven	Opacity Per Push	Opacity Per Push	Opacity Per Push	Maximum Opacity	Remarks
8:50:37	1	C-37	C 46 To 100k			10%	
8:51.42 900 54	a	17-29	C % TE 15 to			1540	A-27 BATTERY SMORIN COLLO CAUSE Niejkek RHADINGS
9 21.48 9 : 11, 22	3	8-29	0 %TC 1546			15%	~ t ~ ~) S
9:1 2.66 9:52. 4 1	i-j	A-2	0 00 TE 10 40				
4:3355 7	, 5	8-2	040723640	3,64sec.		20 %	A - 14 BATTELY SIMCRING CLUD CAUSE Hayter READ Mys.
من بلا: با من بلا: با من باز: 9	6	د-ع	0 % TO 20 40	2.54 Sec		2040 1540	
10,0947 12.01	7.	A-#	0 % TC 15 %				I witch Felding From WHARFSINCE
7 (9) (1)	8	B-4		_			
10:30:36	9	C-4	00/072 2540	7 4656C		25%	
11:0442		A-6	0 0/0 TO 200k	3.695EC		70 °/0	
11.1331	10	m·v			· .		INTERFERANCE FR.
11.1331		BL		· · ·	• •		TATERERAL WHARESMOR, TO TOP OF BA

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Comments: SUN COMING UP RIGHT BE HIND SUFE OVER BATTERIES DIAGETER THE DRIVERS

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Co	ensulting	Engineers, f	Planners and Arc	chitects	EST NOTA	10/14/81	
Time of Quench	Push	Oven	Seconds مر خ م Opacity Per Push	Seconds ≥⊋0.% Opacity Per Push	Seconds ≥40% Opacity Per Push	Maximum Opacity	Remarks
11:34:25	.}	C-6	0% TO 30 40	4.ci sec		2c ¢⁄ę	
11:5 ^{1.35} 11:5 <u>2</u> .22	13	A-8	04/0 To 25510	G.SYSEC		25%	
12:08:25	14	8-8	090 TO 20016	7.83 SEC		20%	
12.16.59 12.18.59	15	c-8	040 TO 10%		·	1090	
مد 12:27 الما عد الما الما عالي الما	م) (A -10	0 °/6 TO 20 °/6	G . 22 SEC		20%	SMCKE FROM WHAR INTERFORCE
12:45.40	17 	B-10 C-10	04070 30%	34. stare	· ·	30-10	DITZ SAID CULDSFOT
12:5822 12:59 1	19	A -13	0% TO 30%	20.64526	·	30%	
13:08:45	20	B-12				-	SMERE FROM WHAR
13 2952	21	C-12	0%1025%	14.27see		254	HARO PUSH SECULAR
13:31 डर्ग 13:38 13	22	A-14	-	-			ATTA DOCR LEAD
137054 1372.00	23	B-14	00/0 70200%	2-56565	. ·		READING TO TAREGUE
13:51 rs 13:	24	C-14	U 40 TO 35 %	15,755vc -		35%0	HARD PUSH SCR BER ON NO CORE FO 20 SEC. THEN PUSHO

Luser Their Pus Nuo

Comments: W. NO SHIFT FROM S TO SE 12.50

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-	C	onsulting	Engineers,	Pianners and Arc	chitects			······································
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-			10 m Pri			•		$\frac{1}{2} = \frac{1}{2} $
2			egan <u>s</u>				<u>AAVC</u>	<u> </u>
• •	Type of	• Insta	llation	COKE CUEN	BATTERES	•		
					ST F3			
- 1 	Time			Seconds ∽≱3c % Opacity	Seconds ≽% Opacity	Seconds ≥ % Opacity	Maximum	
4	Quench	Push	Oven	Per Push	Per Push	Per Push	Opacity	Remarks
	83524	}	C-14 ·	0% TE20%	5. 525		2040	
	2 3 45.55	.2	A-16	00% TO 10%			1000	
	85553 33.56.50	3	B-16	0% TO 5%	· ·		5%	
· . 말	9:05.00	: 4	C-16	0%0705%0	-		5%	
.	9.14.40	י 5	A-18	0% TO 5%			5%	INT CRECLEWIE FLUIN
	5 9:1536	., 6	B-18	· · ·				STEAM S MORE FACIN
	7 9:35.00	7	C-18	0%76 25%	5.7/sec		25%	
	9 :24.45 4 : 45.40	8	A-20	040 TO 1540	-		1540	
7	12:54.24	•	B-30	043 TE 2090	3.00 SEC		20%	
ن	4:54.20	9	مع - ع عد - ع	C=10 TC 2046	7.11 SEC		20%	
	10:06:56	, 11	A-22	ct/c. To 30 40	7-6155c		26%0	

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TEST *3 1915/81

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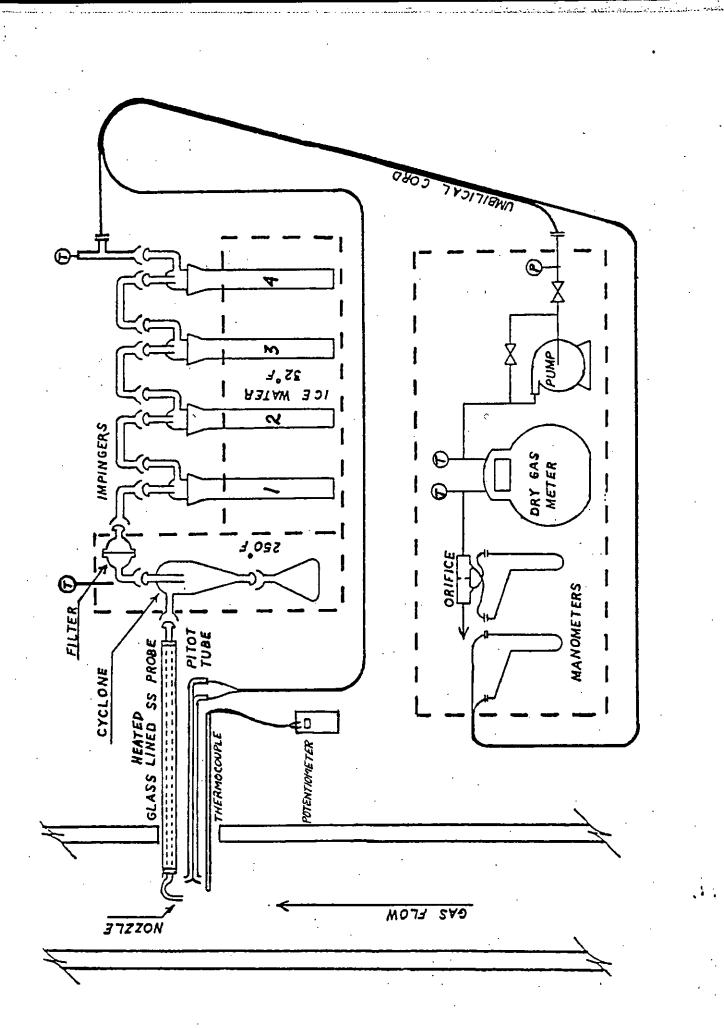
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Betz · Converse · Murdoch · Inc.



Consulting Engineers, Planners and Architects

Time of uench	Push	Oven	Seconds O≥30% Opacity Per Push	Seconds ≥ % Opacity Per Push	Seconds ≥ % Opacity Per Push	Maximum Opacity	Remarks
1 07 35	12	8-22	09%070-2040	7.215EC	· · · · · · · · · · · · · · · · · · ·	20%	
1.08.31	13	د-22	0% TE 2540	14,12565		25%0	
1.23 36 1:31.36 1.32.35	ı -/	A-24	·				INTERFERENCE FROM SMOLE FROM WHARF
1. 1. 41. 42	15	B-24		-			INTER CRANKE FROM SMOKE FROM WARRE
1: 52.47 1:53.50 2:63.28	16	C-24	0% To 5%			15 ⁰ /0	INSTERFERENCE FROM
2:01:21	17	A-26					STACKE FROM WARRE
2-2454	18	B-26	0"10 TU 20%	2.36 <i>55</i> ec.		20%	
1:25 52 1,35 - 2 1,36 - 2	19 20	C-2C A-28	0%701540	3.26 SEC		15°/0 20%	
1; 4957 1; 4957 2; 4459	21	B-28	0 % TO 10 %			10%	
<u>1565</u> 2.57.28	22	A-1.	046702046	4.16 SEC		20%	
371.35 137236	23	B-1	04/0 TC 15 4	í		15%	<i>,</i>
3-2101 3-22.03	24	< −1	0% Tc15%		·.	15 %	
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APPENDIX 3

LABORATORY ANALYSIS AND DATA REDUCTION

APPENDIX 3

LABORATORY ANALYSIS AND DATA REDUCTION

1.0 ANALYTICAL METHODS

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All samples generated during the test program were analyzed at the BCM Laboratory in Norristown, Pennsylvania. The following discussions describe the analytical methods employed.

1.1 Particulate Samples

All glass fiber filters used in the sampling program had been tare-weighed following a 24-hour desiccation period prior to their use in the field. Upon their return to the laboratory, they were desiccated and reweighed. The weight difference was the amount of sample collected.

Nozzle, probe, and filter holder acetone washings were evaporated to dryness in separate tared beakers. The residue was desiccated and the beakers were reweighed to a constant weight. The weight difference was the amount of particulate matter collected at these locations in the sampling train.

Acetone blanks were evaporated to dryness in tared beakers, and were desiccated and reweighed. Any residue which remained was a contaminant in the reagent and was considered a blank weight used as a correction factor in subsequent calculations. The laboratory results of the particulate sampling program are listed in Table 3-1.

1.2 Moisture Content

Silica gel had been tare-weighed prior to its use in the field. Upon its return to the laboratory, the silica gel was reweighed. The entire weight gain was due to water vapor. The total volume of the impinger solutions, minus the original volume of water in the impingers, plus the volume of moisture and/or vapors collected by the silica gel, equaled the total moisture gain of the sampling train. This volume was used as the basis for percent moisture by volume calculations.

2.0 COMPUTER INPUT SHEET

The reduced data calculated from the field data sheets were combined with the laboratory results on the computer input data sheet to facilitate programming. The computer input data sheet follows Table 3-1.

3.0 EQUATIONS FOR THE CALCULATIONS OF TEST RESULTS

والمراجع والمستويون والمرور المراوقا والماد الأر

The equations following the data input sheet were programmed into the computer to facilitate the calculation of the test program results. The equations were prescribed in Methods 2, 3 and 5 of the Federal Register, Volume 42, Number 160, August 8, 1977, appropriately amended, and used to calculate the results of particulate testing and flow, temperature, and static pressure testing.

4.0 PARTICULATE TEST RESULTS

The complete results of the computer analyses of the data generated from the particulate test program are presented on the computer printout at the end of this appendix.

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TABLE 3-1

ومحاور متحمق الانتخار المستحد والمتكاف والمحاور والمحاولا والمت

الەركىتىمىلىغا ئە<u>تەركە ئەتەر بەركە</u> مايە<mark>تىتەر مىلەركىتى</mark>تەر بەركەتكە مەركەتتىمىتە بەركەت .

	<u>Particu</u>			
Run Number	Filter (mg)	P&C** (mg)	Total Catch (mg)	
1	34.8	35.9	70.7	
. 2	7.3	13.5	20.8	
3	7.2	16.3	23.5	

LABORATORY RESULTS*

* Blank corrected

** P&C = probe and cyclone; includes acetone wash of nozzle, probe, cyclone, and front-half of filter holder 60-46 83-02

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L-116016D WARREN TEST #4 Republic Q-CAR XT 6 I Q-CAK 29.94 61-1 061-2 061-2 061-1 062-1 460% 460% 460% 24.72 8 30.56 33.04 203 13.65 0.0 133 81 1 1. 56 19.0 1.20 2. o 1474 2 0 -14 0 191 0 <u>ر</u>، 0 <u>13</u> 9 25 0 106 29.20 126 1 228 622 53.53 166. 194.2 0,0 2 25 - 2. 5 Эİ Φ 2.0 0 CFruker C 137 68 125.9 29.49 1994 203 2.5 765 17.3 0 53. 0.0 0 1-1/-0 9 رم م 0 C 0 0 ? QUENCH, UNI 3074 1.236 137 30. *2* L J 66.5 203 912 1918 0 20.1 29.49 18:0 C C C 0.00 0.7 0.0 0 ວ 52 0 18 Iraverse (Avg.√∆p), in. H₂0 l6 Barometric pressure, in. Hg 28 lesh check rate no. 1, 682 Look check time no. 1, 196. 27 Post Teck check rules, CIC 15 Static pressure, in. H₂0 19 Volume H₂0 collected, ml 25 Meter calibration fector 17 Pitot correction factor Volume titrant, 50₃, ml Volues titrant, SO₂, el 9 Orifice (∆H), in. H₂O 23 Norrelity titrant, 50₃ 24 Thornality titrent, 502 11 Duration of test, min. 8 Mater temperature, ⁰F Stack temperature, ^OF Keight collected, mg 26 Avg. Cosine of angle Test identification 10 Kozzle diameter, in 7 Sample volume, ft³ 12 Volume of CO₂, 2 Stack area, in² Number of tests 14 Volume of 02. 1 Volume of CO, 1 lest type l Heading 20 2 21 22 52

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EQUATIONS FOR PARTICULATE, MOISTURE AND FLOW CALCULATIONS (Based on Standard Conditions of 68°F and 29.92 inches Hg) 1. V_{w(std)} = 0.0471 V_{wc} 2. $V_{m(std)} = 17.64 V_{m} \left[\frac{P_{bar} + (.07355 \Delta H)}{T_{m} + 460} \right]_{Y}$ 3. B_{wo} $= \frac{V_{w(std)}}{V_{m(std)} + V_{w(std)}}$ M_d · $= 0.44(\% CO_2) + 0.28(\% CO) + 0.32(\% O_2) + 0.28(\% N_2)$ 4. 5. $M_s = M_d (1 - B_{wo}) + 18 B_{wo}$ $= \underbrace{(\%0_2) - 0.5(\%C0)}_{0.264(\%N_2) - (\%0_2) + 0.5(\%C0)}$ 6. EA 100 = $(85.49)(60)(C_p) \sqrt{\Delta P} \sqrt{\frac{T_s + 460}{(P_c)(M_c)}}$ 7. V_s 8. Q_s $= \frac{(V_s)(A_s)}{144}$

EGEND

n	= Area of nozzle, ft ²
3	= Area of stack, in ²
vo	= Moisture content of gas stream, dimensionless
ג	= Pitot correction factor, dimensionless
a	= Particulate concentration (stack conditions), gr/ft^3
c	= Particulate concentration at 12% CO _S (dry), gr/dscf
S	= Particulate concentration (dry), gr/dscf
W	<pre>= Particulate concentration (wet), gr/scf</pre>
	= Diameter of nozzle, inches
	= Particulate emission rate, lb/hr
	= Excess air, percent
	= Orifice pressure drop, in. H ₂ O
	= Isokinetic ratio, percent
	= Dry molecular weight of stack gas, lb/lb-mole
	= Molecular weight of stack gas, lb/lb-mole
r	= Barometric pressure, in. Hg
	= Stack pressure (absolute), in. Hg
5	= Average of square roots of Pitot pressure differential, in. H ₂ O
,	
:td)	= Stack gas flow, scfm
1	= Average dry gas meter temperature, °F
	= Average stack temperature, °F

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= Dry sample volume (meter conditions), ft^3

(std) = Dry sample volume (standard conditions), ft3

- = Stack velocity, ft/min
- volume of liquid collected in impingers and silica gel, ml
- (std) = Volume of liquid collected, ft³
 - = Total weight of particulates collected, mg
 - = Duration of test, minutes

COMPUTATION SHEET Sheet Number _____ of ___ Date 10-28-81 ;;* Name of Client Republic Steel J. O. Number 00 - 4683 -02 Q-CAR #1 Project Computed by ______ 3RD week of Testinc 06T 12-16 Description Checked by X - OVENS = TONS COKE/TEST TONS OVEN TON'S COKE X TEST X 60 min = TONS CONE TEST HR Lbs. PARTICULATE/HR X HR TONS CONE = LOS PARTICULATE

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R U IV	TONS/ OVEN	OUENS/ /TEST	TONS COKE/ TEST	TËST TIMË	TONS COKE/HR	LOS PART/ /hr	LOS PART TON COKE
1	12.65	<u>२</u> ५	303.6	50.1	363.6	21.30	.0566
2	12.62	24	303.6	51.92	350.8	7.23	.0206
3	12.65	<u>2</u> 11	303.6	53.53	340,3	१ .ऽ५	, 025 2

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UC = 3	32.00 32.00 30.364 29.792 18.5 18.0 26.92 26.97 57.0 136.0 3637.6 63.5 81970.8	6 .0122 6 .0974 2 .0082 5553		6 450.6 3 101.1
00-2	1 2 2 2 2 2 2 2 2 2 1 2 2 1 1 2 2 2 1 1 2	.0106 .0846 .0072 7.2295	1.5 .0 .17.5 81.0	450.6 108.3
⊌C−1	24.00 5.01 0.15 0.15 0.151 0.121 0.121 0.121 0.1211	. 5 4 5 4 5 4 5 4 5 4 5 4 5 4 5 4 5 4 5	200 200 200 200 200 200 200 200 200 200	2.01C
ERS:	(S& FT) (DSCF) (z) (lb/ld-mole) (f1/min) (df7 SCFM) (ACFM)	DNS: (GRAINS/DSCF) (GRAINS/DSCF) (GRAINS/DSCF) (GRAINS/CF) (LJ/HR)	(VUL Z) (VUL Z) (VUL Z) (VUL Z) (VUL Z)	(ズ) (ズ)
PARAME TERS:	AREA UF BREECHING SAMPLE VULUME MOISTURE MOLECULAR WEIGHT GAS TEMPERATURE GAS VULUME GAS VOLUME GAS VOLUME	PARTICULATE EMISSIONS: CONCENTRATIUN (GRAINS/DSC CONC. @ 12% CU2 (GRAINS/DSC CONC. @ STK COND.(GRAIWS/CF) EMISSION RATE (LB/HR)	ORSAT ANALYSIS: Carbon Diuxide Carbon Monuxide Oxygen Niikogen	EXCESS AIR TSOKIMETICS

THE FOLLOWING RUNS WERE UNDER SATURATED CONDITIONS: 0C-1. UC-2 0C-3

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APPENDIX 4

EQUIPMENT CALIBRATION

PITOT CALIBRATION

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The Pitot tubes were calibrated by measuring the velocity head in a duct with both an "S" type Pitot and a standard Pitot with a known coefficient. This calibration was performed at several different velocities. The Pitot tube coefficient can be calculated as follows:

$$C_{p(test)} = C_{p(std)} - \sqrt{\frac{\Delta P_{std}}{\Delta P_{test}}}$$

where:

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FT

F) {_ $C_{p}(test)$ = Pitot tube coefficient of "S" type Pitot $C_{p}(std)$ = Pitot tube coefficient of standard Pitot ΔP_{test} = Velocity head measured by "S" type Pitot ΔP_{std} = Velocity head measured by standard Pitot

Coefficients were determined for each leg of the "S" type Pitot. No C_p may deviate more than ± 0.01 from the average C_p , and the difference between the average C_p for each leg must be ≤ 0.01 .

DRY GAS METER AND ORIFICE METER

The dry gas meter and orifice were calibrated using a wet test meter. Gases were moved through the dry gas meter at orifice pressure differentials (Δ H) of 0.5, 1.0, and 2.0 inches of water. With the information obtained, γ , the ratio of the accuracy of the wet test meter to dry test meter, and Δ H₀, the orifice pressure differential yielding 0.75 cfm of air at 68°F and 29.92 inches of mercury, were calculated. The γ has a tolerance of 1.00 ±0.01, and the Δ H₀ has a tolerance of 1.84 + 0.26 - 0.24. The γ and Δ H₀ are determined as follows:

$$\gamma = \frac{V_{w}P_{b}(t_{d} + 460)}{V_{d}[P_{b} + .07353(\Delta H)](t_{w} + 460)}$$

$$\Delta H_{0} = \frac{0.0317 (\Delta H)}{P_{b} (t_{d} + 460)} \left(\frac{(T_{w} + 460)^{\theta}}{V_{w}} \right)^{2}$$

where:

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ΔH = Orifice pressure differential, in H₂O
P_b = Barometric pressure, in Hg
t_d = Average temperature of dry gas meter, °F
t_w = Average temperature of wet test meter, °F
θ = Duration of test, minutes
V_d = Dry gas meter volume, ft³
V_w = Wet test meter volume, ft³

9.
$$Q_{s(std)} = Q_{s}(1 - B_{wo}) 17.64 \frac{P_{s}}{T_{s} + 460}$$

10. C's = 0.0154
$$\frac{W_t}{V_m(std)}$$

11.
$$C'_{W} = 0.0154 \frac{W_{t}}{V_{m(std)} + V_{w(std)}}$$

13.
$$C'_a = W_w \frac{(T_s + 460)(29.92)}{(528)(P_s)}$$

14. E = 0.00857
$$Q_{s(std)}$$
 C's

15.
$$A_n = \frac{(\pi)(D_n)^2}{(144)(4)}$$

16. I =
$$\frac{(60)(1.667)(T_s + 460)(0.00267 V_{wc} + V_{m(std)}/17.64)}{(e)(V_s)(P_s)(A_n)}$$

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Time Inty Cas Maren O/C Traine 2816. 2123 Sectial 33.6 22607 3 Intermediation O/C in O/ Norm 0/ Normal 20.6 22607 Pump O/C Oilchard Mich CHARLO Pump Serial No. A Parati Leak Check - Max. Vacuum 2 6 in. Hg Eauk Early 2003 Crit Quick Connects O/C Vacuum Gage O/C Valves O/C 12, 68 Amphenol OK Lights OK Switchus OK Varias OK OK TH 96 7 AND 96 7 AND 1 22 Ruots OK Oil OK Tubing LEA 14 (10: + 72) (1: 0 + 0.) (1 / 22 - 0) (2.30F) (2823+0.0731) (218-4:0) (33: + 629)(2r32)(00)) $(\frac{\partial f g g g}{\partial f})(\frac{\partial f_{1} g}{\partial f})(\frac{\partial f_{1}}{\partial f})$ $(\sqrt{6} 0 6 0) (\sqrt{2} \sqrt{3}) (\sqrt{5} \sqrt{2} + \sqrt{5} 0)$ $(CF_d)(P_b + \Delta N/13.6)(T_{W}^{+4.60})$ Inspector $(CF_{W})(P_{b})(T_{d}^{+4}GU)$ $0.99 \leq \gamma \leq 1.01$ Date 9-15-71 Dox 110. Thermonators Nancmeters Rcnarks 0.98 ." _____ 0.98 0.87 84.9 8.89 599 13 W (0.0317)(2.0) $|(.92 + 460)(<u>2.03</u>)|^{2}$ $(0.0317)(0.5) | (\mathcal{X}, \mathcal{I} + 460)(\mathcal{I}, \mathcal{I}, \mathcal{I}) |^2$ (0.0317)(1.0) $|(9/8 + 460)(8.89)]^2$ 20 ۰<u>۲</u> METER BOX CALIBRATION SHEET $(0.0317)(\Delta H) \left[(T_{w}^{+460})(\theta) \right]^{2}$ (10.000) ٥٢_، ا (4.915) 5.000 5.206 71.8 88.3 81. J , N (CF_{W}) 96 (322) (8/12 + 460) . (2000 1.6≤∆H₈≤2.1 [; [; - P11 94.8 N/ (Pb)(01d+460) (252-2)(52 + 460) [. (3363)(39+ 40) 4.998 5.174 71.5 10.000/10.55 JA ، _, .p Tolerances: CF_W Orifice! ∆H_@ = 1.99 1.81 hian. 2.0 0.5 ·1.0

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· Pitot No. 6-A

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Pitct No. 6 - 14			Date 6-15-31 Engineer Ewistnes				c.3		
				A SIDE			B SIDE]
Range	Run No.	APstd	ΔP	° p	DEV.	ΔP	°p	DEV.	DIF.
		550.	052	. 777	· · · · · · · · · · · · · · · · · · ·	<u>+ . 032</u>	. 777	1.005	
1	2	.052	.050.	. 777 .	- 5	-050	.792 .	0.01	
	3	ΰżζ	.050	.777	0	1.052	,777	- ەن ا	
	AVG.			777	}		.782	J	0.0.5
	1	.19	. २३	\$16.	0	.28	<i>S16</i>	c	
2	2	.19	.23	F. 6	0	.25	. 816	C	
•	3	.19	.28	. Kela	0	.23	. Yib		1 1
	λνG.			. 416			- 816		0.00
			<u></u>		, 			۲ ۲	
	1	.45	.65	. 224	.008	.67	. 811	00,8	
3	2	.46	-65		DIVIE	-66	.826	.067	
	3	.46	64	.839	,006	.67	.820	.001	
	λvg.		1	.832			. 815)	0.012
	1	.66	.88	. 857	0. 003	.88	.857	.0.0	
4	2	_64	39	882	0.00.2	.E3	. 857	24+2.	
	3		.39	. 852	. 00 7	·8°7	852	003	
-	λνg .	· , · · · · · · · · · · · · · · · · · ·		\$154			.855		.301
	1	58	1.35	.799	0	1.35	. 799	0	
5	2	. * *	1.35	.749	<i>r</i> i	1.35	799	i ci	
	3	.84	135	799	0	1.35	. 799		
	AVG.			.799			. 799		0,00
	1	1.20	1.80	. 80%	0	1.50	808	6	
	2	1.20	1.20	. 808	_0	1.90	208	0	
6	3	120	1.40	40.9	0.	1. 80	808	0	
l	λvg.	i	<u>, ,,, ,</u>	808	· · · · · ·	<u></u>	900 974		0.00
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	1	. 1.31	1.98	. foz		1.48	. X02	<u> </u>	
7	2		<u>1.98</u>	.602	<u> </u>	1.98	.802	<i></i>	
	3	<u> </u>	1.98	.802	<u>د</u>	1.98	80 Z	0	/
	λVG.		. {	- 80 2			-80c	l	0.00

 $c_p = 0.99 \sqrt{\frac{\Delta^{P} \pi t d}{\Delta^{P} \cdot s^*}}$

DEV. = $C_p - \overline{C_p}$ DEV. \$ 0.01

• DIF. = $\overline{C_{p(\Lambda)}} - \overline{C_{p(D)}}$ DIF. ≤ 0.01