| | |
|---|---|
| AP42 Section: | 12.2 |
| | |
| Reference: | 94 |
| Title: | Republic Steel Corporation, Warren, Ohio, Particulate Emission Evaluation of the No. 2 Envirotech/Chemico One Spot Quench Car at the Coke Oven Battery, Betz, Converse, Murdoch, Inc., Pittsburgh, PA,<br><br>January 1982. |

~~GCA~~ PACA

JANUARY 1982

# REPORT

AP-42 Section 12.2
Reference
Report Sect. 4
Reference 94

# Republic Steel Corporation

## Warren, Ohio

## Particulate Emission Evaluation of the No. 2 Envirotech/Chemico One Spot Quench Car at the Coke Oven Battery

BCM

**Betz·Converse·Murdoch·Inc.**
Consulting Engineers, Planners and Scientists

SOTDAT/STEEL LIBRARY SYSTEM

Report Title: See title page

Plant and Location: Republic Steel, ~~Youngstown~~ Warren, OH

SCC: 30300303

Testing Date(s): 10/20-22/81

By Whom: BCM

Stack Test Review Attached: No

Reviewed by:

Problems Seen by Reviewer:

Confidentiality Status: Not determined

If status is confidential, list confidential pages or sections:

Source of Determination of the Confidentiality Status:

Report Encoded by:

Date Encoded:

Form Numbers:

Comments:

# PARTICULATE EMISSION EVALUATION
# OF THE
# NO. 2 ENVIROTECH/CHEMICO ONE SPOT QUENCH CAR

AT THE

COKE OVEN BATTERY
OF
REPUBLIC STEEL CORPORATION
WARREN, OHIO

JANUARY 1982

BCM PROJECT NO. 00-4683-02

PREPARED BY

Robert Alfred
ROBERT ALFRED, SCIENTIST II

APPROVED BY

Peter R Charrington
PETER R. CHARRINGTON, P.E.
ASSISTANT VICE PRESIDENT

BETZ•CONVERSE•MURDOCH•INC.
5777 BAUM BOULEVARD
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# CONTENTS

TABLES

## 1.0 INTRODUCTION

Republic Steel Corporation (RSC) retained Betz•Converse•Murdoch•Inc. (BCM) to evaluate its No. 2 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 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 $CO_2$, $O_2$, CO and $N_2$ (by difference)
- Particulate emissions - grains/dry standard cubic feet (g/dscf), lbs/hr, and lbs/ton of coke pushed
- Opacity - % Opaque

## 3.0 PROCEDURES

### 3.1 Field Work

Field testing was conducted October 14 through October 22, 1981. The sampling team consisted of the following BCM personnel:

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

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. 2 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 ($O_2$) and carbon dioxide ($CO_2$) 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.

## 3.4 Calculations

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

## 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

PARTICULATE EMISSIONS RESULTS

| Run Number | Concentration (Grains/DSCF) | Emission Rate (Pounds/Hour) | Lbs/Ton of Coke Pushed* |
|---|---|---|---|
| 1 | .0147 | 10.78 | .0258 |
| 2 | .0152 | 11.92 | .0271 |
| 3 | .0141 | 10.80 | .0248 |
| | | | .0259 lbs/ton ave. |

* Based on 303.6 tons of coke pushed for each 24 oven test

## 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

## 5.1 Particulate Testing Results

The testing for the No. 2 Quench Car during the week of November 19, 1981 was performed with little or no difficulty. On November 21, 1981, three pushes totaling 65 seconds were abandoned during test No. 2. The hot coke began "sticking" in the ovens being pushed. The operator of the quench car who initiated the scrubbing cycle was unaware of the problem until the scrubber was eventually turned off. The scrubber was therefore only scrubbing clean air, so the cubic feet of gas samples and the sampling time for these three pushes were subtracted from the appropriate totals. If they were to be included in the calculations, the isokinetics would rise approximately one percent and the emission concentration would be artificially depressed.

Testing results indicated compliance with the allowable emission rate of 0.03 lb/ton of coke pushed.

## 5.2 Visible Emissions Procedures

The opacity for the No. 2 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, because the location of the observer with respect to the coke ovens precluded it. All operations were recorded by an EPA Certified Emissions 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.

# APPENDIX 1

# BCM PROPOSAL

Betz • Converse • Murdoch • Inc.

# PROPOSAL

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

## 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

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.

- EPA Method 5 sampling procedures will be followed for the particulate sampling with the following exceptions:

  (1) 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°C ± 5°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 $N_2$ 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.

## 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

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 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

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 | Limits of Liability |
|---|---|
| (a) Standard Worker's Compensation and Employer's Liability | Statutory |
| (b) General Liability | |
| Bodily Injury | $500,000 Each Occurrence and Aggregate |
| Property Damage | $500,000 Each Occurrence and Aggregate |
| (c) Automobile Liability | |
| Combined Single Limit (Bodily Injury and Property Damage) | $1,000,000 Each Occurrence |

## 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.

## PROJECT MANAGEMENT

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

:ion Manager - Air Quality

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

ject Engineer - Air Quality

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

## CLIENT RESPONSIBILITY

cessfully complete the field testing, it shall be the responsi- of Republic Steel to provide the following:

A plant liaison for the BCM field testing team during the field testing

Access to the sampling location

Electric power (110V and 20 amp service) to within 50' of the sampling location

All operating data of the coke oven battery during field testing

QUALIFICATIONS

M has performed over 40 tests on the ENVIROTECH/CHEMICO Quench Car ring the past two years. Provided below are the locations of the ojects with plant contacts and phone numbers which Republic should feel ee 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 Works

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

# APPENDIX 2

# FIELD SAMPLING PROGRAM

# 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.

### 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 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.

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°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

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.

Betz • Converse • Murdoch • Inc. BCM

# NOMOGRAPH DATA

PLANT Republic Steel Warren

DATE 9-28-81

SAMPLING LOCATION Q-CAR

| | | |
|---|---|---|
| CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. $H_2O$ | $\Delta H_@$ | 1.75 |
| AVERAGE METER TEMPERATURE (AMBIENT + 20°F), °F | $T_{m\ avg.}$ | 80 |
| PERCENT MOISTURE IN GAS STREAM BY VOLUME | $B_{wo}$ | 20 |
| BAROMETRIC PRESSURE AT METER, in. Hg | $P_m$ | |
| STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. $H_2O$) | $P_s$ | |
| RATIO OF STATIC PRESSURE TO METER PRESSURE | $P_s/P_m$ | |
| AVERAGE STACK TEMPERATURE, °F | $T_{s\ avg.}$ | 150 |
| AVERAGE VELOCITY HEAD, in. $H_2O$ | $\Delta p_{avg.}$ | .7 |
| MAXIMUM VELOCITY HEAD, in. $H_2O$ | $\Delta p_{max.}$ | 1.4 |
| C FACTOR | .7 | |
| CALCULATED NOZZLE DIAMETER, in. | .250 | |
| ACTUAL NOZZLE DIAMETER, in. | .203 | |
| REFERENCE $\Delta p$, in. $H_2O$ | 1.6 | |

# BCM

## FIELD DATA SHEET

PLANT Republic Steel
DATE 10-20-81
SAMPLING LOCATION Q-CAR-2
SAMPLE TYPE S
RUN NUMBER 1 OPERATOR BA
BAROMETRIC PRESSURE 29.2 STATIC PRESSURE -1.7
FILTER NUMBER(S)
GEL NUMBER(S)
THIMBLE NUMBER PLATE NUMBER
$H_2O$ PICKUP (ml) 140

ORSAT:
$CO_2$ .5
$O_2$ 17.5
CO

PYROMETER NUMBER Micromite
THERMOCOUPLE NUMBER 6
PROBE NUMBER 6 TYPE SS/GLASS
NOZZLE NUMBER 4 I.D. .263
METER BOX NUMBER 8 $\Delta H_@$ 1.77
PITOT NUMBER 6A $C_p$ .82
SAMPLE BOX NUMBER(S) 4
ASSUMED MOISTURE (%) 24
ASSUMED METER TEMPERATURE 80
C FACTOR REFERENCE $\Delta p$ 1.2

[illegible]

READ AND RECORD ALL DATA EVERY ____ MINUTES

| TRAVERSE POINT NUMBER | SAMPLING TIME, min | CLOCK TIME (24-hr CLOCK) | GAS METER READING ($V_m$), ft³ | VELOCITY HEAD ($\Delta p_s$), in. $H_2O$ | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in. $H_2O$ DESIRED | ACTUAL | STACK TEMPERATURE ($T_s$), °F | DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F | OUTLET ($T_{m\,out}$), °F | PUMP VACUUM, in. Hg | SAMPLE BOX TEMPERATURE, °F | IMPINGER TEMPERATURE, °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 35.56 | | | | | | | | | |
| D-6 | 52 | 932 | | .50 | .53 | .53 | | | | | | |
| | 66 | | 26.2 | .19 | .20 | .20 | 139 | 52 | 50 | 2 | 250 | 65 |
| D-5 | 47 | 935 | | .80 | .86 | .86 | | | | | | |
| | 58 | | 26.9 | .24 | .25 | .25 | 130 | 52 | 50 | 2 | 250 | 65 |
| D-4 | 5[illegible] | 941 | | 1.2 | 1.4 | 1.4 | | | | | | |
| | 64 | | 28.0 | .61 | .65 | .65 | 130 | 55 | 52 | 2 | 245 | 65 |
| D-3 | 51 | 956 | | 2.0 | 2.1 | 2.1 | | | | 5 | | |
| | 63 | | 29.2 | .95 | 1.0 | 1.0 | 135 | 60 | 58 | 5 | 260 | 66 |
| D-2 | 53 | 1005 | | 2.2 | 2.5 | | | | | 5 | | |
| | 61 | | 30.3 | .95 | 1.0 | 1.0 | 135 | 62 | 60 | | 260 | 66 |
| D-1 | 41 | 1015 | | 3.9 | 3.2 | 3.2 | | | | 8 | | |
| | 83 | | 32.0 | .95 | 1.0 | 1.0 | 136 | 62 | 60 | | 255 | 66 |
| C-6 | 42 | 1022 | - | 1.0 | 1.1 | 1.1 | | | | | | |
| | 62 | | 33.0 | .80 | .85 | .85 | 135 | 60 | 60 | 7 | 255 | 66 |

PLANT DATE 10/20 RUN NUMBER 1

| TRAVERSE POINT NUMBER | SAMPLING TIME, min | CLOCK TIME (24-hr CLOCK) | GAS METER READING ($V_m$), $ft^3$ | VELOCITY HEAD ($\Delta p_s$), in. $H_2O$ | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in. $H_2O$ DESIRED | ACTUAL | STACK TEMPERATURE ($T_s$), °F | DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F | OUTLET ($T_{m\,out}$), °F | PUMP VACUUM, in Hg | SAMPLE BOX TEMPERATURE, °F | IMPINGER TEMPERATURE, °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-5 | 45 | 1110 | | 1.9 | 2.1 | 2.1 | | | | | 250 | 66 |
| | 33 | | 34.1 | 1.1 | 1.3 | 1.3 | 127 | 60 | 60 | 8 | | |
| C-4 | 50 | 1119 | | 3.5 | 3.7 | 3.7 | | | | | | |
| | 65 | | 35.9 | 1.6 | 1.7 | 1.7 | 147 | 60 | 60 | 10 | 245 | 66 |
| C-3 | 50 | 1127 | | 3.4 | 3.8 | 3.8 | | | | | | |
| | 66 | | 37.8 | 1.7 | 1.9 | 1.9 | 140 | 61 | 60 | 11 | 260 | 66 |
| C-2 | 31 | | 38.1 | | ABANDON | | PUSH | | | | | |
| | 48 | 1136 | | 3.4 | 3.8 | 3.8 | | | | | | |
| | 35 | | 39.3 | 1.8 | 2.0 | 2.0 | 146 | 61 | 60 | 11 | 265 | 68 |
| C-1 | | 1145 | | | | | | | | | | |
| | 48 | | | 3.8 | 4.0 | 4.0 | | | | | | |
| | 74 | | 41.1 | 1.8 | 2.0 | 2.0 | 144 | 62 | 61 | 11 | 265 | 70 |
| | | 1200 | | | | | | | | | | |
| B-6 | 47 | | | 1.3 | 1.4 | 1.4 | | | | | | |
| | 61 | | 42.1 | .45 | .47 | .47 | 168 | 63 | 62 | 7 | 250 | 70 |
| B-5 | 49 | 1223 | | .94 | .99 | .99 | | | | | | |
| | 47 | | 42.9 | .42 | .44 | .44 | 164 | 64 | 62 | 4 | 265 | 72 |
| B-4 | 47 | 1236 | | 2.6 | 2.9 | 2.9 | | | | | | |
| | 79 | | 44.3 | .72 | .76 | .76 | 150 | 64 | 62 | 5 | 260 | 70 |
| B-3 | 43 | 1240 | | 2.7 | 3.0 | 3.0 | | | | | | |
| | 56 | | 45.5 | 1.0 | 1.1 | 1.1 | 155 | 65 | 63 | 7 | 255 | 69 |
| B-2 | 43 | 1250 | | 2.8 | 3.0 | 3.0 | | | | | | |
| | 46 | | 46.8 | 1.4 | 1.5 | 1.5 | 161 | 65 | 63 | 9 | 255 | 69 |
| B-1 | 46 | 103 | | 3.7 | 4.0 | 4.0 | | | | | | |
| | 56 | | 48.3 | 1.6 | 1.7 | 1.7 | 153 | 65 | 63 | 10 | 265 | 69 |

PLANT DATE 10/20 RUN NUMBER 1

| TRAVERSE POINT NUMBER | SAMPLING TIME, min | CLOCK TIME (24-hr CLOCK) | GAS METER READING ($V_m$), ft$^3$ | VELOCITY HEAD ($\Delta p_s$), in. $H_2O$ | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in. $H_2O$ DESIRED | ACTUAL | STACK TEMPERATURE ($T_s$), °F | DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F | OUTLET ($T_{m_{out}}$), °F | PUMP VACUUM, in Hg | SAMPLE BOX TEMPERATURE, °F | IMPINGER TEMPERATURE, °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A-6 | | 39 | 48.0 | 42 | .44 | Abandon | | Purge | | 2 | | |
| | 45 | 115 | | .42 | .44 | .44 | | 68 | 67 | | 250 | 78 |
| | 54 | | 49.1 | .18 | .19 | .19 | 164 | | | | | |
| A-5 | | | | | | | | | | | | |
| | 44 | 130 | | .55 | .58 | .58 | | | | 2 | | |
| | 78 | | 49.8 | .18 | .19 | .19 | 164 | 68 | 67 | | 250 | 70 |
| A-4 | 45 | 133 | | .66 | .70 | .70 | | | | 3 | | |
| | 73 | | 50.5 | .26 | .27 | .27 | 170 | 68 | 67 | | 255 | 70 |
| A-3 | 48 | 147 | | .94 | 1.0 | 1.0 | | | | 3 | | |
| | 55 | | 51.3 | .36 | .37 | .37 | 160 | 68 | 67 | | 250 | 70 |
| A-2 | 43 | 156 | | 1.1 | 1.2 | 1.2 | | | | 3 | | |
| | 64 | | 52.2 | .49 | .52 | .52 | 160 | 69 | 67 | | 250 | 70 |
| A-1 | 47 | 211 | | 2.1 | 2.2 | 2.2 | | | | | | |
| | 69 | | 53.45 | .56 | .59 | .59 | 151 | 69 | 67 | 3 | 250 | 70 |
| | 43.63min | 2618 | | | | | | | | | | |
| | | | 22.89 | 1.06 | 1.42 | | 148 | 62.6 | 61.2 | | | |
| | | | | | | | | 61.8 | | | | |
| | Leak Check | | [illegible] cfm At 10"Hg | | | | | | | | | |

BCM

# FIELD DATA SHEET

PLANT Republic Steel
DATE 10-21-81
SAMPLING LOCATION Q-CAR
SAMPLE TYPE 5
RUN NUMBER 2 OPERATOR BA
BAROMETRIC PRESSURE ____ STATIC PRESSURE -1.7
FILTER NUMBER(S) A-5
GEL NUMBER(S) ____
THIMBLE NUMBER — PLATE NUMBER —
$H_2O$ PICKUP (ml) 130

ORSAT:
$CO_2$ 5
$O_2$ 15.5
CO ____

PYROMETER NUMBER Micromite
THERMOCOUPLE NUMBER 6
PROBE NUMBER 6 TYPE SS/Glass
NOZZLE NUMBER 4 I.D. .203
METER BOX NUMBER 8 $\Delta H_@$ 1.77
PITOT NUMBER 6A $C_p$ .82
SAMPLE BOX NUMBER(S) 4 -
ASSUMED MOISTURE (%) 24
ASSUMED METER TEMPERATURE 90
C FACTOR ____ REFERENCE $\Delta p$ 1.7

READ AND RECORD ALL DATA EVERY ____ MINUTES

Leak Check .03 cfm at 15"Hg

| TRAVERSE POINT NUMBER | SAMPLING TIME, min | CLOCK TIME (24-hr CLOCK) | GAS METER READING ($V_m$), ft$^3$ | VELOCITY HEAD ($\Delta p_s$), in. $H_2O$ | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in. $H_2O$ DESIRED | ACTUAL | STACK TEMPERATURE ($T_s$), °F | DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F | OUTLET ($T_{m\,out}$), °F | PUMP VACUUM, in. Hg | SAMPLE BOX TEMPERATURE, °F | IMPINGER TEMPERATURE, °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 54.18 | | | | | | | | | |
| A-6 | 43 | 837 | | .34 | .40 | .40 | | | | | | |
| | .57 | | 54.6 | .19 | .20 | .20 | 141 | 60 | 60 | 2 | 245 | 68 |
| | 14 | | 54.7 | abandon | [illegible] | | | | | | | |
| A-5 | 44 | 850 | | .24 | .25 | | | | | | | |
| | 56 | | 55.2 | .19 | .20 | | 140 | 62 | 62 | 3 | 250 | 68 |
| A-4 | 48 | 901 | | .76 | .82 | .82 | | | | | | |
| | 72 | | 56.1 | .38 | .39 | .39 | 138 | 64 | 63 | 3 | 250 | 70 |
| A-3 | 43 | 912 | | .95 | 1.0 | 1.0 | | | | | | |
| | 59 | | 56.9 | .61 | .65 | .65 | 137 | 66 | 64 | 3 | 255 | 68 |
| A-2 | 47 | 917 | | .75 | .82 | .82 | | | | | | |
| | .51 | | 57.6 | .43 | .45 | .45 | 137 | 68 | 66 | 3 | 255 | 68 |
| A-1 | 47 | 937 | | 2.2 | 2.4 | 2.4 | | | | | | |
| | 70 | | 58.9 | .70 | .75 | .75 | 151 | 68 | 66 | 4 | 260 | 69 |
| B-6 | 44 | 952 | | .80 | .85 | .85 | | | | | | |
| | .55 | | 59.7 | .52 | .55 | .55 | 135 | 69 | 66 | 3 | 260 | 69 |

PLANT DATE 10/21 RUN NUMBER 2

| TRAVERSE POINT NUMBER | SAMPLING TIME min | CLOCK TIME (24 hr CLOCK) | GAS METER READING ($V_m$), $ft^3$ | VELOCITY HEAD ($\Delta p_s$), in $H_2O$ | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in. $H_2O$ DESIRED | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in. $H_2O$ ACTUAL | STACK TEMPERATURE ($T_s$), °F | DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F | DRY GAS METER TEMPERATURE OUTLET ($T_{m\,out}$), °F | PUMP VACUUM, in Hg | SAMPLE BOX TEMPERATURE, °F | IMPINGER TEMPERATURE, °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-5 | 47 | 1003 | | 2.5 | 3.2 | .82 | | | | | | |
| | 55 | | 60.5 | .44 | .45 | .45 | 132 | 70 | 69 | 2 | 250 | 70 |
| B-4 | 46 | 1016 | | 1.7 | 1.8 | 1.8 | | | | | | |
| | 74 | | 61.7 | .68 | .72 | .72 | 134 | 70 | 69 | 5 | 245 | 70 |
| | 78 | | 62.10 | ABANDON PORT | | | | | | | | |
| B-3 | 55 | 1036 | | 3.3 | 3.5 | 3.5 | | | | | | |
| | 47 | | 63.2 | .66 | .70 | .70 | 131 | 70 | 69 | 7 | 250 | 70 |
| B-2 | 48 | 1106 | | 2.4 | 2.5 | 2.5 | | | | | | |
| | 45 | | 64.3 | .84 | .94 | .94 | 124 | 66 | 65 | 7 | 258 | 65 |
| B-1 | 58 | 1118 | | 3.8 | 4.1 | 4.1 | | | | | | |
| | 67 | | 66.2 | 1.6 | 1.7 | 1.7 | 124 | 67 | 65 | 9 | 220 | 65 |
| C-6 | 46 | 1129 | | 2.0 | 2.1 | 2.1 | | | | | | |
| | 61 | | 67.4 | .79 | .83 | .83 | 125 | 68 | 68 | 8 | 260 | 65 |
| B-5 | 46 | 1142 | | 2.2 | 2.4 | 2.4 | | | | | | |
| | 52 | | 68.5 | 1.0 | 1.1 | 1.1 | 133 | 70 | 65 | 6 | 255 | 70 |
| B-4 | 45 | 1152 | | 3.0 | 3.2 | 3.2 | | | | | | |
| | 70 | | 70.1 | 1.4 | 1.5 | 1.5 | 126 | 74 | 72 | 9 | 250 | 65 |
| C-3 | 48 | 1200 | | 3.6 | 3.9 | 3.9 | | | | | | |
| | 57 | | 71.6 | 1.6 | 1.7 | 1.7 | 120 | 74 | 72 | 9 | 250 | 65 |
| C-2 | 49 | 1211 | | 3.9 | 4.1 | 4.1 | | | | | | |
| | 41 | | 73.0 | 1.4 | 1.5 | 1.5 | 126 | 78 | 76 | 9 | 255 | 69 |
| C-1 | 48 | 1224 | | 3.9 | 4.2 | 4.2 | | | | | | |
| | 67 | | 74.8 | 1.7 | 1.8 | 1.8 | 126 | 80 | 77 | 9 | 250 | 65 |

PLANT DATE 10/22 RUN NUMBER 2

| TRAVERSE POINT NUMBER | SAMPLING TIME, min | CLOCK TIME (24 hr CLOCK) | GAS METER READING ($V_m$), $ft^3$ | VELOCITY HEAD ($\Delta p_s$), in. $H_2O$ | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in. $H_2O$ DESIRED | ACTUAL | STACK TEMPERATURE ($T_s$), °F | DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F | OUTLET ($T_{m\,out}$), °F | PUMP VACUUM, in Hg | SAMPLE BOX TEMPERATURE, °F | IMPINGER TEMPERATURE, °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 18 sec | 74.9 BArom | | | | | | | | | |
| | | | S:20D | | | | | | | | | |
| D-6 | 39 | 1335 | | .32 | .34 | .34 | | | | | | |
| | 57 | | 75.3 | .15 | .16 | .16 | 110 | 79 | 76 | 2 | 255 | 68 |
| D-5 | 44 | 1246 | 7 | .95 | 1.0 | 1.0 | | | | | | |
| | 50 | | 76.0 | .27 | .28 | .28 | 110 | 79 | 76 | 3 | 260 | 67 |
| D-4 | 48 | 1256 | | 1.5 | 1.6 | 1.6 | | | | | | |
| | 58 | | 77.1 | .62 | .65 | .65 | 122 | 80 | 79 | 3 | 250 | 68 |
| D-3 | 49 | 1304 | | 1.7 | 1.8 | 1.8 | | | | | | |
| | 48 | | 78.1 | .82 | .87 | .87 | 133 | 80 | 80 | 5 | 255 | 68 |
| D-2 | 49 | 1313 | | 1.9 | 2.1 | 2.1 | | | | | | |
| | 34 | | 79.1 | .95 | 1.0 | 1.0 | 133 | 80 | 80 | 5 | 260 | 67 |
| D-1 | 50 | 1322 | | 2.5 | 2.7 | 2.7 | | | | | | |
| | 57 | | 80.36 | .90 | .95 | .95 | 133 | 80 | 80 | 6 | 255 | 68 |
| | 2493/41.53 | | 26.18/25.58 | | | | 130.2 | 71.8 | 70.2 | | | |
| | | | | | | | | 71.0 | | | | |
| | Leak Check | | L.01 cfm at [illegible] | | | | | | | | | |

BCM

# FIELD DATA SHEET

PLANT Republic Steel/ Warren

DATE 10-22-81

SAMPLING LOCATION O-CAR 2

SAMPLE TYPE 5

RUN NUMBER 3 OPERATOR BD

BAROMETRIC PRESSURE 29.2 STATIC PRESSURE

FILTER NUMBER(S) E6

GEL NUMBER(S)

THIMBLE NUMBER PLATE NUMBER

$H_2O$ PICKUP (ml) 140

ORSAT:

$CO_2$ 1.0

$O_2$ 18.0

CO

PYROMETER NUMBER Micromite

THERMOCOUPLE NUMBER 6

PROBE NUMBER 6 TYPE SS/Glass

NOZZLE NUMBER 3 I.D. .203

METER BOX NUMBER 8 $\Delta H_@$ 1.77

PITOT NUMBER 6A $c_p$ .82

SAMPLE BOX NUMBER(S) 4

ASSUMED MOISTURE (%) 24

ASSUMED METER TEMPERATURE 80

C FACTOR REFERENCE $\Delta p$ 1.2

READ AND RECORD ALL DATA EVERY ___ MINUTES

Leak Check .003 cfm at 15" Hg

| TRAVERSE POINT NUMBER | SAMPLING TIME, min | CLOCK TIME (24-hr CLOCK) | GAS METER READING ($V_m$), $ft^3$ | VELOCITY HEAD ($\Delta p_s$), in. $H_2O$ | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in. $H_2O$ DESIRED | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in. $H_2O$ ACTUAL | STACK TEMPERATURE ($T_s$), °F | DRY GAS METER TEMPERATURE INLET ($T_{m\ in}$), °F | DRY GAS METER TEMPERATURE OUTLET ($T_{m\ out}$), °F | PUMP VACUUM, in. Hg | SAMPLE BOX TEMPERATURE, °F | IMPINGER TEMPERATURE, °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 80.67 | | | | | | | | | |
| D-6 | 43 | | | 1.35 | .32 | .32 | | | | | | |
| | .56 | | 81.16 | .19 | .20 | .20 | 132 | 62 | 60 | 2 | 260 | 65 |
| D-5 | 40 | 805 | | .65 | .69 | .69 | | | | | | |
| | 48 | | 81.72 | .28 | .29 | .29 | 132 | 62 | 60 | 2 | 255 | 65 |
| D-4 | 49 | 822 | | .85 | .92 | .93 | | | | | | |
| | 66 | | 82.64 | .57 | .59 | .59 | 133 | 62 | 60 | 2 | 255 | 65 |
| D-3 | 50 | 832 | | 1.5 | 1.6 | 1.6 | | | | | | |
| | 51 | | 83.76 | .95 | 1.0 | 1.0 | 130 | 62 | 60 | 4 | 250 | 66 |
| B-2 | 45 | 843 | | 2.4 | 2.5 | 2.5 | | | | | | |
| | 44 | | 84.85 | 1.1 | 1.2 | 1.2 | 135 | 62 | 60 | 5 | 255 | 66 |
| D-1 | 44 | 853 | | 3.1 | 3.3 | 3.3 | | | | | | |
| | 53 | | 86.13 | 1.0 | 1.1 | 1.1 | 133 | 62 | 60 | 8 | 250 | 60 |
| C-6 | 49 | 907 | | 1.5 | 1.6 | 1.6 | | | | | | |
| | 43 | | 87.15 | .95 | 1.0 | 1.0 | 152 | 63 | 61 | | 245 | 64 |

PLANT DATE 10/32 RUN NUMBER 3

| TRAVERSE POINT NUMBER | SAMPLING TIME, min | CLOCK TIME (24 hr CLOCK) | GAS METER READING $(V_m)$, $ft^3$ | VELOCITY HEAD $(\Delta p_s)$, in. $H_2O$ | ORIFICE PRESSURE DIFFERENTIAL $(\Delta H)$, in. $H_2O$ DESIRED | ACTUAL | STACK TEMPERATURE $(T_s)$, °F | DRY GAS METER TEMPERATURE INLET $(T_{m\,in})$, °F | OUTLET $(T_{m\,out})$, °F | PUMP VACUUM, in Hg | SAMPLE BOX TEMPERATURE, °F | IMPINGER TEMPERATURE, °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50 | | | 3.0 | 2.1 | 2.1 | | | | | | |
| C-5 | 43 | 918 | 88.30 | 1.1 | 1.2 | 1.2 | 134 | 64 | 62 | 6 | 245 | 65 |
| C-4 | 48 | 931 | | 2.9 | 3.0 | 3.0 | | | | | | |
| | 71 | | 87.85 | 1.4 | 1.5 | 1.5 | 134 | 66 | 63 | 9 | 250 | 65 |
| C-3 | 49 | 942 | | 3.1 | 3.4 | 3.4 | | | | | | |
| | 55 | | 91.40 | 1.7 | 1.8 | 1.8 | 137 | 66 | 63 | 8 | 245 | 65 |
| C-2 | 49 | 952 | | 3.3 | 3.5 | 3.5 | | | | | | |
| | 41 | | 92.81 | 2.6 | 2.6 | 2.6 | 134 | 66 | 63 | 10 | 250 | 66 |
| C-1 | 48 | 1001 | | 3.7 | 3.9 | 3.9 | | | | | | |
| | 67 | | 94.53 | 1.6 | 1.7 | 1.7 | 131 | 66 | 63 | 12 | 250 | 66 |
| B-6 | 41 | 1113 | | .95 | 1.0 | 1.0 | | | | | | |
| | 58 | | 95.38 | .59 | .61 | .61 | 130 | 68 | 66 | 4 | 250 | 67 |
| B-5 | 40 | 1120 | | .72 | .78 | .78 | | | | | | |
| | 44 | | 96.06 | .48 | .50 | .50 | 137 | 68 | 66 | 3 | 255 | 67 |
| B-4 | 45 | 1133 | | 2.1 | 2.2 | 2.2 | | | | | | |
| | 63 | | 97.24 | .76 | .80 | .80 | 140 | 70 | 68 | 6 | 253 | 67 |
| D-3 | 48 | 1143 | | 2.5 | 2.7 | 2.7 | | | | | | |
| | 47 | | 98.39 | 1.1 | 1.2 | 1.2 | 137 | 71 | 69 | 6 | 250 | 68 |
| B-2 | 45 | 1156 | | 2.9 | 3.1 | 3.1 | | | | | | |
| | 64 | | 99.71 | .95 | 1.0 | 1.0 | 137 | 72 | 70 | 7 | 260 | 65 |
| B-1 | 48 | 1206 | | 3.8 | 3.8 | 3.8 | | | | | | |
| | 66 | | 101.36 | 1.4 | 1.5 | 1.5 | 138 | 72 | 70 | 10 | 250 | 65 |
| A-6 | 45 | 1214 | | .41 | .43 | .43 | | | | | | |
| | 63 | | 101.92 | .19 | .20 | .26 | 137 | 72 | 70 | 2 | 250 | 68 |

PLANT DATE 10/22 RUN NUMBER 3

| TRAVERSE POINT NUMBER | SAMPLING TIME, min | CLOCK TIME (24 hr CLOCK) | GAS METER READING ($V_m$), $ft^3$ | VELOCITY HEAD ($\Delta p_s$), in. $H_2O$ | ORIFICE PRESSURE DIFFERENTIAL ($\Delta H$), in. $H_2O$ DESIRED | ACTUAL | STACK TEMPERATURE ($T_s$), °F | DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F | OUTLET ($T_{m\,out}$), °F | PUMP VACUUM, in Hg | SAMPLE BOX TEMPERATURE, °F | IMPINGER TEMPERATURE, °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A-5 | 44 | 1225 | | .55 | .58 | .58 | | | | | | |
| | 89 | | 102.57 | .14 | .15 | .15 | 136 | 72 | 70 | 3 | 245 | 68 |
| A-4 | 47 | 1237 | | .55 | .58 | .58 | | | | | | |
| | 73 | | 103.21 | .14 | .15 | .15 | 137 | 72 | 70 | 3 | 250 | 68 |
| A-3 | 44 | 1250 | | .95 | 1.0 | 1.0 | | | | | | |
| | 60 | | 103.98 | .34 | .35 | .35 | 142 | 74 | 72 | 3 | 250 | 68 |
| A-2 | 44 | 1301 | | .95 | 1.0 | 1.0 | | ~~74~~ | | | | |
| | 86 | | 105.63 | .58 | .60 | .60 | 137 | 74 | 72 | 4 | 250 | 68 |
| A-1 | 44 | 1310 | | 2.3 | 2.4 | 2.4 | | | | | | |
| | 60 | | 106.17 | .68 | .70 | .70 | 135 | 74 | 72 | 7 | 250 | 68 |
| | 2510/ | | | | | | | | | | | |
| | 41.83 | | 25.5 | | | | 135.8 | 67.6 | 65.4 | | | |
| | | | | | | | | 66.5 | | | | |
| | Leak Check | | <.01 cfm AT 10" Hg | | | | | | | | | |

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Consulting Engineers, Planners and Architects

Date 10/20/81 - RUN 1  Location Name REPUBLIC STEEL

Observer DANIEL PETRQUAY  Address WARREN OHIO

Observation Point COKE OVEN TO WEST OF OBSERVER  Weather 50% CLOUD COVER

Oven Distance From 20 YDS  Height 25'

Wind Speed 10-20 MPH  Direction S-SW

Observation Began 9:02  Ended 11:12

Type of Installation Q-CAR

TEST #1  CAR #2

| Time of Quench | Push | Oven | Seconds ≥30% Opacity Per Push | Seconds ≥30% Opacity Per Push | Seconds ≥ % Opacity Per Push | Maximum Opacity | Remarks |
|---|---|---|---|---|---|---|---|
| 9:02:46 903 02 | 1 | A-17 | 0% TO 20% | 2 SEC | | 20% | NO TEST |
| 9:22:51 9:23 43 | 2 | B-17 | 0% TO 5% | | | 5% | |
| 9:36 10 9:36 50 | 3 | C-17 | 0% TO 10% | | | 10% | |
| 9:48:17 9:49 00 | 4 | A-19 | 0% TO 5% | | | 5% | |
| 9:57:14 9:58:05 | 5 | B-19 | 0% TO 10% | | | 10% | |
| 10:26 03 10:26:55 | 6 | C-19 | 0% TO 15% | | | 15% | SMOKE FROM WHARF INTERFERENCE WITH READING |
| 10:15 29 10:16:14 | 7 | A-21 | — | — | | — | |
| 10:28 34 10:29 30 | 8 | B-21 | 0% TO 10% | | | 10% | |
| 11:10 33 11:11 20 | 9 | C-21 | 0% TO 15% | | | 15% | SMOKE FROM WHARF INTERFERENCE WHILE READING |
| 11:20 04 11:20 44 | 10 | A-23 | — | — | | — | |

Comments: SUN DIRECTLY IN OBSERVERS EYES

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Consulting Engineers, Planners and Architects

10/20/81 TEST #1 CAR #2

| Time of Quench | Push | Oven | Seconds 0 ≥ 30 % Opacity Per Push | Seconds ≥ 30 % Opacity Per Push | Seconds ≥ % Opacity Per Push | Maximum Opacity | Remarks |
|---|---|---|---|---|---|---|---|
| 11:23 33<br>11:29 27 | 11 | B-23 | 0% To 20% | 3 SEC. | | 20% | |
| 11:37 51<br>11:39 27 | 12 | C-23 | 0% To 25% | 8 SEC | | 25% | LONG PUSH |
| 11:54.19<br>11:55 44 | 13 | A-25 | 0% To 20% | 5 SEC. | | 20% | |
| 12:06 13<br>12:06 55 | 14 | B-25 | 0% To 20% | 2 SEC. | | 20% | |
| 12:23 34<br>12 24 30 | 15 | C-25 | 0% TO 25% | 6 SEC. | | 25% | INTERFERENCE FROM SMOKE ON WHARF |
| 12:32 35<br>12:33 17 | 16 | A-27 | — | — | | — | INTERFERENCE FROM SMOKE ON WHARF |
| 12 41 54<br>12 42 16 | 17 | B-27 | — | — | | | |
| 12:50 34<br>12:51 48 | 18 | C-27 | 0% To 25% | 8 Sec. | | 25% | |
| 13:04.11<br>13:05 20 | 19 | A-29 | 0% To 20% | 7 SEC. | | 20% | HARD PUSH |
| 13:14.36<br>13:17 07 | 20 | B-29 | 0% To 15% | | | 15% | |
| 13:30 20<br>13:31 04 | 21 | A-2 | 0% To 20% | 3 SEC. | — | 20% | |
| 13 39 20<br>13 40 08 | 22 | B-2 | 0% To 20% | 6 SEC. | | 20% | |
| 13 48 12<br>13 49.16 | 23 | C-2 | 0% To 20% | 6 SEC. | | 20% | |
| 13:57 18<br>13 58 12 | 24 | A-4 | 0% To 20% | 3 sec. | | 20% | |
| 14:12 04<br>14:12 56 | 25 | B-4 | 0% To 20% | 4 SEC | | 20% | |

Comments:

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TEST #2 CAR #2

Date 10/21/81 Location Name REPUBLIC STEEL

Observer DANIEL PETROLAY Address WARREN OHIO

Observation Point WEST OF COKE OVENS Weather 10% CLOUD COVER

Oven Distance From 20 YDS Height 25'

Wind Speed 5-10 MPH Direction SW

Observation Began 8:36 Ended

Type of Installation O-CAR

| Time of Quench | Push | Oven | Seconds 0 ≥ 30 % Opacity Per Push | Seconds ≥ % Opacity Per Push | Seconds ≥ 20 % Opacity Per Push | Maximum Opacity | Remarks |
|---|---|---|---|---|---|---|---|
| 8:26:44<br>8:31:58 | 1 | B-4 | 0% TO 10% | | | 10% | |
| 8:47:37<br>8:50:45 | 2 | C-4 | 0% TO 5% | | | 5% | PUSH PROBLEMS |
| 9:00:03<br>9:02:45 | 3 | A-6 | 0% TO 15% | | | 15% | |
| 9:15:42<br>9:14:21 | 4 | B-6 | 0% TO 10% | | | 10% | |
| 9:25:34<br>9:26:14 | 5 | C-6 | 0% TO 5% | | | 5% | |
| 9:28:55<br>9:28:58 | 6 | A-8 | 0% TO 90% | | 16 SEC | 90% | |
| 9:52:12<br>9:53:03 | 7 | B-8 | 0% TO 10% | | | 10% | |
| 10:04:00<br>10:07:44 | 8 | C-8 | 0% TO 10% | | | 10% | |
| 10:17:09<br>10:18:20 | 9 | A-10 | 0% TO 20% | | 5 SEC | 20% | |
| 10:27:09<br>10:27:42 | 10 | B-10 | 0% TO 20% | | 2 SEC | 20% | SCRUBBER ON 15 SEC<br>NO COKE HARD PUSH |
| 11:37:21<br>11:38:21 | 11 | C-10 | 0% TO 10% | | | 10% | |

Comments:

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Consulting Engineers, Planners and Architects

TEST #2 CAR #2 10/21/81

| Time of Quench | Push | Oven | Seconds 0≥30% Opacity Per Push | Seconds ≥ % Opacity Per Push | Seconds ≥30% Opacity Per Push | Maximum Opacity | Remarks |
|---|---|---|---|---|---|---|---|
| 11:18:20<br>11:19:20 | 12 | A-12 | 0% TO 20% | | 4 SEC. | 20% | |
| 11:30:01<br>11:30:48 | 13 | B-12 | 0% TO 15% | | | 15% | |
| 11:43:00<br>11:45:47 | 14 | C-12 | 0% TO 5% | | | 5% | |
| 11:52:44<br>11:53:28 | 15 | A-14 | — | | — | — | INTERFERENCE FROM SMOKE ON WHARF |
| 12:02:39<br>12:03:11 | 16 | B-14 | — | | — | — | INTERFERENCE FROM SMOKE ON WHARF |
| 12:11:50<br>12:12:20 | 17 | C-14 | 0% TO 20% | | 1 SEC. | 20% | |
| 12:24:40<br>12:25:23 | 18 | A-16 | 0% TO 10% | | | 10% | |
| 12:33:36<br>12:34:01 | 19 | B-16 | 0% TO 20% | | 2 SEC. | 20% | PUSH RAM STUCK |
| 12:35:30<br>12:36:20 | | | | | 2 SEC. | 20% | |
| 12:46:29<br>12:47:11 | 20 | C-16 | 0% TO 20% | | | | |
| 12:56:42<br>12:57:29 | 21 | A-18 | 0% TO 5% | | | 5% | |
| 13:05:01<br>13:05:47 | 22 | B-18 | — | | — | — | INTERFERENCE FROM SMOKE ON WHARF |
| 13:13:48<br>13:14:35 | 23 | C-18 | 0% TO 20% | | 5 SEC. | 20% | |
| 13:22:38<br>13:23:27 | 24 | A-20 | 0% TO 20% | | 2 SEC. | 20% | |

Comments:

# Betz · Converse · Murdoch · Inc. BCM

Consulting Engineers, Planners and Architects


Date 10/22/81 Location Name REPUBLIC STEEL

Observer DANIEL PETRCCAY Address WARREN, OHIO

Observation Point WEST OF COKE OVENS Weather 100% CLOUD COVER

Oven Distance From 25 YDS. Height 30' WhiTE/GRAY CLOUDS

Wind Speed [redacted] 5-10 MPH Direction E.S.E

Observation Began 07:53 Ended

Type of Installation Q-CAR

TEST NO #3 CAR #2

| Time of Quench | Push | Oven | Seconds C ≥30% Opacity Per Push | Seconds ≥ % Opacity Per Push | Seconds ≥30% Opacity Per Push | Maximum Opacity | Remarks |
|---|---|---|---|---|---|---|---|
| 7:53.28 7:54.22 | 1 | B-18 | 0% TO 10% | | | 10% | |
| 8:06.01 8:06.47 | 2 | C-18 | 0% TO 20% | | 8 SEC | 20% | |
| 8:22.17 8:23.06 | 3 | A-20 | 0% TO 20% | | 3 SEC | 20% | |
| 8:32.56 8:33.39 | 4 | B-20 | 0% TO 15% | | | 15% | |
| 8:43.26 8:44.22 | 5 | C-20 | 0% TO 25% | | 13 SEC | 25% | |
| 8:54.25 8:55.50 | 6 | A-22 | — | | — | — | INTERFERENCE FROM SMOKE ON WHARF |
| 9:07.52 9:08.43 | 7 | B-22 | 0% TO 20% | | 4 SEC | 20% | |
| 9:19.46 9:20.35 | 8 | C-22 | 0% TO 20% | | 6 SEC | 20% | INTERFERENCE FROM SMOKE ON WHARF |
| 9:31.25 9:32.19 | 9 | A-24 | — | | — | — | |
| 9:42.55 9:43.40 | 10 | B-24 | 0% TO 20% | | 3 SEC. | 20% | |
| 9:52.55 9:53.45 | 11 | C-24 | 0% TO 20% | | 6 SEC | 20% | |

Comments:

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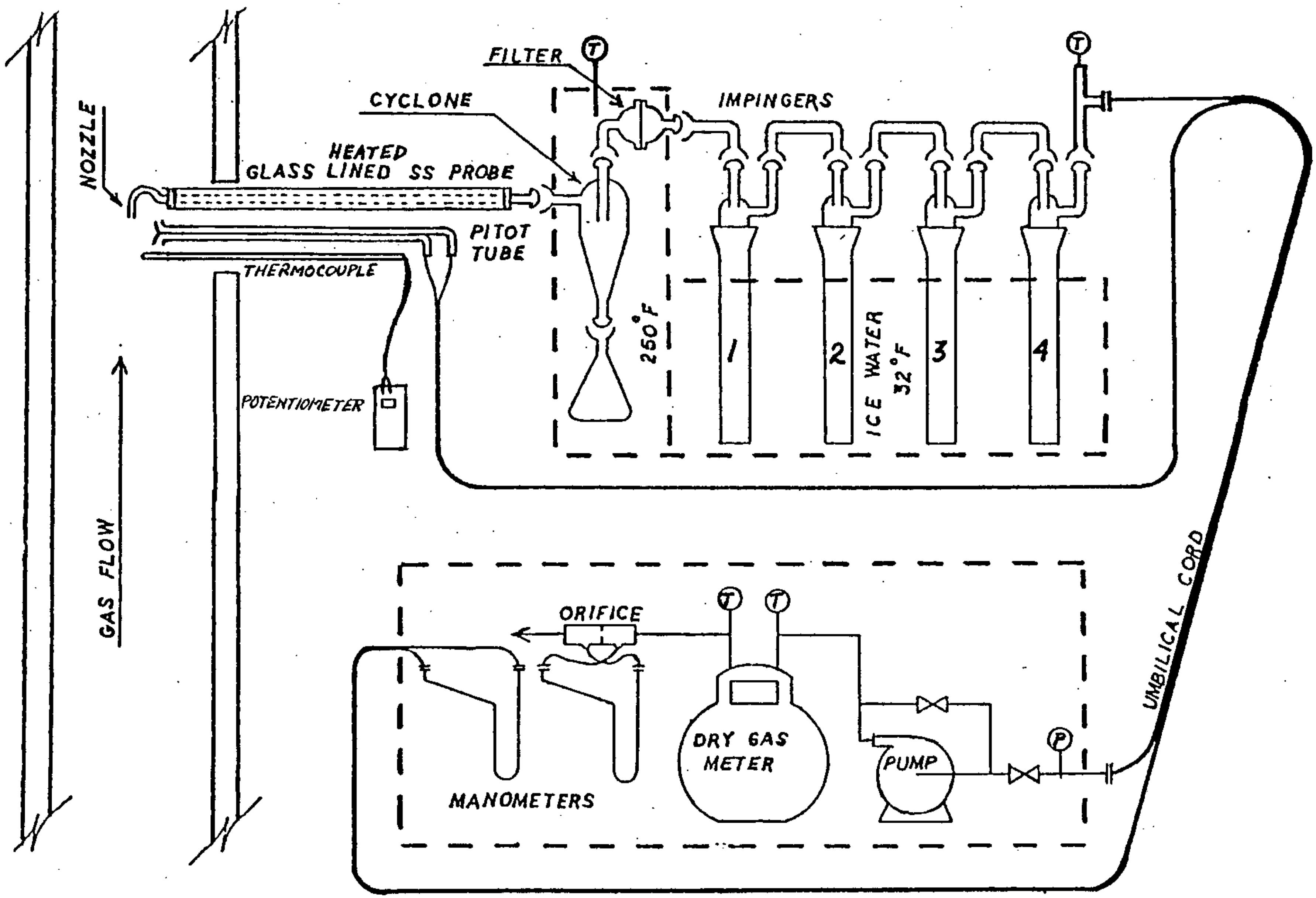
Consulting Engineers, Planners and Architects

| Time of Quench | Push | Oven | Seconds 0 ≥ 30 % Opacity Per Push | Seconds ≥ % Opacity Per Push | Seconds ≥ 30 % Opacity Per Push | Maximum Opacity | Remarks |
|---|---|---|---|---|---|---|---|
| 10:04:22<br>10:05:[illegible] | 12 | A-26 | 0% TO 15% | | | 15% | |
| 11:14:00<br>11:14:45 | 13 | B-26 | 0% TO 10% | | | 10% | |
| 11:23:45<br>11:32:55 | 14 | C-26 | 0% TO 10% | | | 10% | |
| 11:33:33<br>11:34:17 | 15 | A-28 | 0% TO 15% | | | 15% | |
| 11:43:16<br>11:43:55 | 16 | B-28 | 0% TO 10% | | | 10% | |
| 11:57:00<br>11:57:41 | 17 | A-1 | 0% TO 10% | | | 10% | |
| 12:05:12<br>12:06:59 | 18 | B-1 | 0% TO 20% | | 1 SEC | 20% | |
| 12:14:42<br>12:15:24 | 19 | C-1 | 0% TO 10% | | | 10% | |
| 12:25:47<br>12:26:22 | 20 | A-3 | 0% TO 10% | | | 10% | |
| 12:38:06<br>12:38:52 | 21 | B-3 | 0% TO 5% | | | 5% | |
| 12:50:34<br>12:51:10 | 22 | C-3 | 0% TO 5% | | | 5% | |
| 13:01:25<br>13:02:14 | 23 | A-5 | 0% TO 10% | | | 10% | |
| 13:10:24<br>13:11:11 | 24 | B-5 | 0% TO 5% | | | 5% | |

Comments: TEST #3 Q-CAR #2 10/22/81


FILTER
CYCLONE
IMPINGERS
NOZZLE
HEATED
GLASS LINED SS PROBE
PITOT
TUBE
THERMOCOUPLE
POTENTIOMETER
250°F
1
2
3
4
ICE WATER
32°F
GAS FLOW
UMBILICAL CORD
ORIFICE
DRY GAS
METER
PUMP
MANOMETERS

# APPENDIX 3

# LABORATORY ANALYSIS AND DATA REDUCTION

# 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.

## 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.

TABLE 3-1

LABORATORY RESULTS*

| Run Number | Particulate Results Filter (mg) | P&C** (mg) | Total Catch (mg) |
|---|---|---|---|
| 1 | 10.3 | 16.1 | 26.4 |
| 2 | 7.7 | 16.8 | 24.5 |
| 3 | 6.5 | 16.3 | 22.8 |

* Blank corrected

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

7683-02

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Heading | Q-CAR WARREN 4TH WEEK | | | | | | | | |
| 2 | Number of tests | 3 | | | | | | | | |
| 3 | Test type | "EPA" | "EPA" | "EPA" | | | | | | |
| 4 | Test identification | 1 | 2 | 3 | | | | | | |
| 5 | Stack area, $in^2$ | 4608 | 4608 | 4608 | | | | | | |
| 6 | Stack temperature, $^{o}F$ | 148 | 180.2 | 135.8 | | | | | | |
| 7 | Sample volume, $ft^3$ | 27.89 | 25.58 | 25.5 | | | | | | |
| 8 | Meter temperature, $^{o}F$ | 61.8 | 71.0 | 66.5 | | | | | | |
| 9 | Orifice ($\Delta H$), in. $H_2O$ | 1.42 | 1.36 | 1.35 | | | | | | |
| 10 | Nozzle diameter, in | .203 | .203 | .203 | | | | | | |
| 11 | Duration of test, min. | 43.63 | 41.53 | 41.83 | | | | | | |
| 12 | Volume of $CO_2$, % | .5 | .5 | 1.0 | | | | | | |
| 13 | Volume of CO, % | 0 | 0 | 0 | | | | | | |
| 14 | Volume of $O_2$, % | 17.5 | 17.5 | 18.0 | | | | | | |
| 15 | Static pressure, in. $H_2O$ | -1.7 | -1.7 | -1.7 | | | | | | |
| 16 | Barometric pressure, in. Hg | 29.2 | 29.2 | 29.2 | | | | | | |
| 17 | Pitot correction factor | .82 | .82 | .82 | | | | | | |
| 18 | Traverse (Avg.$\sqrt{\Delta p}$), in. $H_2O$ | 1.06 | 1.07 | 1.08 | | | | | | |
| 19 | Volume $H_2O$ collected, ml | 147.7 | 151.0 | 148.4 | | | | | | |
| 20 | Weight collected, mg | 26.4 | 24.5 | 22.8 | | | | | | |
| 21 | Volume titrant, $SO_3$, ml | 0 | 0 | 0 | | | | | | |
| 22 | Volume titrant, $SO_2$, ml | 0 | 0 | 0 | | | | | | |
| 23 | Normality titrant, $SO_3$ | 0 | 0 | 0 | | | | | | |
| 24 | Normality titrant, $SO_2$ | 0 | 0 | 0 | | | | | | |
| 25 | Meter calibration factor | 1 | 1 | 1 | | | | | | |
| 26 | Avg. Cosine of angle | 1 | 1 | 1 | | | | | | |
| 27 | Post leak check rate, CFM | 0 | 0 | 0 | | | | | | |
| 28 | Leak check rate no. 1, CFM | 0 | 0 | 0 | | | | | | |
| 29 | Leak check time no. 1, min. | 0 | 0 | 0 | | | | | | |

Q4,Unn

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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. $V_{m(std)} = 17.64\ V_m \left[\dfrac{P_{bar} + \left(.07355\ \Delta H\right)}{T_m + 460}\right] Y$

3. $B_{wo} = \dfrac{V_{w(std)}}{V_{m(std)} + V_{w(std)}}$

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

5. $M_s = M_d\ (1 - B_{wo}) + 18\ B_{wo}$

6. $EA = \left[\dfrac{(\%O_2) - 0.5(\%CO)}{0.264(\%N_2) - (\%O_2) + 0.5(\%CO)}\right] 100$

7. $V_s = (85.49)(60)(C_p)\ \sqrt{\Delta P}\ \sqrt{\dfrac{T_s + 460}{(P_s)(M_s)}}$

8. $Q_s = \dfrac{(V_s)(A_s)}{144}$

LEGEND

| | | |
|---|---|---|
| $A_n$ | = | 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 |
| $D_n$ | = | Diameter of nozzle, inches |
| E | = | Particulate emission rate, lb/hr |
| EA | = | Excess air, percent |
| $\Delta H$ | = | Orifice pressure drop, in. $H_2O$ |
| I | = | Isokinetic ratio, percent |
| $M_d$ | = | Dry molecular weight of stack gas, lb/lb-mole |
| $M_s$ | = | Molecular weight of stack gas, lb/lb-mole |
| $P_{bar}$ | = | Barometric pressure, in. Hg |
| $P_s$ | = | Stack pressure (absolute), in. Hg |
| $\sqrt{\Delta P}$ | = | Average of square roots of Pitot pressure differential, in. $H_2O$ |
| $Q_s$ | = | Stack gas flow, acfm |
| $Q_{s(std)}$ | = | Stack gas flow, scfm |
| $T_m$ | = | Average dry gas meter temperature, °F |
| $T_s$ | = | Average stack temperature, °F |

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

$V_{m(std)}$ = Dry sample volume (standard conditions), $ft^3$

$V_s$ = Stack velocity, ft/min

$V_{wc}$ = Volume of liquid collected in impingers and silica gel, ml

$V_{w(std)}$ = Volume of liquid collected, $ft^3$

$W_t$ = Total weight of particulates collected, mg

$\theta$ = Duration of test, minutes

BCM

# COMPUTATION SHEET

Sheet Number 1 of 1
Date 10-27-81
J. O. Number 00 - 4683 -02
Computed by BA
Checked by

Name of Client Republic Steel Warren
Project Q-CAR #2
Description 4Th week of Testing OCT 19-23

$$12.65 \frac{\text{TONS}}{\text{OVEN}} \times 24 \frac{\text{OVENS}}{\text{TEST}} = 303.6 \text{ TONS COKE/TEST}$$

$$\frac{303.6 \text{ TONS COKE}}{\text{TEST}} \times \frac{\text{TEST}}{\text{MIN}} \times \frac{60 \text{ min}}{\text{HR}} = \frac{\text{TONS COKE}}{\text{HR}}$$

$$\text{Lbs. PARTICULATE/hR} \times \frac{\text{HR}}{\text{TONS COKE}} = \frac{\text{Lbs PARTICULATE}}{\text{TON COKE}}$$

| RUN | TONS/OVEN | OVENS/TEST | TONS COKE/TEST | TEST TIME | TONS COKE/HR | Lbs PART/hr | Lbs PART/TON COKE |
|---|---|---|---|---|---|---|---|
| 1 | 12.65 | 24 | 303.6 | 43.63 | 417.5 | 10.78 | .0258 |
| 2 | 12.65 | 24 | 303.6 | 41.53 | 438.6 | 11.92 | .0271 |
| 3 | 12.65 | 24 | 303.6 | 41.83 | 435.4 | 10.80 | .0248 |

Q-CAR WARREN 4TH WEEK

| PARAMETERS: | | 1 ~~1,2,3~~ | 2 ~~3~~ | 3 ~~7—A~~ |
|---|---|---|---|---|
| AREA OF BREECHING | (SQ FT) | 32.00 | 32.00 | 32.00 |
| SAMPLE VOLUME | (DSCF) | 27.630 | 24.898 | 25.032 |
| MOISTURE | (%) | 20.1 | 15.4 | 17.9 |
| MOLECULAR WEIGHT | (LB/LB-MOLE) | 26.61 | 27.11 | 26.93 |
| GAS TEMPERATURE | ( F) | 148.0 | 130.2 | 135.8 |
| GAS VELOCITY | (FT/MIN) | 3952.1 | 3894.0 | 3962.4 |
| GAS VOLUME | (DRY SCFM) | 85236.2 | 91557.9 | 89604.9 |
| GAS VOLUME | (ACFM) | 126468.6 | 124609.5 | 126798.3 |
| PARTICULATE EMISSIONS: | | | | |
| CONCENTRATION | (GRAINS/DSCF) | .0147 | .0152 | .0141 |
| CONC. @ 12% CO2 | (GRAINS/DSCF) | .3539 | .3644 | .1687 |
| CONC. @ STK COND. | (GRAINS/CF) | .0099 | .0103 | .0095 |
| EMISSION RATE | (LB/HR) | 10.7760 | 11.9205 | 10.7988 |
| ORSAT ANALYSIS: | | | | |
| CARBON DIOXIDE | (VOL %) | .5 | .5 | 1.0 |
| CARBON MONOXIDE | (VOL %) | .0 | .0 | .0 |
| OXYGEN | (VOL %) | 17.5 | 17.5 | 18.0 |
| NITROGEN | (VOL %) | 82.0 | 82.0 | 81.0 |
| EXCESS AIR | (%) | 421.9 | 421.9 | 531.9 |
| ISOKINETICS | (%) | 105.8 | 101.3 | 99.8 |

THE FOLLOWING RUNS WERE UNDER SATURATED CONDITIONS:

~~3~~ 2
~~7—A~~ 3

# APPENDIX 4

# EQUIPMENT CALIBRATION

# 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

$\Delta P_{test}$ = Velocity head measured by "S" type Pitot

$\Delta P_{std}$ = 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 $\leq 0.01$.

## 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 ($\Delta H$) of 0.5, 1.0, and 2.0 inches of water. With the information obtained, $\gamma$, the ratio of the accuracy of the wet test meter to dry test meter, and $\Delta H_@$, the orifice pressure differential yielding 0.75 cfm of air at 68°F and 29.92 inches of mercury, were calculated. The $\gamma$ has a tolerance of 1.00 ±0.01, and the $\Delta H_@$ has a tolerance of 1.84 + 0.26 - 0.24. The $\gamma$ and $\Delta H_@$ are determined as follows:

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

$$\Delta H_@ = \frac{0.0317 \, (\Delta H)}{P_b \, (t_d + 460)} \left( \frac{(T_w + 460)^{\theta}}{V_w} \right)^2$$

where:

$\Delta H$ = Orifice pressure differential, in $H_2O$

$P_b$ = Barometric pressure, in Hg

$t_d$ = Average temperature of dry gas meter, °F

$t_w$ = Average temperature of wet test meter, °F

$\theta$ = Duration of test, minutes

$V_d$ = Dry gas meter volume, $ft^3$

$V_w$ = Wet test meter volume, $ft^3$

9. $Q_{s(std)} = Q_s(1 - B_{wo})\ 17.64\ \dfrac{P_s}{T_s + 460}$

10. $C'_s = 0.0154\ \dfrac{W_t}{V_{m(std)}}$

11. $C'_w = 0.0154\ \dfrac{W_t}{V_{m(std)} + V_{w(std)}}$

12. $C'_c = \dfrac{12\ C'_s}{\%CO_2}$

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

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

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

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

Pitot No. 6-A    Date 6-5-81    Engineer EWB/PG3

| Range | Run No. | $\Delta P_{std}$ | A SIDE $\Delta P$ | A SIDE $C_p$ | A SIDE DEV. | B SIDE $\Delta P$ | B SIDE $C_p$ | B SIDE DEV. | DIF. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | .032 | .052 | .777 | [illegible] | .052 | .777 | .005 | |
| | 2 | .052 | .050 | 777 | 0 | .050 | .792 | 0.01 | |
| | 3 | 032 | .050 | .777 | 0 | .052 | .777 | .005 | |
| | AVG. | | | .777 | | | .782 | | 0.005 |
| 2 | 1 | .19 | .28 | .816 | 0 | .28 | .816 | 0 | |
| | 2 | .19 | .28 | .816 | 0 | .28 | .816 | 0 | |
| | 3 | .19 | .28 | .816 | 0 | .28 | .816 | 0 | |
| | AVG. | | | .816 | | | .816 | | 0.00 |
| 3 | 1 | .45 | .65 | .824 | .008 | .67 | .811 | .008 | |
| | 2 | .46 | .65 | [illegible] | .0008 | .66 | .826 | .007 | |
| | 3 | .46 | .64 | .839 | .006 | .67 | .820 | .001 | |
| | AVG. | | | .832 | | | .819 | | 0.012 |
| 4 | 1 | .66 | .88 | .857 | 0.003 | .88 | .857 | .002 | |
| | 2 | .66 | .89 | .852 | 0.002 | .88 | .857 | .002 | |
| | 3 | .66 | .89 | .852 | .007 | .89 | .852 | -.005 | |
| | AVG. | | | .854 | | | .855 | | .001 |
| 5 | 1 | .88 | 1.35 | .799 | 0 | 1.35 | .799 | 0 | |
| | 2 | .88 | 1.35 | .799 | 0 | 1.35 | .799 | 0 | |
| | 3 | .88 | 1.35 | .799 | 0 | 1.35 | .799 | 0 | |
| | AVG. | | | .799 | | | .799 | | 0.00 |
| 6 | 1 | 1.20 | 1.80 | .808 | 0 | 1.80 | 808 | 0 | |
| | 2 | 1.20 | 1.80 | .808 | 0 | 1.80 | 808 | 0 | |
| | 3 | 1.20 | 1.80 | .808 | 0 | 1.80 | 808 | 0 | |
| | AVG. | | | 808 | | | .808 | | 0.00 |
| 7 | 1 | 1.31 | 1.98 | .802 | 0 | 1.98 | .802 | 0 | |
| | 2 | 1.31 | 1.98 | .802 | 0 | 1.98 | .802 | 0 | |
| | 3 | 1.31 | 1.98 | .802 | 0 | 1.98 | 802 | 0 | |
| | AVG. | | | .802 | | | .802 | | 0.00 |

$C_p = 0.99\sqrt{\dfrac{\Delta P_{std}}{\Delta P_{"S"}}}$

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

DEV. $\leq 0.01$

DIF. $= \overline{C_{p(A)}} - \overline{C_{p(B)}}$

DIF. $\leq 0.01$

BCM

# METER BOX CALIBRATION SHEET

Date 9-15-81 Box No. 8 Inspector JFA

Pump OK Oil CHANGED Wick CHANGED Pump Serial No. A 72-325281

Manometers OK Knobs OK Oil OK Tubing OK

Quick Connects OK Vacuum Gage OK Valves OK

Dry Gas Meter OK Volume 785.7 ft³ Serial No. 677009

Thermometers OK In 96 °F Out 96 °F Ambient 77

Amphenol OK Lights OK Switches OK Variac OK

Leak Check - Max. Vacuum 26 in. Hg Leak Rate 0.003 CFM

Remarks

| Man. Orifice | $CF_w$ | $CF_d$ | $T_w$ | $IT_d$ | $OT_d$ | $T_d$ | Time $\theta$ |
|---|---|---|---|---|---|---|---|
| 0.5 | 4.998 | 5.174 | 71.5 | 81 | 79 | 80 | 12.68 |
| 1.0 | 5.000 | 5.206 | 71.8 | 88.3 | 81.5 | 84.9 | 8.89 |
| 2.0 | 10.000 | 10.554 | 72 | 94.8 | 81 | 89.9 | 13.03 |

Tolerances: $1.6 \leq \Delta H_@ \leq 2.1$ $0.99 \leq \gamma \leq 1.01$

| $\Delta H_@ =$ | $\frac{(0.0317)(\Delta H)}{(P_b)(OT_d+460)}\left[\frac{(T_w+460)(\theta)}{(CF_w)}\right]^2$ | $\gamma =$ | $\frac{(CF_w)(P_b)(T_d+460)}{(CF_d)(P_b+\Delta H/13.6)(T_w+460)}$ |
|---|---|---|---|
| 1.81 | $\frac{(0.0317)(0.5)}{(29.53)(79+460)}\left[\frac{(71.5+460)(12.68)}{(4.998)}\right]^2$ | 0.98 | $\frac{(4.998)(29.53)(80+460)}{(5.174)(29.53+0.0368)(71.5+460)}$ |
| 1.77 | $\frac{(0.0317)(1.0)}{(29.53)(81.5+460)}\left[\frac{(71.8+460)(8.89)}{(5.000)}\right]^2$ | 0.98 | $\frac{(5.000)(29.53)(84.9+460)}{(5.206)(29.53+0.0737)(71.8+460)}$ |
| 1.89 | $\frac{(0.0317)(2.0)}{(29.53)(85+460)}\left[\frac{(72+460)(13.03)}{(10.000)}\right]^2$ | 0.97 | $\frac{(10.000)(29.53)(89.9+460)}{(10.554)(29.53+0.147)(72+460)}$ |