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.

EPA Contract No. 68–02–4346
Work Assignment 4

December 8, 1988

Final Report

# Determination of the Efficiency of a Four–Stage Mist Eliminator

Candidate Plant
ROLL Technology Corporation
Greenville, South Carolina

Prepared for

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# SECTION 1.0
# INTRODUCTION

During the week of August 8, 1988, an emission measurement program was conducted at ROLL Technology Corporation in Greenville, South Carolina. Primary purpose of this program was to collect data to determine the efficiency of a four-stage horizontal-flow mist eliminator. Based on this determination, it may be necessary to develop a regulatory alternative based on this type of system.

The principal reason for selecting ROLL Technology was that the plant had recently installed a new fume control system. This new mist eliminator system combines both single chevron blade and the mesh pad configuration into one unit. (ROLL had participated in this EPA test program in the past when the EPA tested the packed-bed scrubber/mist eliminator on another plating tank.) The capture and control system servicing Tank No. 6 consists of a double-sided down-draft hood ducted to a moisture extractor followed by a mist eliminator unit containing two sets of overlapping-type blades followed by two mesh pads. Hexavalent chromium emissions were measured at three locations along the duct. These locations are identified in Figure 1-1 as: (1) IA - inlet to the moisture extractor, (2) IB - inlet to the mist eliminator, and (3) O-outlet from the mist eliminator. Figure 1-1 is a schematic showing the sample locations. The emission samples were collected using the Modified Method 13B (MM13B) sample train and the EPA Screening Method. These methods will be discussed in Section 4.0. The samples were analyzed for $Cr^{+6}$ concentration using the diphenylcarbazide colorimetric method. This method will also be discussed later in Section 4.0.

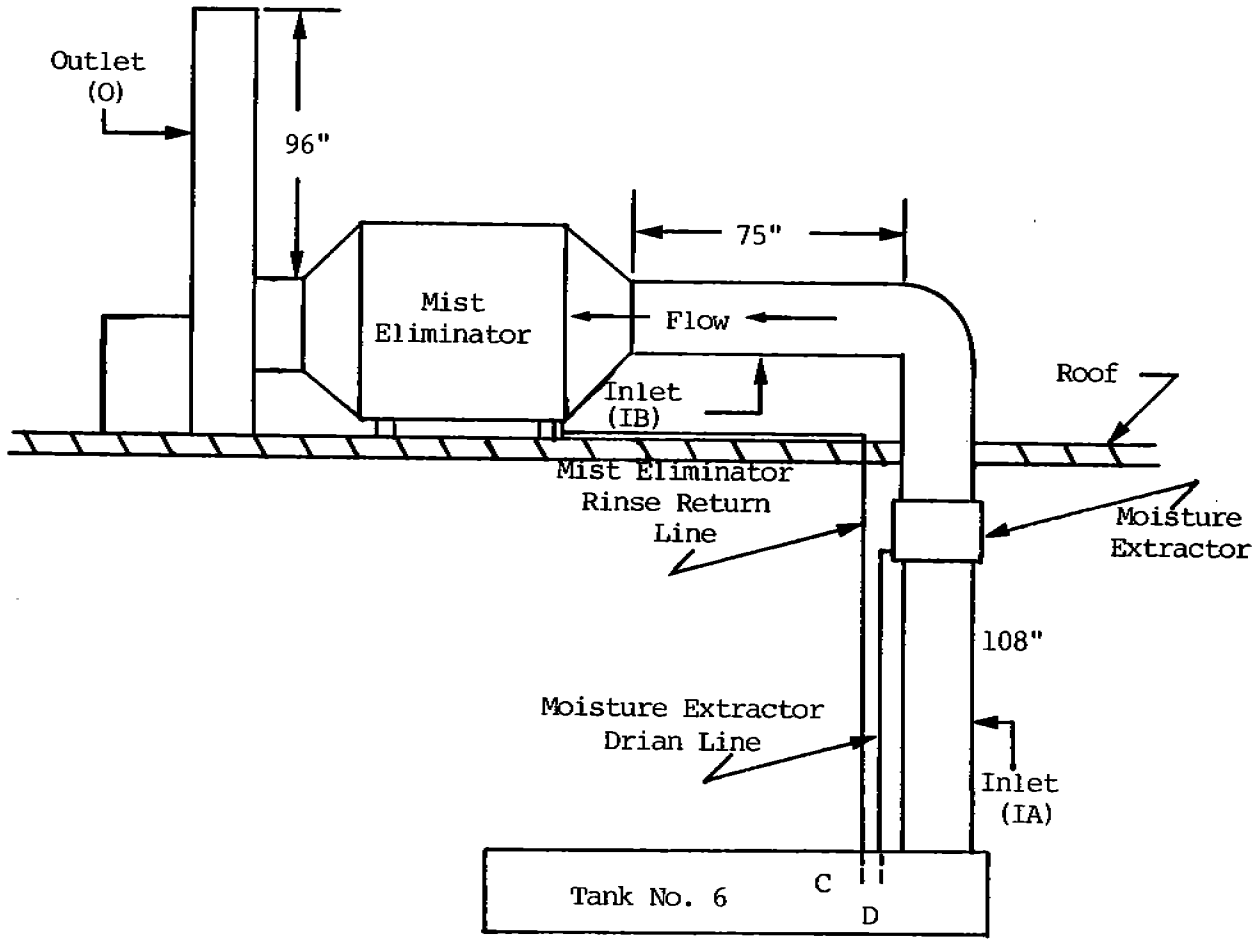



Figure 1-1. Location of sample sites.

PEER Consultants, P.C., located in Dayton, Ohio was responsible for developing the test protocol, conducting the field test, on-site analysis of samples and the preparation of draft and final reports. PEER was supported by its subcontractor, Pacific Environmental Services, Inc. located in Cincinnati, Ohio. Midwest Research Institute, located in Raleigh, North Carolina, was responsible for monitoring the process operation, and the EPA conducted Screening Method testing and monitored the implementation of the test protocol.

# SECTION 2.0
# PROCESS OPERATION

## 2.1 PROCESS DESCRIPTION

Roll Technology, Inc., is a job specializing in precision finishing and refinishing of industrial rolls. Operations performed at this facility include hard chromium plating, sulfamate nickel plating, machining, grinding, and mirror finishing. The plant plates rolls that are used primarily in the paper manufacturing, roofing, laminating, and coating industries.

There are seven hard chromium plating tanks at this facility. On the average, the tanks are charged for a total of 20 hours per day. Approximately 4 hours per day are required for the change-over of rolls. During a change-over, the roll that has been plated is raised out of the plating tank, rinsed with water from a hose, and transferred to the grinding area. Then, the roll to be plated is cleaned with an abrasive cleaner and lowered into the plating solution. Typical plating times range from 12 to 36 hours per roll. Rolls that require longer plating times typically are plated overnight, and rolls that require shorter plating times are plated during the day when personnel are available to perform the change-over.

Tank No. 6 was tested during this source test program. Tank No. 6 is 3.65 m (12.0 ft) long, 0.91 m (3.0 ft) wide, and 2.9 m (9.6 ft) deep and holds approximately 9,270 liters (2,450 gallons) of plating solution. The plating solution contains chromic acid in a concentration of 250 grams per liter (g/ℓ) (33 ounces per gallon) of

water. Sulfuric acid is used as a catalyst at a bath concentration of 2.5 g/ℓ (0.033 oz/gal). The temperature of the plating solution is maintained between 57° and 60°C (135° and 140°F). Tank No. 6 is used to plate small industrial rolls, aircraft engine pistons, and rotary pumps. A manual hoist transfers parts in and out of the plating tank. In addition, the plating tank is equipped with a timer which allows plating operations to be completed during evenings and weekends when no personnel are available to turn off the rectifier. The typical current and voltage applied to Tank No. 6 is 8,000 amperes and 12 volts.

Tank No. 6 is typical of other hard chromium plating tanks used in the electroplating industry, based on operating parameters such as current, voltage, plating time, temperature, and chromic acid concentration. Although the composition of the plating solutions remains constant, the operating voltage and current vary with each roll that is plated.

## 2.2 AIR POLLUTION CONTROL

The capture and control system on Tank No. 6 consists of a double-sided lateral hood ducted to a moisture extractor followed by a mist eliminator unit containing two sets of overlapping-type blades and two mesh pads. Figure 2-1 presents a schematic of the capture and control system on Tank No. 6. The fan used in the ventilation system is rated at 255 cubic meters per minute (9,000 cubic feet per minute).

The four stage mist eliminator unit was fabricated and installed by KCH Services, Inc., in June 1988. This unit replaced the scrubber that was formerly used to control chromic acid mist from the plating tank. Figure 2-2 presents a cross-sectional view of the mist eliminator unit. This unit has a design airflow rate of 280 $m^3$/min (10,000 $ft^3$/min) and a design pressure drop of 0.62 kilopascal (2.5 inches of water column) at a velocity of 140 meters per minute (450 feet per minute). The blade section consists of two sets of overlapping-type blades.

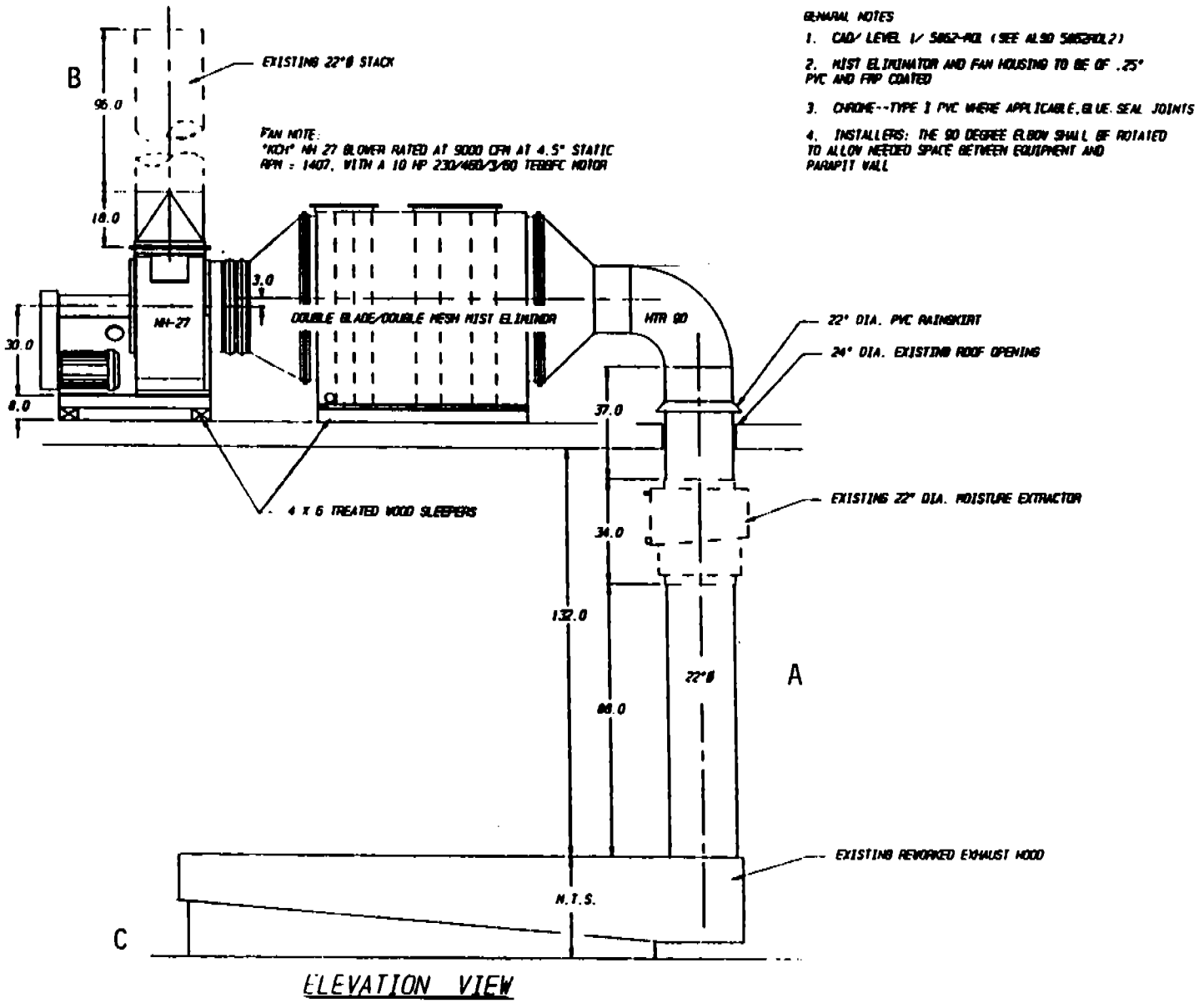



Figure 2-1. Schematic of control device system.

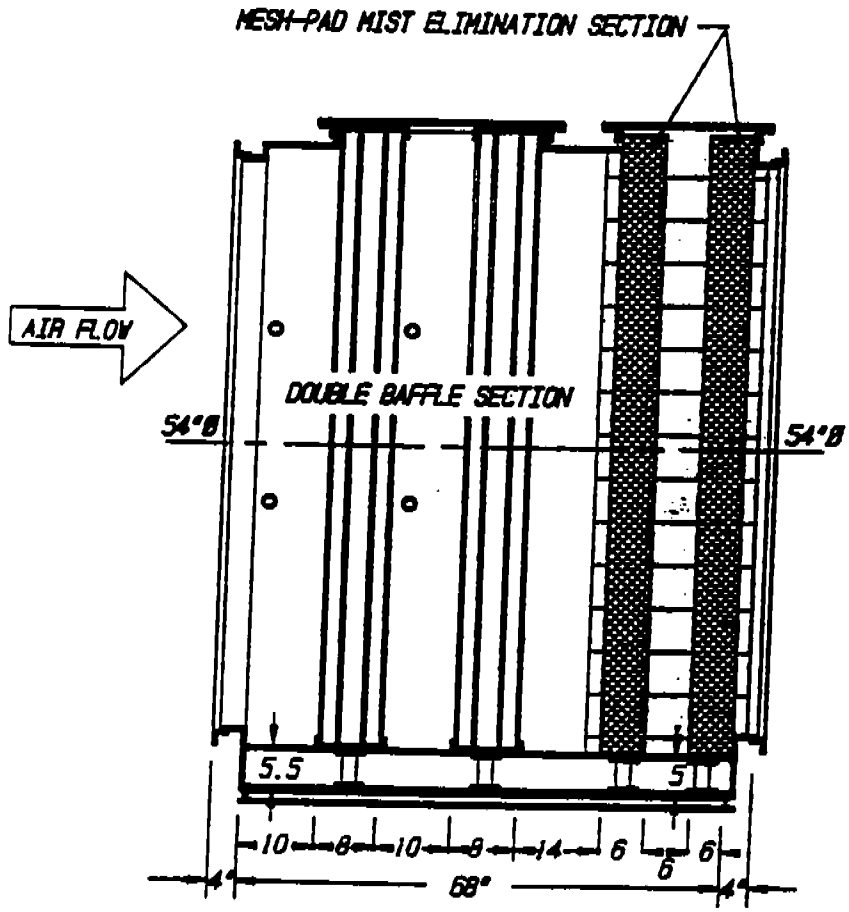



Figure 2-2. Cross section of mist eliminator.

Catchments are located along the overlapping edges of the blades and act as collection troughs that provide a central location for droplet collection and facilitate gravitational drainage of the droplets into a collection sump. Figure 2-3 presents a schematic of this type blade design. Two sets of spray nozzles (three nozzles per set) are located prior to each set of blades and are activated periodically to wash down the blades. The wash down water is drained to a holding tank and recirculated to the plating tank to replace plating solution evaporation losses. The mesh pad section consists of two mesh pads in series. The mesh pads are manufactured by Kimre, Incorporated. Each mesh pad is about 1.4 m (4.5 ft) high, 1.45 m (4.75 ft) wide, and 0.15 m (0.5 ft) deep. Each pad consists of eight layers of mesh. Each layer consists of interlocked polypropylene filaments. Each filament is 0.094 cm (0.037 m) in diameter. The first two layers of each pad have a void space of 97 percent, and the remaining six layers have a void space of 94 percent.

The 22-inch diameter moisture extractor is located in the ductwork near the ceiling of the plating shop. Because moisture extractors are designed for the removal of large droplets that also would be collected in the first stage of the mist eliminator unit, the overall performance measured during testing would be equal to the average performance of the mist eliminator unit used alone.

During testing, the airflow rate at the outlet of the mist eliminator averaged 195 $m^3$/min (6,880 $ft^3$/min) and the pressure drop was measured at 0.84 kPa (3.4 in. of water column).

## 2.3 PROCESS CONDITIONS DURING TESTING

Mass emission tests were conducted at the following locations: (1) the inlet of the moisture extractor, (2) between the moisture extractor and mist eliminator unit, and (3) the outlet of the mist eliminator unit to characterize the performance of the control devices independently and in series.

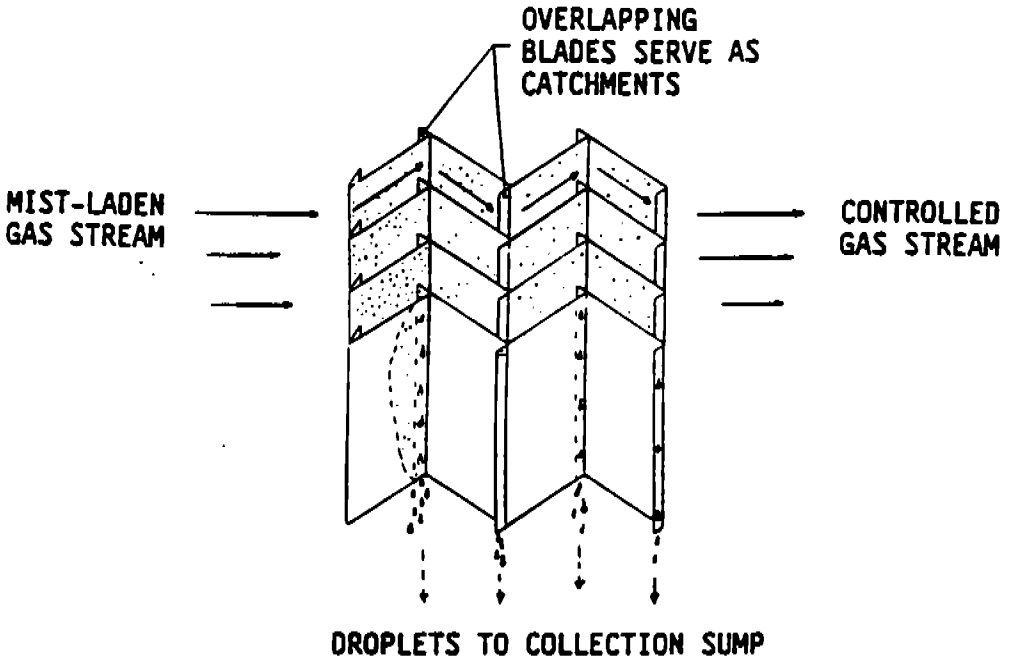



Figure 2-3. Overlapping-type blade design for chevron-blade mist eliminators.

Process parameters recorded during each test run were the plating solution temperature, operating voltage, and operating current. Process data sheets documenting the process paramenters monitored during testing are presented in Appendix A. Data on the average operating parameters recorded for each test run are presented in Table 2-1. The process was operating normally during emission testing. The plating tank was plating two industrial rolls during each source test. The two rolls were identical in size. Each roll measured 69 cm (27 in.) long with a diameter of 41 cm (16 in.). The total current supplied to the tanks during each test run was calculated in terms of ampere-hours and is reported in Appendix A. A summary of the total current values is presented in Table 2-2.

Grab samples from the plating tank were taken during each test run to determine the chromic acid concentration of the plating solution during emission testing. The mist eliminator was washed down with clean water at the beginning of each day, and grab samples of the mist eliminator washdown water were collected. The chromic acid concentrations of the grab samples are reported in Section 3 of this report.

Test run No. 1 was ~~3~~ 3.2 hours in duration and two subsequent runs were 2 hours in duration. Each test run was interrupted 10 to 15 minutes to change test ports. Test run No. 1 was interrupted for 14 minutes due to a power loss to the meter boxes. However, no other process interruptions occurred during the test runs.

TABLE 2-1. AVERAGE OPERATING PARAMETERS DURING EACH MASS EMISSION TEST RUN

| Run No. | Operating current, amperes | Operating voltage, volts | Temperature of plating solution, °C (°F) |
|---|---|---|---|
| 1 | 4,500 ~~4,800~~ | 6.8 | 54 (130) |
| 2 | 5,200 | 7.0 | 54 (130) |
| 3 | 5,200 | 7.3 | 54 (130) |

TABLE 2-2. TOTAL CURRENT SUPPLIED TO TANK NO. 6 DURING EACH MASS EMISSION TEST RUN

| Run No. | Test time, h | Total current, ampere-hours |
|---|---|---|
| 1 | 3.2 ~~3.0~~ | 14,400 +800 = 15,200 |
| 2 | 2.0 | 10,400 |
| 3 | 2.0 | 10,400 |

# SECTION 3.0
# SUMMARY OF RESULTS

## INTRODUCTION

Modified Method 13B (MM13B) samples and the Screening Methods (SM) Samples were collected in triplicate at each sample location. All of the emission samples were analyzed on site for $Cr^{+6}$ concentrations using the procedures outlined in "Draft Method-Determination of Hexavalent Chromium in Dry Particulate Emissions from Stationary Sources". This analytical method is presented in Appendix D.

In addition to the emission samples, grab samples of the plating bath were composited during each MM13B run and analyzed using the same procedures as for the emission samples. Prior to beginning the test program, the moisture extractor and the mist eliminator units were rinsed with freshwater. Following the daily test program, these two units were rinsed again and samples of the rinseate were collected in a polyethylene sample bottle. These samples were also analyzed for $Cr^{+6}$ concentrations. Table 3-1 presents a schedule of the activities during the test program. the results from the aforementioned analysis are presented in the remainder of this section.

## HEXAVALENT CHROMIUM EMISSION RESULTS

Emission samples were collected isokinetically using a method 13B sample train that had been modified by removing the glass fiber filter and placing 100 mℓ of 0.1N NaOH in each of the first two impingers. The impinger solutions were recovered into tared polyethylene sample bottles and the total volume of the recovered samples was determined

TABLE 3-1. SCHEDULE OF ACTIVITIES

| Date (1988) | Sample Type | Run No. | Test Time | Parameter Measured |
|---|---|---|---|---|
| 8/9 | MM13B | IA-1, IB-1, O-1 | 192 min. | $Cr^{+6}$ |
| 8/9 | SM | 1A series | | $Cr^{+6}$ |
| 8/9 | SM | 1B series | | $Cr^{+6}$ |
| 8/9 | SM | 11A thru 14H | | $Cr^{+6}$ |
| 8/9 | SM | 15E thru 18H | | $Cr^{+6}$ |
| 8/10 | Plating Sol. | 1 | | $Cr^{+6}$ |
| 8/10 | Moist. Ext. Rinse | 1 | | $Cr^{+6}$ |
| 8/10 | Mist Elim. Rinse | 1 | | $Cr^{+6}$ |
| 8/10 | MM13B | IA-2, IB-2, O-2 | 120 min. | $Cr^{+6}$ |
| 8/10 | SM | 2A series | | $Cr^{+6}$ |
| 8/10 | SM | 2B series | | $Cr^{+6}$ |
| 8/10 | SM | 21A thru 24D | | $Cr^{+6}$ |
| 8/10 | SM | 25E thru 28H | | $Cr^{+6}$ |
| 8/10 | Plating Sol. | 2 | | $Cr^{+6}$ |
| 8/10 | MM13B | IA-3, IB-3, O-3 | 120 min. | $Cr^{+6}$ |
| 8/10 | SM | 3A series | | $Cr^{+6}$ |
| 8/10 | SM | 3B series | | $Cr^{+6}$ |
| 8/10 | SM | 31A thru 34D | | $Cr^{+6}$ |
| 8/10 | SM | 35E thru 38H | | $Cr^{+6}$ |
| 8/10 | Plating Sol. | 3 | | $Cr^{+6}$ |
| 8/11 | Moist. Ext. Rinse | 2 and 3 | | $Cr^{+6}$ |
| 8/11 | Mist Elim. Rinse | 2 and 3 | | $Cr^{+6}$ |

gravimetrically. Following recovery of the samples, an aliquot of the solution was analyzed for $Cr^{+6}$. The following subsections present the flue gas data and analytical results for each sample location.

Inlet to the Moisture Extractor

Modified Method 13B--

A summary of the flue gas conditions at this location are presented in Table 3-2. The volumetric flowrates were consistent and averaged 171 dry standard cubic meters per minute (dscmm), (6041 dry standard cubic feet per minute, (dscfm). The flue gas temperature averaged 34°C (93°F) and the moisture content averaged 2.52 percent. The flue gas was essentially ambient air and was assigned a dry molecular weight of 28.95 lb/lb mole. The isokinetic sampling rates were within the allowable limitations for these sample runs.

Prior to sampling, it was decided that the first MM13B should be run at 8 minutes per point for a total sample time of 192 minutes. This sample time ensured the collection of a detectable concentration of $Cr^{+6}$. Following the analysis of the sample, it was determined that the sample time per point could be reduced to 5 minutes for a total sample time of 120 minutes. The uncontrolled emissions for each MM13B were consistent and averaged 3.073 milligrams per dry standard cubic meter (mg/dscm). A summary of the MM13B sample volumes, analytical results and emission rates for this location is presented in Table 3-3A.

Screening Method--

A summary of the sample volumes, analytical results and emission rates for the Screening Methods conducted at this location is presented in Table 3-3B.

TABLE 3-2. SUMMARY OF FLUE GAS CONDITIONS

| Run No. | Date | Volumetric Flowrate dscm/min | Volumetric Flowrate dscf/min | Temperature °C | Temperature °F | % Moisture | % Isokinetic |
|---|---|---|---|---|---|---|---|
| IA-1 | 8/9/88 | 177 | 6,248 | 34 | 93 | 2.32 | 96.2 ~~96.1~~ |
| IB-1 | 8/9/88 | 167 | 5,906 | 36 | 97 | 2.50 | 101.9 |
| 0-1 | 8/9/88 | 178 | 6,279 | 37 | 98 | 2.43 | 96.7 |
| IA-2 | 8/10/88 | 166 | 5,868 | 32 | ~~90~~ 89 | 2.62 | 98.3 |
| IB-2 | 8/10/88 | 176 | 6,207 | 34 | 93 | 2.80 | 98.6 |
| 0-2 | 8/10/88 | 171 | 6,053 | 36 | 96 | 3.04 | 97.1 |
| IA-3 | 8/10/88 | 170 | 6,006 | 35 | 95 | 2.62 | 96.2 |
| IB-3 | 8/10/88 | 168 | 5,918 | 37 | 99 | 2.59 | 99.2 |
| 0-3 | 8/10/88 | 176 | 6,229 | 37 | 99 | 2.50 | 94.4 |

TABLE 3-3A. SUMMARY OF SAMPLE VOLUMES, ANALYTICAL RESULTS AND EMISSION RATES FOR THE MOISTURE EXTRACTOR INLET

| Run No. | Volume Metered dscm | dscf | Total Mass Cr+6, mg | Concentration *mg/dscm | gr/dscf | Emission Rates kg/hr | lb/hr |
|---|---|---|---|---|---|---|---|
| IA-1 | 6.482 | 228.891 | 18.3771 | 2.835 | 0.0012 | 0.030 | 0.066 |
| IA-2 | 3.891 | 137.395 | 12.9125 | 3.319 | 0.0015 | 0.033 | 0.073 |
| IA-3 | 3.897 | 137.602 | 11.9374 | 3.064 | 0.0013 | 0.031 | 0.069 |

TABLE 3-3B. SUMMARY OF SCREENING METHOD RESULTS AT MOISTURE EXTRACTOR INLET

| Screening Methods | Volume Sampled | Stack DSCFM | Screen $Mg/m^3$ | *MM13B $Mg/m^3$ | % of MM13B |
|---|---|---|---|---|---|
| 1-A-1 | 8.856 | 6245 | 0.3935 | 2.84 | 13.86 |
| 1-A-2 | 8.390 | 6245 | 1.331 | 2.84 | 46.87 |
| 1-A-3 | 8.754 | 6245 | 0.5337 | 2.84 | 18.79 |
| 1-A-4 | 7.509 | 6245 | 2.114 | 2.84 | 74.44 |
| 1-B-1 | 8.856 | 6245 | 1.745 | 2.84 | 61.44 |
| 1-B-2 | 8.390 | 6245 | 1.870 | 2.84 | 65.85 |
| 1-B-3 | 8.754 | 6245 | 2.127 | 2.84 | 74.89 |
| 1-B-4 | 7.509 | 6245 | 1.438 | 2.84 | 50.63 |
| 2-A-1 | 8.698 | 5873 | 2.520 | 3.32 | 75.90 |
| 2-A-2 | 8.241 | 5873 | 3.144 | 3.32 | 94.67 |
| 2-A-3 | 8.599 | 5873 | 3.213 | 3.32 | 96.77 |
| 2-A-4 | 7.375 | 5873 | 4.937 | 3.32 | 148.70 |
| 2-B-1 | 8.698 | 5873 | 2.063 | 3.32 | 62.14 |
| 2-B-2 | 8.241 | 5873 | 2.404 | 3.32 | 72.41 |
| 2-B-3 | 8.599 | 5873 | 2.377 | 3.32 | 71.60 |
| 2-B-4 | 7.375 | 5873 | 4.293 | 3.32 | 129.31 |
| 3-A-1 | 8.922 | 6006 | 1.381 | 3.07 | 44.98 |
| 3-A-2 | 8.453 | 6006 | 1.377 | 3.07 | 44.85 |
| 3-A-3 | 8.819 | 6006 | 1.880 | 3.07 | 61.24 |
| 3-A-4 | 7.564 | 6006 | 2.001 | 3.07 | 65.18 |
| 3-B-1 | 8.922 | 6006 | 1.864 | 3.07 | 60.72 |
| 3-B-2 | 8.453 | 6006 | 1.815 | 3.07 | 59.10 |
| 3-B-3 | 8.819 | 6006 | 5.999 | 3.07 | 195.41 |
| 3-B-4 | 7.564 | 6006 | 5.831 | 3.07 | 189.93 |

* Slight discrepancy due to difference in claculation procedure

Sample volumes for the screening method were controlled by critical orifices made from hypodermic needles. The needles were checked for flow rates in the lab by using a wet test meter in series with each needle. Numbers obtained in the lab were used to determine sample volumes in the field by applying the ideal gas law. Unfortunately, the ideal gas law is not the correct way to determine sample volumes when using hypodermic needles as critical orfices.

When components are assembled as they are in the screening train, the ideal gas law will not give satisfactory volumes. As air goes through the system and reaches the hypodermic needle, it is cooled. This changes the diameter of the orfice (hypodermic needle) and the cooler temperature may also change the speed of sound. The upstream and downstream pressures also influence the volume, and the simple calculations of the ideal gas law do not give precise volumes. In order to keep the screening method simple, samples volumes should be determined empirically at the site.

The ideal gas law was used to determine sample volumes at the Roll Technology sites, and was adjusted for temperature differences for the speed of sound. While this seemed like a logical approach at the time, the volumes are not correct and the true volumes will probably never be known. The data, however, are still useful. The same error was applied to all samples, so at least the samples give some indication as to the precision of the technique. The reproducibility of the data, especially at the outlet is encouraging.

The screening method tests run at Saint Clair Shores gave values equivalent to about 70% of the values measured by the MM13B tests, and this was without the use of a filter in the screening trains. The addition of a filter was expected to increase the yield at the Roll Technology test, however, such was not the case. There are some possible explanations for this result.

First, sampling was done at a single location during both tests. Although the flow through the ducts was fairly uniform, this does not necessarily mean that the distribution of chromic acid is uniform throughout the stack gas. Thus the concentration sampled could be high, low, or average, but still is probably biased in one (unknown) direction. Another biasing characteristic could be the sample volumes used in the calculations. Calculations performed on a smaller than actual volume will bias the results high; calculations performed on a larger than actual volume will bias the results lower.

While the results from the screening method were somewhat disappointing, the next test will incorporate stack traverses into the SM sampling. It is hoped that the next phase of the test will provide results that more closely agree with the MM 13B trains.

Inlet to the Mist Eliminator

After completion of the cyclonic flow check at this location it was determined that special sampling procedures would need to be implemented. The discussion of those sampling procedures will be presented in Section 4.0 of this report.

Modified Method 13B--

A summary of the flue gas conditions at this location is presented in Table 3-2. The volumetric flowrates were consistent and averaged 170 dry standard cubic meters per minute (dscmm), (6010 dry standard cubic feet per minute, (dscfm). The flue gas temperature averaged 36°C (96°F) and the moisture content averaged 2.63 percent. The flue gas was essentially ambient air and was assigned a dry molecular weight of 28.95 lb/lb mole. The isokinetic sampling rates were within the allowable limitations for these sample runs.

In order to meet the requirements of the cyclonic flow sampling procedure employed, the sampling times at each traverse point were adjusted. Sampling times ranged from 5 minutes, 28 seconds to 11

minutes, 55 seconds, based on a nominal sampling time of 8 minutes per point, a total sampling time of 187 minutes, 40 seconds was attained. This sample time ensured the collection of a detectable concentration of $Cr^{+6}$. Following analysis of the sample it was determined that the nominal sampling time could be reduced to 5 minutes per point which corresponded to actual sampling times ranging from 3 minutes, 31 seconds to 5 minutes, 27 seconds, for a total sampling time of 117 minutes, 11 seconds. The emissions for each MM13B run were consistent and averaged 0.436 milligrams per dry standard cubic meter (mg/dscm). A summary of the MM13B sample volumes, analytical results and emission rates for this location is presented in Table 3-4.

Outlet from the Mist Eliminator

Modified Method 13B--

A summary of the flue gas conditions at this location is presented in Table 3-2. The volumetric flowrates were consistent and averaged 175 dry standard cubic meters per minute (dscmm), (6187 dry standard cubic feet per minute, (dscfm). The flue gas temperature averaged 37°C (98°F) and the moisture content averaged 2.66 percent. The flue gas was essentially ambient air and was assigned a dry molecular weight of 28.95 lb/lb mole. The isokinetic sampling rates were within the allowable limitations for these sample runs.

Prior to sampling it was decided that the first MM13B should be run at 8 minutes per point for a total sample time of 192 minutes. This increased sample time ensured the collection of a detectable concentration of $Cr^{+6}$. Following the analysis of the sample, it was determined that the sample time per point could be reduced to 5 minutes for a total sample time of 120 minutes. The uncontrolled emissions for each MM13B were consistent and averaged 0.0409 milligrams per dry standard cubic meter (mg/dscm). A summary of the MM13B sample volumes, analytical results and emission rates for this location is presented in Table 3-5A and screening method results are presented in Table 3-5B.

TABLE 3-4. SUMMARY OF SAMPLE VOLUMES, ANALYTICAL RESULTS AND EMISSION RATES FOR THE MIST ELIMINATOR INLET

| Run No. | Volume Metered dscm | dscf | Total Mass Cr+6, mg | Concentration mg/dscm | gr/dscf | Emission Rates kg/hr | lb/hr |
|---|---|---|---|---|---|---|---|
| IB-1 | 4.740 | 167.357 | 1.644 | 0.347 | 0.00015 | 0.0035 | 0.~~0076~~ .0077 |
| IB-2 | 3.041 | 107.397 | 1.610 | 0.529 | 0.00023 | 0.0056 | 0.0123 |
| IB-3 | 2.919 | 103.069 | 1.257 | 0.431 | 0.00019 | 0.0043 | 0.0095 |

TABLE 3-5A. SUMMARY OF SAMPLE VOLUMES, ANALYTICAL RESULTS AND EMISSION RATES FOR THE MIST ELIMINATOR OUTLET

| Run No. | Volume Metered dscm | dscf | Total Mass Cr+6, mg | Concentration *mg/dscm | gr/dscf | Emission Rates kg/hr | lb/hr |
|---|---|---|---|---|---|---|---|
| 0-1 | 6.298 | 222.371 | 0.189 | 0.030 | 0.00001 | 0.0003 | 0.0007 |
| 0-2 | 3.810 | 134.539 | 0.165 | 0.043 | 0.00002 | 0.0004 | 0.0010 |
| 0-3 | 3.811 | 134.555 | 0.180 | 0.047 | 0.00002 | 0.0005 | 0.0011 |

TABLE 3-5B. SUMMARY OF SCREENING METHOD RESULTS AT THE MIST ELIMINATOR OUTLET

| Screening Methods | Volume Sampled | Stack DSCFM | Screen $mg/m^3$ | *MM13B $mg/m^3$ | % of MM13B |
|---|---|---|---|---|---|
| 1-1-A | 10.306 | 6279 | 0.01984 | 0.0305 | 65.05 |
| 1-2-B | 14.751 | 6279 | 0.01740 | 0.0305 | 57.05 |
| 1-3-C | 14.665 | 6279 | 0.01979 | 0.0305 | 64.89 |
| 1-4-D | 15.181 | 6279 | 0.01866 | 0.0305 | 61.18 |
| 1-5-E | 10.306 | 6279 | 0.01096 | 0.0305 | 35.93 |
| 1-6-F | 14.751 | 6279 | 0.01815 | 0.0305 | 59.51 |
| 1-7-G | 14.665 | 6279 | 0.01780 | 0.0305 | 58.36 |
| 1-8-H | 15.181 | 6279 | 0.01584 | 0.0305 | 51.93 |
| 2-1-A | 10.449 | 6053 6051 | 0.02193 | 0.0442 | 49.62 |
| 2-2-B | 14.954 | 6051 | 0.01925 | 0.0442 | 43.55 |
| 2-3-C | 14.867 | 6051 | 0.02126 | 0.0442 | 48.10 |
| 2-4-D | 15.391 | 6051 | 0.02203 | 0.0442 | 49.84 |
| 2-5-E | 10.449 | 6053 6051 | 0.01910 | 0.0442 | 43.21 |
| 2-6-F | 14.954 | 6051 | 0.02000 | 0.0442 | 45.25 |
| 2-7-G | 14.867 | 6051 | 0.02252 | 0.0442 | 50.95 |
| 2-8-H | 15.391 | 6051 | 0.02317 | 0.0442 | 52.42 |
| 3-1-A | 10.697 | 6279 6218 | 0.01898 | 0.0481 | 39.46 |
| 3-2-B | 15.310 | 6218 | 0.01845 | 0.0481 | 38.36 |
| 3-3-C | 15.220 | 6218 | 0.01947 | 0.0481 | 40.48 |
| 3-4-D | 15.756 | 6218 | 0.02017 | 0.0481 | 41.93 |
| 3-5-E | 10.695 | 6279 6218 | 0.01700 | 0.0481 | 35.34 |
| 3-6-F | 15.310 | 6218 | 0.01785 | 0.0481 | 37.11 |
| 3-7-G | 15.220 | 6218 | 0.01680 | 0.0481 | 34.93 |
| 3-8-H | 15.756 | 6218 | 0.01952 | 0.0481 | 40.58 |

* Slight discrapency due to difference in calculation procedure.

The $Cr^{+6}$ removal efficiencies for the system were consistent and averaged 98.6%. A summary of removal efficiencies for the system is presented in Table 3-6.

PLATING TANK SOLUTIONS

During each MM13B run, grab samples of the plating bath solution were collected and composited. The samples were analyzed for $Cr^{+6}$ concentration. The results from these analyses are presented in Table 3-7.

MOISTURE EXTRACTOR RINSE

Prior to the start of sampling program the moisture extractor was rinsed with fresh water. The moisture extractor was rinsed daily and a sample of the rinseate was collected and analyzed for $Cr^{+6}$ concentrations. The result of these analyses were presented in Table 3-7.

MIST ELIMINATOR RINSE

Prior to the start of the sampling program the mist eliminator was rinsed with fresh water. The mist eliminator was rinsed daily and a sample of the rinseate was collected and analyzed for $Cr^{+6}$ concentrations. The result of these analyses were presented in Table 3-7.

TABLE 3-6. SUMMARY OF $Cr^{+6}$ REMOVAL EFFICIENCIES

| Run No. | $Cr^{+6}$ Emission Rate lb/hr | $Cr^{+6}$ Removal Efficiency |
|---|---|---|
| IA-1 | 0.0664 | |
| O-1 | 0.0007 | 98.9% |
| IA-2 | 0.0729 | |
| O-2 | 0.0010 | 98.6% |
| IA-3 | 0.0689 | |
| O-3 | 0.0011 | 98.4% |
| Average | | 98.6% |

TABLE 3-7. SUMMARY OF PLATING SOLUTION AND RINSEATE ANALYTICAL RESULTS

| Run No. | $Cr^{+6}$ Concentration, µg/mℓ |
|---|---|
| Plating Solution | |
| IA-1 | 145,872 |
| IA-2 | 115,385 |
| IA-3 | 119,308 |
| Moisture Extractor Rinseate | |
| 8/10/88 | 3,046 |
| 8/11/88 | 6,551 |
| Mist Eliminator Rinseate | |
| 8/10/88 | 461 |
| 8/11/88 | 620 |

## SECTION 4.0
## SAMPLING LOCATIONS AND TEST METHODS

### PLATING TANK EMISSIONS

#### Location of Measurement Sites

EPA Reference Method 1 "Sample and Velocity Traverse for Stationary Sources" was used to select representative measurement sites. The measurement site at the moisture extractor was located in a 21.5 inch ID circular vertical duct. Two 3-inch ID holes were cut in the duct at 90 degrees from each other. The measurement site was 53 inches (2.5 stack diameters) downstream from the nearest flow disturbance (bath) and 55 inches (2.6 stack diameters) upstream from any flow disturbance (90° bend).

The measurement site for the mist eliminator inlet was located in a 21.5 inch ID circular horizontal duct. The measurement site was located 50 inches (2.3 stack diameters) downstream from any flow disturbance (90° bend) and 20 inches (1.2 stack diameters) upstream from the mist eliminator.

The measurement site for the outlet of the mist eliminator was located in a 21.5 inch ID circular vertical duct. The measurement site was located 75 inches (3.5 stack diameters) downstream from the mist eliminator outlet and 20 inches (0.9 stack diameters) upstream from the atmosphere.

According to EPA Method 1 criteria, each site required 24 sample traverse points, 12 along each diameter. With the EPA Task Manager's

approval, the point closest to the port was not sampled because the high static pressure at that point might result in erroneous measurements. Thus it was decided instead to sample point #2 twice. The point closest to the bottom of the duct at the inlet to the mist eliminator was not sampled in order to prevent contamination of the sample due to the presence of liquid accumulated on the duct wall. The EPA Task Manager was consulted and approved this change. Table 4-1 and 4-2 show the traverse points used.

Prior to sampling, verification of the absence of cyclonic flow at each sample traverse point was assessed based on procedures described in EPA Reference Method 1. In this method the face openings of the Type-S pitot tube are aligned perpendicular to the duct cross-sectional plane, designated "0-degree reference." Null (zero) pitot readings obtained at 0-degree reference indicate an acceptable flow condition at a given point. If the point reading were not zero at 0-degree reference, the pitot was rotated until a null reading was obtained. The value of the rotation angle (yaw) was recorded for each point and averaged across the duct. Method 1 criteria stipulate that average angular rotations greater than 20 degrees indicate cyclonic (nonaxial) flow conditions in the duct. The average of the angular rotation for the moisture extractor inlet was 3 degrees, and the average angular rotation at the mist eliminator outlet was 8 degrees. Both of these sites indicated acceptable flow patterns so that extraction of representative samples from these sites was performed using normal sampling procedures. The average of the angular rotation at the mist eliminator inlet was 24 degrees indicating the presence of cyclonic flow, by exceeding the 20 degree limit allowed by Method 1. With the approval of the EPA Task Manager it was decided that the alignment approach for sampling in cyclonic flow be used.

In the alignment method, the sampling rate must be based on the total velocity at each sampling point in order to maintain isokinetic

TABLE 4-1. SAMPLE TRAVERSE POINT LOCATIONS FOR MOISTURE EXTRACTOR INLET AND MIST ELIMINATOR OUTLET

| Traverse Point No. | Location | |
|---|---|---|
| | Moisture Extractor Inlet | Mist Eliminator Outlet |
| 1 | 0.5[a] | 0.5[a] |
| 2 | 1.44 | 1.44 |
| 3 | 2.54 | 2.54 |
| 4 | 3.81 | 3.81 |
| 5 | 5.38 | 5.38 |
| 6 | 7.65 | 7.65 |
| 7 | 13.85 | 13.85 |
| 8 | 16.13 | 16.13 |
| 9 | 17.69 | 17.69 |
| 10 | 18.96 | 18.96 |
| 11 | 20.06 | 20.06 |
| 12 | 21.00[a] | 21.00[a] |

[a] Relocated to the minimum distance from the inside stack wall.

TABLE 4-2. SAMPLE TRAVERSE POINT LOCATIONS-MIST ELIMINATOR INLET

| Traverse Point No. | Traverse | Angle of Flow Deviation | |
|---|---|---|---|
| | | Vertical (degrees) | Horizontal (degrees) |
| 1 | 0.5[a] | C40 | C20 |
| 2 | 1.44 | C45 | C20 |
| 3 | 2.54 | C40 | C15 |
| 4 | 3.81 | C30 | C18 |
| 5 | 5.38 | C20 | C18 |
| 6 | 7.65 | C5 | C21 |
| 7 | 13.85 | C15 | C18 |
| 8 | 16.13 | CC25 | CC 3 |
| 9 | 17.69 | CC20 | CC18 |
| 10 | 18.96 | CC15 | CC44 |
| 11 | 20.06 | CC15 | CC50 |
| 12 | 21.00[a] | CC20 | CC40 |

[a] Relocated to the minimum distance from the inside stack wall.

C - Clockwise

CC - Counter Clockwise

sampling conditions. Since the angle between the flow direction and stack axis varies across the stack, the sampling velocity is not weighted proportionally to the axial, velocity component. Proportional sampling requirements can be satisfied by adjusting the sampling time for each sampling point such that the volume of sample collected at each point is related by a constant to the axial velocity component at each point. Thus,

$$t_2 = t_1 \cos \Phi$$

where

$t_1$ = nominal sampling time per point
$t_2$ = actual sampling time per point
$\Phi$ = angle between flow direction and stack axis

The nominal sampling time per point should be of sufficient duration to ensure collection of sufficient sample volume to provide accurate mass concentration measurements since the application of the above weighting procedure will reduce the actual sampling time.

When sampling to determine a mass emission rate, the volumetric flow rate is determined as:

$$Q = k_p C_p A_s \sqrt{\frac{T_s}{P_s M_s}} \frac{\sum_i^N \left( \sqrt{\Delta P_i} \cos \Phi_i \right)}{N}$$

If negative velocities are encountered at particular sampling points, then no sampling should be conducted at those points and the measured negative axial volume flow rate should be subtracted from the measured positive axial volume flow rate.

Test Methods

Velocity and static pressures, moisture content, and temperature were measured prior to sampling, in order to define sampling rates and

nozzle sizes as described in the EPA Reference Methods 1, 2 and 4. The stack gas molecular weight was not determined by procedures outlined in EPA Method 3. Alternatively, the molecular weight was assigned the value of 29.0 lb/lb mole, as stated in the EPA Method 2, paragraph 3.6.

An EPA MM13B sample train was used to collect the $Cr^{+6}$ samples. The sample train consisted of a 316 stainless steel button-hook design nozzle, an unheated Pyrex glass-lined probe, and a series of four impingers. The first, third and fourth impingers were Greenburg-Smith design, modified by replacing the tip with a 1/2-in. inside diameter glass tube extending to 1/2-in. from the bottom of the flask. The second impinger was a Greenburg-Smith impinger with the standard tip. The first and second impingers contained 100mℓ of 0.1N NaOH. The third impinger was empty and the fourth impinger contained approximately 200 grams of silica gel. On Run IA2, IB2 and O-2, an additional silica-gel filled impinger was added to the sampling train. The balance of the sampling system consisted of a vacuum pump, dry gas meter, calibrated orifice and related temperature and pressure indicating apparatus to determine dry gas sample volume, stack gas temperature, volumetric flow rate and isokinetic sampling rates. During sampling, stack gas temperature and the gas temperature exiting the last impinger were monitored with calibrated thermocouples.

The sampling time was varied from 8 minutes per point (192 minute total sample time) to 5 minutes per point (120 minute total sample time) since the concentration of $Cr^{+6}$ was such that good analytical results could be obtained using the shorter time. The sampling times calculated for the alignment approach varied from 5.63 to 8.75 minutes per point, for an eight minute nominal sampling time and 3.52 to 5.46 minutes for a five minute nominal sampling time.

The impingers were weighed before and after each test to determine the moisture content of the flue gas stream. The contents of the

impingers were placed in a tared polyethylene container. All connecting glassware, the nozzle and probe were rinsed with 0.1 N NaOH and combined with the impinger solution in the polyethylene sample bottle. In recovering, the mist eliminator outlet samples the probe and nozzle rinse were separated from the impinger catch in an effort to concentrate the $Cr^{+6}$ in a smaller sample volume. The liquid level was marked on each sample bottle and each bottle was marked indicating the run number and bottle contents. Appropriate blank solutions were collected.

The polyethylene containers were all tared before their use and weighed after the collection of the sample. The volume of each solution was determined by multiplying the specific gravity of the solution times the net weight of the solution. Each sample, including blanks, was analyzed for $Cr^{+6}$ concentration using analytical methodology recently developed by the EPA.

EMISSION SAMPLE ANALYSIS

The MM13B samples, the Screening Methods samples, the plating solution and the emission control unit rinses were analyzed for $Cr^{+6}$ concentration. The analyses were conducted on site in the plant's analytical laboratory. Immediately following the sample recovery, the samples were submitted to the analyst and the analyses and the calculations were performed the same day. The analytical results were performed on the Hewlett Packard 41CV computer that was set up in the on-site computer center. The calculations were also performed by the EPA Task Manager.

The analytical method entitled "Draft Method - Determination of Hexavalent Chromium in Dry Particulate Emissions from Stationary Sources" was used as a "guideline" in conducting the analyses. This method is currently under development by the EPA and is presented in Appendix D.

There were several variations between the Draft Method and the Analytical Method that was performed in the field. They are described as follows:

1. The collected samples were not digested in an alkaline solution. Aliquots of the recovered samples were pipeted directly from the sample bottle and prepared as in paragraph 5.7.1 of the Draft Method.

2. The pH of the sample aliquot was monitored with a pH meter while adjusting the pH of the aliquot to 2 ± .5.

3. The spectrophotometer was calibrated with standards containing 2 mℓ, 5 mℓ, 7 mℓ, 10 mℓ, 15 mℓ and 20 mℓ of the 5 µg/mℓ working standard. The spectrophotometer calibration factor, $K_C$, was calculated as follows:

$$K_C = 10 \frac{A_1 + 2.5A_2 + 3.5A_3 + 5A_4 + 7.5A_5 + 10A_6}{A_1^2 + A_2^2 + A_3^2 + A_4^2 + A_5^2 + A_6^2}$$

4. The value of this calibration factor was calculated using a computer program that was developed by the EPA Task Manager for the HP41 calculator.

# SECTION 5.0
# QUALITY ASSURANCE

## INTRODUCTION

The goal of the quality assurance activities for this project is to ensure, to the highest degree possible, the accuracy of data collected. The procedures contained in the "Quality Assurance Handbook for Air Pollution Measurement Systems," Volume III, "Stationary Source Specific Methods," EPA-600/4-77-027B served as the basis for performance of all testing and related work activities that were undertaken in this testing program. In addition to the quality assurance measure guidelines presented above, specific quality assurance activities were conducted for several of the individual testing activities, as performed; these are presented in the paragraphs that follow.

## FIELD QUALITY ASSURANCE PROCEDURES

In order to assure a high level of quality control while sampling to allow the comparison of data from these two methods, a field quality assurance program was followed during the test program. Methods used to obtain the required level of quality assurance are itemized below.

### Sample Blanks

Reagent Blanks--

The 0.1N NaOH absorbing solution was transported to the field in its "as-purchased" container. When in the field, the 0.1N NaOH was transferred to a polyethylene wash bottle. From the wash bottle, the NaOH solution was used for sample train preparation and recovery. A

blank sample was collected from the solution in the wash bottle. This sample was given to the on-site laboratory personnel with the emission samples, and analyzed in the same manner. Results of the blank analyses are presented in Table 5-1.

$H_2O$ Blanks--

A distilled water blank was obtained from the wash bottles and analyzed in the same manner as the emission samples.

Duplicate Samples

One sample for every 10 samples analyzed was a duplicate, e.g., if 24 samples were analyzed, 3 duplicate samples would be analyzed. The analytical results for the duplicated samples are presented in Table 5-1.

Standards

Daily, throughout the analysis of the samples, standards were set up as a spot check of the spectrophotometer calibration. The results of these checks are presented in Table 5-1.

Chain of Custody

In an effort to maintain the integrity of all samples taken at the test facility, a chain of custody procedure was followed. A copy of the "Chain-of-Custody" data sheets is included in Appendix E. These sheets include the sample identification, date of sample recovery, name of person who performs the recovery, place of recovery as well as the name of the responsible person from the analytical group who is taking custody of the samples. Once the samples were placed in custody of the analytical group, that group provided for safe storage and maintenance of records sufficient to maintain sample integrity.

TABLE 5-1. SUMMARY OF ANALYTICAL RESULTS FOR QA/QC SAMPLES AND BLANKS

| Sample No. | Date (1988) | Type of Sample | | Total µg $Cr^{+6}$ | |
|---|---|---|---|---|---|
| | | Duplicate | Standard | | |
| 10 µg/mℓ | 8/9 | | X | 10.04 | |
| 10 µg/mℓ | 8/9 | | X | 10.14 | |
| 75 µg/mℓ | 8/9 | | X | 74.73 | |
| 1-A-2 | 8/10 | X | | 344.04 | *(316.21) |
| 50 µg/mℓ | 8/10 | | X | 53.19 | |
| 10 µg/mℓ | 8/10 | | X | 10.70 | |
| 25 µg/mℓ | 8/10 | | X | 26.57 | |
| I-A-2 | 8/10 | X | | 12915.53 | *(12,001.58) |
| 75 µg/mℓ | 8/10 | | X | 77.28 | |
| 3-B-4 | 8/10 | X | | 1295.45 | *(1248.93) |
| 3-B-3 | 8/10 | X | | 1565.31 | *(1498.24) |
| 50 µg/mℓ | 8/29 | | X | 47.10 | |
| Plating Sol. Run 2 | 8/29 | X | | 114,430 µg/mℓ | *(115,385µg/mℓ) |
| **Blanks** | | | | | |
| $H_2O$ | 8/9 | | | 0.00 | |
| 0.1N NaOH | 8/10 | | | 0.392 | |

* Original value aginst which duplicate is to be compared

## Sample Transfer

All MM13B samples collected during testing remained in the custody of PEER Consultants, P.C. All Screening Methods samples were returned to the EPA after analysis. All samples were secured in the mobile laboratory while in the field.

## SAMPLING TRAIN COMPONENTS

The equipment used in this test program, including nozzles, pitot tubes, dry gas meters, orifices, and thermocouples were uniquely identified and were calibrated in accordance with calibration procedures specified in the applicable EPA Reference Method prior to, and at the completion of the testing program. The calibration sheets are presented in Appendix F.

## VERIFICATION OF CALCULATIONS

### Emission Calculations

Dry gas volumes, percent moisture of the stack gas, gas flow rates, and $Cr^{+6}$ emission rates were calculated using a Hewlett Packard 41CV programmable calculator. The programs used can be found in the document: "Source Test Calculation and Check Programs for Hewlett Packard 41 Calculators" (EPA-340/1-85-018). The results were checked and verified by the contractor task manager.

### Chromium Concentration Calculations

All absorbance data for blanks, standards, samples and QA/QC samples were documented in a notebook. The percent absorbance was calculated from the percent transmittance and subsequent calculations were carried out as described in the draft method for hexavalent chromium analysis.

# APPENDIX A

## Process Monitoring Data

8/16/88

## AMPERE-HOUR CALCULATIONS

TEST RUN NO.: 1
TANK NO.: 6

START TIME: 14:47
STOP TIME: 18:34

| Time, 24-h clock | | Time interval, min | | Current, | Ampere-hours | |
|---|---|---|---|---|---|---|
| Inlet | Outlet | Inlet | Outlet | amperes | Inlet | Outlet |
| 14:47 | 14:47 | | | | | |
| 14:50 | 14:50 | 3 | 3 | 4,800 | 240 | 240 |
| 14:54 | 14:54 | 4 | 4 | 4,800 | 320 | 320 |
| Subtotal | | 7 | 7 | | 560 | 560 |
| 15:08 | 15:08 | | | | | |
| 15:10 | 15:10 | 2 | 2 | 4,800 | 160 | 160 |
| 15:20 | 15:20 | 10 | 10 | 4,800 | 800 | 800 |
| 15:30 | 15:30 | 10 | 10 | 4,800 | 800 | 800 |
| 15:40 | 15:40 | 10 | 10 | 4,800 | 800 | 800 |
| 15:50 | 15:50 | 10 | 10 | 4,800 | 800 | 800 |
| 16:00 | 16:00 | 10 | 10 | 4,800 | 800 | 800 |
| 16:10 | 16:10 | 10 | 10 | 4,800 | 800 | 800 |
| 16:20 | 16:20 | 10 | 10 | 4,800 | 800 | 800 |
| 16:32 | 16:32 | 12 | 12 | 4,800 | 960 | 960 |
| Subtotal | | 84 | 84 | | 6,720 | 6,720 |
| 17:05 | 17:05 | | | | | |
| 17:15 | 17:15 | 10 | 10 | 4,800 | 800 | 800 |
| 17:25 | 17:25 | 10 | 10 | 4,800 | 800 | 800 |
| 17:35 | 17:35 | 10 | 10 | 4,800 | 800 | 800 |
| 17:45 | 17:45 | 10 | 10 | 4,800 | 800 | 800 |
| 17:55 | 17:55 | 10 | 10 | 4,800 | 800 | 800 |
| 18:05 | 18:05 | 10 | 10 | 4,800 | 800 | 800 |
| 18:15 | 18:15 | 10 | 10 | 4,800 | 800 | 800 |
| 18:25 | 18:25 | 10 | 10 | 4,800 | 800 | 800 |
| 18:34 | 18:34 | 9 | 9 | 4,800 | 720 | 720 |
| Subtotal | | 89 | 89 | | 7,120 | 7,120 |
| Total | | 180 | 180 | | 14,400 | 14,400 |

1451 – 1634 1708 1844

+ 800

Change amps 4,800 – 4,500 + 800

8/16/88

# AMPERE-HOUR CALCULATIONS

TEST RUN NO.: 2
TANK NO.: 6

START TIME: 11:09
STOP TIME: 13:30

| Time, 24-h clock | | Time interval, min | | Current, | Ampere-hours | |
|---|---|---|---|---|---|---|
| Inlet | Outlet | Inlet | Outlet | amperes | Inlet | Outlet |
| 11:09 | 11:09 | | | | | |
| 11:10 | 11:10 | 1 | 1 | 5,000 | 83 | 83 |
| 11:20 | 11:20 | 10 | 10 | 5,000 | 833 | 833 |
| 11:30 | 11:30 | 10 | 10 | 5,200 | 867 | 867 |
| 11:40 | 11:40 | 10 | 10 | 5,200 | 867 | 867 |
| 11:50 | 11:50 | 10 | 10 | 5,200 | 867 | 867 |
| 12:00 | 12:00 | 10 | 10 | 5,200 | 867 | 867 |
| 12:09 | 12:09 | 9 | 9 | 5,200 | 780 | 780 |
| Subtotal | | 60 | 60 | | 5,164 | 5,164 |
| 12:30 | 12:30 | | | | | |
| 12:40 | 12:40 | 10 | 10 | 5,200 | 867 | 867 |
| 12:50 | 12:50 | 10 | 10 | 5,200 | 867 | 867 |
| 13:00 | 13:00 | 10 | 10 | 5,200 | 867 | 867 |
| 13:10 | 13:10 | 10 | 10 | 5,200 | 867 | 867 |
| 13:20 | 13:20 | 10 | 10 | 5,200 | 867 | 867 |
| 13:30 | 13:30 | 10 | 10 | 5,200 | 867 | 867 |
| Subtotal | | 60 | 60 | | 5,202 | 5,202 |
| Total | | 120 | 120 | | 10,366 | 10,366 |

8/16/88

# AMPERE-HOUR CALCULATIONS

TEST RUN NO.: 3
TANK NO.: 6

START TIME: 15:25
STOP TIME: 17:45

| Time, 24-h clock | | Time interval, min | | Current, | Ampere-hours | |
|---|---|---|---|---|---|---|
| Inlet | Outlet | Inlet | Outlet | amperes | Inlet | Outlet |
| 15:25 | 15:25 | | | | | |
| 15:35 | 15:35 | 10 | 10 | 5,200 | 867 | 867 |
| 15:45 | 15:45 | 10 | 10 | 5,200 | 867 | 867 |
| 15:55 | 15:55 | 10 | 10 | 5,200 | 867 | 867 |
| 16:05 | 16:05 | 10 | 10 | 5,200 | 867 | 867 |
| 16:15 | 16:15 | 10 | 10 | 5,200 | 867 | 867 |
| 16:25 | 16:25 | 10 | 10 | 5,200 | 867 | 867 |
| Subtotal | | 60 | 60 | | 5,202 | 5,202 |
| 16:45 | 16:45 | | | | | |
| 16:55 | 16:55 | 10 | 10 | 5,200 | 867 | 867 |
| 17:05 | 17:05 | 10 | 10 | 5,200 | 867 | 867 |
| 17:15 | 17:15 | 10 | 10 | 5,200 | 867 | 867 |
| 17:25 | 17:25 | 10 | 10 | 5,200 | 867 | 867 |
| 17:35 | 17:35 | 10 | 10 | 5,200 | 867 | 867 |
| 17:45 | 17:45 | 10 | 10 | 5,200 | 867 | 867 |
| Subtotal | | 60 | 60 | | 5,202 | 5,202 |
| Total | | 120 | 120 | | 10,404 | 10,404 |

8/22/88

SOURCE SAMPLING PROGRAM PROCESS DATA SHEET

Place: Roll Technology, Inc., Greenville, South Carolina

Date: August 9, 1988

Tank No. 6 | Test Run No. 1

Test start time | Test stop time

Inlet: 14:47 | Inlet: 18:34
Outlet: 14:47 | Outlet: 18:34

| Time, 24-h clock | Temp., °F | Current, amperes | Voltage, volts | Notes |
|---|---|---|---|---|
| 14:50 | 130 | 4,800 | 6.8 | Started testing: 14:47 |
| 15:00 | 130 | 4,800 | 6.8 | Stopped testing: 14:54 Power loss to meter boxes |
| 15:10 | 130 | 4,800 | 6.8 | Started testing: 15:08 |
| 15:20 | 130 | 4,800 | 6.8 | |
| 15:30 | 130 | 4,800 | 6.8 | |
| 15:40 | 130 | 4,800 | 6.8 | |
| 15:50 | 130 | 4,800 | 6.8 | |
| 16:00 | 130 | 4,800 | 6.8 | |
| 16:10 | 130 | 4,800 | 6.8 | |
| 16:20 | 130 | 4,800 | 6.8 | |
| 16:30 | 130 | 4,800 | 6.8 | Stopped testing: 16:32 Port change |
| 17:05 | 130 | 4,800 | 6.8 | Started testing: 17:05 |
| 17:15 | 130 | 4,800 | 6.8 | |
| 17:25 | 130 | 4,800 | 6.8 | |
| 17:35 | 130 | 4,800 | 6.8 | |
| 17:45 | 130 | 4,800 | 6.8 | |
| 17:55 | 130 | 4,800 | 6.8 | |
| 18:05 | 130 | 4,800 | 6.8 | |
| 18:15 | 130 | 4,800 | 6.8 | |
| 18:25 | 130 | 4,800 | 6.8 | |
| 18:35 | 130 | 4,800 | 6.8 | Stopped testing: 18:34 |

change amps 4800 → 4500

8/22/88

SOURCE SAMPLING PROGRAM PROCESS DATA SHEET

Place: Roll Technology, Inc., Greenville, South Carolina

Date: August 10, 1988

Tank No. 6 Test Run No. 2

| Test start time | Test stop time |
|---|---|
| Inlet: 11:09 | Inlet: 13:30 |
| Outlet: 11:09 | Outlet: 13:30 |

| Time, 24-h clock | Temp., °F | Current, amperes | Voltage, volts | Notes |
|---|---|---|---|---|
| 11:10 | 129 | 5,000 | 7.0 | Started testing: 11:09 |
| 11:20 | 129 | 5,000 | 7.0 | |
| 11:30 | 130 | 5,200 | 7.0 | |
| 11:40 | 130 | 5,200 | 7.0 | |
| 11:50 | 130 | 5,200 | 7.0 | |
| 12:00 | 130 | 5,200 | 7.0 | |
| 12:10 | 130 | 5,200 | 7.0 | Stopped testing: 12:09 Port change |
| 12:30 | 130 | 5,200 | 7.0 | Started testing: 12:30 |
| 12:40 | 130 | 5,200 | 7.0 | |
| 12:50 | 130 | 5,200 | 7.0 | |
| 13:00 | 130 | 5,200 | 7.0 | |
| 13:10 | 130 | 5,200 | 7.0 | |
| 13:20 | 130 | 5,200 | 7.2 | |
| 13:30 | 130 | 5,200 | 7.2 | Stopped testing: 13:30 |

8/16/88

SOURCE SAMPLING PROGRAM PROCESS DATA SHEET

Place: Roll Technology, Inc., Greenville, South Carolina

Date: August 10, 1988

Tank No. 6 Test Run No. 3

Test start time
Inlet: 15:25
Outlet: 15:25

Test stop time
Inlet: 17:45
Outlet: 17:45

| Time, 24-h clock | Temp., °F | Current, amperes | Voltage, volts | Notes |
|---|---|---|---|---|
| 15:25 | 130 | 5,200 | 7.2 | Started testing: 15:25 |
| 15:35 | 130 | 5,200 | 7.2 | |
| 15:45 | 130 | 5,200 | 7.2 | |
| 15:55 | 130 | 5,200 | 7.2 | |
| 16:05 | 130 | 5,200 | 7.2 | |
| 16:15 | 130 | 5,200 | 7.4 | |
| 16:25 | 130 | 5,200 | 7.4 | Stopped testing: 16:25<br>Port change |
| 16:45 | 130 | 5,200 | 7.4 | Started testing: 16:45 |
| 16:55 | 130 | 5,200 | 7.4 | |
| 17:05 | 130 | 5,200 | 7.4 | |
| 17:15 | 130 | 5,200 | 7.4 | |
| 17:25 | 130 | 5,200 | 7.4 | |
| 17:35 | 130 | 5,200 | 7.4 | |
| 17:45 | 130 | 5,200 | 7.4 | Stopped testing: 17:45 |

# APPENDIX B

Field Data Sheets
Flow Rate and Emission Calculation Sheets

# TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

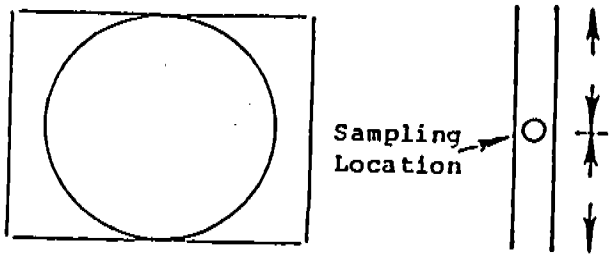
PLANT Roll Tech. Location
DATE 8/9/88
SAMPLING LOCATION Inlet Moisture extra IA
INSIDE OF FAR WALL TO
OUTSIDE OF NIPPLE, (DISTANCE A) 21.5"
INSIDE OF NEAR WALL TO
OUTSIDE OF NIPPLE, (DISTANCE B) —
STACK I.D., (DISTANCE A - DISTANCE B) 21.5"
NEAREST UPSTREAM DISTURBANCE
NEAREST DOWNSTREAM DISTURBANCE
CALCULATOR T. Miller

SCHEMATIC OF SAMPLING LOCATION

| TRAVERSE POINT NUMBER | FRACTION OF STACK I.D. | STACK I.D. | PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH) | DISTANCE B | TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5) |
|---|---|---|---|---|---|
| 1 | 0.021 | 21.5" | 0.5 | — | |
| 2 | 0.067 | | 1.4 | | |
| 3 | 0.118 | | 2.5 | | |
| 4 | 0.177 | | 3.8 | | |
| 5 | 0.250 | | 5.4 | | |
| 6 | 0.356 | | 7.7 | | |
| 7 | 0.644 | | 13.8 | | |
| 8 | 0.750 | | 16.1 | | |
| 9 | 0.823 | | 17.7 | | |
| 10 | 0.882 | | 19.0 | | |
| 11 | 0.933 | | 20.1 | | |
| 12 | 0.979 | | 21.0 | | |

# PRELIMINARY VELOCITY TRAVERSE

Plant: Roll Tech Job No. _____
Date: 8/9/88
Location: IA inlet M.E.
Stack I.D.: 21-5
Barometric Pressure, in. Hg: 29.50
Stack Gauge Pressure, in. $H_2O$: -1.5
Operators: T.M; BG
Pitot Tube I.D. Number: S-4 14-I
Temperature Readout I.D.: T-5
Pitot Tube Leak Check: OK
Run Number _____ Time 11:05 (PRELIMINARY)




Schematic of Traverse Point Layout

| Traverse Point Number | Velocity Head ($\Delta p_s$) in. $H_2O$ | Stack Temp. ($T_s$), °F | Cyclonic Flow Check ° from Null |
|---|---|---|---|
| A-1 | 0.83 | 88 | |
| 2 | 0.78 | 88 | |
| 3 | 0.76 | 88 | |
| 4 | 0.62 | 88 | |
| 5 | 0.47 | 88 | |
| 6 | 0.40 | 88 | |
| 7 | 0.38 | 88 | |
| 8 | 0.44 | 89 | |
| 9 | 0.54 | 89 | |
| 10 | 0.68 | 88 | |
| 11 | 0.72 | 88 | |
| 12 | 0.84 | 88 | |
| | | | |
| | DP=0.58 | | |
| | | | |
| | T=88 | | |
| | | | |
| | | | |
| | | | |
| | | | |
| Average | | | |

| Traverse Point Number | Velocity Head ($\Delta p_s$) in. $H_2O$ | Stack Temp. ($T_s$), °F | Cyclonic Flow Check ° from Null |
|---|---|---|---|
| B-1 | 0.42 | 87 | |
| 2 | 0.38 | 88 | |
| 3 | 0.34 | 88 | |
| 4 | 0.29 | 88 | |
| 5 | 0.25 | 88 | |
| 6 | 0.25 | 88 | |
| 7 | 0.42 | 89 | |
| 8 | 0.62 | 89 | |
| 9 | 0.76 | 89 | |
| 10 | 0.89 | 89 | |
| 11 | 0.90 | 89 | |
| 12 | 0.88 | 89 | |
| | | | |
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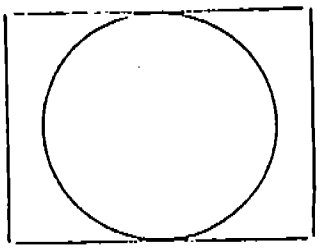
| | | | |
| | | | |
| B-3 | | | |
| Average | | | |

# PRELIMINARY VELOCITY TRAVERSE

Plant: Roll Tech Job No. ____
Date: 8/9/88
Location: IA INlet moist. ex.
Stack I.D.: 21.5
Barometric Pressure, in. Hg: 29.50
Stack Gauge Pressure, in. $H_2O$: ____
Operators: T.M. & B.G.
Pitot Tube I.D. Number: S-4
Temperature Readout I.D.: T-5 / 4-I
Pitot Tube Leak Check: OK
Run Number ____ Time 11:30




Schematic of Traverse Point Layout

## Cyclonic Flow Check

| Traverse Point Number | Velocity Head ($\Delta p_s$) in. $H_2O$ | Stack Temp. ($T_s$), °F | Cyclonic Flow Check ° from Null |
|---|---|---|---|
| A-1 | | | +2½ |
| 2 | | | +7 |
| 3 | | | +7 |
| 4 | | | +4 |
| 5 | | | 0 |
| 6 | | | -9 |
| 7 | | | -2 |
| 8 | | | +3 |
| 9 | | | +5 |
| 10 | | | +7 |
| 11 | | | +7 |
| 12 | | | +5 |
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| | | | |
| | | | |
| Average | | | |

| Traverse Point Number | Velocity Head ($\Delta p_s$) in. $H_2O$ | Stack Temp. ($T_s$), °F | Cyclonic Flow Check ° from Null |
|---|---|---|---|
| B-1 | | | 0 |
| 2 | | | -2 |
| 3 | | | -2 |
| 4 | | | -1 |
| 5 | | | -2½ |
| 6 | | | -4 |
| 7 | | | -4½ |
| 8 | | | 0 |
| 9 | | | -2 |
| 10 | | | -3 |
| 11 | | | -3 |
| 12 | | | -1 |
| | | | |
| | | | |
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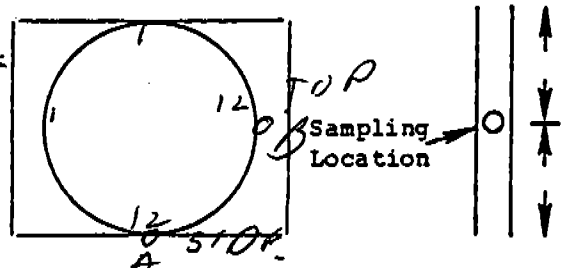
| | | | |
| | | | |
| | | | |
| Average | | | |

PES

## PRELIMINARY VELOCITY TRAVERSE

Plant: Roll Tech
Date: 8-9-88
Location: I-B INLET B ROOF
Stack I.D.: 21"
Barometric Pressure, in. Hg: 29.14
Stack Gauge Pressure, in. $H_2O$: -3.8
Operators:
Pitot Tube I.D. Number: S-3
Temperature Readout I.D.:
Pitot Tube Leak Check:



Schematic of Traverse Point Layout

| Traverse Point Number | Velocity Head ($\Delta p_s$) in. $H_2O$ | Stack Temp. ($T_s$), °F | Cyclonic Flow Check ° from Null |
|---|---|---|---|
| 1 | 1.0 | 90 | c 20 |
| 2 | 1.1 | 90 | c 20 |
| 3 | 1.2 | 91 | c 15 |
| 4 | 1.2 | 89 | c 18 |
| 5 | 1.1 | 89 | c 18 |
| 6 | 1.2 | 89 | c 21 |
| 7 | .42 | 88 | c 18 |
| 8 | .31 | 90 | cc 3 |
| 9 | .25 | 90 | cc 18 |
| 10 | .21 | 90 | cc 45 |
| 11 | .23 | 90 | cc 50 |
| 12 | .23 | 91 | cc 40 |
| | | | |
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| | | | |
| | | | |
| Average | | | |

| Traverse Point Number | Velocity Head ($\Delta p_s$) in. $H_2O$ | Stack Temp. ($T_s$), °F | Cyclonic Flow Check ° from Null |
|---|---|---|---|
| 1 | .48 | 90 | ≈c 40 |
| 2 | .40 | 90 | ≈c 45 |
| 3 | .59 | 90 | ≈c 40 |
| 4 | .55 | 90 | ≈c 30 |
| 5 | .65 | 90 | ≈c 20 |
| 6 | .63 | 90 | ≈c 5 |
| 7 | .58 | 90 | ≈c c 15 |
| 8 | .53 | 90 | ≈cc 25 |
| 9 | .74 | 90 | ≈cc 20 |
| 10 | .80 | 91 | ≈ cc 15 |
| 11 | .94 | 90 | ≈ cc 15 |
| 12 | .95 | 91 | ≈ cc 20 |
| | | | |
| | | | |
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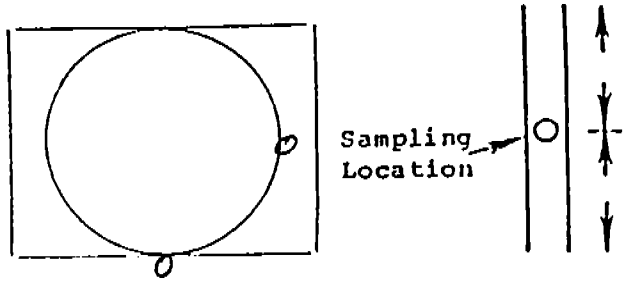
| | | | |
| | | | |
| B-5 | | | |
| Average | | | |

# PRELIMINARY VELOCITY TRAVERSE

Plant: Roll Technology Job No. _____
Date: 8/9/88
Location: OUTLET Roof
Stack I.D.: 21
Barometric Pressure, in. Hg: _____
Stack Gauge Pressure, in. $H_2O$: -0.43
Operators: J. Blanc
Pitot Tube I.D. Number: _____
Temperature Readout I.D.: _____
Pitot Tube Leak Check: _____
Run Number _____ Time _____




Schematic of Traverse Point Layout

| Traverse Point Number | Velocity Head ($\Delta p_s$) in. $H_2O$ | Stack Temp. ($T_s$), °F | Cyclonic Flow Check ° from Null |
|---|---|---|---|
| 1 | .55 | 93 | c 3 |
| 2 | .56 | 93 | c 12 |
| 3 | .53 | 93 | c 10 |
| 4 | .52 | 93 | c 11 |
| 5 | .53 | 93 | c 13 |
| 6 | .56 | 93 | 0 |
| 7 | .58 | 94 | cc 5 |
| 8 | .60 | 93 | cc 7 |
| 9 | .59 | 92 | cc 10 |
| 10 | .61 | 92 | cc 9 |
| 11 | .58 | 92 | cc 5 |
| 12 | .58 | 92 | cc 4 |
| | | | |
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| | | | |
| | | | |
| Average | | | |

| Traverse Point Number | Velocity Head ($\Delta p_s$) in. $H_2O$ | Stack Temp. ($T_s$), °F | Cyclonic Flow Check ° from Null |
|---|---|---|---|
| 1 | 54 | 93 | c 15 |
| 2 | .55 | 93 | c 15 |
| 3 | .56 | 93 | c 12 |
| 4 | 52 | 93 | c 10 |
| 5 | .47 | 94 | c 9 |
| 6 | .45 | 94 | c 6 |
| 7 | .50 | 94 | cc 3 |
| 8 | .49 | 94 | cc 5 |
| 9 | .49 | 95 | cc 8 |
| 10 | .50 | 95 | cc 7 |
| 11 | .44 | 95 | cc 5 |
| 12 | .41 | 95 | cc 2 |
| | | | |
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| | | | |
| | | | |
| | | | |
| Average | | | |

NOMOGRAPH DATA

Plant: _____ Date: _____

Sampling Location: _____

MB-3

| | | |
|---|---|---|
| Calibrated Pressure Differential Across Orifice, in. $H_2O$ | $\Delta H_@$ | 1.987 |
| Average Meter Temperature (ambient + 20°F), °F | $T_{m_{avg}}$ | 120 |
| Percent Moisture in Gas Stream by Volume | $B_{wo}$ | 2 |
| Barometric Pressure at Meter, in. Hg. | $P_m$ | 29.15 |
| Static Pressure in Stack, in. Hg. ($P_m \pm 0.073$ x stack gauge pressure in in. $H_2O$) | $P_s$ | -3.8 |
| Ratio of Static Pressure to Meter Pressure | $P_s / P_m$ | |
| Average Stack Temperature, °F | $T_{s_{avg}}$ | 95 |
| Average Velocity Head, in. $H_2O$ | $\Delta p_{avg}$ | .68 |
| Maximum Velocity Head, in. $H_2O$ | $\Delta p_{max}$ | 1.2 |
| C Factor | | 1.25 |
| Calculated Nozzle Diameter, in. | | 251 .250 248 .249 |
| Actual Nozzle Diameter, in. | | |
| Reference Δp, in. $H_2O$ | | 1.385 |

NOMOGRAPH DATA

Plant: ~~CET~~ ROLL TECH Date: _____

Sampling Location: OUTLET

| | | |
|---|---|---|
| Calibrated Pressure Differential Across Orifice, in. $H_2O$ | $\Delta H_@$ | 1.78 |
| Average Meter Temperature (ambient + 20°F), °F | $T_{m_{avg}}$ | 110 |
| Percent Moisture in Gas Stream by Volume | $B_{wo}$ | 2 |
| Barometric Pressure at Meter, in. Hg. | $P_m$ | 27.15 |
| Static Pressure in Stack, in. Hg. ($P_m \pm 0.073$ x stack gauge pressure in in. $H_2O$) | $P_s$ | -.54 |
| Ratio of Static Pressure to Meter Pressure | $P_s/P_m$ | |
| Average Stack Temperature, °F | $T_{s_{avg}}$ | 97 |
| Average Velocity Head, in. $H_2O$ | $\Delta P_{avg}$ | .53 |
| Maximum Velocity Head, in. $H_2O$ | $\Delta P_{max}$ | .60 |
| C Factor | | 1.1 |
| Calculated Nozzle Diameter, in. | | 291 297, 299 = 297 |
| Actual Nozzle Diameter, in. | | |
| Reference $\Delta p$, in. $H_2O$ | | |

* lost ele. power (Down 7 min)
* lost ele. power (Down 1 min.)

# FIELD DATA

Plant Roll Tech.
Date 8/9/88 Job No. 958
Sampling Location IA (INLET MOIST. EX.)
Sample Type MMBB
Run Number IA-1
Operator T. MILLER
Ambient Temperature
Barometric Pressure 29.24
Static Pressure ($P_s$) -1.5"
Filter Number(s) NA
Pretest Leak Rate 0.001 cfm @ 12 in. Hg
Pretest Pitot Leak Check ok
Pretest Orsat Leak Check NA
Read and Record all Data Every 4.0 Minutes

Page 1 of 2

Schematic of Traverse Point Layout

Probe Length and Type 3' Pyrex
Pitot Tube I.D. No. S-4 Cp ~~0.88~~ 0.84
Nozzle I.D. 0.301 | 0.303 | 0.304 | Avg. 0.303
Assumed Moisture, % 2.5
Temp. Readout S/N T-5
Meter Box Number MB-4
Meter $\Delta H_@$ 1.441
C Factor 0.90
Meter Gamma 1.009
Heater Box Setting NA
Reference $\Delta p$ ~~0.58~~ 0.24
Post Test Leak Rate 0.002 cfm @ 15 in. Hg
Post Test Pitot Leak Check
Post Test Orsat Leak Check NA

Temp. Sensor ID No. 4-I | MB-4-I | MB-4-O | — | SH-5 | —

| Traverse Point Number | Sampling Time (min) | Clock Time (24-hour clock) | Gas Meter Reading ($V_m$) ft³ | Velocity Head ($\Delta P_g$) in. H₂O | Orifice Pressure Differential ($\Delta H$) in. H₂O Required | Orifice Pressure Differential ($\Delta H$) in. H₂O Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{min}$) °F | Dry Gas Meter Temp. Outlet ($T_{mout}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp. °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1451 | 549.530 | | | | | | | | | | |
| A-2 | 4.0 | | 554.650 | 0.60 | 5.0 | 5.0 | 93 | 92 | 90 | 11.5 | — | 66 | — |
| * | ~~5.0~~ 5.1 | 1456 | 556.220 | 0.70 | 5.3 | 5.3 | 92 | 103 | 91 | 12.0 | — | 66 | — |
| * | ~~8.0~~ 5.1 | 1457 | 560.810 | 0.66 | 5.0 | 5.0 | 93 | 114 | 93 | 7.5 | — | <68 | — |
| | 12.0 ~~13.0~~ | 1503 | 566.520 | 0.66 | 5.0 | 5.0 | 92 | 108 | 94 | 7.1 | — | <68 | — |
| A-3 | 16.0 ~~20.0~~ | | 572.090 | 0.68 | 5.1 | 5.1 | 93 | 119 | 98 | 7.1 | — | <68 | — |
| | ~~20.0~~ | | 577.695 | 0.68 | 5.1 | 5.1 | 93 | 123 | 98 | 7.1 | — | 71 | — |
| A-4 | ~~24.0~~ | | 583.330 | 0.60 | 4.5 | 4.5 | 93 | 128 | 102 | 6.1 | — | 71 | — |
| | ~~28.0~~ | | 588.680 | 0.61 | 4.6 | 4.6 | 93 | 130 | 103 | 6.1 | — | 69 | — |
| A-5 | 32.0 | | 594.020 | 0.50 | 3.8 | 3.8 | 93 | 132 | 103 | 6.1 | — | 68 | — |
| | 36.0 | | 598.995 | 0.50 | 3.8 | 3.8 | 93 | 133 | 107 | 5.3 | — | 68 | — |
| A-6 | ~~40.0~~ | | 604.200 | 0.40 | 3.1 | 3.1 | 93 | 134 | 108 | 5.3 | — | 68 | — |
| | 44.0 | | 608.560 | 0.40 | 3.1 | 3.1 | 93 | 134 | 110 | 4.0 | — | 68 | — |
| A-7 | 48.0 | | 613.060 | 0.45 | 3.4 | 3.4 | 93 | 134 | 110 | 4.0 | — | 66 | — |
| | 52.0 | | 617.730 | 0.44 | 3.3 | 3.3 | 93 | 134 | 112 | 4.8 | — | 65 | — |
| A-8 | 56.0 | | 621.300 | 0.68 | 5.1 | 5.1 | 93 | 135 | 113 | 4.8 | — | 66 | — |
| | 60.0 | | 627.845 | 0.68 | 5.1 | 5.1 | 93 | 138 | 115 | 7.5 | — | 66 | — |
| A-9 | 64.0 | | 633.510 | 0.77 | 5.8 | 5.8 | 93 | 139 | 116 | 7.2 | — | 67 | — |
| | 68.0 | | 639.460 | 0.77 | 5.8 | 5.8 | 93 | 145 | 117 | 8.9 | — | 66 | — |
| A-10 | 72.0 | | 643.920 | 0.83 | 6.2 | 6.2 | 93 | 145 | 118 | 8.9 | — | 65 | — |
| | 76.0 | | 651.680 | 0.86 | 6.5 | 6.5 | 94 | 147 | 120 | 9.9 | — | 62 | — |
| | | | | | | | | 148 | 121 | 9.9 | — | 62 | — |

B-9

Plant Name: Roll Tech. Test Date: 8/9/88

Run Number: IA-1 (INLET/MOISTURE EX.) Operator: T. MILLER

Page 2 of 2

| Traverse Point Number | Sampling Time, (min) / Clock Time (24-hour clock) | Gas Meter Reading ($V_m$) ft³ | Velocity Head ($\Delta P_s$) in. $H_2O$ | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Desired | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 76.0 / 1614 | 651.680 | | | | | | | | | | |
| A-12 | 80.0 / | 657.950 | 0.88 | 6.6 | 6.6 | 93 | 151 | 123 | 10.9 | — | 62 | — |
| | 84.0 / | 664.550 | 0.88 | 6.6 | 6.6 | 93 | 153 | 124 | 10.9 | — | 62 | — |
| A-12 | 88.0 / | 670.850 | 0.88 | 6.6 | 6.6 | 94 | 153 | 125 | 10.9 | — | 61 | — |
| | 92.0 / | 677.290 | 0.88 | 6.6 | 6.6 | 93 | 154 | 126 | 10.9 | — | 62 | — |
| | 96.0 / 1632 | 683.706 | 0.88 | 6.6 | 6.6 | 93 | 155 | 127 | 10.9 | — | 62 | — |
| B-2 | 0 / 1708 | 683.706 | | | | | | | | | | |
| | 4.0 / | 688.435 | 0.42 | 3.2 | 3.2 | 94 | 110 | 109 | 4.1 | — | 56 | — |
| | 8.0 / | 693.560 | 0.42 | 3.2 | 3.2 | 94 | 116 | 110 | 4.1 | — | 50 | — |
| | 12.0 / | 697.520 | 0.42 | 3.2 | 3.2 | 94 | 123 | 110 | 4.1 | — | 56 | — |
| B-3 | 16.0 / | 699.745 | 0.40 | 3.0 | 3.0 | 94 | 126 | 110 | 4.0 | — | 57 | — |
| | 20.0 / | 705.940 | 0.40 | 3.0 | 3.0 | 94 | 127 | 110 | 4.0 | — | 57 | — |
| B-4 | 24.0 / | 710.116 | 0.38 | ~~4.0~~ 2.2 | ~~4.0~~ 2.2 | 94 | 128 | 111 | 3.5 | — | 57 | — |
| | 28.0 / | 714.030 | 0.30 | 2.2 | 2.2 | 94 | 130 | 112 | 3.0 | — | 56 | — |
| B-5 | 32.0 / | 717.850 | 0.27 | 2.1 | 2.1 | 94 | 131 | 114 | 2.8 | — | 56 | — |
| | 36.0 / | 721.740 | 0.27 | 2.1 | 2.1 | 94 | 131 | 114 | 2.8 | — | 56 | — |
| B-6 | 40.0 / | 725.320 | 0.27 | 2.1 | 2.1 | 94 | 132 | 115 | 2.8 | — | 56 | — |
| | 44.0 / | 729.075 | 0.27 | 2.1 | 2.1 | 94 | 132 | 116 | 2.8 | — | 56 | — |
| B-7 | 48.0 / | 732.810 | 0.41 | 3.1 | 3.1 | 94 | 132 | 116 | 4.0 | — | 57 | — |
| | 52.0 / | 737.290 | 0.42 | 3.2 | 3.2 | 94 | 135 | 116 | 4.2 | — | 58 | — |
| B-8 | 56.0 / | 751.650 | 0.55 | 4.2 | 4.2 | 94 | 138 | 118 | 6.0 | — | 58 | — |
| | 60.0 / | 746.755 | 0.55 | 4.3 | 4.3 | 94 | 139 | 118 | 6.0 | — | 58 | — |
| B-9 | 64.0 / | 751.995 | 0.74 | 5.5 | 5.5 | 94 | 144 | 120 | 8.1 | — | 59 | — |
| | 68.0 / | 757.830 | 0.75 | 5.6 | 5.6 | 94 | 146 | 128 | 8.5 | — | 59 | — |
| B-10 | 72.0 / | 763.690 | 0.95 | 7.0 | 7.0 | 93 | 150 | 122 | 12.5 | — | 59 | — |
| | 76.0 / | 770.310 | 0.97 | 7.1 | 7.1 | 93 | 153 | 122 | 12.5 | — | 60 | — |
| B-11 | 80.0 / | 777.020 | 0.97 | 7.1 | 7.1 | 93 | 156 | 124 | 13.0 | — | 61 | — |
| | 84.0 / | 783.735 | 0.97 | 7.1 | 7.1 | 94 | 154 | 126 | 13.0 | — | 60 | — |
| B-12 | 88.0 / | 790.470 | 0.97 | 7.1 | 7.1 | 94 | 156 | 126 | 13.0 | — | 61 | — |
| | 92.0 / | 797.285 | 0.97 | 7.1 | 7.1 | 93 | 157 | 128 | 13.0 | — | 61 | — |
| | 94.0 / 1849 | 804.004 | 0.97 | 7.1 | 7.1 | 93 | 157 | 128 | 13.0 | — | | — |
| | / | | | | | | | | | | | |

SAMPLE RECOVERY DATA

Plant: Ball Technology Run No.: I-A-1

Date: 8/9/88 Sample Box No.: RAC#2 Job No.: _____

Sample Location: Inlet to moisture extractor

Sample Type: MM13B Filter No.: N/A

Sample Recovery Person: B. A. Gerber

Comments: _____

FRONT HALF

Acetone Container No.: N/A Liquid Level Marked: N/A Sealed: N/A

Filter Container No.: N/A _____ _____ Sealed: N/A

Description of Filter: N/A

Samples stored and locked: Yes

BACK HALF/MOISTURE

Container No: I-A-1 _____ _____

Liquid Level Marked: Yes Sealed: ✓

| IMP. NO. | CONTENTS | INITIAL VOL (ml) | WEIGHT (grams) INITIAL | FINAL | NET |
|---|---|---|---|---|---|
| 1 | | | 593.0 | 650.6 | |
| 2 | | | 613.8 | 620.4 | |
| 3 | | | 507.5 | 516.0 | |
| 4 | | | 676.7 | 719.4 | |
| 5 | | | | | |
| 6 | | | | | |
| TOTAL | | | | | |

Description of Impinger Catch: Clear

## RUN IA-1 CALCULATION SUMMARY

$$\sqrt{\Delta P_s (T_s + 460)}$$

XROM "PRESS"
NO. OF POINTS ? 48.0000

DELTA P ? .6600 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .6600 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .6600 RUN
STACK TEMP ? 92.0000 RUN
DELTA P ? .6800 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .6800 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .6000 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .6100 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .5000 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .5000 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .4000 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .4000 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .4500 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .4400 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .6800 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .6800 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .7700 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .7700 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .8300 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .8600 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .8800 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .8800 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .8800 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .8800 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .8800 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .4200 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .4200 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .4200 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .4000 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .4000 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .3000 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .3000 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .2700 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .2700 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .2700 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .4100 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .4200 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .5500 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .5500 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .7400 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .7500 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .9500 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .9700 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .9700 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .9700 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .9700 RUN
STACK TEMP ? 94.0000 RUN
DELTA P ? .9700 RUN
STACK TEMP ? 93.0000 RUN
DELTA P ? .9700 RUN
STACK TEMP ? 93.0000 RUN

SQRT PSTS = 18.3061
AVE STK TEMP = 93.4167

## RUN IA-1 CALCULATION SUMMARY

### Method 5 Calculations

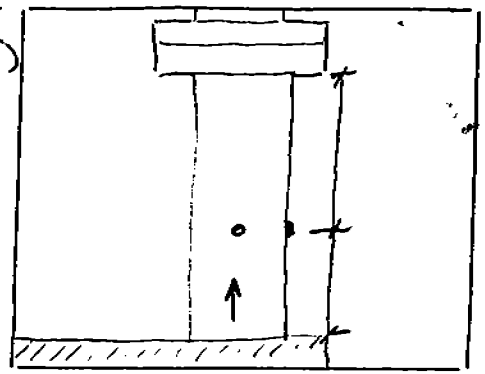
```
                    ---
                XROM "METH 5"
RUN NUMBER
IA-1                          RUN
METER BOX Y?
              1.0090          RUN
DELTA H?
              4.7100          RUN
BAR PRESS ?
             29.2400          RUN
METER VOL ?
            254.1740          RUN
MTR TEMP F?
            125.0000          RUN
STATIC HOH IN ?
             -1.5000          RUN
STACK TEMP.
             93.0000          RUN
ML. WATER ?
            115.4000          RUN

SAT % = 5.4

IMP. % HOH = 2.3

% HOH=2.3

% CO2?
               .7000          RUN
% OXYGEN?
             21.0000          RUN
% CO ?
              0.0000          RUN

MWd =28.95
MW WET=28.70

SQRT PSTS ?
             18.3061          RUN
TIME MIN ?
            192.0000          RUN
NOZZLE DIA ?
               .3030          RUN
STK DIA INCH ?
             21.5000          RUN

* VOL MTR STD = 228.891
  STK PRES ABS = 29.13
  VOL HOH GAS = 5.43
  % MOISTURE = 2.32
  MOL DRY GAS = 0.977
  % NITROGEN = 78.30
  MOL WT DRY = 28.95
  MOL WT WET = 28.70
  VELOCITY FPS = 45.47
  STACK AREA = 2.52
  STACK ACFM = 6,878.
* STACK DSCFM = 6,245.
  % ISOKINETIC =  96.17

END OF FIELD DATA
```

### Emission Rate Calculations

```
                          FIX 5
                            ON
                XROM "MASSFLO"
RUN NUMBER
IA-1                          RUN

VOL MTR STD ?
            228.89100         RUN
STACK DSCFM ?
          6,245.00000         RUN
FRONT 1/2 MG ?
             18.37710         RUN
BACK 1/2 MG ?
                              RUN

F  GR/DSCF = 0.00124
F  MG/MMM = 2.83527
F  LB/HR = 0.06632
F  KG/HR = 0.03008

                              RUN
B  GR/DSCF = 0.00000
B  MG/MMM = 0.00000
B  LB/HR = 0.00000
B  KG/HR = 0.00000

T  GR/DSCF = 0.00124
T  MG/MMM = 2.83527
T  LB/HR = 0.06632
T  KG/HR = 0.03008
```

## FIELD DATA

Plant Roll Tech.
Date 8/10/88 Job No. 958
Sampling Location IA (INLET To MOIST. EX.)
Sample Type MM5 B
Run Number IA-2
Operator T. MILLER
Ambient Temperature 86°F
Barometric Pressure 29.25"
Static Pressure ($P_s$)
Filter Number(s) NA
Pretest Leak Rate = 0.003 cfm @ 15 in. Hg
Pretest Pitot Leak Check OK
Pretest Orsat Leak Check NA
Read and Record all Data Every 5.0 Minutes



Schematic of Traverse Point Layout

Probe Length and Type 3' PYREX
Pitot Tube I.D. No. S-4 Cp 0.88 0.84 | 40
Nozzle I.D. 0.301 | 0.303 | 0.304 | Avg. 0.303
Assumed Moisture, % 8.6
Temp. Readout S/N T-5
Meter Box Number MB-4
Meter $\Delta H_@$ 1.441
C Factor 0.90
Meter Gamma 1.009
Heater Box Setting NA
Reference $\Delta p$ 0.24
Post Test Leak Rate = 0.002 cfm @ 15 in. Hg
Post Test Pitot Leak Check OK
Post Test Orsat Leak Check NA

Page 1 of 2

| Traverse Point Number | Sampling Time, (min) | Clock Time (24-hour clock) | Gas Meter Reading ($V_m$) $ft^3$ | Velocity Head ($\Delta P_g$) in. $H_2O$ | Orifice Pressure Differential ($\Delta H$) in. $H_2O$ Desired | Orifice Pressure Differential ($\Delta H$) in. $H_2O$ Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp. °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Temp. Sensor ID No. | 4I | MB-4-I | MB-4-O | | — | | | | | SM-5 | — |
| | 0 | 1111 | 804.331 | | | | | | | | | | |
| B-1 | 5.0 | | 809.620 | 0.36 | 2.7 | 2.7 | 87 | 88 | 85 | 4.2 | — | 48 | — |
| B-2 | 10.0 | | 814.905 | 0.38 | 2.8 | 2.8 | 88 | 94 | 86 | 4.2 | — | 43 | — |
| B-3 | 15.0 | | 820.4-- | 0.38 | 2.8 | 2.8 | 88 | 102 | 87 | 4.2 | — | 46 | — |
| B-4 | 20.0 | | 825.280 | 0.32 | 2.4 | 2.4 | 88 | 108 | 89 | 3.9 | — | 46 | — |
| B-5 | 25.0 | | 830.145 | 0.30 | 2.3 | 2.3 | 88 | 112 | 92 | 3.5 | — | 47 | — |
| B-6 | 30.0 | | 834.925 | 0.29 | 2.2 | 2.2 | 88 | 115 | 94 | 3.5 | — | 48 | — |
| B-7 | 35.0 | | 839.620 | 0.28 | 2.1 | 2.1 | 89 | 117 | 98 | 4.1 | — | 48 | — |
| B-8 | 40.0 | | 845.155 | 0.42 | 3.2 | 3.2 | 89 | 121 | 100 | 5.0 | — | 49 | — |
| B-9 | 45.0 | | 851.690 | 0.59 | 4.4 | 4.4 | 89 | 126 | 102 | 7.1 | — | 49 | — |
| B-10 | 50.0 | | 859.020 | 0.76 | 5.7 | 5.7 | 88 | 132 | 96 | 9.8 | — | 56 | — |
| B-11 | 55.0 | | 867.2-- | 0.89 | 6.5 | 6.5 | 88 | 139 | 108 | 11.8 | — | 63 | — |
| B-12 | 60.0 | 1211 | 874.977 | 0.95 | 7.0 | 7.0 | 88 | 145 | 145 112 | 13.0 | + | <68 | — |
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Plant Name: Roll Tech. Test Date: 8/10/88

Run Number: IA-2 Operator: T. MILLER

Page 2 of 2

| Traverse Point Number | Sampling Time, (min) | / Clock Time / (24-hour clock) | Gas Meter Reading ($V_m$) $ft^3$ | Velocity Head ($\Delta P_s$) in. $H_2O$ | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Desired | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 60 / | 1231 | 874.977 | | | | | | | | | | |
| A-2 | 65 / | | 881.820 | 0.63 | 4.7 | 4.7 | 90 | 113 | 107 | 7.1 | — | 50 | — |
| -2 | 70 / | | 888.540 | 0.65 | 4.8 | 4.8 | 90 | 123 | 108 | 7.3 | — | 50 | — |
| -3 | 75 / | | 895.590 | 0.70 | 5.2 | 5.2 | 91 | 131 | 110 | 8.0 | — | 52 | — |
| 4 | 80 / | | 901.745 | 0.50 | 3.8 | 3.8 | 91 | 135 | 112 | 5.5 | — | 54 | — |
| 5 | 85 / | | 907.490 | 0.41 | 3.1 | 3.1 | 90 | 135 | 113 | 4.5 | — | 56 | — |
| 6 | 90 / | | 912.830 | 0.39 | 3.0 | 3.0 | 91 | 135 | 114 | 4.5 | — | 57 | — |
| 7 | 95 / | | 918.125 | 0.37 | 2.8 | 2.8 | 91 | 135 | 115 | 4.0 | — | 57 | — |
| 8 | 100 / | | 924.570 | 0.58 | 4.4 | 4.4 | 91 | 136 | 116 | 6.5 | — | 56 | — |
| 9 | 105 / | | 931.480 | 0.67 | 5.0 | 5.0 | 91 | 139 | 117 | 7.5 | — | 57 | — |
| 10 | 110 / | | 938.980 | 0.79 | 5.9 | 5.9 | 91 | 143 | 118 | 9.9 | — | 57 | — |
| 11 | 115 / | | 946.630 | 0.82 | 6.3 | 6.3 | 91 | 145 | 120 | 10.5 | — | 58 | — |
| 12 | 120 / | 1331 | 954.453 | 0.86 | 6.5 | 6.5 | 91 | 148 | 122 | 11.0 | — | 61 | — |
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SAMPLE RECOVERY DATA

Plant: Roll Technology Run No.: I-A-2

Date: 8/10/88 Sample Box No.: _____ Job No.: _____

Sample Location: Inlet to Moisture Extractor

Sample Type: MM13B Filter No.: _____

Sample Recovery Person: _____

Comments: _____

FRONT HALF

Acetone Container No.: _____ Liquid Level Marked: _____ Sealed: _____

Filter Container No.: _____ _____ _____ Sealed: _____

Description of Filter: _____

Samples stored and locked: _____

BACK HALF/MOISTURE

Container No: _____ _____ _____

Liquid Level Marked: _____ Sealed: _____

| IMP. NO. | CONTENTS | INITIAL VOL (ml) | WEIGHT (grams) INITIAL | FINAL | NET |
|---|---|---|---|---|---|
| 1 | .1 N NaOH | 100 | 602.6 | 640.0 | 37.4 |
| 2 | " | 100 | 632.8 | 635.2 | 2.4 |
| 3 | mt | — | 507.1 | 506.8 | -0.3 |
| 4 | Silica gel | — | 698.2 | 726.0 | 27.8 |
| 5 | " | | 701.9 | 713.2 | 11.3 |
| 6 | | | | | |
| TOTAL | | | | | 78.6 |

Description of Impinger Catch: _____

$$\sqrt{\Delta P_s (T_s + 460)}$$

```
                XROM "PRESS"
NO. OF POINTS ?
          24.00000      RUN
DELTA P ?
          .36000        RUN
STACK TEMP ?
          87.00000      RUN
DELTA P ?
          .38000        RUN
STACK TEMP ?
          88.00000      RUN
DELTA P ?
          .38000        RUN
STACK TEMP ?
          88.00000      RUN
DELTA P ?
          .32000        RUN
STACK TEMP ?
          88.00000      RUN
DELTA P ?
          .30000        RUN
STACK TEMP ?
          88.00000      RUN
DELTA P ?
          .29000        RUN
STACK TEMP ?
          88.00000      RUN
DELTA P ?
          .28000        RUN
STACK TEMP ?
          89.00000      RUN
DELTA P ?
          .42000        RUN
STACK TEMP ?
          89.00000      RUN
DELTA P ?
          .59000        RUN
STACK TEMP ?
          89.00000      RUN
DELTA P ?
          .76000        RUN
STACK TEMP ?
          88.00000      RUN
DELTA P ?
          .89000        RUN
STACK TEMP ?
          88.00000      RUN
DELTA P ?
          .95000        RUN
STACK TEMP ?
          88.00000      RUN
DELTA P ?
          .63000        RUN
STACK TEMP ?
          90.00000      RUN
DELTA P ?
          .65000        RUN
STACK TEMP ?
          90.00000      RUN
DELTA P ?
          .70000        RUN
STACK TEMP ?
          91.00000      RUN
DELTA P ?
          .50000        RUN
STACK TEMP ?
          91.00000      RUN
DELTA P ?
          .41000        RUN
STACK TEMP ?
          90.00000      RUN
DELTA P ?
          .39000        RUN
STACK TEMP ?
          91.00000      RUN
DELTA P ?
          .37000        RUN
STACK TEMP ?
          91.00000      RUN
DELTA P ?
          .58000        RUN
STACK TEMP ?
          91.00000      RUN
DELTA P ?
          .67000        RUN
STACK TEMP ?
          91.00000      RUN
DELTA P ?
          .79000        RUN
STACK TEMP ?
          91.00000      RUN
DELTA P ?
          .82000        RUN
STACK TEMP ?
          91.00000      RUN
DELTA P ?
          .86000        RUN
STACK TEMP ?
          91.00000      RUN

SQRT PSTS = 17.13110
AVE STK TEMP = 89.45833
```

## Method 5 Calculations

```
                XROM "METH 5"
RUN NUMBER
IA-1
                              RUN
METER BOX Y?
          1.0090              RUN
DELTA H?
          4.1500              RUN
BAR PRESS ?
          29.2500             RUN
METER VOL ?
          150.1220            RUN
MTR TEMP F?
          115.0000            RUN
STATIC HOH IN ?
          -1.5000             RUN
STACK TEMP.
          89.5000             RUN
ML. WATER ?
          78.6000             RUN

SAT % = 4.8

IMP. % HOH = 2.6
% HOH=2.6

% CO2?
          .7000               RUN
% OXYGEN?
          21.0000             RUN
% CO ?
                              RUN

MWd =28.95
MW WET=28.66

SQRT PSTS ?
          17.1311             RUN
TIME MIN ?
          120.0000            RUN
NOZZLE DIA ?
          .3030               RUN
STK DIA INCH ?
          21.5000             RUN

* VOL MTR STD = 137.395
  STK PRES ABS = 29.14
  VOL HOH GAS = 3.70
  % MOISTURE = 2.62
  MOL DRY GAS = 0.974
  % NITROGEN = 78.30
  MOL WT DRY = 28.95
  MOL WT WET = 28.66
  VELOCITY FPS = 42.57
  STACK AREA = 2.52
  STACK ACFM = 6,439.
* STACK DSCFM = 5,868.
  % ISOKINETIC =  98.30
```

## Emission Rate Calculations

```
                              RUN

RUN NUMBER
IA-2                          RUN

VOL MTR STD ?
          137.39500           RUN
STACK DSCFM ?
          5,868.00000         RUN
FRONT 1/2 MG ?
          12.91250            RUN
BACK 1/2 MG ?
                              RUN

F  GR/DSCF = 0.00145
F  MG/MMM = 3.31884
F  LB/HR = 0.07295
F  KG/HR = 0.03309

                              RUN
B  GR/DSCF = 0.00000
B  MG/MMM = 0.00000
B  LB/HR = 0.00000
B  KG/HR = 0.00000

T  GR/DSCF = 0.00145
T  MG/MMM = 3.31884
T  LB/HR = 0.07295
T  KG/HR = 0.03309
```

## FIELD DATA

Plant Roll Tech.
Date 8/10/88 Job No. 958
Sampling Location INLET; MOIST. EK.
Sample Type MM13B
Run Number IA-3
Operator T. MILLER
Ambient Temperature 94°F
Barometric Pressure 29.15 "Hg
Static Pressure ($P_g$) -1.5 "$H_2O$
Filter Number(s) NA
Pretest Leak Rate = 0.004 cfm @ 16.5 in. Hg
Pretest Pitot Leak Check OK
Pretest Orsat Leak Check NA
Read and Record all Data Every 5.0 Minutes

Schematic of Traverse Point Layout

Probe Length and Type 3' Pyrex
Pitot Tube I.D. No. S-4 Cp ~~0.88~~ 0.84 Up
Nozzle I.D. 0.301 | 0.303 | 0.304 | Avg. 0.303
Assumed Moisture, % 2.5
Temp. Readout S/N T-5
Meter Box Number MB-4
Meter $\Delta H_@$ 1.441
C Factor 0.90
Meter Gamma 1.009
Heater Box Setting NA
Reference Δp 0.24
Post Test Leak Rate = 0.002 cfm @ 15 in. Hg
Post Test Pitot Leak Check
Post Test Orsat Leak Check NA

Page 1 of 2

| Traverse Point Number | Sampling Time, (min) / Clock Time (24-hour clock) | Gas Meter Reading ($V_m$) ft³ | Velocity Head ($\Delta P_g$) in. $H_2O$ | Orifice Pressure Differential (ΔH) in. $H_2O$ Desired | Orifice Pressure Differential (ΔH) in. $H_2O$ Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp. °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp. Sensor ID No. | | | | | | 4I | MB-4-I | MB-4-O | | — | SH-5 | — |
| | 0 / 1528 | 954.810 | | | | | | | | | | |
| A-2 | 5.0 / | 962.440 | 0.84 | 6.3 | 6.3 | 94 | 100 | 96 | 11.1 | — | 52 | — |
| -2 | 10.0 / | 970.230 | 0.88 | 6.5 | 6.5 | 95 | 118 | 98 | 12.0 | — | 46 | — |
| -3 | 15.0 / | 977.050 | 0.63 | 4.7 | 4.7 | 95 | 127 | 102 | 7.5 | — | 49 | — |
| 4 | 20.0 / | 984.8-- | 0.62 | 4.6 | 4.6 | 95 | 130 | 104 | 7.5 | — | 50 | — |
| 5 | 25.0 / | 990.120 | 0.52 | 4.0 | 4.0 | 95 | 133 | 107 | 6.1 | — | 51 | — |
| 6 | 30.0 / | 995.510 | 0.39 | 3.0 | 3.0 | 95 | 135 | 110 | 4.5 | — | 52 | — |
| 7 | 35.0 / | 001.280 | 0.42 | 3.2 | 3.2 | 95 | 135 | 111 | 4.9 | — | 51 | — |
| 8 | 40.0 / | 8.127 | 0.52 | 3.9 | 3.9 | 95 | 135 | 113 | 6.0 | — | 51 | — |
| 9 | 45.0 / | 13.725 | 0.62 | 4.6 | 4.6 | 95 | 138 | 114 | 7.1 | — | 52 | — |
| 10 | 50.0 / | 20.735 | 0.70 | 5.3 | 5.3 | 95 | 140 | 116 | 8.9 | — | 52 | — |
| 11 | 55.0 / | 28.185 | 0.80 | 6.0 | 6.0 | 95 | 144 | 118 | 10.3 | — | 53 | — |
| 12 | 60.0 / 1628 | 36.025 | 0.86 | 6.5 | 6.5 | 95 | 147 | 120 | 11.9 | — | 54 | — |
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PACIFIC ENVIRONMENTAL SERVICES, INC.

Plant Name: Roll Tech. Test Date: 8/10/88

Run Number: IA-3 Operator: T. Miller

Page 2 of 2

| Traverse Point Number | Sampling / Clock Time, (min) / (24-hour clock) | Gas Meter Reading ($V_m$) $ft^3$ | Velocity Head ($\Delta P_s$) in. $H_2O$ | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Desired | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 40.0 / 1645 | 36.025 | | | | | | | | | | |
| B-2 | 65.0 / | 41.540 | 0.40 | 3.0 | 3.0 | 95 | 119 | 114 | 4.3 | — | 68 | — |
| 2 | 70.0 / | 46.830 | 0.37 | 2.8 | 2.8 | 96 | 125 | 114 | 4.1 | — | 53 | — |
| 3 | 75.0 / | 51.810 | 0.32 | 2.5 | 2.5 | 96 | 129 | 115 | 3.8 | — | 54 | — |
| 4 | 80.0 / | 56.640 | 0.29 | 2.3 | 2.3 | 96 | 132 | 116 | 3.5 | — | 56 | — |
| 5 | 85.0 / | 61.115 | 0.26 | 2.0 | 2.0 | 96 | 133 | 116 | 3.0 | — | 56 | — |
| 6 | 90.0 / | 65.345 | 0.24 | 1.8 | 1.8 | 97 | 133 | 117 | 2.8 | — | 58 | — |
| 7 | 95.0 / | 70.725 | 0.41 | 3.1 | 3.1 | 96 | 134 | 118 | 4.5 | — | 54 | — |
| 8 | 100.0 / | 77.130 | 0.57 | 4.3 | 4.3 | 96 | 138 | 119 | 2.5 | — | 52 | — |
| 9 | 105.0 / | 84.115 | 0.70 | 5.3 | 5.3 | 94 | 142 | 120 | 5.9 | — | 52 | — |
| 10 | 110.0 / | 91.829 | 0.89 | 6.5 | 6.5 | 97 | 147 | 122 | 12.0 | — | 54 | — |
| 11 | 115.0 / | 99.825 | 0.96 | 7.0 | 7.0 | 96 | 151 | 124 | 13.0 | — | 55 | — |
| 12 | 120.0 / | 107.926 | 0.94 | 7.0 | 6.9 | 95 | 154 | 126 | 13.0 | — | 58 | — |
| B-19 | / | | | | | | | | | | | |
| | / | $V_m$=153.116 | $\sqrt{\Delta P_{ave}}$=0.75 | | $\Delta H_{ave}$= 4.42 | $T_{s\,ave}$= 95.5°F | $T_{m\,in}$= 134°F | $T_{m\,out}$= 114°F | | | | |
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PACIFIC ENVIRONMENTAL SERVICES, INC.

## SAMPLE RECOVERY DATA

Plant: Roll Technology Run No.: I-A-3

Date: 8/10/88 Sample Box No.: RAC #2 Job No.: 958

Sample Location: Inlet to moisture extractor

Sample Type: MM13B Filter No.: NA

Sample Recovery Person: J.B. & T.M.

Comments: _____

FRONT HALF

Acetone Container No.: ✓ Liquid Level Marked: ✓ Sealed: ✓

Filter Container No.: ✓ — — Sealed: —

Description of Filter: NA

Samples stored and locked: given to analyst

BACK HALF/MOISTURE

Container No: _____ _____ _____

Liquid Level Marked: _____ Sealed: _____

| IMP. NO. | CONTENTS | INITIAL VOL (ml) | WEIGHT (grams) INITIAL | FINAL | NET |
|---|---|---|---|---|---|
| 1 | .1 N NaOH | 100 | 592.6 | 624.5 | 31.9 |
| 2 | " | 100 | 616.0 | 617.3 | 1.3 |
| 3 | MT | — | 508.4 | 511.3 | 2.9 |
| 4 | Silica Gel | — | 741.0 | 777.7 | 36.7 |
| 5 | " " | — | 715.4 | 721.2 | 5.8 |
| 6 | | | | | |
| TOTAL | | | | 78.6 | |

Description of Impinger Catch: _____

RUN IA-3 CALCULATION SUMMARY

$$\sqrt{\Delta P_s (T_s + 460)}$$

```
                XROM "PRESS"
NO. OF POINTS ?
          24.0000      RUN
DELTA P ?
            .8400      RUN
STACK TEMP ?
          94.0000      RUN
DELTA P ?
           8.0000      CLX
            .8800      RUN
STACK TEMP ?
          95.0000      RUN
DELTA P ?
            .6300      RUN
STACK TEMP ?
          95.0000      RUN
DELTA P ?
            .6200      RUN
STACK TEMP ?
          95.0000      RUN
DELTA P ?
            .5200      RUN
STACK TEMP ?
          95.0000      RUN
DELTA P ?
            .3900      RUN
STACK TEMP ?
          95.0000      RUN
DELTA P ?
            .4200      RUN
STACK TEMP ?
          95.0000      RUN
DELTA P ?
            .5200      RUN
STACK TEMP ?
          95.0000      RUN
DELTA P ?
            .6200      RUN
STACK TEMP ?
          95.0000      RUN
                       RUN
DELTA P ?
            .7000      RUN
STACK TEMP ?
          95.0000      RUN
DELTA P ?
            .8000      RUN
STACK TEMP ?
          95.0000      RUN
DELTA P ?
            .8600      RUN
STACK TEMP ?
          95.0000      RUN
DELTA P ?
            .4000      RUN
STACK TEMP ?
          95.0000      RUN
DELTA P ?
            .3700      RUN
STACK TEMP ?
          96.0000      RUN
DELTA P ?
            .3200      RUN
STACK TEMP ?
          96.0000      RUN
DELTA P ?
            .2900      RUN
STACK TEMP ?
          96.0000      RUN
DELTA P ?
            .2600      RUN
STACK TEMP ?
          96.0000      RUN
DELTA P ?
            .2400      RUN
STACK TEMP ?
          97.0000      RUN
DELTA P ?
            .4100      RUN
STACK TEMP ?
          96.0000      RUN
DELTA P ?
            .5700      RUN
STACK TEMP ?
          96.0000      RUN
DELTA P ?
            .7000      RUN
STACK TEMP ?
          96.0000      RUN
DELTA P ?
            .8900      RUN
STACK TEMP ?
          97.0000      RUN
DELTA P ?
            .9600      RUN
STACK TEMP ?
          96.0000      RUN
DELTA P ?
            .9400      RUN
STACK TEMP ?
          95.0000      RUN

SQRT PSTS = 17.7399
AVE STK TEMP = 95.4583
                XROM "METH 5"
RUN NUMBER
```

## Method 5 Calculations

```
                XROM "METH 5"
RUN NUMBER
IA-3                     RUN
METER BOX Y?
           1.0090        RUN
DELTA H?
           4.4200        RUN
BAR PRESS ?
          29.1500        RUN
METER VOL ?
         153.1160        RUN
MTR TEMP F?
         124.0000        RUN
STATIC HOH IN ?
            .0000        CLX
          -1.5000        RUN
STACK TEMP.
          95.0000        RUN
ML. WATER ?
          78.6000        RUN

SAT % = 5.7

IMP. % HOH = 2.6

% HOH=2.6

% CO2?
            .7000        RUN
% OXYGEN?
          21.0000        RUN
% CO ?                   RUN

MWd =28.95
MW WET=28.67

SQRT PSTS ?
          17.7399        RUN
TIME MIN ?
         120.0000        RUN
NOZZLE DIA ?
            .3030        RUN
STK DIA INCH ?
          21.5000        RUN

* VOL MTR STD = 137.602
  STK PRES ABS = 29.04
  VOL HOH GAS = 3.70
  % MOISTURE = 2.62
  MOL DRY GAS = 0.974
  % NITROGEN = 78.30
  MOL WT DRY = 28.95
  MOL WT WET = 28.67
  VELOCITY FPS = 44.15
  STACK AREA = 2.52
  STACK ACFM = 6,679.
* STACK DSCFM = 6,006.
  % ISOKINETIC =  96.19
```

## Emission Rate Calculations

```
                XROM "MASSFLO"
RUN NUMBER
IA-3                     RUN
VOL MTR STD ?
          137.602        RUN
STACK DSCFM ?
          6,006.00       RUN
FRONT 1/2 MG ?
          11.9374        RUN
BACK 1/2 MG ?
                         RUN

F  GR/DSCF = 1.34E-3
F  MG/MMM = 3.06
F  LB/HR = 0.07
F  KG/HR = 0.03

                       FIX 5
                         RUN
B  GR/DSCF = 0.00000
B  MG/MMM = 0.00000
B  LB/HR = 0.00000
B  KG/HR = 0.00000

T  GR/DSCF = 0.00134
T  MG/MMM = 3.06360
T  LB/HR = 0.06892
T  KG/HR = 0.03126
```

# FIELD DATA

Plant ~~Allied~~ ROLL TECHN.
Date 8-9-88 Job No. 958
Sampling Location INLET B
Sample Type MM13 B
Run Number IB-1
Operator J. BLAU, A. WEISMAN
Ambient Temperature 93
Barometric Pressure 29.24
Static Pressure ($P_s$) -3.8
Filter Number(s) —
Pretest Leak Rate = 0 cfm @ 10 in. Hg
Pretest Pitot Leak Check O.K
Pretest Orsat Leak Check
Read and Record all Data Every 4 Minutes

Schematic of Traverse Point Layout

Probe Length and Type 3' GLASS
Pitot Tube I.D. No. Cp .84
Nozzle I.D. 248 | 250 | 251 | Avg. 250
Assumed Moisture, % 2.5
Temp. Readout S/N 7-1
Meter Box Number MB-3
Meter $\Delta H_@$ 1.987
C Factor 1.25
Meter Gamma 1.000
Heater Box Setting —
Reference $\Delta p$ .385
Post Test Leak Rate = .003 cfm @ 5 in. Hg
Post Test Pitot Leak Check O.K
Post Test Orsat Leak Check

Page 1 of 2

Temp. Sensor ID No. 5A | MB3I | MB3O | SH4

| | Traverse Point Number | Sampling Time, (min) | /Clock Time /(24-hour clock) | Gas Meter Reading ($V_m$) $ft^3$ | Velocity Head ($\Delta P_s$) in. $H_2O$ | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Desired | Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp °F | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 14:49 | 877.792 | | | | | | | | | | | |
| 2 | 1 | 4 | | 881.435 | .53 | 2.4 | 2.4 | 94 | 107 | 104 | 2 | | 68 | | 40 |
| | 6 42 | 6:42 | * | 884.635 | .45 | 2.1 | 2.1 | 95 | 121 | 118 | 2 | | 66 | | ~~45~~ |
| 2 | 2 | 8 | | 887.531 | .45 | 2.1 | 2.1 | 96 | 128 | 112 | 2 | | 65 | | 45 |
| | 6:11 | 12:53 | | 890.132 | .43 | 2.0 | 2.0 | 95 | 128 | 115 | 2 | | 65 | | |
| 3 | 3 | 16.00 | | 893.871 | .46 | 2.1 | 2.1 | 96 | 129 | 117 | 2 | | 65 | | |
| | 6:42 | 19.35 | | 897.611 | .59 | 1.8 | 1.8 | 96 | 132 | 117 | 2 | | 65 | | 30 |
| 4 | 7.35 | 24.00 | | 899.635 | .42 | 1.9 | 1.9 | 95 | 133 | 117 | 2 | | 64 | | |
| | | 27.10 | * | 900.000 | .46 | 2.2 | 2.2 | 95 | 135 | 118 | 2 | | 64 | | 20 |
| 5 | 8:14 | 28.00 | | 903.361 | .46 | 2.2 | 2.2 | 95 | 135 | 118 | 2 | | 64 | | |
| | | 32.00 | | 906.745 | .46 | 2.1 | 2.1 | 96 | 138 | 120 | 2 | | 64 | | |
| 6 | 8:43 | 36.14 | | 909.983 | .47 | 2.2 | 2.2 | 96 | 140 | 121 | 2 | | 63 | | 5 |
| | | 40.00 | | 913.163 | .53 | 2.5 | 2.5 | 96 | 143 | 123 | 2 | | 63 | | |
| | 8:27 | 44.00 | * | 913.231 | .49 | 2.5 | 2.5 | 95 | 143 | 123 | 2 | | 63 | | 15 |
| 7 | | 44.57 | X | 913.615 | .49 | 2.5 | 2.5 | 95 | 146 | 123 | 2 | | 63 | | |
| | 7.56 | 48.00 | | 917.231 | .50 | 2.5 | 2.5 | 95 | 147 | 124 | 2 | | 63 | | |
| | | 52 | | 920.731 | .53 | 2.5 | 2.5 | 95 | 148 | 126 | 2 | | 63 | | |
| 8 | 8:44 | 56.52 | * | 924.381 | .51 | 2.4 | 2.4 | 97 | 149 | 128 | 2 | | 64 | | 25 |
| | | 60 | | 928.383 | .76 | 3.6 | 3.6 | 96 | 150 | 128 | 2 | | 64 | | |
| 9 | | 64.08 | | 933.281 | .73 | 3.5 | 3.5 | 97 | 154 | 130 | 2 | | 65 | | |
| | | 60 | | | .88 | 4.2 | 4.2 | 97 | 156 | 131 | 2 | | 64 | | |



PACIFIC ENVIRONMENTAL SERVICES, INC.

24
1.4
6

Plant Name: ROLL TECH  Test Date: 8-9

Run Number: IB-1  Operator: S. BLAU

Page 2 of 3

| Traverse Point Number | Sampling Time, (min) / Clock Time /(24-hour clock) | Gas Meter Reading ($V_m$) ft³ | Velocity Head ($\Delta P_s$) in. $H_2O$ | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Desired | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 68 / | 936.961 | | | | | | | | | | |
| 10 | 72 / | 941.635 | .85 | 4.1 | 4.1 | 96 | 158 | 132 | 2 | | 64 | |
| 10 | 76 / | 946.531 | .92 | 4.4 | 4.4 | 97 | 159 | 134 | 2 | | 65 | |
| | 80 / | 951.161 | .95 | 4.5 | 4.5 | 98 | 162 | 134 | 2 | | 66 | |
| 11 | 84 / | 955.981 | .88 | 4.2 | 4.2 | 98 | 166 | 135 | 2 | | 67 | |
| | 88 / | 959.631 | .87 | 4.2 | 4.2 | 92 | 159 | 135 | 2 | | 68 | |
| 12 | 92 / | 964.785 | .87 | 4.2 | 4.2 | 95 | 158 | 135 | 2 | | 67 | |
| | 96 02/16:31 | 968.086 | .88 | 4.3 | 4.3 | 93 | 157 | 135 | 2 | | 67 | |
| | LEAK CHECK, PORT CHANGE | | | | | .00 2CFM | | 5 11 | | | | |
| | / | 966.276 | | | | | | | | | | |
| 20 2 | 0 / 17.06 | 974.062 | 1.1 | 5.1 | 5.1 | 97 | 124 | 124 | 2 | | 66 | |
| 2 B-23 | 4 / | 979.111 | 1.2 | 5.1 | 5.1 | 97 | 138 | 126 | 2 | | 61 | |
| 25 2 | 8.14 / | 983981 | 1.2 | 5.6 | 5.6 | 94 | 146 | 125 | 2 | | 66 | |
| 2 | 12 / | 989.961 | 1.1 | 5.2 | 5.2 | 94 | 152 | 127 | 2 | | 65 | |
| 15 3 | 16/28 / | 994.283 | 1.1 | 5.2 | 5.2 | 98 | 154 | 128 | 2 | | 64 | |
| 3 | 20. / | 999.713 | 1.1 | 5.2 | 5.2 | 99 | 155 | 129 | 2 | | 64 | |
| | 24.80 / | 000.131 | 1.1 | 5.2 | 5.2 | 97 | 155 | 130 | 2 | | 67 | |
| 18 4 | 24/55 / | 004.993 | 1.1 | 5.2 | 5.2 | 97 | 156 | 130 | 2 | | 64 | |
| | 28 / | 010.315 | 1.1 | 5.2 | 5.2 | 98 | 155 | 130 | 2 | | 64 | |
| | 32. / | 012.611 | 1.1 | 5.2 | 5.2 | 98 | 156 | 131 | 2 | | 64 | |
| 5 | 33/15 / | 016.163 | 1.2 | 5.7 | 5.7 | 98 | 156 | 131 | 2 | | 64 | |
| | 36 / | 021.261 | 1.1 | 5.2 | 5.2 | 97 | 157 | 132 | 2 | | 64 | |
| | 40 / | 023.161 | 1.2 | 5.7 | 5.7 | 99 | 157 | 132 | 2 | | 65 | |
| 6 | 41.35 / | 026.631 | 1.0 | 4.8 | 4.8 | 97 | 157 | 132 | 2 | | 64 | |
| | 44 / | 031.361 | 1.0 | 4.8 | 4.8 | 98 | 157 | 132 | 2 | | 64 | |
| | 48 / | 035.811 | 1.0 | 4.8 | 4.8 | 98 | 156 | 132 | 2 | | 63 | |
| 7 | 49.45 / | 035.811 | .39 | 1.9 | 1.9 | 97 | 156 | 132 | 2 | | 65 | |
| | 52 / | 038.763 | .37 | 1.8 | 1.8 | 95 | 151 | 133 | 2 | | 64 | |
| | 56. / | 041.962 | .35 | 1.7 | 1.7 | 97 | 148 | 132 | 2 | | 63 | |
| 8 | 58 05 / | 041.811 | .28 | 1.3 | 1.3 | 97 | 148 | 132 | 2 | | 64 | |
| | 60 / | | .28 | 1.3 | 1.3 | 97 | 144 | 131 | 2 | | 63 | |

PACIFIC ENVIRONMENTAL SERVICES, INC.

Plant Name: Roll Tech

Test Date: 8-9-88

Run Number: B-1

Operator: J. Blau

Page 3 of 3

| Traverse Point Number | Sampling Time, (min) / Clock Time (24-hour clock) | Gas Meter Reading ($V_m$) $ft^3$ | Velocity Head ($\Delta P_s$) in. $H_2O$ | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Desired | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 60 / | 044.311 | | | | | | | | | | |
| | 69 / | 046.931 | .28 | 1.3 | | 98 | 142 | 130 | | | 66 | |
| | 66/50 | 048.831 | 24 | 1.1 | | 98 | 141 | 129 | | | 65 | |
| | 68 / | 050.311 | .24 | 1.1 | | 98 | 141 | 128 | | | 64 | |
| | 72 / | 053.621 | .24 | 1.1 | | 98 | 142 | 129 | | | 63 | |
| | 75/01 | 054.682 | .41 | 1.8 | | 98 | 141 | 128 | | | 64 | |
| | 76 / | 056.531 | .40 | 1.8 | | 98 | 142 | 128 | | | 64 | |
| | 80 / | 060.631 | .40 | 1.8 | | 98 | 143 | 128 | | | 65 | |
| | 81,28 / | 001.835 | .540 | 2.5 | | 98 | 143 | 128 | | | 64 | |
| | 84 / | 062.431 | .59 | 2.5 | | 98 | 141 | 128 | | | 65 | |
| | 86/56 / | 063.631 | .41 | 1.9 | 1.9 | 98 | 144 | 128 | | | 66 | |
| | 88 / | 063.311 | .43 | 2.0 | 2.0 | 98 | 144 | 128 | | | 66 | |
| | 92 / | 066.961 | 43 | 2.0 | 2.0 | 98 | 143 | 128 | | | 65 | |
| | 93/38 / | 069.715 | .43 | 2.0 | 2.0 | 88 | 144 | 128 | | | 64 | |
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SAMPLE RECOVERY DATA

Plant: Ball Technology Run No.: I-B-1

Date: 8/9/88 Sample Box No.: RAC#1 Job No.: _____

Sample Location: Inlet to Mist eliminator

Sample Type: MM13B Filter No.: N/A

Sample Recovery Person: B.A. Gerber

Comments: _____

FRONT HALF

Acetone Container No.: N/A Liquid Level Marked: N/A Sealed: N/A

Filter Container No.: N/A _____ _____ Sealed: N/A

Description of Filter: N/A

Samples stored and locked: Yes

BACK HALF/MOISTURE

Container No: IB-1 _____ _____

Liquid Level Marked: Yes Sealed: Yes

| IMP. NO. | CONTENTS | INITIAL VOL (ml) | WEIGHT (grams) INITIAL | FINAL | NET |
|---|---|---|---|---|---|
| 1 | | | 577.7 ~~579.5~~ | 612.1 | |
| 2 | | | 576.5 | 592.0 | |
| 3 | | | 514.0 | 518.2 | |
| 4 | | | 758.8 | 795.7 | |
| 5 | | | | | |
| 6 | | | | | |
| TOTAL | | | | | |

Description of Impinger Catch: Clear

## RUN IB-1 CALCULATION SUMMARY

BEGIN STK TEMP

| | | |
|---|---|---|
| STK TEMP 1. | 94. | RUN |
| STK TEMP 2. | 96. | RUN |
| STK TEMP 3. | 96. | RUN |
| STK TEMP 4. | 6. | CLR |
| | 96. | RUN |
| STK TEMP 5. | 95. | RUN |
| STK TEMP 6. | 96. | RUN |
| STK TEMP 7. | 95. | RUN |
| STK TEMP 8. | 97. | RUN |
| STK TEMP 9. | 97. | RUN |
| STK TEMP 10. | 98. | RUN |
| STK TEMP 11. | 95. | RUN |
| STK TEMP 12. | 94. | RUN |
| STK TEMP 13. | 97. | RUN |
| STK TEMP 14. | 99. | RUN |
| STK TEMP 15. | 98. | RUN |
| STK TEMP 16. | 98. | RUN |
| STK TEMP 17. | 97. | RUN |
| STK TEMP 18. | 98. | RUN |
| STK TEMP 19. | 96. | RUN |
| STK TEMP 20. | 97. | RUN |
| STK TEMP 21. | 98. | RUN |
| STK TEMP 22. | 98. | RUN |
| STK TEMP 23. | 98. | RUN |
| STK TEMP 24. | 98. | RUN |

Average = 97

$$\sqrt{\Delta P_s (T_s + 460)}$$

BEGIN SQRT PSTS

| | | |
|---|---|---|
| DELTA P 1. | .53 | RUN |
| DELTA P 2. | .44 | RUN |
| DELTA P 3. | .45 | RUN |
| DELTA P 4. | .41 | RUN |
| DELTA P 5. | .46 | RUN |
| DELTA P 6. | .50 | RUN |
| DELTA P 7. | .51 | RUN |
| DELTA P 8. | .75 | RUN |
| DELTA P 9. | .87 | RUN |
| DELTA P 10. | .93 | RUN |
| DELTA P 11. | .88 | RUN |
| DELTA P 12. | .87 | RUN |
| DELTA P 13. | 1.2 | RUN |
| DELTA P 14. | 1.2 | RUN |
| DELTA P 15. | 1.1 | RUN |
| DELTA P 16. | 1.1 | RUN |
| DELTA P 17. | 1.2 | RUN |
| DELTA P 18. | 1.0 | RUN |
| DELTA P 19. | .37 | RUN |
| DELTA P 20. | .28 | RUN |
| DELTA P 21. | .24 | RUN |
| DELTA P 22. | .40 | RUN |
| DELTA P 23. | .54 | RUN |
| DELTA P 24. | .48 | RUN |

$$\cos\phi \sqrt{\Delta P_s (T_s + 460)}$$

BEGIN COS SQRT PSTS

| | | |
|---|---|---|
| DEGREES 1. | 40. | RUN |
| DEGREES 2. | 45. | RUN |
| DEGREES 3. | 40. | RUN |
| DEGREES 4. | 30. | RUN |
| DEGREES 5. | 20. | RUN |
| DEGREES 6. | 5. | RUN |
| DEGREES 7. | 15. | RUN |
| DEGREES 8. | 25. | RUN |
| DEGREES 9. | 20. | RUN |
| DEGREES 10. | 15. | RUN |
| DEGREES 11. | 15. | RUN |
| DEGREES 12. | 20. | RUN |
| DEGREES 13. | 20. | RUN |
| DEGREES 14. | 20. | RUN |
| DEGREES 15. | 15. | RUN |
| DEGREES 16. | 18. | RUN |
| DEGREES 17. | 18. | RUN |
| DEGREES 18. | 21. | RUN |
| DEGREES 19. | 18. | RUN |
| DEGREES 20. | 3. | RUN |
| DEGREES 21. | 18. | RUN |
| DEGREES 22. | 44. | RUN |
| DEGREES 23. | 50. | RUN |
| DEGREES 24. | 40. | RUN |

DELTA H = 3.26
METER TEMP = 136.
STACK TEMP = 97.
SQRT PSTS = 19.2052
COS SQRT PSTS = 17.5127
MINUTES = 57.67

## Sample Times

| | XROM "TWA" |
|---|---|
| NO. POINTS ? | 24. RUN |
| POINT 1, MINUTES ? | 6. RUN |
| SECONDS ? | 42. RUN |
| POINT 2, MINUTES ? | 6. RUN |
| SECONDS ? | 11. RUN |
| POINT 3, MINUTES ? | 6. RUN |
| SECONDS ? | 42. RUN |
| POINT 4, MINUTES ? | 7. RUN |
| SECONDS ? | 35. RUN |
| POINT 5, MINUTES ? | 9. RUN |
| SECONDS ? | 4. RUN |
| POINT 6, MINUTES ? | 8. RUN |
| SECONDS ? | 43. RUN |
| POINT 7, MINUTES ? | 7. CLX |
| | 11. RUN |
| SECONDS ? | 55. RUN |
| POINT 8, MINUTES ? | 7. RUN |
| SECONDS ? | 16. RUN |
| POINT 9, MINUTES ? | 7. RUN |
| SECONDS ? | 52. RUN |
| POINT 10, MINUTES ? | 8. RUN |
| SECONDS ? | 0. RUN |
| POINT 11, MINUTES ? | 8. RUN |
| SECONDS ? | 0. RUN |
| POINT 12, MINUTES ? | 6. RUN |
| SECONDS ? | 2. RUN |
| POINT 13, MINUTES ? | 8. RUN |
| SECONDS ? | 14. RUN |
| POINT 14, MINUTES ? | 8. RUN |
| SECONDS ? | 14. RUN |
| POINT 15, MINUTES ? | 8. RUN |
| SECONDS ? | 27. RUN |
| POINT 16, MINUTES ? | 8. RUN |
| SECONDS ? | 20. RUN |
| POINT 17, MINUTES ? | 8. RUN |
| SECONDS ? | 20. RUN |
| POINT 18, MINUTES ? | 8. RUN |
| SECONDS ? | 10. RUN |
| POINT 19, MINUTES ? | 8. RUN |
| SECONDS ? | 20. RUN |
| POINT 20, MINUTES ? | 8. RUN |
| SECONDS ? | 45. RUN |
| POINT 21, MINUTES ? | 8. RUN |
| SECONDS ? | 20. RUN |
| POINT 22, MINUTES ? | 6. RUN |
| SECONDS ? | 18. RUN |
| POINT 23, MINUTES ? | 5. RUN |
| SECONDS ? | 28. RUN |
| POINT 24, MINUTES ? | 6. RUN |
| SECONDS ? | 42. RUN |
| TOTAL SEC = 11,260. | |

## ΔH

| | |
|---|---|
| BEGIN DELTA H | |
| DELTA H 1. | 2.25 RUN |
| DELTA H 2. | 2.1 RUN |
| DELTA H 3. | 2.05 RUN |
| DELTA H 4. | 1.85 RUN |
| DELTA H 5. | 2.16 RUN |
| DELTA H 6. | 2.4 RUN |
| DELTA H 7. | 2.5 RUN |
| DELTA H 8. | 3.55 RUN |
| DELTA H 9. | 4.15 RUN |
| DELTA H 10. | 4.45 RUN |
| DELTA H 11. | 4.2 RUN |
| DELTA H 12. | 4.23 RUN |
| DELTA H 13. | 5.1 RUN |
| DELTA H 14. | 5.4 RUN |
| DELTA H 15. | 5.2 RUN |
| DELTA H 16. | 5.2 RUN |
| DELTA H 17. | 5.53 RUN |
| DELTA H 18. | 4.8 RUN |
| DELTA H 19. | 1.8 RUN |
| DELTA H 20. | 1.3 RUN |
| DELTA H 21. | 1.1 RUN |
| DELTA H 22. | 1.8 RUN |
| DELTA H 23. | 2.5 RUN |
| DELTA H 24. | 2.0 RUN |

## Tm

| | |
|---|---|
| TEMP IN? | 107. RUN |
| TEMP OUT? | 104. RUN |
| TEMP IN? | 125. RUN |
| TEMP OUT? | 110. RUN |
| TEMP IN? | 129. RUN |
| TEMP OUT? | 116. RUN |
| TEMP IN? | 133. RUN |
| TEMP OUT? | 117. RUN |
| TEMP IN? | 136. RUN |
| TEMP OUT? | 119. RUN |
| TEMP IN? | 142. RUN |
| TEMP OUT? | 123. RUN |
| TEMP IN? | 147. RUN |
| TEMP OUT? | 124. RUN |
| TEMP IN? | 151. RUN |
| TEMP OUT? | 129. RUN |
| TEMP IN? | 157. RUN |
| TEMP OUT? | 132. RUN |
| TEMP IN? | 161. RUN |
| TEMP OUT? | 134. RUN |
| TEMP IN? | 163. RUN |
| TEMP OUT? | 135. RUN |
| TEMP IN? | 158. RUN |
| TEMP OUT? | 135. RUN |
| TEMP IN? | 131. RUN |
| TEMP OUT? | 125. RUN |
| TEMP IN? | 149. RUN |
| TEMP OUT? | 126. RUN |
| TEMP IN? | 155. RUN |
| TEMP OUT? | 129. RUN |
| TEMP IN? | 156. RUN |
| TEMP OUT? | 130. RUN |
| TEMP IN? | 157. RUN |
| TEMP OUT? | 132. RUN |
| TEMP IN? | 157. RUN |
| TEMP OUT? | 132. RUN |
| TEMP IN? | 152. RUN |
| TEMP OUT? | 132. RUN |
| TEMP IN? | 145. RUN |
| TEMP OUT? | 131. RUN |
| TEMP IN? | 141. RUN |
| TEMP OUT? | 129. RUN |
| TEMP IN? | 142. RUN |
| TEMP OUT? | 128. RUN |
| TEMP IN? | 142. RUN |
| TEMP OUT? | 128. RUN |
| TEMP IN? | 144. RUN |
| TEMP OUT? | 128. RUN |

## RUN IB-1 CALCULATION SUMMARY

BEGIN STK TEMP

| | | |
|---|---|---|
| STK TEMP 1. | 94. | RUN |
| STK TEMP 2. | 96. | RUN |
| STK TEMP 3. | 96. | RUN |
| STK TEMP 4. | 96. | RUN |
| STK TEMP 5. | 95. | RUN |
| STK TEMP 6. | 96. | RUN |
| STK TEMP 7. | 95. | RUN |
| STK TEMP 8. | 97. | RUN |
| STK TEMP 9. | 97. | RUN |
| STK TEMP 10. | 98. | RUN |
| STK TEMP 11. | 95. | RUN |
| STK TEMP 12. | 94. | RUN |
| STK TEMP 13. | 97. | RUN |
| STK TEMP 14. | 99. | RUN |
| STK TEMP 15. | 98. | RUN |
| STK TEMP 16. | 98. | RUN |
| STK TEMP 17. | 97. | RUN |
| STK TEMP 18. | 98. | RUN |
| STK TEMP 19. | 96. | RUN |
| STK TEMP 20. | 97. | RUN |
| STK TEMP 21. | 98. | RUN |
| STK TEMP 22. | 98. | RUN |
| STK TEMP 23. | 98. | RUN |
| STK TEMP 24. | 98. | RUN |

$$\sqrt{\Delta P_s (T_s + 460)}$$

BEGIN SQRT PSTS

| | | |
|---|---|---|
| DELTA P 1. | .53 | RUN |
| DELTA P 2. | .44 | RUN |
| DELTA P 3. | .45 | RUN |
| DELTA P 4. | .41 | RUN |
| DELTA P 5. | 4. | CLX |
| | .46 | RUN |
| DELTA P 6. | .5 | RUN |
| DELTA P 7. | .51 | RUN |
| DELTA P 8. | .75 | RUN |
| DELTA P 9. | .87 | RUN |
| DELTA P 10. | .93 | RUN |
| DELTA P 11. | .88 | RUN |
| DELTA P 12. | .87 | RUN |
| DELTA P 13. | 1.2 | RUN |
| DELTA P 14. | 1.2 | RUN |
| DELTA P 15. | 1.1 | RUN |
| DELTA P 16. | 1.1 | RUN |
| DELTA P 17. | 1.2 | RUN |
| DELTA P 18. | 1.0 | RUN |
| DELTA P 19. | .37 | RUN |
| DELTA P 20. | .28 | RUN |
| DELTA P 21. | .24 | RUN |
| DELTA P 22. | .40 | RUN |
| DELTA P 23. | .54 | RUN |
| DELTA P 24. | .43 | RUN |

$$\cos\Phi \sqrt{\Delta P_s (T_s + 460)}$$

BEGIN COS SQRT PSTS

| | | |
|---|---|---|
| DEGREES 1. | 40. | RUN |
| DEGREES 2. | 45. | RUN |
| DEGREES 3. | 40. | RUN |
| DEGREES 4. | 30. | RUN |
| DEGREES 5. | 20. | RUN |
| DEGREES 6. | 5. | RUN |
| DEGREES 7. | 15. | RUN |
| DEGREES 8. | 25. | RUN |
| DEGREES 9. | 20. | RUN |
| DEGREES 10. | 15. | RUN |
| DEGREES 11. | 15. | RUN |
| DEGREES 12. | 20. | RUN |
| DEGREES 13. | 20. | RUN |
| DEGREES 14. | 20. | RUN |
| DEGREES 15. | 15. | RUN |
| DEGREES 16. | 18. | RUN |
| DEGREES 17. | 18. | RUN |
| DEGREES 18. | 21. | RUN |
| DEGREES 19. | 18. | RUN |
| DEGREES 20. | 3. | RUN |
| DEGREES 21. | 8. | CLX |
| | 18. | RUN |
| DEGREES 22. | 44. | RUN |
| DEGREES 23. | 50. | RUN |
| DEGREES 24. | 40. | RUN |

DELTA H = 3.26
METER TEMP = 136.
STACK TEMP = 97.
SQRT PSTS = 19.2052
COS SQRT PSTS = 17.5127
MINUTES = 187.67

SF 07

## RUN IB-1 CALCULATION SUMMARY

### Method 5 Calculations

```
RUN NUMBER
IB-1
          3.0000     CL
                     RU
METER BOX Y?
          1.0000     RU
DELTA H?
          3.2600     RU
BAR PRESS ?
         29.2400     RU
METER VOL ?
        191.7330     RU
MTR TEMP F?
         36.0000     RU
STATIC HOA IN ?
         -3.8000     RU
STACK TEMP ?
         97.0000     RU
ML. WATER ?
         91.0000     RU

SAT % = 6.1

IMP. % HOH = 2.5
% HOH=2.5

% CO2?
           .7000     RUN
% OXYGEN?
         21.0000     RUN
% CO ?
          0.0000     RUN

MWd =28.95
MW WET=28.68

SQRT PSTS ?
                   SF 0;
          3.2052     RUN
COS SQRT PSTS ?
         17.5127     RUN
TIME MIN ?
         87.6670     RUN
NOZZLE DIA ?
           .2500     RUN
STK DIA INCH ?
         21.5000     RUN

* VOL MTR STD = 167.357
  STK PRES ABS = 28.96
  VOL H2O GAS = 4.58
  % MOISTURE = 2.50
  MOL DRY GAS = 0.975
  % NITROGEN = 78.30
  MOL WT DRY = 28.95
  MOL WT WET = 28.68
  VELOCITY FPS = 43.64
  STACK AREA = 2.52
  STACK ACFM = 6,601.
* STACK DSCFM = 5,906.
  % ISOKINETIC = 101.9

END OF FIELD DATA
```

### Emission Rate Calculations

```
                    XROM "MASSFLO"
RUN NUMBER
IB-1                          RUN
VOL MTR STD ?
        167.35700             RUN
STACK DSCFM ?
       5,906.00000            RUN
FRONT 1/2 MG ?
          1.64425             RUN
BACK 1/2 MG ?
                              RUN

F  GR/DSCF = 0.00015
F  MG/MMM = 0.34695
F  LB/HR = 0.00768
F  KG/HR = 0.00348

                              RUN
B  GR/DSCF = 0.00000
B  MG/MMM = 0.00000
B  LB/HR = 0.00000
B  KG/HR = 0.00000

I  GR/DSCF = 0.00015
I  MG/MMM = 0.34695
I  LB/HR = 0.00768
I  KG/HR = 0.00348
```

# FIELD DATA

Plant ROLL JACK
Date 8-10-87 Job No.
Sampling Location INLET B
Sample Type MM13B
Run Number I B - 2
Operator J. BLAIR
Ambient Temperature
Barometric Pressure 29.25
Static Pressure ($P_g$) -3.8
Filter Number(s)
Pretest Leak Rate = 0 cfm @ 5 in. Hg
Pretest Pitot Leak Check
Pretest Orsat Leak Check
Read and Record all Data Every 5 Minutes

Schematic of Traverse Point Layout

Probe Length and Type 3' GLASS
Pitot Tube I.D. No. Cp .84
Nozzle I.D. Avg. .250
Assumed Moisture, % 2.5
Temp. Readout S/N T-1
Meter Box Number MB-3
Meter $\Delta H_@$ 1.987
C Factor
Meter Gamma 1.000
Heater Box Setting
Reference $\Delta p$
Post Test Leak Rate = .002 cfm @ 7 in. Hg
Post Test Pitot Leak Check O.K
Post Test Orsat Leak Check

Page of Temp. Sensor ID No.

| Traverse Point Number | Sampling Time, (min) / Clock Time (24-hour clock) | Gas Meter Reading ($V_m$) ft³ | Velocity Head ($\Delta P_g$) in. H₂O | Orifice Pressure Differential (ΔH) in. H₂O Desired | Orifice Pressure Differential (ΔH) in. H₂O Actual | Stack Temp. ($T_g$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 / 11:09 | 69.749 | | | | | | | | | | |
| 45 1 | 4 / 11 / | 73.481 | .59 | 2.6 | 2.6 | 91 | 97 | 96 | | | 66 | |
| | 5 / | 76.162 | .58 | 2.6 | 2.6 | 90 | 100 | 97 | 2 | | | |
| 45 2 | 8 / 03 / | | | | | | | | | | | |
| | 10 / | | | | | | | | | | | |
| 40 3 | 12 / 14 / | 81.863 | .98 | 4.4 | 4.4 | 92 | 107 | 98 | 2 | | 63 | |
| | 15 / | | | | | | | | | | | |
| 30 4 | 16 / 18 / | 86.432 | .92 | 4.2 | 4.2 | 91 | 117 | 98 | 2 | | | |
| | 20 / | | | | | | | | | | | |
| 20 5 | 22 / 06 / | 92.003 | .91 | 4.1 | 4.1 | 90 | 121 | 101 | 2 | | 64 | |
| | 25 / | | | | | | | | | | | |
| 5 6 | 27 / 33 / | 96.931 | .73 | 3.3 | 3.3 | 91 | 126 | 103 | 2 | | 62 | |
| | 30 / | | | | | | | | | | | |
| 15 7 | 32 / 50 / | 101.673 | .61 | 2.8 | 2.8 | 91 | 132 | 106 | 2 | | 66 | |
| | 35 / | | | | | | | | | | | |
| 25 8 | 37 / 48 / | 106.431 | .67 | 3.1 | 3.1 | 93 | 133 | 108 | 2 | | 60 | |
| | 40 / | | | | | | | | | | | |
| 20 9 | 42 / 58 / | 111.237 | .82 | 3.8 | 3.8 | 91 | 135 | 111 | 2 | | 59 | |
| | 45 / | | | | | | | | | | | |
| 15 10 | 48 / 15 / | | .84 | 3.9 | 3.9 | 95 | 141 | 115 | 2 | | 58 | |
| | 50 / | | | | | | | | | | | |

B-30

Plant Name: ROLL TECH  Test Date: 8-10-88

Run Number: IB-2  Operator: J. BLAU

Page 2 of 2

| Traverse Point Number | Sampling Time, (min) / Clock Time (24-hour clock) | Gas Meter Reading ($V_m$) ft³ | Velocity Head ($\Delta P_s$) in. $H_2O$ | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Desired | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 48/15/ | 117.765 | | | | | | | | | | |
| 15 11 | 53/32/ | 123.883 | .93 | 4.4 | 4.4 | 93 | 141 | 117 | 2 | | 63 | |
| 12 | 58/38/ 12:07 | 129.656 | .87 | 4.2 | 4.2 | 94 | 144 | 119 | 2 | | 63 | |
| | / | LEAK CHECK | | | .006 | | 10" HG | | | | | |
| | 0 / | | | | | | | | | | | |
| | / | 129.828 | | | | | | | | | | |
| 20 1 | 5/09/ 12:29 | 136.03 | 1.1 | 5.1 | 5.1 | 94 | 121 | 119 | 5 | | 66 | |
| 20 2 | 10/16/ | 142.63 | 1.1 | 5.1 | 5.1 | 92 | 135 | 119 | 5 | | 64 | |
| 15 3 | 15/33/ | 150.231 | 1.2 | 5.6 | 5.6 | 94 | 144 | 118 | 6 | | 62 | |
| 15 4 | 20/45/ | 155.903 | .97 | 4.6 | 4.6 | 95 | 150 | 120 | 5 | | 67 | |
| 18 5 | 25/57/ | 162.961 | 1.2 | 5.7 | 5.7 | 95 | 152 | 122 | 7 | | 59 | |
| 21 6 | 31/03/ | 170.811 | 1.0 | 4.7 | 4.7 | 95 | 155 | 125 | 7 | | 54 | |
| 15 17 | 36/15/ | 174.183 | .30 | 1.4 | 1.4 | 95 | 158 | 128 | 7 | | 54 | |
| 3-8 | 41/43/ | 177.863 | .21 | 1.0 | 1.0 | 94 | 150 | 129 | 7 | | 58 | |
| 44 9 | 46/55/ | 180.622 | .25 | 1.2 | 1.2 | 95 | 148 | 129 | 7 | | 60 | |
| 24 10 | 50/51/ | 183.641 | .41 | 1.7 | 1.9 | 95 | 144 | 128 | 2 | | 61 | |
| 50 11 | 54/22/ | 186.431 | .64 | 3.0 | 3.0 | 95 | 145 | 129 | 2 | | 64 | |
| 46 12 | 58/33/ 12:27 | 190.950 | .66 | 3.1 | 3.1 | 95 | 147 | 129 | 3 | | 64 | |
| | / | | | | | | | | | | | |
| | / | | | | | | | | | | | |
| | / | | | | | | | | | | | |
| SAMPLE TIME | 58/38 | TO 58/33 | OR | 1160 | 71 | OR | 117 min | 11 sec. | | | | |
| | / | | | | | | | | | | | |
| | / | | | | | | | | | | | |
| | / | | | | | | | | | | | |
| | / | | | | | | | | | | | |
| | / | | | | | | | | | | | |
| | / | | | | | | | | | | | |
| | / | | | | | | | | | | | |
| | / | | | | | | | | | | | |
| | / | | | | | | | | | | | |

PEI

# SAMPLE RECOVERY DATA

Plant: Roll Tech. Run No.: I-B-2

Date: 8/10/88 Sample Box No.: 1 Job No.: 958

Sample Location: INLET

Sample Type: MMBB Filter No.: NA

Sample Recovery Person: B.G.; T.M

Comments: _____

## FRONT HALF

Acetone Container No.: _____ Liquid Level Marked: _____ Sealed: _____

Filter Container No.: _____ _____ _____ Sealed: _____

Description of Filter: _____

Samples stored and locked: _____

## BACK HALF/MOISTURE

Container No: _____ _____ _____

Liquid Level Marked: _____ Sealed: _____

| IMP. NO. | CONTENTS | INITIAL VOL (ml) | WEIGHT (grams) INITIAL | FINAL | NET |
|---|---|---|---|---|---|
| 1 | NaOH | ~100 | 580.0 | 609.7 | 29.7 |
| 2 | NaOH | ~100 | 578.6 | 584.2 | 5.6 |
| 3 | MT | - | 513.5 | 515.5 | 2 |
| 4 | Silica-Gel | - | 741.5 | 769.4 | 27.9 |
| 5 | Silica-Gel | - | 753.0 | 953.5 | .5 |
| 6 | | | | | 65.7 |
| TOTAL | | | | | |

Description of Impinger Catch: _____

# RUN IB-2 CALCULATION SUMMARY

## Sample Times

XROM "TWA"

NO. POINTS ? 24. RUN
POINT 1. MINUTES ? 4. RUN
SECONDS ? 11. RUN
POINT 2. MINUTES ? 3. RUN
SECONDS ? 52. RUN
POINT 3. MINUTES ? 4. RUN
SECONDS ? 11. RUN
POINT 4. MINUTES ? 4. RUN
SECONDS ? 44. RUN
POINT 5. MINUTES ? 5. RUN
SECONDS ? 8. RUN
POINT 6. MINUTES ? 5. RUN
SECONDS ? 27. RUN
POINT 7. MINUTES ? 5. RUN
SECONDS ? 17. RUN
POINT 8. MINUTES ? 4. RUN
SECONDS ? 58. RUN
POINT 9. MINUTES ? 5. RUN
SECONDS ? 8. RUN
POINT 10. MINUTES ? 5. RUN
SECONDS ? 17. RUN
POINT 11. MINUTES ? 5. RUN
SECONDS ? 17. RUN
POINT 12. MINUTES ? 5. RUN
SECONDS ? 8. RUN
POINT 13. MINUTES ? 5. RUN
SECONDS ? 8. RUN
POINT 14. MINUTES ? 5. RUN
SECONDS ? 8. RUN
POINT 15. MINUTES ? 5. RUN
SECONDS ? 17. RUN
POINT 16. MINUTES ? 5. RUN
SECONDS ? 12. RUN
POINT 17. MINUTES ? 5. RUN
SECONDS ? 12. RUN
POINT 18. MINUTES ? 5. RUN
SECONDS ? 6. RUN
POINT 19. MINUTES ? 5. RUN
SECONDS ? 12. RUN
POINT 20. MINUTES ? 5. RUN
SECONDS ? 28. RUN
POINT 21. MINUTES ? 5. RUN
SECONDS ? 12. RUN
POINT 22. MINUTES ? 3. RUN
SECONDS ? 56. RUN
POINT 23. MINUTES ? 3. RUN
SECONDS ? 31. RUN
POINT 24. MINUTES ? 4. RUN
SECONDS ? 11. RUN
TOTAL SEC = 7,031.

## ΔH

BEGIN DELTA H
DELTA H 1. 2.6 RUN
DELTA H 2. 2.6 RUN
DELTA H 3. 4.4 RUN
DELTA H 4. 4.2 RUN
DELTA H 5. 4.1 RUN
DELTA H 6. 3.3 RUN
DELTA H 7. 2.8 RUN
DELTA H 8. 3.1 RUN
DELTA H 9. 3.8 RUN
DELTA H 10. 3.9 RUN
DELTA H 11. 4.4 RUN
DELTA H 12. 4.2 RUN
DELTA H 13. 5.1 RUN
DELTA H 14. 5.1 RUN
DELTA H 15. 5.6 RUN
DELTA H 16. 4.6 RUN
DELTA H 17. 5.7 RUN
DELTA H 18. 4.7 RUN
DELTA H 19. 1.4 RUN
DELTA H 20. 1.0 RUN
DELTA H 21. 1.2 RUN
DELTA H 22. 1.9 RUN
DELTA H 23. 3.0 RUN
DELTA H 24. 3.1 RUN

## Tm

BEGIN MTR TEMP
TEMP IN? 97. RUN
TEMP OUT? 96. RUN
TEMP IN? 100. RUN
TEMP OUT? 97. RUN
TEMP IN? 107. RUN
TEMP OUT? 98. RUN
TEMP IN? 117. RUN
TEMP OUT? 98. RUN
TEMP IN? 121. RUN
TEMP OUT? 101. RUN
TEMP IN? 126. RUN
TEMP OUT? 103. RUN
TEMP IN? 132. RUN
TEMP OUT? 106. RUN
TEMP IN? 133 RUN
TEMP OUT? ~~100.~~ RUN
CLX
RDN
TEMP IN? 108. RUN
TEMP OUT? 135. RUN
TEMP IN? 111. RUN
TEMP OUT? 141. RUN
TEMP IN? 115. RUN
TEMP OUT? 141. RUN
TEMP IN? 117. RUN
TEMP OUT? 144. RUN
TEMP IN? 119. RUN
TEMP OUT? 121. RUN
TEMP IN? 119. RUN
TEMP OUT? 135. RUN
TEMP IN? 119. RUN
144. RUN

## RUN IB-2 CALCULATION SUMMARY

| | | |
|---|---|---|
| TEMP OUT? | | |
| TEMP IN? | 118. | RUN |
| TEMP OUT? | 150. | RUN |
| TEMP IN? | 120. | RUN |
| TEMP OUT? | 152. | RUN |
| TEMP IN? | 122. | RUN |
| TEMP OUT? | 155. | RUN |
| TEMP IN? | 125. | RUN |
| TEMP OUT? | 158. | RUN |
| TEMP IN? | 128. | RUN |
| TEMP OUT? | 150. | RUN |
| TEMP IN? | 129. | RUN |
| TEMP OUT? | 145. | RUN |
| TEMP IN? | 129. | RUN |
| TEMP OUT? | 144. | RUN |
| TEMP IN? | 128. | RUN |
| TEMP OUT? | 145. | RUN |
| TEMP IN? | 129. | RUN |
| TEMP OUT? | 147. | RUN |
| BEGIN STK TEMP | 129. | RUN |
| STK TEMP 1. | 91. | RUN |
| STK TEMP 2. | 90. | RUN |
| STK TEMP 3. | 92. | RUN |
| STK TEMP 4. | 91. | RUN |
| STK TEMP 5. | 90. | RUN |
| STK TEMP 6. | 91. | RUN |
| STK TEMP 7. | 91. | RUN |
| STK TEMP 8. | 93. | RUN |
| STK TEMP 9. | 91. | RUN |
| STK TEMP 10. | 95. | RUN |
| STK TEMP 11. | 93. | RUN |
| STK TEMP 12. | 94. | RUN |
| STK TEMP 13. | 94. | RUN |
| STK TEMP 14. | 92. | RUN |
| STK TEMP 15. | 94. | RUN |
| STK TEMP 16. | 95. | RUN |
| STK TEMP 17. | 95. | RUN |
| STK TEMP 18. | 95. | RUN |
| STK TEMP 19. | 95. | RUN |
| STK TEMP 20. | 94. | RUN |
| STK TEMP 21. | 95. | RUN |
| STK TEMP 22. | 95. | RUN |
| STK TEMP 23. | 95. | RUN |
| STK TEMP 24. | 95. | RUN |

$\sqrt{\Delta P_s (T_s + 460)}$

| | | |
|---|---|---|
| BEGIN SQRT PSTS | | |
| DELTA P 1. | .59 | RUN |
| DELTA P 2. | .58 | RUN |
| DELTA P 3. | .98 | RUN |
| DELTA P 4. | .92 | RUN |
| DELTA P 5. | .91 | RUN |
| DELTA P 6. | .73 | RUN |
| DELTA P 7. | .61 | RUN |
| DELTA P 8. | .67 | RUN |
| DELTA P 9. | .82 | RUN |
| DELTA P 10. | .84 | RUN |
| DELTA P 11. | .93 | RUN |
| DELTA P 12. | .89 | RUN |
| DELTA P 13. | 1.1 | RUN |
| DELTA P 14. | 1.1 | RUN |
| DELTA P 15. | 1.2 | RUN |
| DELTA P 16. | .97 | RUN |
| DELTA P 17. | 1.2 | RUN |
| DELTA P 18. | 1.0 | RUN |
| DELTA P 19. | .30 | RUN |
| DELTA P 20. | .21 | RUN |
| DELTA P 21. | .25 | RUN |
| DELTA P 22. | .41 | RUN |
| DELTA P 23. | .64 | RUN |
| DELTA P 24. | .66 | RUN |

$\cos\Phi \sqrt{\Delta P_s (T_s + 460)}$

| | | |
|---|---|---|
| BEGIN COS SQRT PSTS | | |
| DEGREES 1. | 45. | RUN |
| DEGREES 2. | 45. | RUN |
| DEGREES 3. | 40. | RUN |
| DEGREES 4. | 30. | RUN |
| DEGREES 5. | 20. | RUN |
| DEGREES 6. | 5. | RUN |
| DEGREES 7. | 15. | RUN |
| DEGREES 8. | 25. | RUN |
| DEGREES 9. | 20. | RUN |
| DEGREES 10. | 15. | RUN |
| DEGREES 11. | 15. | RUN |
| DEGREES 12. | 5. | CLX |
| | 15. | RUN |
| DEGREES 13. | 20. | RUN |
| DEGREES 14. | 20. | RUN |
| DEGREES 15. | 15. | RUN |
| DEGREES 16. | 18. | RUN |
| DEGREES 17. | 18. | RUN |
| DEGREES 18. | 21. | RUN |
| DEGREES 19. | 18. | RUN |
| DEGREES 20. | 3. | RUN |
| DEGREES 21. | 18. | RUN |
| DEGREES 22. | 44. | RUN |
| DEGREES 23. | 50. | RUN |
| DEGREES 24. | 50. | RUN |

DELTA H = 3.61
METER TEMP = ~~160.~~ 126
STACK TEMP = 95.
SQRT PSTS = 20.3048
COS SQRT PSTS = 18.3160
MINUTES = 117.18

# RUN IB-2 CALCULATION SUMMARY

## Method 5 Calculations

```
                XROM "METH 5
RUN NUMBER
 B-2
                                RU
METER BOX Y?
            1.0000              RU
DELTA H?
            3.6100              RU
BAR PRESS ?
           29.2500              RU
METER VOL ?
           20.8290              RU
MTR TEMP F?
          126.0000              RU
% OTHER GAS
REMOVED BEFORE
DRY GAS METER ?
                                RU
STATIC HOH IN ?
           -3.8000              RU
STACK TEMP
           93.0000              RU
ML. WATER ?
           65.7000              RU

SAT % = 5.4

IMP. % HOH = 2.8

% HOH=2.8

% CO2?
             .7000              RU
% OXYGEN?
           21.0000              RU
% CO ?
             .0000              RU
MOL WT OTHER?
                                RU

MWd =28.95
MW WET=28.65

SQRT PSTS ?
           20.3048              RU
COS SQRT PSTS ?
           18.3160              RU
TIME MIN ?
           17.1800              RU
NOZZLE DIA ?
             .2500              RU
STK DIA INCH ?
           21.5000              RU

* VOL MTR STD = 107.397
  STK PRES ABS = 28.97
  VOL HOH GAS = 3.09
  % MOISTURE = 2.80
  MOL DRY GAS = 0.972
  % NITROGEN = 78.30
  MOL WT DRY = 28.95
  MOL WT WET = 28.65
  VELOCITY FPS = 45.66
  STACK AREA = 2.52
  STACK ACFM = 6,907.
  STACK DSCFM = 6,207.
  % ISOKINETIC =  98.58
```

## Emission Rate Calculations

```
                                RUN
RUN NUMBER
IB-2                            RUN
VOL MTR STD ?
          107.39700             RUN
STACK DSCFM ?
        6,207.00000             RUN
FRONT 1/2 MG ?
            1.60952             RUN
BACK 1/2 MG ?
                                RUN

F  GR/DSCF = 0.00023
F  MG/MMM = 0.52924
F  LB/HR = 0.01230
F  KG/HR = 0.00558

                                RUN
B  GR/DSCF = 0.00000
B  MG/MMM = 0.00000
B  LB/HR = 0.00000
B  KG/HR = 0.00000

T  GR/DSCF = 0.00023
T  MG/MMM = 0.52924
T  LB/HR = 0.01230
T  KG/HR = 0.00558
```

FIELD DATA

Plant ROLL TECH
Date 8-10-88 Job No.
Sampling Location INLET B
Sample Type MM 13B
Run Number IB-3
Operator S. BLAU
Ambient Temperature 96
Barometric Pressure 29.15
Static Pressure ($P_g$) -3.8
Filter Number(s)
Pretest Leak Rate = 0 cfm @ 10 in. Hg
Pretest Pitot Leak Check O.K
Pretest Orsat Leak Check
Read and Record all Data Every 1 Minutes
Page ____ of ____

Schematic of Traverse Point Layout

Probe Length and Type 3' GLASS
Pitot Tube I.D. No. ____ Cp .84
Nozzle I.D. | | | Avg. .250
Assumed Moisture, % 2.5
Temp. Readout S/N T-1
Meter Box Number MB-3
Meter $\Delta H_@$ 1.987
C Factor
Meter Gamma 1.000
Heater Box Setting
Reference $\Delta p$
Post Test Leak Rate = .003 cfm @ 15 in. Hg
Post Test Pitot Leak Check O.K
Post Test Orsat Leak Check

Temp. Sensor ID No. 5A | MB 3 | MB 3 | | | SH 2

| Traverse Point Number | Sampling Time (min) | Clock Time (24-hour clock) | Gas Meter Reading ($V_m$) ft³ | Velocity Head ($\Delta P_g$) in. $H_2O$ | Orifice Pressure Differential ($\Delta H$) in. $H_2O$ Desired | Orifice Pressure Differential ($\Delta H$) in. $H_2O$ Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 15:26 | 191.123 | | | | | | | | | | |
| 452 | 4 | | 194.48 | .47 | 2.1 | 2.1 | 96 | 108 | 108 | 2 | | 68 | |
| 452 | 8 | 03 | 197.813 | .54 | 2.4 | 2.4 | 97 | 113 | 108 | 2 | | 66 | |
| 403 | 12 | 14 | 201.237 | .51 | 2.3 | 2.3 | 99 | 119 | 109 | 2 | | 61 | |
| 304 | 16 | 58 | 205.563 | .71 | 3.5 | 3.5 | 100 | 124 | 108 | 2 | | 63 | |
| 205 | 22 | 06 | 210.481 | .52 | 2.4 | 2.4 | 100 | 131 | 110 | 2 | | 61 | |
| 5 6 | 27 | 33 | 214.731 | .51 | 2.3 | 2.3 | 99 | 134 | 112 | 2 | | 63 | |
| 157 | 32 | 50 | 219.461 | .50 | 2.3 | 2.3 | 97 | 136 | 115 | 2 | | 64 | |
| 258 | 37 | 48 | 224.226 | .72 | 3.3 | 3.3 | 100 | 135 | 117 | 2 | | 65 | |
| 209 | 42 | 56 | 230.301 | .88 | 4.1 | 4.1 | 96 | 141 | 118 | 2 | | 62 | |
| 15 10 | 48 | 15 | 236.415 | .98 | 4.6 | 4.6 | 97 | 145 | 121 | 2 | | 64 | |
| 15 11 | 53 | 32 | 242.732 | .97 | 4.5 | 4.5 | 97 | 147 | 123 | 2 | | 66 | |
| 20 12 | 58 | 38 | 16:15 248.991 | .98 | 4.6 | 4.6 | 98 | 150 | 125 | 2 | | 66 | |
| | | | | LEAK CHECK | | | .003 | 21 | VAC | | | | |
| | | | 16:44 249.456 | | | | | | | | | | |
| H 202 | 5 | 08 | 255.49 | 1.1 | 5.1 | 5.1 | 93 | 125 | 121 | 6 | | | |
| 202 | 10 | 16 | 261.98 | .99 | 4.6 | 4.6 | 95 | 136 | 120 | 6 | | 66 | |
| 153 | 15 | 33 | 268.815 | 1.1 | 5.1 | 5.1 | 98 | 143 | 120 | 6 | | 58 | |
| 184 | 20 | 45 | 275.461 | 1.6 | 5.2 | 5.2 | 96 | 148 | 121 | 6 | | 59 | |
| 165 | 25 | 57 | | 1.2 | 5.7 | 5.7 | 98 | 152 | 123 | 6 | | 59 | |
| | | | | | | | | | | | | 62 | |

B-36

Plant Name: ROLL TECH  Test Date: 8-10-88

Run Number: IB-3  Operator: O. BLAL

Page 2 of 2

| Traverse Point Number | Sampling Time, (min) / Clock Time (24-hour clock) | Gas Meter Reading ($V_m$) $ft^3$ | Velocity Head ($\Delta P_s$) in. $H_2O$ | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Desired | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25/571 | 282.131 | | | | | | | | | | |
| 21 6 | 31/031 | 289.262 | 1.1 | 5.1 | 5.1 | 102 | 154 | 124 | 5 | | 63 | |
| 17 7 | 36/151 | 292.611 | .29 | 1.4 | 1.4 | 102 | 159 | 125 | 2 | | 66 | |
| 3 8 | 41/431 | 296.161 | .21 | .97 | .97 | 103 | 140 | 125 | 2 | | 63 | |
| 44 9 | 46/551 | 298.761 | .24 | 1.2 | 1.2 | 102 | 142 | 125 | 2 | | 61 | |
| 44 10 | 50/511 | 301.578 | .35 | 1.6 | 1.6 | 101 | 140 | 125 | 2 | | 64 | |
| 50 11 | 54/321 | 304.561 | .55 | 2.6 | 2.6 | 100 | 140 | 125 | 3 | | 67 | |
| 40 12 | 58/391 | 308.605 | .59 | 2.8 | 2.8 | 100 | 144 | 125 | 3 | | 67 | |
| | / | | | | | | | | | | | |
| | / | | | | | | | | | | | |
| | SAMPLE TIME 11 min 11 sec | | | | | | | | | | | |
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B-37

## SAMPLE RECOVERY DATA

Plant: Boll Tech Run No.: I-B-3

Date: 8/10/88 Sample Box No.: BAC#1 Job No.: 958

Sample Location: Inlet to Mist Elim.

Sample Type: MM13B Filter No.: NA

Sample Recovery Person: WJO, BG

Comments: —

FRONT HALF

Acetone Container No.: ✓ Liquid Level Marked: ✓ Sealed: ✓

Filter Container No: — — — — Sealed: —

Description of Filter: NA

Samples stored and locked: given to analyst

BACK HALF/MOISTURE

Container No: ____ ____ ____

Liquid Level Marked: ____ Sealed: ____

| IMP. NO. | CONTENTS | INITIAL VOL (ml) | WEIGHT (grams) INITIAL | FINAL | NET |
|---|---|---|---|---|---|
| 1 | NaOH | 100 | 579.9 | 603.0 | 23.1 |
| 2 | NaOH | 100 | 587.6 | 592.4 | 4.8 |
| 3 | MT | MT | 513.4 | 515.7 | 2.3 |
| 4 | Silica Gel | — | 753.5 | 781.5 | 28.0 |
| 5 | | | | | |
| 6 | | | | | |
| TOTAL | | | | | 58.2 |

Description of Impinger Catch: —



F1

# RUN IB-3 CALCULATION SUMMARY

## Sample Times

XROM "TWA"

NO. POINTS ? 24.00 RUN
POINT 1, MINUTES ? 4. RUN
SECONDS ? 11. RUN
POINT 2, MINUTES ? 3. RUN
SECONDS ? 52. RUN
POINT 3, MINUTES ? 5. CLX
4. RUN
SECONDS ? 11. RUN
POINT 4, MINUTES ? 4. RUN
SECONDS ? 44. RUN
POINT 5, MINUTES ? 5. RUN
SECONDS ? 8. RUN
POINT 6, MINUTES ? 5. RUN
SECONDS ? 27. RUN
POINT 7, MINUTES ? 5. RUN
SECONDS ? 17. RUN
POINT 8, MINUTES ? 4. RUN
SECONDS ? 58. RUN
POINT 9, MINUTES ? 5. RUN
SECONDS ? 8. RUN
POINT 10, MINUTES ? 5. RUN
SECONDS ? 19. RUN
POINT 11, MINUTES ? 5. RUN
SECONDS ? 17. RUN
POINT 12, MINUTES ? 5. RUN
SECONDS ? 6. RUN
POINT 13, MINUTES ? 5. RUN
SECONDS ? 8. RUN
POINT 14, MINUTES ? 5. RUN
SECONDS ? 8. RUN
POINT 15, MINUTES ? 5. RUN
SECONDS ? 17. RUN
POINT 16, MINUTES ? 5. RUN
SECONDS ? 12. RUN
POINT 17, MINUTES ? 5. RUN
SECONDS ? 12. RUN
POINT 18, MINUTES ? 5. RUN
SECONDS ? 6. RUN
POINT 19, MINUTES ? 5. RUN
SECONDS ? 12. RUN
POINT 20, MINUTES ? 5. RUN
SECONDS ? 28. RUN
POINT 21, MINUTES ? 5. RUN
SECONDS ? 12. RUN
POINT 22, MINUTES ? 3. RUN
SECONDS ? 56. RUN
POINT 23, MINUTES ? 3. RUN
SECONDS ? 31. RUN
POINT 24, MINUTES ? 4. RUN
SECONDS ? 11. RUN
TOTAL SEC = 7,031.

## ΔH

BEGIN DELTA H
DELTA H 1. 2.1 RUN
DELTA H 2. 2.4 RUN
DELTA H 3. 2.3 RUN
DELTA H 4. 3.5 RUN
DELTA H 5. 2.4 RUN
DELTA H 6. 2.3 RUN
DELTA H 7. 2.3 RUN
DELTA H 8. 3.3 RUN
DELTA H 9. 4.1 RUN
DELTA H 10. 4.6 RUN
DELTA H 11. 4.5 RUN
DELTA H 12. 4.6 RUN
DELTA H 13. 5.1 RUN
DELTA H 14. 4.6 RUN
DELTA H 15. 5.1 RUN
DELTA H 16. 5.2 RUN
DELTA H 17. 5.7 RUN
DELTA H 18. 5.1 RUN
DELTA H 19. 1.4 RUN
DELTA H 20. .97 RUN
DELTA H 21. 1.2 RUN
DELTA H 22. 1.6 RUN
DELTA H 23. 2.6 RUN
DELTA H 24. 2.8 RUN

## Tm

BEGIN MTR TEMP
TEMP IN? 108. RUN
TEMP OUT? 108. RUN
TEMP IN? 113. RUN
TEMP OUT? 108. RUN
TEMP IN? 119. RUN
TEMP OUT? 109. RUN
TEMP IN? 124. RUN
TEMP OUT? 108. RUN
TEMP IN? 131. RUN
TEMP OUT? 110. RUN
TEMP IN? 134. RUN
TEMP OUT? 112. RUN
TEMP IN? 136. RUN
TEMP OUT? 115. RUN
TEMP IN? 138. RUN
TEMP OUT? 117. RUN
TEMP IN? 141. RUN
TEMP OUT? 118. RUN
TEMP IN? 145. RUN
TEMP OUT? 121. RUN
TEMP IN? 147. RUN
TEMP OUT? 123. RUN
TEMP IN? 150. RUN
TEMP OUT? 125. RUN
TEMP IN? 125. RUN
TEMP OUT? 121. RUN
TEMP IN? 136. RUN
TEMP OUT? 120. RUN

## RUN IB-3 CALCULATION SUMMARY

| | | |
|---|---|---|
| TEMP IN? | 143. | RUN |
| TEMP OUT? | 120. | RUN |
| TEMP IN? | 148. | RUN |
| TEMP OUT? | 121. | RUN |
| TEMP IN? | 152. | RUN |
| TEMP OUT? | 123. | RUN |
| TEMP IN? | 154. | RUN |
| TEMP OUT? | 124. | RUN |
| TEMP IN? | 155. | RUN |
| TEMP OUT? | 125. | RUN |
| TEMP IN? | 140. | RUN |
| TEMP OUT? | 125. | RUN |
| TEMP IN? | 142. | RUN |
| TEMP OUT? | 125. | RUN |
| TEMP IN? | 140. | RUN |
| TEMP OUT? | 125. | RUN |
| TEMP IN? | 140. | RUN |
| TEMP OUT? | 125. | RUN |
| TEMP IN? | 144. | RUN |
| TEMP OUT? | 125. | RUN |

BEGIN STK TEMP

| | | |
|---|---|---|
| STK TEMP 1. | 96. | RUN |
| STK TEMP 2. | 97. | RUN |
| STK TEMP 3. | 99. | RUN |
| STK TEMP 4. | 100. | RUN |
| STK TEMP 5. | 100. | RUN |
| STK TEMP 6. | 99. | RUN |
| STK TEMP 7. | 97. | RUN |
| STK TEMP 8. | 100. | RUN |
| STK TEMP 9. | 96. | RUN |
| STK TEMP 10. | 97. | RUN |
| STK TEMP 11. | 97. | RUN |
| STK TEMP 12. | 98. | RUN |
| STK TEMP 13. | 93. | RUN |
| STK TEMP 14. | 95. | RUN |
| STK TEMP 15. | 98. | RUN |
| STK TEMP 16. | 96. | RUN |
| STK TEMP 17. | 98. | RUN |
| STK TEMP 18. | 102. | RUN |
| STK TEMP 19. | 102. | RUN |
| STK TEMP 20. | 103. | RUN |
| STK TEMP 21. | 102. | RUN |
| STK TEMP 22. | 101. | RUN |
| STK TEMP 23. | 100. | RUN |
| STK TEMP 24. | 100. | RUN |

$$\sqrt{\Delta P_s (T_s + 460)}$$

BEGIN SQRT PSTS

| | | |
|---|---|---|
| DELTA P 1. | .47 | RUN |
| DELTA P 2. | .54 | RUN |
| DELTA P 3. | .51 | RUN |
| DELTA P 4. | .71 | RUN |
| DELTA P 5. | .52 | RUN |
| DELTA P 6. | .51 | RUN |
| DELTA P 7. | .50 | RUN |
| DELTA P 8. | .72 | RUN |
| DELTA P 9. | .88 | RUN |
| DELTA P 10. | .98 | RUN |
| DELTA P 11. | .97 | RUN |
| DELTA P 12. | .98 | RUN |
| DELTA P 13. | 1.1 | RUN |
| DELTA P 14. | .99 | RUN |
| DELTA P 15. | 1.1 | RUN |
| DELTA P 16. | 1.1 | RUN |
| DELTA P 17. | 1.2 | RUN |
| DELTA P 18. | 1.1 | RUN |
| DELTA P 19. | .29 | RUN |
| DELTA P 20. | .21 | RUN |
| DELTA P 21. | .24 | RUN |
| DELTA P 22. | .35 | RUN |
| DELTA P 23. | .55 | RUN |
| DELTA P 24. | .59 | RUN |

COSΦ $\sqrt{\Delta P_s (T_s + 460)}$

BEGIN COS SQRT PSTS

| | | |
|---|---|---|
| DEGREES 1. | 45. | RUN |
| DEGREES 2. | 45. | RUN |
| DEGREES 3. | 40. | RUN |
| DEGREES 4. | 30. | RUN |
| DEGREES 5. | 20. | RUN |
| DEGREES 6. | 5. | RUN |
| DEGREES 7. | 15. | RUN |
| DEGREES 8. | 25. | RUN |
| DEGREES 9. | 20. | RUN |
| DEGREES 10. | 15. | RUN |
| DEGREES 11. | 15. | RUN |
| DEGREES 12. | 20. | RUN |
| DEGREES 13. | 20. | RUN |
| DEGREES 14. | 20. | RUN |
| DEGREES 15. | 15. | RUN |
| DEGREES 16. | 18. | RUN |
| DEGREES 17. | 18. | RUN |
| DEGREES 18. | 21. | RUN |
| DEGREES 19. | 18. | RUN |
| DEGREES 20. | 3. | RUN |
| DEGREES 21. | 44. | RUN |
| DEGREES 22. | 44. | RUN |
| DEGREES 23. | 50. | RUN |
| DEGREES 24. | 0. | CLX |
| | 40. | RUN |

DELTA H = 3.38
METER TEMP = 129.
STACK TEMP = 99.
SQRT PSTS = 19.5756
COS SQRT PSTS = 17.6530

MINUTES = 117.18

## RUN IB-3 CALCULATION SUMMARY

### Method 5 Calculations

```
                                RUN
METER BOX Y?
            1.0000              RUN
DELTA H?
            3.3800              RUN
BAR PRESS ?
           29.1500              RUN
METER VOL ?
          117.0170              RUN
MTR TEMP F?
          129.0000              RUN
STATIC HOH IN ?
           -3.8000              RUN
STACK TEMP
           99.0000              RUN
ML. WATER ?
           58.2000              RUN

SAT % = 6.5

IMP. % HOH = 2.6
% HOH=2.6

% CO2?
             .7000              RUN
% OXYGEN?
           21.0000              RUN
% CO ?
            0.0000              RUN

MWd =28.95
MW WET=28.67

SQRT PSTS ?
           19.5756              RUN
COS SQRT PSTS ?
           17.6530              RUN
TIME MIN ?
          117.1800              RUN
NOZZLE DIA ?
             .2500              RUN
STK DIA INCH ?
           21.5000              RUN

* VOL MTR STD = 103.069
  STK PRES ABS = 28.87
  VOL HOH GAS = 2.74
  % MOISTURE = 2.59
  MOL DRY GAS = 0.974
  % NITROGEN = 78.30
  MOL WT DRY = 28.95
  MOL WT WET = 28.67
  VELOCITY FPS = 44.06
  STACK AREA = 2.52
  STACK ACFM = 6,666.
* STACK DSCFM = 5,918.
  % ISOKINETIC =  99.19
```

### Emission Rate Calculations

```
                                RUN
RUN NUMBER
IB-3                            RUN
VOL MTR STD ?
          103.06900             RUN
STACK DSCFM ?
        5,918.00000             RUN
FRONT 1/2 MG ?
            1.25670             RUN
BACK 1/2 MG ?
                                RUN

F  GR/DSCF = 0.00019
F  MG/MMM = 0.43058
F  LB/HR = 0.00954
F  KG/HR = 0.00433
                                RUN
B  GR/DSCF = 0.00000
B  MG/MMM = 0.00000
B  LB/HR = 0.00000
B  KG/HR = 0.00000

T  GR/DSCF = 0.00019
T  MG/MMM = 0.43058
T  LB/HR = 0.00954
T  KG/HR = 0.00433
```

# FIELD DATA

Plant ROLL TECH
Date 8-9-88 Job No.
Sampling Location OUTLET ROOF
Sample Type MM 13 B
Run Number 0-1
Operator J. BLAU, E HOLLINS
Ambient Temperature 83
Barometric Pressure 29.24
Static Pressure ($P_s$) -.43
Filter Number(s) —
Pretest Leak Rate = 0 cfm @ 10 in. Hg
Pretest Pitot Leak Check O.K
Pretest Orsat Leak Check —
Read and Record all Data Every 4 Minutes

Schematic of Traverse Point Layout

Probe Length and Type 3' GLASS
Pitot Tube I.D. No. Cp .84
Nozzle I.D. .296 | .297 | .298 | Avg. ~~.250~~ .297
Assumed Moisture, % 2.5
Temp. Readout S/N T-1
Meter Box Number MB-1
Meter $\Delta H_@$ 1.78
C Factor 1.1
Meter Gamma .998
Heater Box Setting —
Reference $\Delta p$ .3
Post Test Leak Rate = .006 cfm @ 10 in. Hg
Post Test Pitot Leak Check O.K
Post Test Orsat Leak Check

Page ____ of ____

Temp. Sensor ID No. 4H | MB1 | MB1 | ~~SH2~~ | SH2

| Traverse Point Number | Sampling Time, (min) | /Clock Time /(24-hour clock) | Gas Meter Reading ($V_m$) ft³ | Velocity Head ($\Delta P_s$) in. $H_2O$ | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Desired | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 ~~14.51~~ | 14.51 | 639.696 | | 4.9 | 4.9 | | | | | | | |
| 2 | 4 | / | 646.432 | .55 | ~~98~~ | ~~98~~ | 94 | ~~98~~ | 98 | 4 | | 68 | |
| | 8 | / | 649.831 | .53 | 4.9 | 4.9 | 93 | 116 | 100 | 4 | | 66 | |
| 2 | 12 | / | 654.671 | .53 | 4.5 | 4.5 | 97 | 120 | 102 | 4 | | 66 | |
| | 16 | / | 659.633 | .52 | 4.3 | 4.3 | 97 | 111 | 102 | 4 | | 66 | |
| 3 | 20 | / | 663.761 | .53 | 4.4 | 4.4 | 97 | 118 | 102 | 4 | | 65 | |
| | 24 | / | 666.593 | .53 | 4.5 | 4.5 | 97 | 120 | 104 | 4 | | 65 | |
| 4 | 28 | / | ~~671.615~~ | .64 | 5.4 | 5.4 | 97 | 123 | 105 | 5 | | 64 | |
| | 32 | / | 679.361 | .64 | 5.4 | 5.4 | 97 | 128 | 108 | 5 | | 63 | |
| 5 | 36 | / | 684.562 | .64 | 5.4 | 5.4 | 97 | 130 | 110 | 5 | | 63 | |
| | 40 | / | 688.693 | .64 | 5.4 | 5.4 | 95 | 130 | 109 | 5 | | 63 | |
| 6 | 44 | / | 694.481 | .64 | 5.5 | 5.5 | 99 | 132 | 110 | 5 | | 62 | |
| | 48 | / | 700.701 | .65 | 5.5 | 5.5 | 98 | 138 | 110 | 5 | | 62 | |
| 7 | 52 | / | 704.961 | .60 | 5.2 | 5.2 | 99 | 140 | 111 | 5 | | 63 | |
| | 56 | / | 710.461 | .59 | 5.1 | 5.1 | 99 | 138 | 112 | 5 | | 64 | |
| 8 | 60 | / | 714.892 | .57 | 4.9 | 4.9 | 98 | 138 | 112 | 5 | | 64 | |
| | 64 | / | 720.311 | .57 | 4.9 | 4.9 | 98 | 136 | 112 | 5 | | 64 | |
| 9 | 68 | / | 724.932 | .60 | 5.1 | 5.1 | 101 | 132 | 112 | 5 | | 64 | |
| | 72 | / | 730.311 | .60 | 5.1 | 5.1 | 99 | 131 | 113 | 5 | | 63 | |
| 10 | 76 | / | 736.105 | .64 | 5.5 | 5.5 | 99 | 133 | 115 | 5 | | 64 | |
| | | / | | .64 | 5.5 | 5.5 | 98 | 134 | 116 | 5 | | 64 | |



PACIFIC ENVIRONMENTAL SERVICES, INC.

Plant Name: ROLL TECH

Test Date: 8-9-88

Run Number: 0-1

Operator: J. BLAU

Page 2 of 2

| Traverse Point Number | Sampling Time, (min) | /Clock Time /(24-hour clock) | Gas Meter Reading ($V_m$) $ft^3$ | Velocity Head ($\Delta P_s$) in. $H_2O$ | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Desired | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Im-pinger Temp. °F | Probe Temp °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 80 | / | 741.232 | | | | | | | | | | |
| 11 | 84 | / | 746.163 | .63 | 5.5 | 5.5 | 96 | 132 | 118 | 5 | | 68 | |
| | 88 | / | 751.731 | .64 | 5.6 | 5.6 | 95 | 135 | 118 | 5 | | 67 | |
| 12 | 92 | / | 756.431 | .67 | 5.8 | 5.8 | 97 | 134 | 116 | 5 | | 66 | |
| | 96 | / 16:34 | 762.034 | .67 | 5.8 | 5.8 | 97 | 134 | 116 | 5 | | 67 | |
| | Port 6 Hanover | | 762.034 | | | | | | | | | | |
| 2 | 0 | / 17.08 | 768.536 | .63 | 5.3 | 5.3 | 97 | 106 | 106 | 5 | | 67 | |
| | 4 | / | 772.591 | .62 | 5.2 | 5.2 | 102 | 118 | 110 | 5 | | 64 | |
| 2 | 8 | / | 777.831 | .62 | 5.2 | 5.2 | 102 | 126 | 110 | 5 | | 64 | |
| | 12 | / | 782.761 | .62 | 5.2 | 5.2 | 102 | 126 | 112 | 5 | | 63 | |
| 3 | 16 | / | 788.282 | .64 | 5.4 | 5.4 | 103 | 128 | 112 | 5 | | 63 | |
| | 20 | / | 793.561 | .66 | 5.6 | 5.6 | 102 | 130 | 114 | 4 | | 63 | |
| 4 | 24 | / | 798.831 | .68 | 5.8 | 5.8 | 99 | 128 | 112 | 4 | | 63 | |
| | 28 | / | 804.164 | .70 | 6.0 | 6.0 | 100 | 129 | 112 | 4 | | 63 | |
| 5 | 32 | / | 809.865 | .69 | 5.9 | 5.9 | 100 | 132 | 113 | 4 | | 63 | |
| | 36 | / | 815.461 | .67 | 5.7 | 5.7 | 100 | 131 | 113 | 4 | | 63 | |
| 6 | 40 | / | 820.361 | .67 | 5.7 | 5.7 | 99 | 128 | 112 | 4 | | 64 | |
| | 44 | / | 825.561 | .63 | 5.4 | 5.4 | 99 | 132 | 114 | 4 | | 64 | |
| 7 | 48 | / | 830.931 | .63 | 5.4 | 5.4 | 99 | 131 | 114 | 4 | | 63 | |
| | 52 | / | 836.161 | .61 | 5.2 | 5.2 | 99 | 131 | 114 | 4 | | 64 | |
| 8 | 56 | / | 840.631 | .59 | 5.1 | 5.1 | 98 | 134 | 115 | 4 | | 63 | |
| | 60 | / | 846.361 | .59 | 5.1 | 5.1 | 99 | 132 | 114 | 4 | | 62 | |
| 9 | 64 | / | 850.731 | .60 | 5.2 | 5.2 | 99 | 132 | 114 | 4 | | 63 | |
| | 68 | / | 856.126 | .59 | 5.1 | 5.1 | 97 | 132 | 114 | 4 | | 65 | |
| 10 | 72 | / | 861.031 | .59 | 5.1 | 5.1 | 98 | 132 | 114 | 4 | | 65 | |
| | 76 | / | 869.63 | .61 | 5.2 | 5.2 | 99 | 130 | 114 | 4 | | 66 | |
| 11 | 80 | / | 873.631 | .63 | 5.4 | 5.4 | 100 | 130 | 114 | 4 | | 65 | |
| | 84 | / | 878.351 | .63 | 5.4 | 5.4 | 100 | 130 | 114 | 4 | | 64 | |
| 12 | 88 | / | ~~[illegible]~~ | ~~.60~~ | ~~5.5~~ | ~~5.5~~ | ~~100~~ | ~~130~~ | ~~112~~ | ~~4~~ | | ~~65~~ | |
| | 92 | / | 882.661 | .65 | 5.6 | 5.6 | 100 | 130 | 112 | 4 | | 65 | |
| | 96 | / | 886.856 | .65 | 5.6 | 5.6 | 100 | 130 | 111 | 4 | | 65 | |
| | | / | | | | | | | | | | | |



PACIFIC ENVIRONMENTAL SERVICES, INC.

PES

SAMPLE RECOVERY DATA

Plant: Ball Technology Run No.: O-1

Date: 8/9/88 Sample Box No.: ~~RAC #2~~ Oil Blue Job No.: 958

Sample Location: Mist Eliminator Outlet

Sample Type: HM13B Filter No.: NA

Sample Recovery Person: B.G. & T.M.

Comments: _____

FRONT HALF

Acetone Container No.: O-1 Liquid Level Marked: ✓ Sealed: ✓

Filter Container No.: - - - Sealed: -

Description of Filter: NA

Samples stored and locked: _____

BACK HALF/MOISTURE

Container No: _____ _____ _____

Liquid Level Marked: _____ Sealed: _____

| IMP. NO. | CONTENTS | INITIAL VOL (ml) | WEIGHT (grams) INITIAL | FINAL | NET |
|---|---|---|---|---|---|
| 1 | NaOH | ~100 | 594.5 | 655.2 | 60.7 |
| 2 | NaOH | ~100 | 590.2 | 602.8 | 12.6 |
| 3 | MT | - | 494.6 | 500.4 | 5.8 |
| 4 | Silica-Gel | - | 728.7 | 767.3 | 38.6 |
| 5 | | | | | |
| 6 | | | | | |
| TOTAL | | | | | 117.7 |

Description of Impinger Catch: _____

## RUN O-1 CALCULATION SUMMARY

$$\sqrt{\Delta P_s (T_s + 460)}$$

XROM "PRESS"
NO. OF POINTS ? 48.00 RUN
DELTA P ? .55 RUN
STACK TEMP ? 94.00 RUN
DELTA P ? .53 RUN
STACK TEMP ? 93.00 RUN
DELTA P ? .53 RUN
STACK TEMP ? 97.00 RUN
DELTA P ? .52 RUN
STACK TEMP ? 97.00 RUN
DELTA P ? .53 RUN
STACK TEMP ? 97.00 RUN
DELTA P ? .53 RUN
STACK TEMP ? 97.00 RUN
DELTA P ? .64 RUN
STACK TEMP ? 97.00 RUN
DELTA P ? .64 RUN
STACK TEMP ? 97.00 RUN
DELTA P ? .64 RUN
STACK TEMP ? 97.00 RUN
DELTA P ? .64 RUN
STACK TEMP ? 95.00 RUN
DELTA P ? .64 RUN
STACK TEMP ? 99.00 RUN
DELTA P ? .65 RUN
STACK TEMP ? 98.00 RUN
DELTA P ? .60 RUN
STACK TEMP ? 99.00 RUN
DELTA P ? .59 RUN
STACK TEMP ? 99.00 RUN
DELTA P ? .57 RUN
STACK TEMP ? 98.00 RUN
DELTA P ? .57 RUN
STACK TEMP ? 98.00 RUN
DELTA P ? .60 RUN
STACK TEMP ? 101.00 RUN
DELTA P ? .60 RUN
STACK TEMP ? 99.00 RUN
DELTA P ? .64 RUN
STACK TEMP ? 99.00 RUN
DELTA P ? .64 RUN
STACK TEMP ? 98.00 RUN
DELTA P ? .63 RUN
STACK TEMP ? 96.00 RUN
DELTA P ? .64 RUN
STACK TEMP ? 95.00 RUN
DELTA P ? .67 RUN
STACK TEMP ? 97.00 RUN
DELTA P ? .67 RUN
STACK TEMP ? 97.00 RUN
DELTA P ? .63 RUN
STACK TEMP ? 97.00 RUN
DELTA P ? .62 RUN
STACK TEMP ? 102.00 RUN
DELTA P ? .62 RUN
STACK TEMP ? 102.00 RUN
DELTA P ? .62 RUN
STACK TEMP ? 102.00 RUN
DELTA P ? .64 RUN
STACK TEMP ? 103.00 RUN
DELTA P ? .66 RUN
STACK TEMP ? 102.00 RUN
DELTA P ? .63 RUN
STACK TEMP ? 99.00 RUN
DELTA P ? .70 RUN
STACK TEMP ? 100.00 RUN
DELTA P ? .69 RUN
STACK TEMP ? 100.00 RUN
DELTA P ? .67 RUN
STACK TEMP ? 100.00 RUN
DELTA P ? .67 RUN
STACK TEMP ? 99.00 RUN
DELTA P ? .63 RUN
STACK TEMP ? 99.00 RUN
DELTA P ? .63 RUN
STACK TEMP ? 99.00 RUN
DELTA P ? .61 RUN
STACK TEMP ? 99.00 RUN
DELTA P ? .59 RUN
STACK TEMP ? 98.00 RUN
DELTA P ? .59 RUN
STACK TEMP ? 99.00 RUN
DELTA P ? .60 RUN
STACK TEMP ? 99.00 RUN
DELTA P ? .59 RUN
STACK TEMP ? 97.00 RUN
DELTA P ? .59 RUN
STACK TEMP ? 98.00 RUN
DELTA P ? .61 RUN
STACK TEMP ? 99.00 RUN
DELTA P ? .63 RUN
STACK TEMP ? 100.00 RUN
DELTA P ? .63 RUN
STACK TEMP ? 100.00 RUN
DELTA P ? .65 RUN
STACK TEMP ? 100.00 RUN
DELTA P ? .65 RUN
STACK TEMP ? 100.00 RUN

SQRT PSTS = 18.57
AVE STK TEMP = 98.48
1.00 _CLX

# RUN O-1 CALCULATION SUMMARY

## Method 5 Calculations

```
RUN NUMBER
O-1
METER BOX Y?
          .9980
DELTA H?
         5.3000     RU
BAR PRESS ?
        29.2400     RU
METER VOL ?
       247.1600     RU
MTR TEMP F?
        20.0000     RU
STATIC H2O IN ?
         -.4300     RU
STACK TEMP.
        88.0000     RU
ML. WATER ?
       117.7000     RU

SAT % = 6.2

IMP. % H2O = 2.4
% H2O=2.4

% CO2?
          .7000     RU
% OXYGEN?
       21.0000     RU
% CO ?
        0.0000     RU

MWd =28.95
MW WET=28.69

SQRT PSTS ?
        18.5652     RU
TIME MIN ?
       92.0000     RU
NOZZLE DIA ?
         .2970     RU
STK DIA INCH ?
       21.5000     RU

* VOL MTR STD = 222.371
  STK PRES ABS = 29.21
  VOL CO2 GAS = 5.54
  % MOISTURE = 2.48
  MOL DRY GAS = 0.976
  % NITROGEN = 78.30
  MOL WT DRY = 28.95
  MOL WT WET = 28.69
  VELOCITY FPS = 46.06
  STACK AREA = 2.52
  STACK SCFM = 6,967.
* STACK DSCFM = 6,279.
  % ISOKINETIC = 96.71
```

## Emission Rate Calculations

```
                                RUN
RUN NUMBER
O-1                             RUN
VOL MTR STD ?
       222.37100                RUN
STACK DSCFM ?
     6,279.00000                RUN
FRONT 1/2 MG ?
          .18870                RUN
BACK 1/2 MG ?
                                RUN

F  GR/DSCF = 0.00001
F  MG/MMM = 0.02997
F  LB/HR = 0.00070
F  KG/HR = 0.00032

                                RUN
B  GR/DSCF = 0.00000
B  MG/MMM = 0.00000
B  LB/HR = 0.00000
B  KG/HR = 0.00000

I  GR/DSCF = 0.00001
I  MG/MMM = 0.02997
I  LB/HR = 0.00070
I  KG/HR = 0.00032
```

FIELD DATA

Plant ROLL J=H
Date 8-10-88 Job No. 758
Sampling Location OUTLET
Sample Type MM5
Run Number 0-2
Operator J. BLAU
Ambient Temperature 90
Barometric Pressure 29.25
Static Pressure ($P_s$) -.43
Filter Number(s)
Pretest Leak Rate = 0 cfm @ 15 in. Hg
Pretest Pitot Leak Check O.K
Pretest Orsat Leak Check O.K
Read and Record all Data Every 5 Minutes

Schematic of Traverse Point Layout

Probe Length and Type 8' GLASS
Pitot Tube I.D. No. Cp .84
Nozzle I.D. | | | Avg. .297
Assumed Moisture, % I + 2.5
Temp. Readout S/N I-1
Meter Box Number MB 1
Meter $\Delta H_@$ 1.78
C Factor
Meter Gamma @ 0.998
Heater Box Setting
Reference Δp
Post Test Leak Rate = .001 cfm @ 11 in. Hg
Post Test Pitot Leak Check O.K
Post Test Orsat Leak Check O.K

Page of

Temp. Sensor ID No.

| Traverse Point Number | Sampling Time, (min) / Clock Time (24-hour clock) | Gas Meter Reading ($V_m$) ft³ | Velocity Head ($\Delta P_s$) in. $H_2O$ | Orifice Pres. Differential (ΔH) in. $H_2O$ Desired | Orifice Pres. Differential (ΔH) in. $H_2O$ Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 / 11:11 | 887.273 | | | | | | | | | | |
| 1 | 5 / | 892.703 | .45 | 3.7 | 3.7 | 94 | 90 | 90 | 4 | 63 | 63 | |
| 2 | 10 / | 898.162 | .46 | 3.8 | 3.8 | 95 | 92 | 90 | 4 | | 61 | |
| 3 | 15 / | 903.731 | .50 | 4.1 | 4.1 | 95 | 100 | 91 | 4 | | 60 | |
| 4 | 20 / | 909.632 | .57 | 4.8 | 4.8 | 94 | 110 | 93 | 4 | | 60 | |
| 5 | 25 / | 915.461 | .56 | 4.7 | 4.7 | 94 | 116 | 96 | 4 | | 60 | |
| 6 | 30 / | 921.631 | .59 | 5.0 | 5.0 | 94 | 120 | 98 | 4 | | 62 | |
| 7 | 35 / | 927.932 | .54 | 4.9 | 4.9 | 93 | 121 | 101 | 4 | | 64 | |
| 8 | 40 / | 934.152 | .58 | 4.9 | 4.9 | 96 | 125 | 103 | 4 | | 65 | |
| 9 | 45 / | 940.431 | .58 | 4.9 | 4.9 | 95 | 128 | 106 | 4 | | 64 | |
| 10 | 50 / | 946.90 | .63 | 5.4 | 5.4 | 94 | 130 | 107 | 5 | | 64 | |
| 11 | 55 / | 953.211 | .65 | 5.6 | 5.6 | 94 | 128 | 108 | 5 | | 63 | |
| 12 | 60 / 12:11 | 959.970 | .66 | 5.7 | 5.7 | 96 | 133 | 110 | 5 | | 61 | |
| — | PORT CHANGE | | | | | | | | | | | |
| — | 0 / 12:31 | 959.970 | | | | | | | | | | |
| 1 | 5 / | 967.062 | .54 | 4.5 | 4.5 | 97 | 110 | 108 | 4 | | 66 | |
| 2 | 10 / | 972.131 | .54 | 4.6 | 4.6 | 96 | 118 | 108 | 4 | | 60 | |
| 3 | 15 / | 979.932 | .6 | 5.2 | 5.2 | 97 | 124 | 108 | 4 | | 60 | |
| 4 | 20 / | 985.132 | .64 | 5.5 | 5.5 | 97 | 130 | 110 | 4 | | 63 | |
| 5 | 25 / | 991.851 | .64 | 5.5 | 5.5 | 98 | 134 | 112 | 5 | | 63 | |
| 6 | 30 / | | .60 | 5.2 | 5.2 | 98 | 136 | 112 | 5 | | 62 | |


PACIFIC ENVIRONMENTAL SERVICES, INC.

Plant Name: Roll Tech

Run Number: O-2

Page 2 of 2

Test Date: 8-10-88

Operator: J. [illegible]

| Traverse Point Number | Sampling Time, (min) | Clock Time (24-hour clock) | Gas Meter Reading ($V_m$) ft³ | Velocity Head ($\Delta P_s$) in. $H_2O$ | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Desired | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 | | 998.200 | | | | | | | | | | |
| | 35 | | 4.731 | .58 | 5.0 | 5.0 | 98 | 136 | 118 | 4 | | 64 | |
| | 40 | | 10.311 | .56 | 4.8 | 4.8 | 98 | 137 | 115 | 4 | | 64 | |
| | 45 | | 16.561 | .56 | 4.8 | 4.8 | 98 | 136 | 118 | 4 | | 64 | |
| | 50 | | 22.801 | .57 | 4.9 | 4.9 | 100 | 138 | 117 | 4 | | 63 | |
| | 55 | | 29.066 | .61 | 5.3 | 5.3 | 98 | 132 | 117 | 4 | | 65 | |
| | 60 | 13:31 | 035.489 | .63 | 5.5 | 5.5 | 98 | 127 | 117 | 5 | | 65 | |

B-48

PES

SAMPLE RECOVERY DATA

Plant: Roll Technology Run No.: O-2

Date: 8/9/88 Sample Box No.: Big Blue Job No.: 958

Sample Location: outlet

Sample Type: MM13B Filter No.: _____

Sample Recovery Person: HJO/BG

Comments: _____

FRONT HALF

Acetone Container No.: _____ Liquid Level Marked: _____ Sealed: _____

Filter Container No.: _____ _____ _____ Sealed: _____

Description of Filter: _____

Samples stored and locked: _____

BACK HALF/MOISTURE

Container No: _____ _____ _____

Liquid Level Marked: _____ Sealed: _____

| IMP. NO. | CONTENTS | INITIAL VOL (ml) | WEIGHT (grams) INITIAL | FINAL | NET |
|---|---|---|---|---|---|
| 1 | NaOH | ~100 | 594.5 | 632.9 | 38.4 |
| 2 | NaOH | ~100 | 589.0 | 602.3 | 13.3 |
| 3 | MT | - | 494.7 | 499.4 | 4.7 |
| 4 | Silica-Gel | - | 707.4 | 738.7 | 31.3 |
| 5 | Silica-Gel | - | 712.3 | 714.3 | 2 |
| 6 | | | | | |
| TOTAL | | | | | 89.7 |

Description of Impinger Catch: _____

## RUN O-2 CALCULATION SUMMARY

$\sqrt{\Delta P_s \cdot (T_s + 460)}$

```
                    XROM "PRESS
IO. OF POINTS ?
                24.0000     RU
ELTA P ?
                .4500       RU
TACK TEMP ?
                94.0000     RU
ELTA P ?
                .4600       RU
TACK TEMP ?
                95.0000     RU
ELTA P ?
                .5000       RU
TACK TEMP ?
                95.0000     RU
ELTA P ?
                .5700       RU
TACK TEMP ?
                94.0000
ELTA P ?
                .5600
TACK TEMP ?
                94.0000     RU
ELTA P ?
                .5900       RU
TACK TEMP ?
                94.0000     RU
ELTA P ?
                .5800       RU
TACK TEMP ?
                93.0000     RU
ELTA P ?
                .5800       RU
TACK TEMP ?
                96.0000     RU
ELTA P ?
                .5800       RU
TACK TEMP ?
                95.0000     RU
ELTA P ?
                .6300       RU
TACK TEMP ?
                94.0000     RU
ELTA P ?
                .6500       RU
TACK TEMP ?
                94.0000     RU
ELTA P ?
                .6600       RU
TACK TEMP ?
                96.0000     RU
ELTA P ?
                .5400       RU
TACK TEMP ?
                97.0000     RU
ELTA P ?
                .5400       RUN
TACK TEMP ?
                96.0000     RUN
ELTA P ?
                .6100       RUN
TACK TEMP ?
                97.0000     RUN
DELTA P ?
                .6400       RUN
STACK TEMP ?
                97.0000     RUN
DELTA P ?
                .6400       RU
STACK TEMP ?
                97.0000     RU
DELTA P ?
                .6000       RU
STACK TEMP ?
                99.0000     RU
DELTA P ?
                .5800       RU
STACK TEMP ?
                98.0000     RU
DELTA P ?
                .5600       RU
STACK TEMP ?
                98.0000     RU
DELTA P ?
                .5600       RU
STACK TEMP?
                98.0000     RUN
```

```
DELTA P ?
                .5700       RUN
STACK TEMP ?                RUN
                100.0000    RUN
DELTA P ?
                .6100       RUN
STACK TEMP ?
                98.0000     RUN
DELTA P ?
                [illegible]
STACK TEMP ?
                98.0000     RUN
SQRT PSTS = 17.9208
```

### Method 5 Calculations

```
                    XROM "METH 5"
RUN NUMBER
O-=
O-2
METER BOX Y?                RUN
DELTA H?        .9980       RUN
BAR PRESS ?     4.9000      RUN
METER VOL ?     29.2500     RUN
MTR TEMP F?     148.2160    RUN
STATIC HOH IN ?     14.5000     RUN
STACK TEMP.     -.4300      RUN
ML. WATER ?     96.0000     RUN
                89.7000     RUN

SAT % = 5.9

IMP. % HOH = 3.0
% HOH=3.0

% CO2?
% OXYGEN?        .7000       RUN
% CO ?           21.0000     RUN
                0.0000      RUN
MWd =28.95
MW WET=28.62

SQRT PSTS ?
TIME MIN ?      17.9208     RUN
NOZZLE DIA ?    120.0000    RUN
STK DIA INCH ?  .2970       RUN
                21.5000     RUN
* VOL MTR STD = 134.539
  STK PRES ABS = 29.22
  VOL HOH GAS = 4.22
  % MOISTURE = 3.04
  MOL DRY GAS = 0.970
  % NITROGEN = 78.30
  MOL WT DRY = 28.95
  MOL WT WET = 28.62
  VELOCITY FPS = 44.50
  STACK AREA = 2.52
  STACK ACFM = 6,732.
* STACK DSCFM = 6,053.
  % ISOKINETIC = 97.12
```

### Emission Rate Calculations

```
                                RUN
RUN NUMBER
O-2                             RUN
VOL MTR STD ?
                134.53900       RUN
STACK DSCFM ?
                6,053.00000     RUN
FRONT 1/2 MG ?
                .16480          RUN
BACK 1/2 MG ?
                                RUN

F   GR/DSCF = 0.00002
F   MG/MMM = 0.04326
F   LB/HR = 0.00098
F   KG/HR = 0.00044

B   GR/DSCF = 0.00000           RUN
B   MG/MMM = 0.00000
B   LB/HR = 0.00000
B   KG/HR = 0.00000

T   GR/DSCF = 0.00002
T   MG/MMM = 0.04326
T   LB/HR = 0.00098
T   KG/HR = 0.00044
```

FIELD DATA

Plant ROLC TECH
Date 8-10-88 Job No.
Sampling Location OUTLET
Sample Type MM13D
Run Number 0-3
Operator J. BLAIR
Ambient Temperature 97
Barometric Pressure 29.15
Static Pressure ($P_s$) -.43
Filter Number(s)
Pretest Leak Rate = 0 cfm @ 11 in. Hg
Pretest Pitot Leak Check
Pretest Orsat Leak Check
Read and Record all Data Every ___ Minutes

Schematic of Traverse Point Layout

Probe Length and Type 3' 62453
Pitot Tube I.D. No. ____ Cp .84
Nozzle I.D. | | | Avg. .297
Assumed Moisture, % 2.5
Temp. Readout S/N T-1
Meter Box Number MB-1
Meter $\Delta H_@$ 1.78
C Factor —
Meter Gamma .998
Heater Box Setting —
Reference $\Delta p$ —
Post Test Leak Rate = .006 cfm @ 11 in. Hg
Post Test Pitot Leak Check O.K
Post Test Orsat Leak Check

Page ___ of ___

Temp. Sensor ID No.

| Traverse Point Number | Sampling Time, (min) / Clock Time (24-hour clock) | Gas Meter Reading ($V_m$) ft³ | Velocity Head ($\Delta P_s$) in. $H_2O$ | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Desired | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 / 15:28 | 035.710 | | | | | | | | | | |
| 1 | 5 / | 41.473 | .50 | 4.0 | 4.0 | 98 | 100 | 100 | 3 | | 66 | |
| 2 | / | 46.913 | .51 | 4.1 | 4.1 | 110 | 112 | 101 | 3 | | 61 | |
| 3 | / | 53.231 | .54 | 4.4 | 4.4 | 101 | 120 | 103 | 3 | | 64 | |
| 4 | / | 59.231 | .62 | 5.0 | 5.0 | 100 | 126 | 106 | 3 | | 63 | |
| 5 | / | 65.386 | .62 | 5.1 | 5.1 | 100 | 124 | 108 | 3 | | 64 | |
| 6 | / | 71.583 | .63 | 5.3 | 5.3 | 97 | 126 | 118 | 4 | | 64 | |
| 7 | / | 78.371 | .62 | 5.1 | 5.1 | 100 | 127 | 100 | 4 | | 63 | |
| 8 | / | 84.531 | .64 | 5.3 | 5.3 | 98 | 131 | 111 | 4 | | 63 | |
| 9 | / | 90.771 | .62 | 5.1 | 5.1 | 96 | 124 | 112 | 4 | | 64 | |
| 10 | / | 97.031 | .63 | 5.2 | 5.2 | 97 | 124 | 112 | 4 | | 63 | |
| 11 | 55 / | 103.461 | .63 | 5.1 | 5.1 | 99 | 122 | 110 | 4 | | 64 | |
| 12 | 60 / 16:28 | 109.685 | .64 | 5.2 | 5.2 | 99 | 124 | 112 | 4 | | 65 | |
| 96:44 | PORT CHANGE | 109.685 | | | | | | | | | | |
| | 5 / 16:49 | 116.226 | 61 | 4.9 | 4.9 | 95 | 108 | 108 | 4 | | 68 | |
| | 10 / | 122.461 | .63 | 5.1 | 5.1 | 95 | 118 | 106 | 4 | | 54 | |
| | 15 / | 128.703 | .64 | 5.2 | 5.2 | 96 | 124 | 118 | 4 | | 55 | |
| | 20 / | 134.991 | .63 | 5.2 | 5.2 | 98 | 128 | 110 | 4 | | 56 | |
| | 25 / | 141.301 | .62 | 5.1 | 5.1 | 96 | 128 | 111 | 4 | | 60 | |
| | 30 / | 147.542 | .61 | 5.0 | 5.0 | 99 | 128 | 112 | 4 | | 62 | |
| | 35 / | | .60 | 4.9 | 4.9 | 102 | 131 | 112 | 4 | | 63 | |

Plant Name: Roll Tech

Run Number: 0 0-3

Page 2 of 2

Test Date: 8-9-88

Operator: J. ALAN

| Traverse Point Number | Sampling Time, (min) | Clock Time (24-hour clock) | Gas Meter Reading ($V_m$) $ft^3$ | Velocity Head ($\Delta P_s$) in. $H_2O$ | Orifice Pres. Differential ($\Delta H$) in. $H_2O$ Desired | Actual | Stack Temp. ($T_s$) °F | Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F | Outlet ($T_{m_{out}}$) °F | Pump Vacuum in. Hg | Sample Box Temp. Filter Temp. °F | Impinger Temp. °F | Probe Temp °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 35 | | 154.161 | | | | | | | | | | |
| | 40 | | 161.031 | .59 | 4.8 | 4.6 | 112 | 132 | 113 | 3 | | 67 | |
| | 45 | | 166.611 | .60 | 4.9 | 4.9 | 103 | 132 | 114 | 9 | | 63 | |
| | 50 | | 172.531 | .63 | 5.2 | 5.2 | 103 | 132 | 115 | 4 | | 60 | |
| | 55 | | 178.831 | .65 | 5.3 | 5.3 | 102 | 133 | 114 | 4 | | 63 | |
| | 60 | 17:49 | 185.086 | .65 | 5.6 | 5.6 | 100 | 126 | 114 | 9 | | 61 | |
| | | | ~~149.226~~ 346 | √ΔP 0.7819 | | 5.00 | 99 | 124 | 110 | | | | |
| | | | 149.346 | | | | | | | | | | |

SAMPLE RECOVERY DATA

Plant: Roll Technology Run No.: 0-3

Date: 8/10/88 Sample Box No.: Big Blue Job No.: 958

Sample Location: Outlet from mist eliminator

Sample Type: MM13B Filter No.: NA

Sample Recovery Person: J-B, & T.M.

Comments: _____

FRONT HALF

Acetone Container No.: — Liquid Level Marked: ✓ Sealed: ✓

Filter Container No: — — — — Sealed: —

Description of Filter: NA

Samples stored and locked: given to analyst

BACK HALF/MOISTURE

Container No: _____ _____ _____

Liquid Level Marked: _____ Sealed: _____

| IMP. NO. | CONTENTS | INITIAL VOL (ml) | WEIGHT (grams) | | |
|---|---|---|---|---|---|
| | | | INITIAL | FINAL | NET |
| 1 | .1 N NaOH | 100 | 597.6 | 628.9 | 31.3 |
| 2 | " | 100 | 591.2 | 599.7 | 8.5 |
| 3 | MT | — | 495.5 | 499.4 | 3.9 |
| 4 | Silica Gel | — | 714.3 | 744.0 | 29.7 |
| 5 | | | | | |
| 6 | | | | | |
| TOTAL | | | | | 73.4 |

Description of Impinger Catch: _____



F1

# RUN O-3 CALCULATION SUMMARY

```
                    FIX 4
          XROM "PRESS"
NO. OF POINTS ?
          24.0000      RUN
DELTA P ?
          .5000        RUN
STACK TEMP ?
          98.0000      RUN
DELTA P ?
          .5100        RUN
STACK TEMP ?
          100.0000     RUN
DELTA P ?
          .5400        RUN
STACK TEMP ?
          101.0000     RUN
DELTA P ?
          .6200        RUN
STACK TEMP ?
          100.0000     RUN
DELTA P ?
          .6200        RUN
STACK TEMP ?
          100.0000     RUN
DELTA P ?
          .6300        RUN
STACK TEMP ?
          99.0000      RUN
DELTA P ?
          .6200        RUN
STACK TEMP ?
          100.0000     RUN
DELTA P ?
          .6400        RUN
STACK TEMP ?
          98.0000      RUN
DELTA P ?
          .6200        RUN
STACK TEMP ?
          96.0000      RUN
DELTA P ?
          .6300        RUN
STACK TEMP ?
          97.0000      RUN
DELTA P ?
          .6300        RUN
STACK TEMP ?
          99.0000      RUN
DELTA P ?
          .6400        RUN
STACK TEMP ?
          97.0000      RUN
DELTA P ?
          .6100        RUN
STACK TEMP ?
          95.0000      RUN
DELTA P ?
          .6300        RUN
STACK TEMP ?
          95.0000      RUN
DELTA P ?
          .6400        RUN
STACK TEMP ?
          96.0000      RUN
DELTA P ?
          .6300        RUN
STACK TEMP ?
          98.0000      RUN
DELTA P ?
          .6200        RUN
STACK TEMP ?
          98.0000      RUN
DELTA P ?
          .6100        RUN
STACK TEMP ?
          99.0000      RUN
DELTA P ?
          .6000        RUN
STACK TEMP ?
          102.0000     RUN
DELTA P ?
          .5900        RUN
STACK TEMP ?
          102.0000     RUN
DELTA P ?
          .6000        RUN
STACK TEMP ?
          103.0000     RUN
DELTA ?
          .6300        RUN
STACK TEMP ?
          103.0000     RUN
DELTA P ?
          .6500        RUN
STACK TEMP ?
          102.0000     RUN
DELTA P ?
          .6800        RUN
STACK TEMP ?
          100.0000     RUN
SQRT PSTS = 18.4878
[illegible] = 99.0833
```

## Method 5 Calculations

```
RUN NUMBER
O-3
METER BOX Y?                RU
DELTA H?        .998(       [illegible]
BAR PRESS ?     5.000(      [illegible]
METER VOL ?     29.1500     RU
MTR TEMP ?      [illegible].3460   RU
S[illegible] HOH IN ?   [illegible]7.0000   RU
S[illegible] TEMP ?     [illegible].4300   RU
ML. WATER ?     99.0000     RU
                73.4000     RU

SAT % = 6.4

IMP. % HOH = 2.5
% HOH=2.5

% CO2?
% OXYGEN?        .7000       RU
% CO ?           21.0000     RU
                            RU

MWd =28.95
MW WET=28.68

SQRT PSTS ?
TIME MIN ?      18.4878     RUN
NOZZLE DIA ?    120.0000    RUN
STK DIA INCH ?  .2970       RUN
                21.5000     RUN

* VOL MTR STD = [illegible].555
  STK PRES ABS = [illegible].12
  VOL HOH GAS = 3.45
  % MOISTURE = 2.50
  MOL DRY GAS = 0.975
  % NITROGEN = 78.30
  MOL WT DRY = [illegible]
  MOL WT WET
  VELOCITY F[illegible] = [illegible]
  STACK AREA = [illegible]
  STACK ACFM = [illegible]
* STACK DSCFM = 6,229.
  % ISOKINETIC = 94.39
```

## Emission Rate Calculations

```
                                RUN
RUN NUMBER
O-3                             RUN
VOL MTR STD ?
          134.55500             RUN
STACK DSCFM ?
          6,229.00000           RUN
FRONT 1/2 MG ?
          .18010                RUN
BACK 1/2 MG ?
                                RUN

F  GR/DSCF = 0.00002
F  MG/MMM = 0.04727
F  LB/HR = 0.00110
F  KG/HR = 0.00050

                                RUN
B  GR/DSCF = 0.00000
B  MG/MMM = 0.00000
B  LB/HR = 0.00000
B  KG/HR = 0.00000

T  GR/DSCF = 0.00002
T  MG/MMM = 0.04727
T  LB/HR = 0.00110
T  KG/HR = 0.00050
```

PLANT ROLL TECHNOLOGY LOCATION GREENVILLE, SOUTH CAROLINA

SAMPLED SOURCE MOISTURE EXTRACTOR, INLET

| RUN | DATE | (1) $V_m$ Std. | (2) DSCFM |
|---|---|---|---|
| IA-1 | 8/9/88 | 228.891 | 6,248 |
| IA-2 | 8/10/88 | 137.395 | 5,868 |
| IA-3 | 8/10/88 | 137.602 | 6,006 |
| | | | |

| FRONT HALF MILLIGRAMS | | | |
|---|---|---|---|
| PROBE | CYCLONE | FILTER | (3) TOTAL |
| 18.3771 | | | 18.3771 |
| 12.9125 | | | 12.9125 |
| 11.9374 | | | 11.9374 |
| | | | |

| (4) BACK HALF | 5 FRONT + BACK TOTAL |
|---|---|
| | |
| | |
| | |
| | |

CONCENTRATIONS

| | FRONT HALF | | | |
|---|---|---|---|---|
| RUN | Gr/DSCF | $Mg/M^3$ | Lb/Hr | Kg/Hr |
| IA-1 | 0.0012 | 2.835 | 0.0664 | 0.0301 |
| IA-2 | 0.0015 | 3.319 | 0.0729 | 0.0331 |
| IA-3 | 0.0013 | 3.064 | 0.0689 | 0.0313 |
| | | | | |
| | 6 | 7 | 8 | 9 |

| BACK HALF | | | |
|---|---|---|---|
| Gr/DSCF | $Mg/M^3$ | Lb/Hr | Kg/Hr |
| | | | |
| | | | |
| | | | |
| | | | |
| 10 | 17 | 18 | 19 |

| TOTAL | | | |
|---|---|---|---|
| Gr/DSCF | $Mg/M^3$ | Lb/Hr | Kg/Hr |
| | | | |
| | | | |
| | | | |
| | | | |
| 20 | 21 | 22 | 23 |

Remarks: BLANK CORRECTIONS: IA-1 = $(24.658\ mg/l\ Cr^{+6} - 0.004\ mg/l)(0.7544\ l) = 18.3771\ mg\ Cr^{+6}$

IA-2 = $(15.222\ mg/l\ Cr^{+6} - 0.004\ mg/l\ Cr^{+6})(0.8485\ l) = 12.9125\ mg\ Cr^{+6}$

IA-3 = $(15.457\ mg/l\ Cr^{+6} - 0.004\ mg/l\ Cr^{+6})(0.7725\ l) = 11.9374\ mg\ Cr^{+6}$

# SAMPLING SUMMARY SHEET

PLANT Roll Technology

LOCATION Greenville, South Carolina

SAMPLED SOURCE Mist Eliminator Inlet

| Run | Date | $N_p$ | (3) $Y_m$ | (4) $\Delta H$ | (5) P Bar. | (6) $V_m$ | (7) $T_m$ | (8) $V_m$ Std. | (9) % | (10) $P_{st}$ | 17 $P_s$ | (18) $T_s$ | (19) VP | (20) $V_w$ | 21 $V_{w_{gas}}$ | 22 %M | 23 $M_d$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IB-1 | 8/9/88 | 24 | 1.000 | 3.26 | 29.24 | 191.733 | 136 | 167.357 | — | -3.8 | 28.96 | 97 | — | 91.0 | 4.28 | 2.50 | .975 |
| IB-2 | 8/10/88 | 24 | 1.000 | 3.61 | 29.25 | 120.829 | 126 | 107.397 | — | -3.8 | 28.97 | 93 | — | 65.7 | 3.09 | 2.80 | .972 |
| IB-3 | 8/10/88 | 24 | 1.000 | 3.38 | 29.15 | 117.017 | 129 | 103.069 | — | -3.8 | 28.87 | 99 | — | 58.2 | 2.74 | 2.59 | .974 |
| | | | | | | | | | | | | | | | | | |

| Run | (24) $CO_2$ | (25) $O_2$ | 26 $N_2$ | (27) CO | (28) — | 29 $MW_d$ | 30 MW | (31) $C_p\sqrt{\Delta P_s(T_s+460)}$ | (32) | (33) $T_t$ | (34) $D_n$ | 35 $V_s$ | (36) $D_s$ | (37) Area | 38 ACFM | (39) DSCFM | 40 %I |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IB-1 | 0.7 | 21 | 78.3 | — | — | 28.95 | 28.68 | .84 | 19.2052 | 187.67 | .250 | 43.6 | 21.5 | 2.52 | 6,601 | 5,906 | 101.9 |
| IB-2 | 0.7 | 21 | 78.3 | — | — | 28.95 | 28.65 | .84 | 17.6127 | | | | | | | | |
| IB-3 | 0.7 | 21 | 78.3 | — | — | 28.95 | 28.67 | .84 | 20.3048 | 117.18 | .250 | 45.7 | 21.5 | 2.52 | 6,907 | 6,207 | 98.6 |
| | | | | | | | | | 18.3160 | | | | | | | | |
| | | | | | | | | | 19.5756 | 117.18 | .250 | 44.1 | 21.5 | 2.52 | 6,666 | 5,918 | 99.2 |
| | | | | | | | | | 17.6530 | | | | | | | | |

$$V_m \text{ Std.} = V_m \frac{17.64 \times V_m \left(P \text{ Bar.} + \frac{\Delta H}{13.6}\right)}{(T_m + 460)}$$

$$V_{w_{gas}} = 0.0471\ V_w$$

$$MW_d = 2CO_2 \times .44 + (O_2 \times .32) + (2CO \times 2N_2) \times .28 + \left(2\text{Other} \times \frac{\text{Mol. wt.}}{100}\right)$$

$$MW = MW_d \times M_d + 18(1 - M_d)$$

$$V_s = 85.49 \times C_p \sqrt{P_s (T_s + 460)} \left[\frac{1}{P_s \times MW}\right]^{1/2}$$

$$\%I = \frac{0.09450 \times (T_s + 460) \times V_m \text{ Std.}}{V_s \times T_s \times P_s \times M_d \times A_n}$$

$$\%M = \frac{100 \times V_{w_{gas}}}{V_m \text{ Std.} + V_{w_{gas}}}$$

$$M_d = \frac{100 - \%M}{100}$$

$$P_s = P \text{ Bar.} + \frac{P_{st}}{13.6}$$

$N_p$ = Total No. of Sampling points

$Y_m$ = Meter Box Correction Factor

$\Delta H$ = Average Orifice Pressure Drop, Inches $H_2O$

P Bar. = Barometric Pressure, Inches Hg. Absolute

$V_m$ = Volume of Dry Gas at Meter Conditions, DCF

$T_m$ = Average Meter Temperature, °F.

$V_m$ Std. = Volume of Dry Gas at STP, DSCF[a]

% = Per Cent other gas removed before Dry Gas Meter

$P_{st}$ = Static Pressure of Stack Gas, Inches $H_2O$

$P_s$ = Stack Gas Pressure, Inches Hg.

$T_s$ = Average Stack Temperature, °F

VP = Vapor Pressure of $H_2O$ at Stack Temperature

$V_w$ = Total $H_2O$ Collected in Impingers and Silica Gel

$V_{w_{gas}}$ = Volume of water vapor collected at STP, SCF[b]

%M = Per Cent Moisture by volume

$M_d$ = Mole Fraction of Dry Gas

$CO_2$ = Volume % Dry

$O_2$ = Volume % Dry

$N_2$ = Volume % Dry

CO = Volume % Dry

$MW_d$ = Molecular Weight of Stack Gas Dry Basis

MW = Molecular Weight of Stack Gas, Wet Basis

$C_p$ = Pitot Tube Coefficient

$\sqrt{\Delta P (T_s + 460)}$ Is determined by averaging the square root of the product of the velocity head ( P ) and the absolute stack temperature from each sampling point.

$T_t$ = Net time of test in minutes

$D_n$ = Sampling Nozzle Diameter, Inches

$A_n$ = Area of Nozzle opening, $ft^2$.

$V_s$ = Stack Gas Velocity at Stack Conditions, Feet per second.

$D_s$ = Diameter of Stack, Inches

Area = Area of duct in $ft^2$

ACFM = Actual Cubic Feet per minute

DSCFM = Dry Standard Cubic Feet per minute

%I = Per Cent Isokinetic

[a] Dry Standard Cubic Feet @ 68°F, 29.92 in. Hg.

[b] Standard Conditions @ 68°F. 29.92 in. Hg.

SUMMARY OF EMISSIONS

PLANT Roll Technology LOCATION Greenville, South Carolina

SAMPLED SOURCE Mist Eliminator, Inlet

| RUN | DATE | (1) $V_m$ Std. | (2) DSCFM |
|---|---|---|---|
| IB-1 | 8/9/88 | 167.357 | 5.906 |
| IB-2 | 8/10/88 | 107.397 | 6.207 |
| IB-3 | 8/10/88 | 103.069 | 5.918 |
| | | | |

| FRONT HALF MILLIGRAMS | | | |
|---|---|---|---|
| PROBE | CYCLONE | FILTER | (3) TOTAL |
| 1.6442 | | | 1.6442 |
| 1.6095 | | | 1.6095 |
| 1.2567 | | | 1.2567 |
| | | | |

| (4) BACK HALF | 5 FRONT + BACK TOTAL |
|---|---|
| | |
| | |
| | |
| | |

CONCENTRATIONS

| FRONT HALF | | | |
|---|---|---|---|
| RUN | Gr/DSCF | $Mg/M^3$ | Lb/Hr | Kg/Hr |
| IB-1 | 0.00015 | 0.347 | 0.0077 | 0.0035 |
| IB-2 | 0.0002 | 0.529 | 0.0123 | 0.0056 |
| IB-3 | 0.00019 | 0.431 | 0.0095 | 0.0043 |
| | | | | |
| | 6 | 7 | 8 | 9 |

| BACK HALF | | | |
|---|---|---|---|
| Gr/DSCF | $Mg/M^3$ | Lb/Hr | Kg/Hr |
| | | | |
| | | | |
| | | | |
| | | | |
| 10 | 17 | 18 | 19 |

| TOTAL | | | |
|---|---|---|---|
| Gr/DSCF | $Mg/M^3$ | Lb/Hr | Kg/Hr |
| | | | |
| | | | |
| | | | |
| | | | |
| 20 | 21 | 22 | 23 |

Remarks: BLANK CORRECTIONS: IB-1 $(2.13 mg/l Cr^{+6} - 0.004 mg/l Cr^{+6})(.7734 l) = 1.64425 mg Cr^{+6}$

IB-2 $(1.856 mg/l Cr^{+6} - 0.004 mg/l Cr^{+6})(.8672 l) = 1.6095 mg Cr^{+6}$

IB-3 $(1.715 mg/l Cr^{+6} - 0.004 mg/l Cr^{+6})(.7354 l) = 1.2567 mg Cr^{+6}$

SAMPLING SUMMARY SHEET

PLANT ROLL TECHNOLOGY LOCATION GREENVILLE, SOUTH CAROLINA

SAMPLED SOURCE MIST ELIMINATOR, OUTLET

| Run | Date | $N_p$ | (3) $Y_m$ | (4) $\Delta H$ | (5) P Bar. | (6) $V_m$ | (7) $T_m$ | (8) $V_{m\ Std.}$ | (9) % | (10) $P_{st}$ | 17 $P_s$ | (18) $T_s$ | (19) VP | (20) $V_w$ | 21 $V_{w_{gas}}$ | 22 %M | 23 $M_d$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-1 | 8/9/88 | 24 | 0.998 | 5.30 | 29.24 | 247.160 | 120 | 222.371 | — | -.43 | 29.21 | 98 | — | 117.7 | 5.54 | 2.43 | .976 |
| 0-2 | 8/10/88 | 24 | 0.998 | 4.90 | 29.25 | 148.216 | 145 | 134.539 | — | -.43 | 29.22 | 96 | — | 89.7 | 4.22 | 3.04 | .970 |
| 0-3 | 8/10/88 | 24 | 0.998 | 5.00 | 29.15 | 149.346 | 117 | 134.555 | — | -.43 | 29.12 | 99 | — | 73.4 | 3.45 | 2.50 | .975 |
| | | | | | | | | | | | | | | | | | |

| Run | (24) $CO_2$ | (25) $O_2$ | 26 $N_2$ | (27) CO | (28) — | 29 $MW_d$ | 30 MW | (31) $C_p$ | (32) $C_p\sqrt{\Delta P_s(T_s + 460)}$ | 33 $T_t$ | 34 $D_n$ | 35 $V_s$ | 36 $D_s$ | (37) Area | 38 ACFM | (39) DSCFM | 40 %I |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-1 | .7 | 21 | 78.3 | — | — | 28.95 | 28.69 | .84 | 18.5652 | 192 | .297 | 46.1 | 21.5 | 2.52 | 6967 | 6279 | 96.7 |
| 0-2 | .7 | 21 | 78.3 | — | — | 28.95 | 28.69 | .84 | 17.9208 | 120 | .297 | 44.5 | 21.5 | 2.52 | 6732 | 6053 | 97.1 |
| 0-3 | .7 | 21 | 78.3 | — | — | 28.95 | 28.68 | .84 | 18.4878 | 120 | .297 | 45.9 | 21.5 | 2.52 | 6950 | 6229 | 94.4 |
| | | | | | | | | | | | | | | | | | |

$$V_{m\ Std.} = V_m \frac{17.64 \times V_m \left(P\ Bar. + \frac{\Delta H}{13.6}\right)}{(T_m + 460)}$$

$$V_{w_{gas}} = 0.0471\ V_w$$

$$MW_d = 100 \times .44 + (\%O_2 \times .32) + (\%CO \times .28) + (\%Other \times \frac{Mol.\ wt.}{100})$$

$$MW = MW_d \times M_d + 18(1 - M_d)$$

$$V_s = 85.49 \times C_p \sqrt{\Delta P_s (T_s + 460)} \left[\frac{1}{P_s \times MW}\right]^{1/2}$$

$$\%I = \frac{0.09450 \times (T_s + 460) \times V_{m\ Std.}}{V_s \times T_t \times P_s \times M_d \times A_n}$$

$$\%M = \frac{100 \times V_{w_{gas}}}{V_{m\ Std.} + V_{w_{gas}}}$$

$$M_d = \frac{100 - \%M}{100}$$

$$P_s = P\ Bar. \pm \frac{P_{st}}{13.6}$$

$N_p$ = Total No. of Sampling points

$Y_m$ = Meter Box Correction Factor

$\Delta H$ = Average Orifice Pressure Drop, Inches $H_2O$

P Bar. = Barometric Pressure, Inches Hg, Absolute

$V_m$ = Volume of Dry Gas at Meter Conditions, DCF

$T_m$ = Average Meter Temperature, °F.

$V_{m\ Std.}$ = Volume of Dry Gas at STP, DSCF[a]

% = Per Cent other gas removed before Dry Gas Meter

$P_{st}$ = Static Pressure of Stack Gas, Inches $H_2O$

$P_s$ = Stack Gas Pressure, Inches Hg.

$T_s$ = Average Stack Temperature, °F

VP = Vapor Pressure of $H_2O$ At Stack Temperature

$V_w$ = Total $H_2O$ Collected in Impingers and Silica Gel

$V_{w_{gas}}$ = Volume of water vapor collected at STP, SCF[b]

%M = Per Cent Moisture by volume

$M_d$ = Mole Fraction of Dry Gas

$\%CO_2$ = Volume % Dry

$\%O_2$ = Volume % Dry

$\%N_2$ = Volume % Dry

%CO = Volume % Dry

$MW_d$ = Molecular Weight of Stack Gas Dry Basis

MW = Molecular Weight of Stack Gas, Wet Basis

$C_p$ = Pitot Tube Coefficient

$\sqrt{\Delta P (T_s + 460)}$ Is determined by averaging the square root of the product of the velocity head ( $\Delta P$ ) and the absolute stack temperature from each sampling point.

$T_t$ = Net time of test in minutes

$D_n$ = Sampling Nozzle Diameter, inches

$A_n$ = Area of Nozzle opening, $ft^2$.

$V_s$ = Stack Gas Velocity at Stack Conditions, Feet per second.

$D_s$ = Diameter of Stack, inches

Area = Area of duct in $ft^2$

ACFM = Actual Cubic Feet per minute

DSCFM = Dry Standard Cubic Feet per minute

%I = Per Cent Isokinetic

[a] Dry Standard Cubic Feet @ 68°F, 29.92 in. Hg.

[b] Standard Conditions @ 68°F, 29.92 in. Hg.

## SUMMARY OF EMISSIONS

PLANT ROLL TECHNOLOGY

LOCATION GREENVILLE, SOUTH CAROLINA

SAMPLED SOURCE MIST ELIMINATOR OUTLET

| RUN | DATE | ① $V_m$ Std. | ② DSCFM |
|---|---|---|---|
| 0-1 | 8/9/88 | 222.371 | 6,279 |
| 0-2 | 8/10/88 | 134.539 | 6,053 |
| 0-3 | 8/10/88 | 134.555 | 6,229 |
| | | | |

FRONT HALF MILLIGRAMS

| PROBE | CYCLONE | FILTER | ③ TOTAL |
|---|---|---|---|
| 0.1886 | | | 0.1886 |
| 0.1648 | | | 0.1648 |
| 0.1802 | | | 0.1802 |
| | | | |

| ④ BACK HALF | 5 FRONT + BACK TOTAL |
|---|---|
| | |
| | |
| | |
| | |

B-60

### CONCENTRATIONS

FRONT HALF

| RUN | Gr/DSCF | Mg/M³ | Lb/Hr | Kg/Hr |
|---|---|---|---|---|
| 0-1 | 0.00001 | 0.0299 | 0.0007 | 0.0003 |
| 0-2 | 0.00002 | 0.0432 | 0.0010 | 0.0004 |
| 0-3 | 0.00002 | 0.0473 | 0.0011 | 0.0005 |
| | | | | |
| | 6 | 7 | 8 | 9 |

BACK HALF

| Gr/DSCF | Mg/M³ | Lb/Hr | Kg/Hr |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| 10 | 17 | 18 | 19 |

TOTAL

| Gr/DSCF | Mg/M³ | Lb/Hr | Kg/Hr |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| 20 | 21 | 22 | 23 |

Remarks: BLANK CORRECTION: 0-1 (0.213-0.004) mg/l $Cr^{+6}$ (.6883 l) = 0.1438 mg $Cr^{+6}$, (0.288-0.004)(.1578 l) = 0.0448 mg $Cr^{+6}$ + 0.1438 = 0.1886 mg $Cr^{+6}$

0-2 (0.147-0.004) mg/l $Cr^{+6}$ (.3538 l) = 0.0506 mg $Cr^{+6}$, (0.200-0.004)(.5825) = 0.1142 + 0.0506 = 0.1648 mg $Cr^{+6}$

0-3 (0.236-0.004)(0.2905 l) = 0.0674 mg $Cr^{+6}$ (0.230-0.004)(.4989 l) = .1128 + 0.0674 = 0.1802 mg $Cr^{+6}$

Roll Technology Coepoeation- Greenville, S.C.

8/9/88 1140

Standard Curve

| Std. Concentration | %T |
|---|---|
| 100 ug/ml | 11.3 |
| 75 ug/ml | 19.5 |
| 50 ug/ml | 33.5 |
| 35 ug/ml | 45.2 |
| 25 ug/ml | 57.5 |
| 10 ug/ml | 80.5 |

$K_C = 1.0526$

| Sample | %T | A | ml sample | dilution | ug Cr++ / ml | Volume Collected | Total ug Cr++ in sample |
|---|---|---|---|---|---|---|---|
| BL | 100 | | | | | | |
| 1A1 - inlet | 33.5 | .475 | 50 | 1 | 1.0 | 98.7 | 98.69 |
| 1A2 - inlet | 26.0 | .585 | 20 | 1 | 3.1 | 102.7 | 316.21 |
| 1A3 - inlet | 55.2 | .258 | 20 | 1 | 1.4 | 97.4 | 132.29 |
| 1A4 - inlet | 11.0 | .959 | 20 | 1 | 5.0 | 89.1 | 449.52 |
| 10ug/ml | 80.9 | | | | | | |
| 1-A-out | 94.3 | .025 | 50 | 1 | .054 | 107.9 | 5.79 |
| 1-2-B-out | 93.0 | .032 | 50 | 1 | .066 | 109.6 | 7.27 |
| 1-3-C-out | 92.0 | .036 | 50 | 1 | .076 | 107.8 | 8.22 |
| 1-4-D-out | 92.5 | .034 | 50 | 1 | .071 | 112.5 | 8.02 |
| 10ug/ml | 80.1 | .096 | 100 | 1 | .101 | 100 | 10.14 |
| 1-5-E out | 97.0 | .013 | 50 | 1 | .028 | 115.0 | 3.20 |
| 1-6-F-out | 93.0 | .032 | 50 | 1 | .066 | 114.2 | 7.58 |
| 1-7-G-out | 93.1 | .031 | 50 | 1 | .065 | 113.0 | 7.39 |
| 1-8-H-out | 93.8 | .028 | 50 | 1 | .059 | 116.3 | 6.81 |
| 75ug/ml | 19.5 | .710 | 100 | 1 | .747 | 100 | 74.73 |
| I-A-1 (HM13B) | 1.0 | 2.0 | 10 | 1 | 21.052 | 745.4 | 15,692.16 |
| I-B-1 " | 49.7 | .304 | 15 | 1 | 2.13 | 773.4 | 1,647.94 |
| O-1 (probe+tip) | 79.2 | .101 | 50 | 1 | .213 | 688.3 | 146.75 |
| O-1 (nozzle/tube) | 73.0 | .137 | 50 | 1 | .288 | 157.8 | 45.40 |
| 1B1 - inlet (SM) | 15.0 | .824 | 20 | 1 | 4.336 | 100.9 | 437.53 |
| 1B2 - " " | 17.0 | .770 | 20 | 1 | 4.050 | 109.7 | 444.30 |
| 1B3 - " " | 12.0 | .921 | 20 | 1 | 4.846 | 108.8 | 527.27 |
| 1B4 - " " | 30.8 | .511 | 20 | 1 | 2.692 | 113.6 | 305.78 |
| I-A-1 (HM13B) | 34.0 | .469 | 2 | | 24.658 | 745.4 | 18,380.27 |

8/9/88 Sample Log

Sample Identification

| | |
|---|---|
| IIA | Outlet |
| 13c | Outlet |
| 12b | Outlet |
| 14d | Outlet |
| 1A1 | ~~Outlet~~ Inlet |
| 1A3 | Inlet |
| 1A2 | Inlet |
| 1A4 | Inlet |
| 15E | Outlet |
| 16F | Outlet |
| 17G | Outlet |
| 18H | Outlet |
| 1B1 | Inlet |
| 1B2 | Inlet |
| 1B3 | Inlet |
| 1B4 | Inlet |
| I-A-1 | |
| I-B-1 | |

O-1 - impinger/probe rinse
O-1 - Nozzle + U tube rinse
Roll Tech., Plating Tank 6

Rau Technology Corp. 8/10/88

Std. Curves

| Std. Concentration | %T |
|---|---|
| 100 ug/ml | 13.5 |
| 75 ug/ml | 21.0 |
| 50 ug/ml | 34.0 |
| 35 ug/ml | 48.5 |
| 25 ug/ml | 60.0 |
| 10 ug/ml | 81.7 |

$K_L = 1.1229$

| Sample | %T | A | ml of aliquot | dilution | ug/ml Cr+6 | Total Vol. Sample | ug Cr+6 per Sample |
|---|---|---|---|---|---|---|---|
| Plating Tank 8/9 | 25.5 | .594 | 50 | 1:100,000 | 145,872 | 1000 | |
| H. Extractor rinse 8/10 | 24.0 | .620 | 50 | 1:2000 | 3,046 | 1000 | |
| H. Elim. rinse 8/10 | 64.9 | .188 | 50 | 1:1000 | 461 | 1000 | |
| 1-A-2 (SH) dupe | 28.5 | .545 | 20 | 1 | 3.350 | 102.7 | 344.04 |
| 2A1 inlet (SH) | 9.0 | 1.046 | 20 | | 5.87 | 105.7 | 620.61 |
| 2A2 " " | 6.2 | 1.208 | 20 | | 6.78 | 108.2 | 733.61 |
| 2A3 " " | 5.0 | 1.301 | 20 | | 7.305 | 107.1 | 782.33 |
| 2A4 " " | 1.9 | 1.721 | 20 | | 9.66 | 106.7 | 1,031.14 |
| NaOH Blank | 99.2 | .003 | 50 | | .004 | 100 | .392 |
| 2B1 inlet (SH) | 37.0 | .432 | 10 | | 4.85 | 104.8 | 508.14 |
| 2B2 " " | 36.0 | 0.444 | 10 | | 4.98 | 112.6 | 561.01 |
| 2B3 " " | 33.8 | 0.471 | 10 | | 5.29 | 109.4 | 578.70 |
| 2B4 " " | 18.4 | 0.735 | 10 | | 8.26 | 108.6 | 896.53 |
| 50 ug/ml | 33.6 | 0.474 | 100 | | 0.532 | 100 | 53.19 |
| 2A outlet (SH) | 94.0 | 0,027 | 50 | | 0.060 | 107.6 | 6.49 |
| 2B " " | 93.0 | 0.032 | 50 | | 0.071 | 115.2 | 8.15 |
| 2C " " | 92.0 | 0.036 | 50 | | 0.081 | 110.0 | 8.95 |
| 2D " " | 91.2 | 0.040 | 50 | | 0.090 | 106.8 | 9.60 |
| 10 ug/ml | 80.3 | 0.095 | 100 | | 0.107 | 100 | 10.70 |
| 2E outlet inlet (SH) | 95.0 | 0.022 | 50 | | 0.050 | 112.9 | 5.65 |
| 2F " " | 92.9 | 0.032 | 50 | | 0.072 | 117.9 | 8.47 |
| 2G " " | 92.0 | 0.036 | 50 | | 0.081 | 116.6 | 9.48 |
| 2H " " | 91.0 | 0.041 | 50 | | 0.092 | 109.8 | 10.10 |
| dup 2A4 inlet SH | 12.7 | 0.896 | 10 | | 10.06 | 106.7 | 1,073.76 |

8/10/88 Sample Log

Moisture Extractor rinse 8/10
Mist Eliminator Rinse 8/10
2A1
2A2
2A3
2A4
2B1
2B2
2B3
2B4
21A
22B
23C
24D
25E
26F
27G
28H
I-A-2 imp + Nozzle + probe
I-B-2 " " "
O-2 Nozzle + probe
O-2 imp. CATCH
31A (SM) outlet
32B " "
33C " "
34D " "
35E " "
36F " "
37G " "
38H " "
I-A-3 (MM13B)
I-B-3 "
Plating Tank - Run 2 - 8/11
Plating Tank - Run 3 - 8/11
Moisture Extractor rinse - 8/11
Mist eliminator - 8/11

# Rolltechnology Blocks

| Sample | %T | A | ml aliquot | dilution | ug/ml Cr+6 | Total Volume Sample | ug/sample Cr+6 |
|---|---|---|---|---|---|---|---|
| I-A-2 (MM13B) | 5.5 | 1.26 | 10 | | 14.144 | 848.5 | 12,001.58 |
| I-B-2 " | 56.5 | 0.248 | 15 | | 1.856 | 867.2 | 1609.67 |
| O-2 P/N " | 86.0 | 0.065 | 50 | | 0.147 | 353.8 | 52.05 |
| O-2 Imp " | 81.5 | 0.089 | 50 | | 0.200 | 582.5 | 116.22 |
| 25 ug/ml | 58 | 0.237 | 100 | | 0.266 | 100 | 26.57 |
| 31A (SM) outlet | 95 | 0.022 | 50 | | 0.050 | 115 | 5.75 |
| 32B | | | | | | | |
| ~~32B~~ " " | 93 | 0.032 | 50 | | 0.071 | 113 | 8.00 |
| 33C " " | 93 | 0.032 | 50 | | ~~0.388~~ 0.071 | 118.5 | 8.39 |
| 34D " " | 92 | 0.036 | 50 | | 0.081 | 110.6 | 9.00 |
| 35E " " | 95.5 | 0.020 | 50 | | 0.045 | 114.7 | 5.15 |
| 36F " " | 93 | 0.032 | 50 | | 0.071 | 109.3 | 7.74 |
| 37G " " | 93.5 | 0.029 | 50 | | 0.066 | 110.5 | 7.24 |
| 38H " " | 92.5 | 0.034 | 50 | | 0.076 | 114.6 | 8.71 |
| 3A1 (SM) inlet | 53.5 | 0.272 | 10 | | 3.050 | 114.4 | 348.96 |
| 3A2 " " | 56.0 | 0.252 | 10 | | 2.828 | 116.6 | 329.70 |
| 3A3 " " | 42.5 | 0.372 | 10 | | 4.173 | 112.5 | 469.44 |
| 3A4 " " | 45.5 | 0.342 | 10 | | 3.840 | 111.6 | 428.57 |
| 3B1 " " | 41.0 | 0.387 | 10 | | 4.348 | 108.3 | 470.89 |
| 3B2 " " | 43.5 | 0.342 | 10 | | 3.846 | 113.1 | 434.33 |
| 3B3 " " | 6 | 1.222 | 10 | | 13.720 | 109.2 | 1498.24 |
| 3B4 " " | 9.5 | 1.022 | 10 | | 11.479 | 108.8 | 1248.93 |
| Imp IA2 (MM13B) | 21 | 0.678 | 5 | | 15.222 | 848.5 | 12915.53 |
| 75 ug/ml | 20.5 | 0688 | 100 | | 0.773 | 100 | 77.28 |
| Imp 3B4 | ~~29.5~~ | 0.530 | 5 | | 11.907 | 108.8 | 1295.45 |
| Imp 3B3 | 23 | 0.638 | 5 | | 14.334 | 109.2 | 1565.31 |
| IA3 (MM13B) | 20.5 | 0.688 | 5 | | 15.457 | ~~772.5~~ | 11,948.25 |
| IB3 " | 59 | 0.229 | 15 | | 1.715 | 734.5 | 1259.96 |
| O-3 P/N | 78.5 | 0.105 | 50 | | 0.236 | ~~290.5~~ | 68.59 |
| O-3 imp | 79 | 0.102 | 50 | | 0.230 | 498.9 | 114.70 |

ROLL TECHNOLOGY CORP. 8/29/88

STD. CURVE

| STD. CONCENTRATION | %T |
|---|---|
| 100 µg/ml | 12.2 |
| 75 µg/ml | 20.4 |
| 50 µg/ml | 34.9 |
| 35 µg/ml | 47.8 |
| 25 µg/ml | 58.0 |
| 10 µg/ml | 82.9 |

Kc = 1.0912

| SAMPLE | %T | A | ml ALIQUOT | DILUTION | µg/ml | TOTAL VOL SAMPLE (ml) | TOTAL µg |
|---|---|---|---|---|---|---|---|
| M. ELIMINATOR RINSE 8/11 | 52.0 | 0.2840 | 50 | 1:1,000 | 620 | 1,000 | |
| M. EXTRACTOR RINSE 8/11 | 50.1 | 0.3000 | 50 | 1:2,000 | 6,551 | 1,000 | |
| PLATING TANK RUN2 | 29.6 | 0.529 | 50 | 1:100,000 | 115,385 | 1,000 | |
| PLATING TANK RUN3 | 28.4 | 0.547 | 50 | 1:100,000 | 119,308 | 1,000 | |
| 50µg/ml STD. | 35.4 | 0.445 | ~~50~~ 10.0 | 1 | 0.971 | 100 | 97.096 |
| PLATING TANK RUN2 (DUPLICATE) | 29.9 | 0.524 | 50 | 1:100,000 | 114,430 | 1,000 | |

# APPENDIX C

## Calculation Checks

# SAMPLING SUMMARY SHEET

PLANT ROLL TECHNOLOGY CORPORATION LOCATION GREENVILLE, SOUTH CAROLINA

SAMPLED SOURCE Inlet Moisture Extractor

| Run | Date | $N_p$ | (3) $Y_m$ | (4) $\Delta H$ | (5) P Bar. | (6) $V_m$ | (7) $T_m$ | (8) $V_m$ Std. | (9) % | (10) $P_{st}$ | 17 $P_s$ | (18) $T_s$ | (19) VP | (20) $V_w$ | 21 $V_{w_{gas}}$ | 22 %M | 23 $M_d$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IA-1 | 9Aug 88 | 24/2 | 1.009 | 4.7 | 29.24 | 254.174 | 125 | 228.885 | | -1.5 | 29.13 | 93 | | 115.4 | 5.43 | 2.32 | .977 |
| IA-2 | 10Aug 88 | 24 | 1.009 | 4.2 | 29.25 | 150.122 | 115 | 137.412 | | -1.5 | 29.14 | 89 | | 78.6 | 3.70 | 2.62 | .974 |
| IA-3 | 10Aug 88 | 24 | 1.009 | 4.4 | 29.15 | 153.116 | 124 | 137.595 | | -1.5 | 29.04 | 95 | | 78.6 | 3.70 | 2.62 | .974 |
| | | | | | | | | | | | | | | | | | |

| Run | (24) $CO_2$ | (25) $O_2$ | 26 $N_2$ | (27) CO | (28) — | 29 $MW_d$ | 30 MW | (31) $C_p$ | (32) $\sqrt{\Delta P_s (T_s + 460)}$ | (33) $T_t$ | (34) $D_n$ | 35 $V_s$ | (36) $D_s$ | (37) Area | 38 ACFM | 39 DSCFM | 40 %I |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IA1 | 0.7 | 21.0 | 78.3 | | | 28.95 | 28.70 | .84 | 18.3061 | 192 | .303 | 45.5 | 21.5 | 2.52 | 6878 | 6245 | 96.2 |
| IA-2 | 0.7 | 21.0 | 78.3 | | | 28.95 | 28.66 | .84 | 17.1311 | 120 | .303 | 42.6 | 21.5 | 2.52 | 6439 | 5873 | 98.2 |
| IA-3 | 0.7 | 21.0 | 78.3 | | | 28.95 | 28.67 | .84 | 17.7379 | 120 | .303 | 44.2 | 21.5 | 2.52 | 6679 | 6006 | 96.2 |
| | | | | | | | | | | | | | | | | | |

C-2

$$V_m \text{ Std.} = Y_m \frac{17.64 \times V_m \left(P \text{ Bar.} + \frac{\Delta H}{13.6}\right)}{(T_m + 460)}$$

$$V_{w_{gas}} = 0.0471\ V_w$$

$$MW_d = \%CO_2 \times .44 + (\%O_2 \times .32) + (\%CO + \%N_2) \times .28 + \left(\%\text{Other} \times \frac{\text{Mol. wt.}}{100}\right)$$

$$MW = MW_d \times M_d + 18(1 - M_d)$$

$$V_s = 85.49 \times C_p \sqrt{\Delta P_s (T_s + 460)} \left[\frac{1}{P_s \times MW}\right]^{1/2}$$

$$\%I = \frac{0.09450 \times (T_s + 460) \times V_m \text{ Std.}}{V_s \times T_t \times D_n^2 \times M_d \times A_n}$$

$$\%M = \frac{100 \times V_{w_{gas}}}{V_m \text{ Std.} + V_{w_{gas}}}$$

$$M_d = \frac{100 - \%M}{100}$$

$$P_s = P \text{ Bar.} \pm \frac{P_{st}}{13.6}$$

$N_p$ = Total No. of Sampling points

$Y_m$ = Meter Box Correction Factor

$\Delta H$ = Average Orifice Pressure Drop, inches $H_2O$

P Bar. = Barometric Pressure, Inches Hg, Absolute

$V_m$ = Volume of Dry Gas at Meter Conditions, DCF

$T_m$ = Average Meter Temperature, °F.

$V_m$ Std. = Volume of Dry Gas at STP, DSCF[a]

% = Per Cent other gas removed before Dry Gas Meter

$P_{st}$ = Static Pressure of Stack Gas, inches $H_2O$

$P_s$ = Stack Gas Pressure, inches Hg.

$T_s$ = Average Stack Temperature, °F

VP = Vapor Pressure of $H_2O$ At Stack Temperature

$V_w$ = Total $H_2O$ Collected in Impingers and Silica Gel

$V_{w_{gas}}$ = Volume of water vapor collected at STP, SCF[b]

%M = Per Cent Moisture by volume

$M_d$ = Mole Fraction of Dry Gas

$\%CO_2$ = Volume % Dry

$\%O_2$ = Volume % Dry

$\%N_2$ = Volume % Dry

%CO = Volume % Dry

$MW_d$ = Molecular Weight of Stack Gas Dry Basis

MW = Molecular Weight of Stack Gas, Wet Basis

$C_p$ = Pitot Tube Coefficient

$\sqrt{\Delta P (T_s + 460)}$ Is determined by averaging the square root of the product of the velocity head ( $P_s$ ) and the absolute stack temperature from each sampling point.

$T_t$ = Net time of test in minutes

$D_n$ = Sampling Nozzle Diameter, inches

$A_n$ = Area of Nozzle opening, $ft^2$.

$V_s$ = Stack Gas Velocity at Stack Conditions, Feet per second.

$D_s$ = Diameter of Stack, inches

Area = Area of duct in $ft^2$

ACFM = Actual Cubic Feet per minute

DSCFM = Dry Standard Cubic Feet per minute

%I = Per Cent Isokinetic

[a] Dry Standard Cubic Feet @ 68°F, 29.92 in. Hg.

[b] Standard Conditions @ 68°F. 29.92 in. Hg.

SUMMARY OF EMISSIONS

PLANT ROLL TECHNOLOGY CORPORATION LOCATION GREENVILLE, SOUTH CAROLINA

SAMPLED SOURCE

| RUN | DATE | (1) $V_m$ Std. | (2) DSCFM |
|---|---|---|---|
| IA-1 | 9AUG88 | 228.885 | 6245 |
| IA 2 | 10AUG88 | 137.412 | 5873 |
| IA 3 | 10AUG88 | 137.595 | 6006 |
| | | | |

| FRONT HALF MILLIGRAMS | | | | (4) | 5 |
|---|---|---|---|---|---|
| PROBE | CYCLONE | FILTER | (3) Micrograms TOTAL | BACK HALF | FRONT + BACK TOTAL |
| | | | 18.380,3 | | |
| | | | 12.00158 | | |
| | | | 11.94325 | | |
| | | | | | |

CONCENTRATIONS

| FRONT HALF | | | | | BACK HALF | | | | TOTAL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RUN | Gr/DSCF | $Mg/M^3$ | Lb/Hr | Kg/Hr | Gr/DSCF | $Mg/M^3$ | Lb/Hr | Kg/Hr | Gr/DSCF | $Mg/M^3$ | Lb/Hr | Kg/Hr |
| IA-1 | .00124 | 2.84 | .0663 | .0301 | | | | | | | | |
| IA2 | .00135 | 3.08 | .0679 | .0308 | | | | | | | | |
| IA3 | .00137 | 3.07 | .0690 | .0313 | | | | | | | | |
| | | | | | | | | | | | | |
| | 6 | 7 | 8 | 9 | 10 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |

Remarks:

PLANT ROL ECHNOLOGY CORPORATION LOCATION GREENVILLE, SOUTH CAROLINA

SAMPLED SOURCE Outlet Moisture Extractor - Inlet Chevron Blade Demister

| Run | Date | $N_p$ | (3) $Y_m$ | (4) $\Delta H$ | (5) P Bar. | (6) $V_m$ | (7) $T_m$ | (8) $V_m$ Std. | (9) % | (10) $P_{st}$ | 17 $P_s$ | (18) $T_s$ | (19) VP | (20) $V_w$ | 21 $V_{w_{gas}}$ | 22 %M | 23 $M_d$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IB1 | 9AUG88 | 24 | 1.00 | 3.23 | 29.24 | 191.733 | 136 | 167.345 | | -3.8 | 28.96 | 97 | | 91.0 | 4.28 | 2.5 | .975 |
| IB2 | 10AUG88 | 24 | 1.00 | 3.61 | 29.25 | 120.829 | 126 | 107.397 | | -3.8 | 28.97 | 93 | | 65.7 | 3.09 | 2.8 | .972 |
| IB3 | 10AUG88 | 24 | 1.00 | 3.38 | 29.15 | 117.017 | 129 | 103.069 | | -3.8 | 28.87 | 99 | | 58.2 | 2.74 | 2.6 | .974 |
| | | | | | | | | | | | | | | | | | |

C-4

| Run | (24) $CO_2$ | (25) $O_2$ | 26 $N_2$ | (27) CO | (28) ___ | 29 $MW_d$ | 30 MW | (31) $C_p$ | (32) $\sqrt{\Delta P_s(T_s + 460)}$ | (33) $T_t$ | (34) $D_n$ | 35 $V_s$ | (36) $D_s$ | (37) Area | 38 ACFM | 39 DSCFM | 40 %I |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IB1 | 0.7 | 21.0 | 78.3 | | | 28.95 | 28.68 | .84 | 19.0202 / 17.3223 | 182.66 | .250 | 43.2 | 21.5 | 2.52 | 6529 | 5841 | 105.7 |
| IB2 | 0.7 | 21.0 | 78.3 | | | 28.95 | 28.65 | .84 | 20.3048 / 18.4126 | 117.18 | .250 | 45.9 | 21.5 | 2.52 | 6943 | 6239 | 98.6 |
| IB3 | 0.7 | 21.0 | 78.3 | | | 28.95 | 28.67 | .84 | 20.0202 / 18.2291 | 117.18 | .250 | 45.5 | 21.5 | 2.52 | 6883 | 6111 | 97.0 |
| | | | | | | | | | | | | | | | | | |

$$V_m \text{ Std.} = Y_m \frac{17.64 \times V_m \left(P \text{ Bar.} + \frac{\Delta H}{13.6}\right)}{(T_m + 460)}$$

$$V_{w_{gas}} = 0.0471\ V_w$$

$$MW_d = CO_2 \times .44 + (O_2 \times .32) + (CO + N_2) \times .28 + \left(\%\text{Other} \times \frac{\text{Mol. wt.}}{100}\right)$$

$$MW = MW_d \times M_d + 18(1 - M_d)$$

$$V_s = 85.49 \times C_p \sqrt{\Delta P_s (T_s + 460)} \left[\frac{1}{P_s \times MW}\right]^{1/2}$$

$$\%I = \frac{0.09450 \times (T_s + 460) \times V_m \text{ Std.}}{V_s \times T_t \times P_s \times M_d \times A_n}$$

$$\%M = \frac{100 \times V_{w_{gas}}}{V_m \text{ Std.} + V_{w_{gas}}}$$

$$M_d = \frac{100 - \%M}{100}$$

$$P_s = P \text{ Bar.} \pm \frac{P_{st}}{13.6}$$

$N_p$ = Total No. of Sampling points

$Y_m$ = Meter Box Correction Factor

$\Delta H$ = Average Orifice Pressure Drop, Inches $H_2O$

P Bar. = Barometric Pressure, Inches Hg. Absolute

$V_m$ = Volume of Dry Gas at Meter Conditions, DCF

$T_m$ = Average Meter Temperature, °F.

$V_m$ Std. = Volume of Dry Gas at STP, DSCF[a]

% = Per Cent other gas removed before Dry Gas Meter

$P_{st}$ = Static Pressure of Stack Gas, Inches $H_2O$

$P_s$ = Stack Gas Pressure, Inches Hg.

$T_s$ = Average Stack Temperature, °F

VP = Vapor Pressure of $H_2O$ At Stack Temperature

$V_w$ = Total $H_2O$ Collected in Impingers and Silica Gel

$V_{w_{gas}}$ = Volume of water vapor collected at STP, SCF[b]

%M = Per Cent Moisture by volume

$M_d$ = Mole Fraction of Dry Gas

$CO_2$ = Volume % Dry

$O_2$ = Volume % Dry

$N_2$ = Volume % Dry

CO = Volume % Dry

$MW_d$ = Molecular Weight of Stack Gas Dry Basis

MW = Molecular Weight of Stack Gas, Wet Basis

$C_p$ = Pitot Tube Coefficient

$\sqrt{\Delta P (T_s + 460)}$ Is determined by averaging the square root of the product of the velocity head ( P ) and the absolute stack temperature from each sampling point.

$T_t$ = Net time of test in minutes

$D_n$ = Sampling Nozzle Diameter, Inches

$A_n$ = Area of Nozzle opening, $ft^2$.

$V_s$ = Stack Gas Velocity at Stack Conditions, Feet per second.

$D_s$ = Diameter of Stack, Inches

Area = Area of duct in $ft^2$

ACFM = Actual Cubic Feet per minute

DSCFM = Dry Standard Cubic Feet per minute

%I = Per Cent Isokinetic

[a] Dry Standard Cubic Feet @ 68°F, 29.92 in. Hg.

[b] Standard Conditions @ 68°F, 29.92 in. Hg.

SUMMARY OF EMISSIONS

PLANT ROLL TECHNOLOGY CORPORATION LOCATION GREENVILLE, SOUTH CAROLINA

SAMPLED SOURCE Outlet Moisture Extractor - Inlet Chevron Blade Demister

| RUN | DATE | (1) $V_m$ Std. | (2) DSCFM |
|---|---|---|---|
| IB 1 | 9 AUG BB | 167.345 | 5841 |
| IB 2 | 10 AUG BB | 107.397 | 6239 |
| IB 3 | 10 AUG BB | 103.069 | 6111 |
| | | | |

FRONT HALF MILLIGRAMS

| PROBE | CYCLONE | FILTER | (3) TOTAL |
|---|---|---|---|
| | | | 1617.44 |
| | | | 1609.67 |
| | | | 1259.96 |
| | | | |

| (4) BACK HALF | 5 FRONT + BACK TOTAL |
|---|---|
| | |
| | |
| | |
| | |

C5

CONCENTRATIONS

FRONT HALF

| RUN | Gr/DSCF | $Mg/M^3$ | Lb/Hr | Kg/Hr |
|---|---|---|---|---|
| IB 1 | .00015 | .348 | .0076 | .0035 |
| IB 2 | .00023 | .529 | .0124 | .0056 |
| IB 3 | .00019 | .432 | .0099 | .0045 |
| | | | | |

1 6 7 8 9

BACK HALF

| Gr/DSCF | $Mg/M^3$ | Lb/Hr | Kg/Hr |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

10 17 18 19

TOTAL

| Gr/DSCF | $Mg/M^3$ | Lb/Hr | Kg/Hr |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

20 21 22 23

Remarks:

PLANT ROL ECHNOLOGY CORPORATION LOCATION GREENVILLE, SOUTH CAROLINA

SAMPLED SOURCE Outlet Chevron Blade Demister

| Run | Date | $N_p$ | (3) $Y_m$ | (4) $\Delta H$ | (5) P Bar. | (6) $V_m$ | (7) $T_m$ | (8) $V_m$ Std. | (9) % | (10) $P_{st}$ | 17 $P_s$ | (18) $T_s$ | (19) VP | (20) $V_w$ | 21 $V_{w_{gas}}$ | 22 %M | 23 $M_d$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-1 | 9 Aug 88 | 24½ | .998 | 5.29 | 29.24 | 247.160 | 120 | 222.366 | | -.43 | 29.21 | 98 | | 117.7 | 5.54 | 2.43 | .976 |
| 0-2 | 10 Aug 88 | 24 | .998 | 4.92 | 29.25 | 148.216 | 115 | 134.429 | | -.43 | 29.22 | 96 | | 89.7 | 4.22 | 3.05 | .970 |
| 0-3 | 10 Aug 88 | 24 | .998 | 5.00 | 29.15 | 149.346 | 117 | 134.555 | | -.43 | 29.12 | 100 | | 73.4 | 3.45 | 2.50 | .975 |
| | | | | | | | | | | | | | | | | | |

| Run | (24) $CO_2$ | (25) $O_2$ | 26 $N_2$ | (27) CO | (28) ___ | 29 $MW_d$ | 30 MW | (31) $C_p$ | (32) $C_p\sqrt{\Delta P}(T_s + 460)$ | (33) $T_t$ | (34) $D_n$ | 35 $V_s$ | (36) $D_s$ | (37) Area | 38 ACFM | 39 DSCFM | 40 %I |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-1 | 0.7 | 21 | 78.3 | 0.0 | | 28.95 | 28.69 | .84 | 18.5652 | 180 | .297 | 46.1 | 21.5 | 2.52 | 6967 | 6279 | 96.7 |
| 0-2 | 0.7 | 21 | 78.3 | | | 28.95 | 28.62 | .84 | 17.9145 | 120 | .297 | 44.5 | 21.5 | 2.52 | 6730 | 6051 | 97.1 |
| 0-3 | 0.7 | 21 | 78.3 | | | 28.95 | 28.68 | .84 | 18.4893 | 120 | .297 | 46.0 | 21.5 | 2.52 | 6950 | 6218 | 94.6 |
| | | | | | | | | | | | | | | | | | |

$$V_{m\,Std.} = Y_m \frac{17.64 \times V_m \left(P\,Bar. + \frac{\Delta H}{13.6}\right)}{(T_m + 460)}$$

$$V_{w_{gas}} = 0.0471\ V_w$$

$$MW_d = \%CO_2 \times .44 + (\%O_2 \times .32) + (\%CO + \%N_2) \times .28 + (\%Other \times \frac{Mol.\ wt.}{100})$$

$$MW = MW_d \times M_d + 18(1 - M_d)$$

$$V_s = 85.49 \times C_p \sqrt{P_s\ (T_s + 460)} \left[\frac{1}{P_s \times MW}\right]^{1/2}$$

$$\%I = \frac{0.09450 \times (T_s + 460) \times V_{m\,Std.}}{V_s \times T_t \times P_s \times M_d \times A_n}$$

$$\%M = \frac{100 \times V_{w_{gas}}}{V_{m\,Std.} + V_{w_{gas}}}$$

$$M_d = \frac{100 - \%M}{100}$$

$$P_s = P\,Bar. \pm \frac{P_{st}}{13.6}$$

$N_p$ = Total No. of Sampling points

$Y_m$ = Meter Box Correction Factor

$\Delta H$ = Average Orifice Pressure Drop, inches $H_2O$

P Bar. = Barometric Pressure, Inches Hg, Absolute

$V_m$ = Volume of Dry Gas at Meter Conditions, DCF

$T_m$ = Average Meter Temperature, °F.

$V_{m\,Std.}$ = Volume of Dry Gas at STP. DSCF[a]

I = Per Cent other gas removed before Dry Gas Meter

$P_{st}$ = Static Pressure of Stack Gas, inches $H_2O$

$P_s$ = Stack Gas Pressure, inches Hg.

$T_s$ = Average Stack Temperature, °F

VP = Vapor Pressure of $H_2O$ At Stack Temperature

$V_w$ = Total $H_2O$ Collected in Impingers and Silica Gel

$V_{w_{gas}}$ = Volume of water vapor collected at STP, SCF[b]

%M = Per Cent Moisture by volume

$M_d$ = Mole Fraction of Dry Gas

$\%CO_2$ = Volume % Dry

$\%O_2$ = Volume % Dry

$\%N_2$ = Volume % Dry

%CO = Volume % Dry

$MW_d$ = Molecular Weight of Stack Gas Dry Basis

MW = Molecular Weight of Stack Gas, Wet Basis

$C_p$ = Pitot Tube Coefficient

$C_p\sqrt{\Delta P\ (T_s + 460)}$ Is determined by averaging the square root of the product of the velocity head ( $P_s$ ) and the absolute stack temperature from each sampling point.

$T_t$ = Net time of test in minutes

$D_n$ = Sampling Nozzle Diameter, inches

$A_n$ = Area of Nozzle opening, $ft^2$.

$V_s$ = Stack Gas Velocity at Stack Conditions, Feet per second.

$D_s$ = Diameter of Stack, inches

Area = Area of duct in $ft^2$

ACFM = Actual Cubic Feet per minute

DSCFM = Dry Standard Cubic Feet per minute

%I = Per Cent Isokinetic

[a] Dry Standard Cubic Feet @ 68°F, 29.92 in. Hg.

[b] Standard Conditions @ 68°F. 29.92 in. Hg.

## SUMMARY OF EMISSIONS

PLANT ROLL TECHNOLOGY CORPORATION LOCATION GREENVILLE, SOUTH CAROLINA

SAMPLED SOURCE

| RUN | DATE | (1) $V_m$ Std. | (2) DSCFM |
|---|---|---|---|
| 0-1 | 9 AUG 88 | 222.346 | 6279 |
| 0-2 | 10 AUG 88 | 134.421 | 6051 |
| 0-3 | 10 AUG 88 | 134.555 | 6218 |
| | | | |

| FRONT HALF MILLIGRAMS | | | | (4) | 5 |
|---|---|---|---|---|---|
| PROBE | CYCLONE | FILTER | (3) TOTAL | BACK HALF | FRONT + BACK TOTAL |
| | | | 192.15 | | |
| | 116.22 | 52.05 | 168.27 | | |
| | 13.54 | 114.70 | | | |
| | | | | | |

## CONCENTRATIONS

| FRONT HALF | | | | | BACK HALF | | | | TOTAL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RUN | Gr/DSCF | $Mg/M^3$ | Lb/Hr | Kg/Hr | Gr/DSCF | $Mg/M^3$ | Lb/Hr | Kg/Hr | Gr/DSCF | $Mg/M^3$ | Lb/Hr | Kg/Hr |
| 01 | .00001 | .0305 | .00072 | .00033 | | | | | | | | |
| 0-2 | .00002 | .0412 | .00130 | .0045 | | | | | | | | |
| 0-3 | .00002 | .0481 | .00112 | .00051 | | | | | | | | |
| | | | | | | | | | | | | |
| | 6 | 7 | 8 | 9 | 10 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |

Remarks:

# APPENDIX D

## Draft Method - Determination of Hexavalent Chromium in Dry Particulate Emissions from Stationary Sources

# DRAFT METHOD - DETERMINATION OF HEXAVALENT CHROMIUM IN DRY PARTICULATE EMISSIONS FROM STATIONARY SOURCES

## 1.0 APPLICABILITY AND PRINCIPLE

### 1.1 Applicability

This method applies to the determination of hexavalent chromium ($Cr^{+6}$) in dry particulate emissions only from specified stationary sources whose emissions do not contain acids or organics.

### 1.2 Principle

Particulate emissions are collected from the source by use of Method 5. (Appendix A, 40 CFR Part 60). The collected samples are digested in an alkaline solution and analyzed for $Cr^{+6}$ by the diphenylcarbazide colorimetric method.

## 2.0 RANGE, SENSITIVITY, PRECISION, AND INTERFERENCES

### 2.1 Range

A straight-line response curve can be obtained in the range 5 µg $Cr^{+6}$/100 mℓ to 100 µg $Cr^{+6}$/100 mℓ. For a minimum analytical accuracy of ±10 percent, the lower limit of the range is 10 µg/100 mℓ. The upper limit can be extended by appropriate dilution.

### 2.2 Sensitivity

A minimum detection limit of 1 µg $Cr^{+6}$/100 mℓ has been observed.

### 2.3 Precision

The overall precision for sample collection and analysis for $Cr^{+6}$ in dry particulate emissions was determined at a ferrochrome smelter, a chemical plant, and a refractory brick plant. Replicate Method 5 filters

with both high and low particulate loadings were analyzed. The relative standard deviations were less than 10 percent in all cases.

2.4 Interference

Molybdenum, mercury and vanadium react with diphenylcarbazide to form a color; however, approximately 20 mg of these elements can be present in a sample without creating a problem. Iron produces a yellow color, but this effect is not measured photometrically at 540 nm. No interference was observed at the sources listed in Section 2.3.

3.0 APPARATUS

3.1 Sampling Train

Same as Method 5, Section 2.1.

3.2 Sample Recovery

Same as Method 5, Section 2.2.

3.3 Analysis

The following equipment is needed.

3.3.1 Beakers--

Borosilicate, 250-mℓ, with watchglass covers.

3.3.2 Filtration Apparatus--

Vacuum unit constructed of plastic or glass, to accommodate 47-mm diameter, 3.0-µg size Teflon filters (NOTE: Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency).

3.3.3 Volumetric Flasks--

100-mℓ and other appropriate volumes.

3.3.4 Hot Plate

3.3.5 Pipettes--

Assorted sizes, as needed.

3.3.6 Spectrophotometer--

To measure absorbance at 540 nm.

4.0 REAGENTS

Unless otherwise indicated, all reagents shall conform to the specifications established by the Committee on Analytical Reagents of the American Chemical Society. Where such specifications are not available, use the best available grade.

4.1 Sampling

Same as Method 5, Section 3.1.

4.2 Sample Recovery

Same as Method 5, Section 3.2.

4.3 Analysis

The following reagents are required.

4.3.1 Water--

Deionized distilled, meeting American Society for Testing and Materials (ASTM) specifications for type 2 reagent - ASTM Test Method D 1193-77 (incorporated by reference - see Section 61.18).

4.3.2 Digestion Solution--

Dissolve 20.0 g NaOH and 30.0 g anhydrous $Na_2CO_3$ in water in a 1-liter volumetric flask, and dilute to the mark. Store the solution in a tightly capped polyethylene bottle. Prepare fresh monthly.

4.3.3 Potassium Dichromate Stock Solution--

Dissolve 141.4 mg of analytical reagent grade $K_2Cr_2O_7$ in water, and dilute to 1 liter (1 mℓ = 50 μg $Cr^{+6}$).

4.3.4 Potassium Dichromate Standard Solution--

Dilute 10.00 mℓ $K_2Cr_2O_7$ stock solution to 100 mℓ (1 mℓ = 5 μg $Cr^{+6}$) with water.

4.3.5 Sulfuric Acid, 10 percent (v/v)--

Dilute 10 mℓ $H_2SO_4$ to 100 mℓ in water.

4.3.6 Acetone--

Same as Method 5, Section 3.2.

4.3.7 Diphenylcarbazide Solution--

Dissolve 250 mg of 1, 5-diphenylcarbazide in 50 mℓ acetone. Store in a brown bottle. Discard when the solution becomes discolored.

5.0 PROCEDURE

5.1 Sampling

Same as Method 5, Section 4.1.

5.2 Sample Recovery

Same as Method 5, Section 4.2.

5.3 Preservation

Tests with dry particulate source samples from the sources described in Section 2.3 demonstrated that the $Cr^{+6}$ content of the samples was stable. Nevertheless, all samples should be protected from extreme heat, kept dry and should be analyzed within 1 month of collection.

5.4 Sample Digestion and Preparation

Place the contents of Container Number 2 (the acetone probe rinse) in a 250-mℓ beaker. Evaporate to dryness. Place the contents of Container Number 1 in the same beaker (cut the filter into small pieces). Add 40 mℓ of digestion solution (Section 4.3.2). Cover the beaker with the watchglass, and heat to near boiling on a hot plate with constant stirring for 30 minutes. Do not allow the solution to evaporate to dryness.

Cool the solution, and transfer it quantitatively to the filtration apparatus with water. Filter the solution through the 47-mm Teflon filter. Transfer the filtrate from the filter flask quantitatively to a 100 mℓ volumetric flask. Fill to the mark with water.

5.5 Reagent Blank Preparation

Take a representative amount of acetone and a blank Method 5 filter and proceed as in Section 5.4.

5.6 Silica Gel Weighing

Weigh the spent silica gel (Container Number 3) or silica gel plum impinger to the nearest 0.5 g using a balance. This step may be conducted in the field.

5.7 Analysis

5.7.1 Color Development and Measurement--

Transfer a 50-mℓ or smaller aliquot of the prepared sample to a 100 mℓ volumetric flask and add sufficient water to bring the volume to approximately 80 mℓ. Adjust the pH to 2 ± 0.5 with 10 percent $H_2SO_4$, add 2.0 mℓ of diphenylcarbazide solution, and dilute to volume with water. Allow the solution to stand about 10 minutes for color development. For each set of samples analyzed, treat an identical aliquot of reagent blank solution in the same way. Transfer a portion of the sample to a 1-cm absorption cell and measure the absorbance a the optimum wavelength (Section 6.2.1). Measure and subtract the reagent blank absorbance reading, if any, to obtain a net reading. If the absorbance of the sample exceeds the absorbance of the 100 μg $Cr^{+6}$ standard as determined in Section 6.2.2, dilute the sample and the reagent blank with equal volumes of water.

5.7.2 Check for Matrix Effects on the $Cr^{+6}$ Results--

Since the analysis for $Cr^{+6}$ by colorimetry is sensitive to the chemical composition of the sample (matrix effects), the analyst shall check

at least one sample from each source using the method of additions as follows:

Obtain two equal volume aliquots of the same sample solution. The aliquots should contain between 30 and 50 µg of $Cr^{+6}$ (less is acceptable if not possible). Spike one of the aliquots with an aliquot of standard solution that contains between 30 and 50 µg of $Cr^{+6}$. Now treat both the spiked and unspiked sample aliquots as described in Section 5.7.1.

Next, calculate the $Cr^{+6}$ mass ($C_s$), in µg in the aliquot of the unspiked sample solution by using the following equation.

$$C_s = C_a \frac{A_s}{A_t - A_s} \qquad \text{Eq. 1-1}$$

Where:

$C_a$ = $Cr^{+6}$ in the standard solution, µg.

$A_s$ = Absorbance of the unspiked sample solution.

$A_t$ = Absorbance of the spiked sample solution.

Volume corrections will not be required since the solutions as analyzed have been made to the same final volume. If the results of the method of additions procedure used on the single source sample do not agree to within 10 percent of the value obtained by the routine spectrophotometric analysis, then reanalyze all samples from the source using this method of additions procedure.

## 6.0 CALIBRATION

### 6.1 Sampling Train

Perform all of the calibrations described in Method 5, Section 5.

## 6.2 Spectrophotometer Calibration

### 6.2.1 Optimum Wavelength Determination--

Calibrate the wavelength scale of the spectrophotometer every 6 months. The calibration may be accomplished by using an energy source with an intense line emission such as a mercury lamp, or by using a series of glass filters spanning the measuring range of the spectrophotometer. Calibration materials are available commercially and from the National Bureau of Standards. Specific details on the use of such materials are normally supplied by the vendor; general information about calibration techniques can be obtained from general reference books on analytical chemistry. The wavelength scale of the spectrophotometer shall read correctly within ±5 nm, at all calibration points; otherwise, repair and recalibrate the spectrophotometer. Once the wavelength scale of the spectrophotometer is in proper calibration, use 540 nm as the optimum wavelength for the measurement of the absorbance of the standards and samples.

Alternatively, a scanning procedure may be employed to determine the proper measuring wavelength. If the instrument is a double-beam spectrophotometer, scan the spectrum between 530 and 550 nm using the 50 µg $Cr^{+6}$ standard solution (Section 4.3.4) in the sample cell and a blank solution in the reference cell. If a peak does not occur, the spectrophotometer is malfunctioning. When a peak is obtained within the 530 to 550 nm range, record and use the wavelength at which this peak occurs as the optimum wavelength for the measurement of absorbance of both the standards and the samples. For a single-beam spectrophotometer, follow the scanning procedure described above, except scan the blank and standard solutions separately. For this instrument, the optimum wavelength is the wavelength at which the maximum difference in absorbance between the standard and the blank occurs.

### 6.2.2 Spectrophotometer Calibration--

Alternative calibration procedures are allowed provided acceptable accuracy and precision can be demonstrated. Add 0.0 mℓ, 1 mℓ, 2 mℓ,

5 mℓ, 10 mℓ, 15 mℓ, and 20 mℓ of the working standard solution (1 mℓ = 5 μg $Cr^{+6}$) to a series of seven 100-ml volumetric flasks. Dilute each to mark with water. Analyze these calibration standards as in Section 5.7.1. This calibration procedure must be repeated on each day that samples are analyzed. Calculate the spectrophotometer calibration factor $K_C$ as follows:

$$K_C = 5 \frac{A_1 + 2A_2 + 5A_3 + 10A_4 + 15A_5 + 20A_6}{A_1^2 + A_2^2 + A_3^2 + A_4^2 + A_5^2 + A_6^2}$$

where:

$K_C$ = Calibration factor.
$A_1$ = Absorbance of the 5 μg $Cr^{+6}$/100 mℓ standard.
$A_2$ = Absorbance of the 10 μg $Cr^{+6}$/100 mℓ standard.
$A_3$ = Absorbance of the 25 μg $Cr^{+6}$/100 mℓ standard.
$A_4$ = Absorbance of the 50 μg $Cr^{+6}$/100 mℓ standard.
$A_5$ = Absorbance of the 75 μg $Cr^{+6}$/100 mℓ standard.
$A_6$ = Absorbance of the 100 μg $Cr^{+6}$/100 mℓ standard.

6.2.2.1 Spectrophotometer Calibration Quality Control--Multiply the absorbance value obtained for each standard by the $K_C$ factor (least squares slope) to determine the distance each calibration point lies from the theoretical calibration line. These calculated concentration values shall not differ from the actual concentrations (i.e., 5, 10, 25, 50, 75, and 100 μg $Cr^{+6}$/100 ℓ) by more than ___ percent (to be determined) for five of the six standards.

## 7.0 EMISSION CALCULATIONS

Carry out the calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after final calculations.

7.1 Total $Cr^{+6}$ in Sample.

Calculate m, the total μg $Cr^{+6}$ in each sample, as follows:

$$m = \frac{100\ K_c\ AF}{v_a}$$

Where:

100 = Volume in mℓ of total sample.

A = Absorbance of sample.

F = Dilution factor (required only if sample dilution was needed to reduce the absorbance into the range of calibration).

$v_a$ = Volume in mℓ of aliquot analyzed.

7.2 Average Dry Gas Meter Temperature and Average Orifice Pressure Drop

Same as Method 5, Section 6.2.

7.3 Dry Gas Volume, Volume of Water Vapor, Moisture Content

Same as Method 5, Section 6.3, 6.4, and 6.5, respectively.

7.4 $Cr^{+6}$ Emission Concentration

Calculate $c_s$ (g/dscm), the $Cr^{+6}$ concentration in the stack gas, dry basis, corrected to standard conditions, as follows:

$$c_s = 10^{-6}g/\mu g)(m/V_{m(std)})$$

7.5 Isokinetic Variation, Acceptable Results

Same as Method 5, Sections 6.11 and 6.12, respectively.

8.0 BIBLIOGRAPHY

1. Test Methods for Evaluating Solid Waste. U.S. Environmental Protection Agency. SW-846, 2nd Edition. July 1982.

2. Cox, X.B., R.W. Linton, and F.E. Butler. Determination of Chromium Speciation in Environmental Particles - A Multitechnique Study of Ferrochrome Smelter Dust. Accepted for publication in Environmental Science and Technology.

3. Same as in Bibliography of Method 5, Citations 2 to 5 and 7.

# APPENDIX E

## Chain-of-Custody Data Sheets

PES

SAMPLE CHAIN OF CUSTODY

Plant: BroCTech Test Number: _____

Date Sampled: 8/9/88 Run Number: IA-1

SAMPLE RECOVERY

| Container Code | Description |
|---|---|
| IA-1 | probe/nozzle rinse / imp. solution |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature: _____

Title: _____

Location at which Recovery was Done: _____

Date and Time of Recovery: _____

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: Helen Owens

Title: _____

Date and Time of Receipt: _____

Sample Storage: _____

Laboratory Person Receiving Sample

Signature: Helen Owens

Title: Sample Analyst

Date and Time of Receipt: 8/9/88 1830

Sample Storage: _____

ANALYSIS

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| IA-1 | Cr+6/Diphenyl | 8/9/88 1900 | HJO |
| | | | |
| | | | |
| | | | |

## SAMPLE CHAIN OF CUSTODY

Plant: Ball Tech. Test Number: IA2

Date Sampled: 8/10/88 Run Number: _____

**SAMPLE RECOVERY**

| Container Code | Description |
|---|---|
| IA2 | probe/nozzle rinse, imp. solutions |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature: _____

Title: _____

Location at which Recovery was Done: _____

Date and Time of Recovery: _____

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: Heidi Owens

Title: Sample Analyst

Date and Time of Receipt: 8/10/88 1330

Sample Storage: lab

Laboratory Person Receiving Sample

Signature: HJO

Title: SA

Date and Time of Receipt: 8/10 ~~1330~~ 1430

Sample Storage: lab

**ANALYSIS**

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| IA2 | Cr⁺⁶/Diphenyl | 8/10/88, 1430 | HJO |
| | | | |
| | | | |
| | | | |

SAMPLE CHAIN OF CUSTODY

Plant: Rad Technology  Test Number: IA-3

Date Sampled: 8/10/88  Run Number:

SAMPLE RECOVERY

| Container Code | Description |
|---|---|
| IA-3 | impingr sol., probe/nozzle rinse |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature:

Title:

Location at which Recovery was Done:

Date and Time of Recovery:

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: Julie Owens

Title: Sampl Analyst

Date and Time of Receipt: 8/10/88 730pm

Sample Storage: laboratory

Laboratory Person Receiving Sample

Signature: Julie J. Owens

Title: SA

Date and Time of Receipt: 8/10/88 730

Sample Storage: lab

ANALYSIS

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| IA 3 | Cr⁺⁶/diphenyl | 8/10/88 800p | HJO |
| | | | |
| | | | |
| | | | |

SAMPLE CHAIN OF CUSTODY

Plant: Bay Technology  Test Number: _____

Date Sampled: 8/9/88  Run Number: 0-1

SAMPLE RECOVERY

| Container Code | Description |
|---|---|
| 0-1 | probe/nozzle rinse ; imp solution |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature: _____

Title: _____

Location at which Recovery was Done: _____

Date and Time of Recovery: _____

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: Helen Owens

Title: Sample Analyst

Date and Time of Receipt: 8/9/88 1830

Sample Storage: lab

Laboratory Person Receiving Sample

Signature: HJO

Title: SA

Date and Time of Receipt: 8/9/88 1830

Sample Storage: lab

ANALYSIS

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| 0-1 | Cr⁺⁶/Diphenyl | 8/9/88 1900 | HJO |
| | | | |
| | | | |
| | | | |

SAMPLE CHAIN OF CUSTODY

Plant: Bou Technology Test Number: _____

Date Sampled: 8/10/88 Run Number: 0-2

**SAMPLE RECOVERY**

| Container Code | Description |
|---|---|
| 0-2 | imp. solution/probe + nozzle rinse |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature: _____

Title: _____

Location at which Recovery was Done: _____

Date and Time of Recovery: _____

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: Helen Owens

Title: Sample Analyst

Date and Time of Receipt: 8/10/88 1430

Sample Storage: lab

Laboratory Person Receiving Sample

Signature: HJO

Title: SA

Date and Time of Receipt: 8/10/88 1430

Sample Storage: lab

**ANALYSIS**

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| 0-2 | Cr+6 Diphenyl | 8/10/88 1500 | HJO |
| | | | |
| | | | |
| | | | |

SAMPLE CHAIN OF CUSTODY

Plant: Roll Technology Test Number: _____

Date Sampled: 8/10/88 Run Number: 0-3

SAMPLE RECOVERY

| Container Code | Description |
|---|---|
| 0-3 | probe/nozzle rinse; impinger solution |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature: _____

Title: _____

Location at which Recovery was Done: _____

Date and Time of Recovery: _____

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: Helen Owens

Title: Sample Analyst

Date and Time of Receipt: 8/10/88 1830

Sample Storage: lab

Laboratory Person Receiving Sample

Signature: [illegible]

Title: SA

Date and Time of Receipt: 8/10/88 1830

Sample Storage: lab

ANALYSIS

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| 0-3 | Cr+6/Diphenyl | 8/10/88 1845 | [illegible] |
| | | | |
| | | | |
| | | | |

SAMPLE CHAIN OF CUSTODY

Plant: Bell Technology  Test Number: _____

Date Sampled: 8/9/88  Run Number: IB1

SAMPLE RECOVERY

| Container Code | Description |
|---|---|
| IB-1 | probe/nozzle rinse; impinger solution |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature: _____

Title: _____

Location at which Recovery was Done: _____

Date and Time of Recovery: _____

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: Helen Owens

Title: Sample Analyst

Date and Time of Receipt: 8/9/88 1830

Sample Storage: Lab

Laboratory Person Receiving Sample

Signature: HO

Title: SA

Date and Time of Receipt: 8/9/88 1830

Sample Storage: Lab

ANALYSIS

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| IB-1 | Cr+6/Diphenyl | 8/9/88 1900 | HO |
| | | | |
| | | | |
| | | | |

SAMPLE CHAIN OF CUSTODY

Plant: Bac Technology Test Number: _____

Date Sampled: 8/10/88 Run Number: IB-2

SAMPLE RECOVERY

| Container Code | Description |
|---|---|
| IB-2 | probe/nozzle rinse & imp solution |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature: _____

Title: _____

Location at which Recovery was Done: _____

Date and Time of Recovery: _____

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: Helen Owens

Title: Sample Analysis

Date and Time of Receipt: 8/10/88 1300

Sample Storage: Lab

Laboratory Person Receiving Sample

Signature: HJO

Title: SA

Date and Time of Receipt: 8/10/88 1300

Sample Storage: Lab

ANALYSIS

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| IB2 | Cr+6 / Diphenyl | 8/10/88 1300 | HJO |
| | | | |
| | | | |
| | | | |

SAMPLE CHAIN OF CUSTODY

Plant: Ball Technology Test Number: _____

Date Sampled: 8/10/88 Run Number: IB3

SAMPLE RECOVERY

| Container Code | Description |
|---|---|
| IB3 | probe/nozzle rinse; impinger sol. |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature: _____

Title: _____

Location at which Recovery was Done: _____

Date and Time of Recovery: _____

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: Helen Owens

Title: Sample Analyst

Date and Time of Receipt: 8/10/88 1800

Sample Storage: lab

Laboratory Person Receiving Sample

Signature: HO

Title: SA

Date and Time of Receipt: 8/10/88 1800

Sample Storage: lab

ANALYSIS

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| IB3 | $Cr^{+6}$/Diphenyl | 8/10/88 1800 | HO |
| | | | |
| | | | |
| | | | |

SAMPLE CHAIN OF CUSTODY

Plant: Ball Technology Test Number: _____

Date Sampled: 8/9/88 Run Number: PS-1

SAMPLE RECOVERY

| Container Code | Description |
|---|---|
| PS-1 | plating solution - Run #1 |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature: HJO

Title: _____

Location at which Recovery was Done: _____

Date and Time of Recovery: _____

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: _____

Title: _____

Date and Time of Receipt: _____

Sample Storage: _____

Laboratory Person Receiving Sample

Signature: Helen Owens

Title: Sample Analyst

Date and Time of Receipt: 8/9/88 1815

Sample Storage: _____

ANALYSIS

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| PS-1 | Ortho/Diphenyl | 8/10/88 1000 | HJO |
| | | | |
| | | | |
| | | | |

PES

SAMPLE CHAIN OF CUSTODY

Plant: Ball Tech. Test Number: _____

Date Sampled: 8/10/88 Run Number: Mist Elim-1

SAMPLE RECOVERY

| Container Code | Description |
|---|---|
| Mist Elim-1 | mist eliminator rinse |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature: Helen J Owens

Title: _____

Location at which Recovery was Done: _____

Date and Time of Recovery: _____

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: _____

Title: _____

Date and Time of Receipt: _____

Sample Storage: _____

Laboratory Person Receiving Sample

Signature: Helen J Owens

Title: Sample Analyst

Date and Time of Receipt: 8/10/88 ~~1030~~ 1030

Sample Storage: Lab

ANALYSIS

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| Mist Elim1 | Grtg/Diphenyl | 8/10/88 1015 | HJO |
| | | | |
| | | | |
| | | | |

SAMPLE CHAIN OF CUSTODY

Plant: Ball Technology  Test Number: _____

Date Sampled: 8/10/88  Run Number: Moist. Extn - 1

SAMPLE RECOVERY

| Container Code | Description |
|---|---|
| Moist Extr.-1 | Moisture extractor rinse - #1 |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature: Helen Owens

Title: 8/10/88 0815

Location at which Recovery was Done: Plant

Date and Time of Recovery: _____

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: _____

Title: _____

Date and Time of Receipt: _____

Sample Storage: _____

Laboratory Person Receiving Sample

Signature: Helen Owens

Title: Sample Analyst

Date and Time of Receipt: 8/10/88 1015

Sample Storage: Lab

ANALYSIS

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| Moist Ext.-1 | Cr+6 / Diphenyl | 8/10/88 1015 | HJO |
| | | | |
| | | | |
| | | | |

SAMPLE CHAIN OF CUSTODY

Plant: Ball Technology Test Number: PS-2

Date Sampled: 8/10/88 Run Number: _____

SAMPLE RECOVERY

| Container Code | Description |
|---|---|
| PS-2 | plating solution Run #2 |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature: Helen Owens

Title: Sample Analyst

Location at which Recovery was Done: _____

Date and Time of Recovery: _____

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: _____

Title: _____

Date and Time of Receipt: _____

Sample Storage: _____

Laboratory Person Receiving Sample

Signature: Helen Owens

Title: SA

Date and Time of Receipt: 8/10/88 1400

Sample Storage: lab

ANALYSIS

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| PS-2 | Cr⁺⁶/Diphenyl | 8/16/88 1000 | HO |
| | | | |
| | | | |
| | | | |

SAMPLE CHAIN OF CUSTODY

Plant: Rad Technology  Test Number: _____

Date Sampled: 8/10/88  Run Number: PS-3

SAMPLE RECOVERY

| Container Code | Description |
|---|---|
| PS-3 | plating solution - run #3 |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature: Helen Owens

Title: _____

Location at which Recovery was Done: _____

Date and Time of Recovery: _____

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: _____

Title: _____

Date and Time of Receipt: _____

Sample Storage: _____

Laboratory Person Receiving Sample

Signature: Helen Owens

Title: Sample Analyst

Date and Time of Receipt: 8/10/88 1900

Sample Storage: lab

ANALYSIS

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| PS-3 | Cr⁺⁶ Diphenyl | 8/10/88 1900 | |
| | | | |
| | | | |
| | | | |

PES

SAMPLE CHAIN OF CUSTODY

Plant: Ball Tech Test Number: _____

Date Sampled: 8/11/88 Run Number: Moist. Ext. -2

SAMPLE RECOVERY

| Container Code | Description |
|---|---|
| Moist Ext. - 2 | moisture extraction rinse |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature: Helen Owens

Title: _____

Location at which Recovery was Done: plant

Date and Time of Recovery: 8/11/88 0830

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: HJO

Title: _____

Date and Time of Receipt: _____

Sample Storage: _____

Laboratory Person Receiving Sample

Signature: Helen Owens

Title: Sample Analyst

Date and Time of Receipt: ~~8/10/88~~ ~~8/10/88~~ 8/11/88 0830

Sample Storage: VAN

ANALYSIS

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| Moist Ext. 2 | $Cr^{+6}$/Diphenyl | 8/18/88 1030 | HJO |
| | | | |
| | | | |
| | | | |

SAMPLE CHAIN OF CUSTODY

Plant: Ball Tech  Test Number: _____

Date Sampled: 8/11/88  Run Number: Mist Elim - 2

SAMPLE RECOVERY

| Container Code | Description |
|---|---|
| Mist Elim-2 | mist eliminator wash |
| | |
| | |
| | |

Person Engaged in Sample Recovery

Signature: HJO

Title: _____

Location at which Recovery was Done: _____

Date and Time of Recovery: _____

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: _____

Title: _____

Date and Time of Receipt: _____

Sample Storage: _____

Laboratory Person Receiving Sample

Signature: Helen Ollis

Title: Sample Analyst

Date and Time of Receipt: 8/11/88 0830

Sample Storage: Vault

ANALYSIS

| Container Code | Method of Analysis | Date and Time of Analysis | Signature of Analyst |
|---|---|---|---|
| Mist Elim-2 | Cr+6 / Diphenyl | 8/18/88 1030 | HJO |
| | | | |
| | | | |
| | | | |

# APPENDIX F

## Equipment Calibration Data

## PITOT TUBE CALIBRATION DATA SHEET

Calibrated By: T. MILLER

Date: 8-12-87

Pitot I.D. No.: S-1

Effective Length: 2.5' (30")

Pitot Tube Assembly Level? Yes ✓ No _____

Pitot Tube Openings Damaged? Yes (explain below) _____ No ✓

$\alpha_1$ = 1 ° (<10°) $\alpha_2$ = 2 ° (<10°)

$\beta_1$ = 1 ° (<5°) $\beta_2$ = 0 ° (<5°)

$\gamma$ = 1 ° $\theta$ = 2 ° A = 0.915 °

z = A sin $\gamma$ = 0.016 cm (in.) 0.32 cm (<1/8 in.)

w = A sin $\theta$ = 0.032 cm (in.) 0.08 cm (<1/32 in.)

$P_A$ = 0.458 cm (in.)

$P_B$ = 0.457 cm (in.)

$D_t$ = 0.380 cm (in.)

Comments: _____

Calibration Required? Yes _____ No ✓

PITOT TUBE CALIBRATION DATA SHEET

Calibrated By: T. Miller, J. Black

Date: 1/11/88

Pitot I.D. No.: S-2

Effective Length: 4'

Pitot Tube Assembly Level? Yes ✓ No

Pitot Tube Openings Damaged? Yes (explain below) No ✓

$\alpha_1$ = 1° (<10°) $\alpha_2$ = 1° (<10°)

$\beta_1$ = 0 (<5°) $\beta_2$ = -1° (<5°)

$\gamma$ = 2° $\theta$ = 1° A = 0.884 IN.

z = A sin$\gamma$ = 0.03 cm (in.) 0.32 cm (<1/8 in.)

w = A sin$\theta$ = 0.15 cm (in.) 0.08 cm (<1/32 in.)

$P_A$ = 0.442 cm (in.)

$P_B$ = 0.442 cm (in.)

$D_t$ = 0.382 cm (in.)

Comments:

Calibration Required? Yes No ✓

PITOT TUBE CALIBRATION DATA SHEET

Calibrated By: T. MILLER

Date: 8-12-87

Pitot I.D. No.: S-4

Effective Length: 3' (ON ENCONEC PROBE)

Pitot Tube Assembly Level? Yes ✓ No _____

Pitot Tube Openings Damaged? Yes (explain below) _____ No ✓

$\alpha_1$ = 1 ° (<10°) $\alpha_2$ = 1 ° (<10°)

$\beta_1$ = 0 ° (<5°) $\beta_2$ = 0 ° (<5°)

$\gamma$ = 1 ° $\theta$ = 1 ° A = 0.932 °

z = A sin $\gamma$ = 0.016 cm (in.) 0.32 cm (<1/8 in.)

w = A sin $\theta$ = 0.016 cm (in.) 0.08 cm (<1/32 in.)

$P_A$ = 0.466 cm (in.)

$P_B$ = 0.466 cm (in.)

$D_t$ = 0.371 cm (in.)

Comments: _____

Calibration Required? Yes _____ No _____

# TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 1-20-88 Thermocouple number SH-5

Ambient temperature _____°F Barometric pressure 29.05 in. Hg

Calibrator T. Miller Reference: mercury-in-glass ASTM-3F(34078)

other _____

| Reference point number[a] | Source[b] (specify) | Reference thermometer temperature, °F | Thermocouple potentiometer temperature, °F | Temperature difference,[c] % |
|---|---|---|---|---|
| 1 | ambient | 75 | 73 | 2.7 |
| 2 | ice bath | 32 | 32 | 0 |
| 3 | heated oil | 428 | 428 | 0 |

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °C} + 273) - (\text{test thermom temp, °C} + 273)}{\text{ref temp, °C} + 273}\right] 100 \leq 1.5\%$.

# TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 1-20-88 Thermocouple number SH-4

Ambient temperature 75 °C Barometric pressure 29.05 in. Hg

Calibrator T. Miller Reference: mercury-in-glass ASTM 3F (34078)

other

| Reference point number[a] | Source[b] (specify) | Reference thermometer temperature, °C | Thermocouple potentiometer temperature, °C | Temperature difference,[c] % |
|---|---|---|---|---|
| 1 | ambient | 75 | 73 | 2.7 |
| 2 | ice bath | 33 | 33 | 0 |
| 3 | heated oil | 430 | 430 | 0 |

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °C} + 273) - (\text{test thermom temp, °C} + 273)}{\text{ref temp, °C} + 273}\right] 100 \leq 1.5\%$.

# TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 1-20-88 Thermocouple number SH-2

Ambient temperature 75 °C Barometric pressure 29.05 in. Hg

Calibrator T. Miller Reference: mercury-in-glass ASTM-3F(34078)

other

| Reference point number[a] | Source[b] (specify) | Reference thermometer temperature, °F | Thermocouple potentiometer temperature, °F | Temperature difference,[c] % |
|---|---|---|---|---|
| 1 | ambient | 75 | 73 | 2.7 |
| 2 | ice bath | 32 | 32 | 0 |
| 3 | heated oil | 430 | 430 | 0 |

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °C} + 273) - (\text{test thermom temp, °C} + 273)}{\text{ref temp, °C} + 273}\right] 100 \leq 1.5\%$.

# TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 1-20-88 Thermocouple number 5A

Ambient temperature 75 °F Barometric pressure 29.08 in. Hg

Calibrator T. Miller Reference: mercury-in-glass ASTM-3F (34078)

other

| Reference point number[a] | Source[b] (specify) | Reference thermometer temperature, °F | Thermocouple potentiometer temperature, °F | Temperature difference,[c] % |
|---|---|---|---|---|
| 1 | ambient | 75 | 74 | 1.3 |
| 2 | ice bath | 32 | 32 | 0 |
| 3 | heated oil | 416 | 416 | 0 |

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °C} + 273) - (\text{test thermom temp, °C} + 273)}{\text{ref temp, °C} + 273}\right] 100 \leq 1.5\%$.

# TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 3-13-87 Thermocouple number MB-4 RAC-2

Ambient temperature 24.4 °C Barometric pressure — in. Hg

Calibrator J Meadows Reference: mercury-in-glass _____

other _____

| Reference point number[a] | Source[b] (specify) | Reference thermometer temperature, °C | Thermocouple potentiometer temperature, °C | Temperature difference,[c] % |
|---|---|---|---|---|
| Meter In | Ambient | 76 (24.4) | 75 (23.9) | 0.17 |
| Meter Out | | 76 (24.4) | 74 (23.3) | 0.37 |

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °C} + 273) - (\text{test thermom temp, °C} + 273)}{\text{ref temp, °C} + 273}\right] 100 \leq 1.5\%$.

# TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 9-17-87 Thermocouple number MB-30

Ambient temperature 80 °F °C Barometric pressure 29.28 in. Hg

Calibrator J R B Reference: mercury-in-glass 7L4787

other

| Reference point number[a] | Source[b] (specify) | Reference thermometer temperature, °C °F | Thermocouple potentiometer temperature, °C | Temperature difference,[c] % |
|---|---|---|---|---|
| 1 | AMBIENT | 80 | 79.6°F | 0 |
| 2 | ICE WATER | 32 | 31.8 | 0 |

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °C} + 273) - (\text{test thermom temp, °C} + 273)}{\text{ref temp, °C} + 273}\right] 100 \leq 1.5\%$.

PES

# TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 9-17-87 Thermocouple number MB-3 I

Ambient temperature 80°F Barometric pressure 29.28 in. Hg

Calibrator J R Blair Reference: mercury-in-glass 7L4787

other

| Reference point number[a] | Source[b] (specify) | Reference thermometer temperature, °F | Thermocouple potentiometer temperature, °F | Temperature difference,[c] % |
|---|---|---|---|---|
| 1 | AMBIENT | 80°F | 79.8°F | 0 |
| | ICE WATER | 32 | 31.6 | 0 |

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °C} + 273) - (\text{test thermom temp, °C} + 273)}{\text{ref temp, °C} + 273}\right] 100 \leq 1.5\%$.

# TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 4-14-87 Thermocouple number MB-1 RAC 1065

Ambient temperature 74 °F °C Barometric pressure 29.40 in. Hg

Calibrator FM Reference: mercury-in-glass ASTM 15-67 C

other

| Reference point number[a] | Source[b] (specify) | Reference thermometer temperature, °C | Thermocouple potentiometer temperature, °C | Temperature difference,[c] % |
|---|---|---|---|---|
| METER INLET | AMB. AIR | 74°F (23.3°C) | 72°F (22.2°C) | 0,37 |
| METER OUTLET | AMB. AIR | 74°F (23.3°C) | 72°F (22.2°C) | 0,37 |

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °C} + 273) - (\text{test thermom temp, °C} + 273)}{\text{ref temp, °C} + 273}\right] 100 \leq 1.5\%$.

## DRY GAS METER AND ORIFICE CALIBRATION

Date: 8-3-88 Box No.: MB-4

Barometric Pressure, $P_b$ = 29.62 in. Hg Dry Gas Meter No.: Ref.

| Orifice Manometer Setting, ΔH, in. $H_2O$ | Gas Vol. Wet Test Meter $V_w$, $ft^3$ | Gas Vol. Dry Gas Meter $V_d$, $ft^3$ | Temperature: Wet Test Meter $t_w$, °F | Temperature: Dry Gas Meter Inlet $t_{di}$, °F | Temperature: Dry Gas Meter Outlet $t_{do}$, °F | Temperature: Dry Gas Meter Average $t_d$, °F | Time θ, min. | Y | ΔH@ |
|---|---|---|---|---|---|---|---|---|---|
| 0.5 | 4.533 | 4.637 | 80 | | | 89 | 10.0 | 0.993 | 1.383 |
| 1.0 | 6.346 | 6.529 | 81 | | | 98 | 10.0 | 1.000 | 1.394 |
| 2.0 | 8.715 | 8.997 | 81 | | | 109 | 10.0 | 1.014 | 1.450 |
| 4.0 | 12.030 | 12.437 | 82 | | | 124 | 10.0 | 1.016 | 1.525 |
| 6.0 | 14.528 | 15.332 | 81 | | | 120 | 10.0 | 1.016 | 1.515 |
| 8.0 | 12.496 | 13.020 | 81 | | | 120 | 10.0 | 1.009 | 1.356 |
| | | | | | | Average | | 1.009 | 1.441 |

Calculations:

| ΔH | $\frac{\Delta H}{13.6}$ | Y: $\frac{V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6}) (t_w + 460)}$ | ΔH@: $\frac{0.0317\ \Delta H}{P_b (t_d + 460)} \left[ \frac{(t_w + 460)\ e}{V_w} \right]^2$ |
|---|---|---|---|
| 0.5 | 0.0368 | | |
| 1.0 | 0.0737 | | |
| 2.0 | 0.147 | | |
| 4.0 | 0.294 | | |
| 6.0 | 0.431 | | |
| 8.0 | 0.588 | | |

Y = ratio of accuracy of wet test meter to dry test meter. Tolerance = 0.01.

ΔH@ = orifice pressure differential that gives 0.75 cfm of air at 70°F and 29.92 inches of mercury, in. $H_2O$. Tolerance = 0.15.

## DRY GAS METER AND ORIFICE CALIBRATION

Date: 8/4/88 Box No.: MB-3

Barometric Pressure, $P_b$ = 29.58 in. Hg Dry Gas Meter No.: REF

| Orifice Manometer Setting, ΔH, in. $H_2O$ | Gas Vol. Wet Test Meter $V_w$, $ft^3$ | Gas Vol. Dry Gas Meter $V_d$, $ft^3$ | Temperature: Wet Test Meter $t_w$, °F | Temperature: Dry Gas Meter Inlet $t_{di}$, °F | Temperature: Dry Gas Meter Outlet $t_{do}$, °F | Temperature: Dry Gas Meter Average $t_d$, °F | Time θ, min. | Y | ΔH@ |
|---|---|---|---|---|---|---|---|---|---|
| 0.5 | 5.349 | 5.537 | 76 | 100 | 93 | 96 °F 556 °R | 15.0 | 1.000 | 2.177 |
| 1.0 | 5.194 | 5.448 | 76 | 112 | 99 | 105.5 °F 565.5 °R | 10.0 | 1.001 | 2.020 |
| 2.0 | 5.650 | 5.987 | 76 | 122 | 104 | 113/573 | 8.0 | 1.002 | 2.155 |
| 4.0 | 8.034 | 8.588 | 76 | 134 | 108 | 121°F/581R | 8.0 | 1.003 | 2.102 |
| 6.0 | 9.364 | 10.129 | 76 | 144 | 114 | 129F/589 | 7.0 | 1.000 | 1.753 |
| 8.0 | 7.776 | 8.483 | 76 | 149 | 119 | 134/594 | 5.0 | 0.995 | 1.714 |
| | | | | | | Average | | 1.000 | 1.987 |

Calculations:

| ΔH | $\frac{\Delta H}{13.6}$ | Y: $\frac{V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6}) (t_w + 460)}$ | ΔH@: $\frac{0.0317 \Delta H}{P_b (t_d + 460)} \left[\frac{(t_w + 460)\ e}{V_w}\right]^2$ |
|---|---|---|---|
| 0.5 | 0.0368 | | |
| 1.0 | 0.0737 | | |
| 2.0 | 0.147 | | |
| 4.0 | 0.294 | | |
| 6.0 | 0.431 | | |
| 8.0 | 0.588 | | |

Y = ratio of accuracy of wet test meter to dry test meter. Tolerance = 0.01.

ΔH@ = orifice pressure differential that gives 0.75 cfm of air at 70°F and 29.92 inches of mercury, in. $H_2O$. Tolerance = 0.15.

Ref. meter Y = .9985

# DRY GAS METER AND ORIFICE CALIBRATION

Date: 4-16-88 Box No.: MB-1

Barometric Pressure, $P_b$ = 29.40 in. Hg Dry Gas Meter No.: _____

| Orifice Manometer Setting, ΔH, in. $H_2O$ | Gas Vol. Wet Test Meter $V_w$, $ft^3$ | Gas Vol. Dry Gas Meter $V_d$, $ft^3$ | Temperature: Wet Test Meter $t_w$, °F | Temperature: Dry Gas Meter Inlet $t_{di}$, °F | Temperature: Dry Gas Meter Outlet $t_{do}$, °F | Temperature: Dry Gas Meter Average $t_d$, °F | Time θ, min. | Y | ΔH@ |
|---|---|---|---|---|---|---|---|---|---|
| 0.5 | 5.608 | 5.901 | 70 | 97/102 | 82/86 | 552°R | 13.98 | .987 | 1.71 |
| 1.0 | 5.437 | 5.745 | 70 | 101/107 | 87/89 | 556 | 9.62 | .989 | 1.71 |
| 2.0 | 5.910 | 6.228 | 70 | 106/112 | 89/91 | 560 | 7.60 | .996 | 1.79 |
| 4.0 | 7.117 | 7.459 | 70 | 109/118 | 91/93 | 563 | 6.45 | 1.002 | 1.77 |
| 6.0 | 6.309 | 6.571 | 71 | 115/119 | 93/94 | 565 | 4.67 | 1.005 | 1.77 |
| 8.0 | 7.553 | 7.836 | 71 | 116/122 | 94/96 | 567 | 5.08 | 1.007 | 1.95 |
| | | | | | | Average | | 0.998 | 1.78 |

Calculations:

| ΔH | $\frac{\Delta H}{13.6}$ | $Y = \frac{V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6}) (t_w + 460)}$ | $\Delta H@ = \frac{0.0317 \Delta H}{P_b (t_d + 460)} \left[\frac{(t_w + 460)\, e}{V_w}\right]^2$ |
|---|---|---|---|
| 0.5 | 0.0368 | | |
| 1.0 | 0.0737 | | |
| 2.0 | 0.147 | | |
| 4.0 | 0.294 | | |
| 6.0 | 0.431 | | |
| 8.0 | 0.588 | | |

Y = ratio of accuracy of wet test meter to dry test meter. Tolerance = 0.01.

ΔH@ = orifice pressure differential that gives 0.75 cfm of air at 70°F and 29.92 inches of mercury, in. $H_2O$. Tolerance = 0.15.

## POSTTEST DRY GAS METER CALIBRATION DATA FORM

Test numbers IB1-3 Date 8-15-88 Meter box number MB-3 Plant Roll Technology

Barometric pressure, $P_b$ = 29.49 in. Hg Dry gas meter number _____ Pretest Y 1.000

| Orifice manometer setting, (ΔH), in. $H_2O$ | Gas volume: Wet test meter ($V_w$), $ft^3$ | Gas volume: Dry gas meter ($V_d$), $ft^3$ | Temperature: Wet test meter ($t_w$), °F | Temperature: Dry gas meter: Inlet ($t_{d_i}$), °F | Temperature: Dry gas meter: Outlet ($t_{d_o}$), °F | Temperature: Dry gas meter: Average ($t_d$), [a] °F | Time (θ), min | Vacuum setting, in. Hg | $Y_i$ | $Y_i$ = $\frac{V_w P_b (t_d + 460)}{V_d \left(P_b + \frac{\Delta H}{13.6}\right)(t_w + 460)}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.3 | 194.139 | 322.823 | 75 | 117.7 | 92.7 | 112.3 | 10.0 | 5.0 | 1.0086 | $\frac{9.653 \cdot 29.49 \cdot 572.3}{10.155 \cdot 29.73 \cdot 535}$ |
| | 203.792 | 332.978 | 75 | 137.7 | 101.1 | | | | | |
| 3.3 | 204.029 | 333.231 | 75 | 137.7 | 101.1 | 123.0 | 10.0 | 5.0 | 1.0124 | $\frac{9.552 \cdot 29.49 \cdot 583}{10.199 \cdot 29.73 \cdot 535}$ |
| | 213.581 | 343.430 | 75 | 144.2 | 109.0 | | | | | |
| 3.3 | 213.839 | 343.709 | 75 | 136.3 | 109.3 | 126.7 | 10.0 | 5.0 | 1.0044 | $\frac{9.280 \cdot 29.49 \cdot 586.7}{10.050 \cdot 29.73 \cdot 535}$ |
| | 223.119 | 353.759 | 75 | 146.8 | 114.3 | | | | | |
| | | | | | | | | | Y = 1.008 | |

[a] If there is only one thermometer on the dry gas meter, record the temperature under $t_d$.

$V_w$ = Gas volume passing through the wet test meter, $ft^3$.

$V_d$ = Gas volume passing through the dry gas meter, $ft^3$.

$t_w$ = Temperature of the gas in the wet test meter, °F.

$t_{d_i}$ = Temperature of the inlet gas of the dry gas meter, °F.

$t_{d_o}$ = Temperature of the outlet gas of the dry gas meter, °F.

$t_d$ = Average temperature of the gas in the dry gas meter, obtained by the average of $t_{d_i}$ and $t_{d_o}$, °F.

ΔH = Pressure differential across orifice, in $H_2O$.

$Y_i$ = Ratio of accuracy of wet test meter to dry gas meter for each run.

Y = Average ratio of accuracy of wet test meter to dry gas meter for all three runs; tolerance = pretest Y ±0.05Y

$P_b$ = Barometric pressure, in. Hg.

θ = Time of calibration run, min.



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## POSTTEST DRY GAS METER CALIBRATION DATA FORM

Test numbers 01-3 Date 8-15-88 Meter box number MB-1 Plant Roll Technology

Barometric pressure, $P_b$ = 29.49 in. Hg Dry gas meter number _____ Pretest Y 0.998

| Orifice manometer setting, (ΔH), in. $H_2O$ | Gas volume: Wet test meter ($V_w$), $ft^3$ | Gas volume: Dry gas meter ($V_d$), $ft^3$ | Temperature: Wet test meter ($t_w$), °F | Temperature: Dry gas meter: Inlet ($t_{d_i}$), °F | Temperature: Dry gas meter: Outlet ($t_{d_o}$), °F | Temperature: Dry gas meter: Average[a] ($t_d$), °F | Time (θ), min | Vacuum setting, in. Hg | $Y_i$ | $Y_i \frac{V_w P_b (t_d + 460)}{V_d P_b + \frac{\Delta H}{13.6} t_w + 460}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.5 | 236.848 | 198.923 | 77 | 104 | 80 | 98.25 | 10.0 | 4.0 | 1.0100 | 11.785 · 29.49 · 558.25 / 11.995 · 29.82 · 537 |
| 4.5 | 248.633 | 210.918 | 77 | 123 | 86 | | | | | |
| 4.5 | 248.633 | 210.918 | 77 | 118 | 87 | 107.5 | 10.0 | 4.0 | 1.0158 | 11.843 · 29.49 · 562.5 / 11.782 · 29.82 · 537 |
| 4.5 | 260.046 | 222.660 | 77 | 131 | 94 | | | | | |
| 4.5 | 260.046 | 222.660 | 77 | 128 | 94 | 114.0 | 10.0 | 4.0 | 1.0186 | 11.869 · 29.49 · 574 / 11.798 · 29.82 · 537 |
| | 271.415 | 234.458 | 77 | 135 | 99 | | | | | |
| | | | | | | | | | Y = 1.015 | |

[a] If there is only one thermometer on the dry gas meter, record the temperature under $t_d$.

$V_w$ = Gas volume passing through the wet test meter, $ft^3$.

$V_d$ = Gas volume passing through the dry gas meter, $ft^3$.

$t_w$ = Temperature of the gas in the wet test meter, °F.

$t_{d_i}$ = Temperature of the inlet gas of the dry gas meter, °F.

$t_{d_o}$ = Temperature of the outlet gas of the dry gas meter, °F.

$t_d$ = Average temperature of the gas in the dry gas meter, obtained by the average of $t_{d_i}$ and $t_{d_o}$, °F.

ΔH = Pressure differential across orifice, in $H_2O$.

$Y_i$ = Ratio of accuracy of wet test meter to dry gas meter for each run.

Y = Average ratio of accuracy of wet test meter to dry gas meter for all three runs; tolerance = pretest Y ±0.05Y

$P_b$ = Barometric pressure, in. Hg.

θ = Time of calibration run, min.



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## POSTTEST DRY GAS METER CALIBRATION DATA FORM

Test numbers IA1-3 Date 8-15-88 Meter box number M13-4 Plant Roll Technology

Barometric pressure, $P_b$ = 29.49 in. Hg Dry gas meter number _____ Pretest Y 1.009

| Orifice manometer setting, (ΔH), in. $H_2O$ | Gas volume: Wet test meter ($V_w$), $ft^3$ | Gas volume: Dry gas meter ($V_d$), $ft^3$ | Temperature: Wet test meter ($t_w$), °F | Temperature: Dry gas meter: Inlet ($t_{d_i}$), °F | Temperature: Dry gas meter: Outlet ($t_{d_o}$), °F | Temperature: Dry gas meter: Average[a] ($t_d$), °F | Time (θ), min | Vacuum setting, in. Hg | $Y_i$ | $Y_i \frac{V_w P_b (t_d + 460)}{V_d \left(P_b + \frac{\Delta H}{13.6}\right)(t_w + 460)}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.1 | 295.633 | 132.638 | 77 | 119 | 96 | | | | | |
| | 308.017 | 145.483 | 77 | 135 | 98 | 112.0 | 10.0 | 6.5 | 1.0166 | 12.384 · 29.49 · 572 / 12.845 · 29.79 · 537 |
| 4.1 | 308.017 | 145.483 | 78 | 124 | 98 | | | | | |
| | 320.400 | 158.429 | 78 | 144 | 106 | 118.0 | 10.0 | 6.5 | 1.0173 | 12.383 · 29.49 · 528 / 12.946 · 29.79 · 538 |
| 4.1 | 320.400 | 158.429 | 78 | 132 | 106 | | | | | |
| | 332.599 | 171.177 | 78 | 148 | 112 | 124.5 | 10.0 | 6.5 | 1.0292 | 12.199 · 29.49 · 584.5 / 12.748 · 29.79 · 538 |
| | | | | | | | | | Y = 1.021 | |

[a] If there is only one thermometer on the dry gas meter, record the temperature under $t_d$.

$V_w$ = Gas volume passing through the wet test meter, $ft^3$.

$V_d$ = Gas volume passing through the dry gas meter, $ft^3$.

$t_w$ = Temperature of the gas in the wet test meter, °F.

$t_{d_i}$ = Temperature of the inlet gas of the dry gas meter, °F.

$t_{d_o}$ = Temperature of the outlet gas of the dry gas meter, °F.

$t_d$ = Average temperature of the gas in the dry gas meter, obtained by the average of $t_{d_i}$ and $t_{d_o}$, °F.

ΔH = Pressure differential across orifice, in $H_2O$.

$Y_i$ = Ratio of accuracy of wet test meter to dry gas meter for each run.

Y = Average ratio of accuracy of wet test meter to dry gas meter for all three runs; tolerance = pretest Y ±0.05Y

$P_b$ = Barometric pressure, in. Hg.

θ = Time of calibration run, min.



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## TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 8-4-88 Thermocouple number 4-H

Ambient temperature 75 °F Barometric pressure 29.58 in. Hg

Calibrator TM Reference: mercury-in-glass Ref.

other

| Reference point number[a] | Source[b] (specify) | Reference thermometer temperature, °C | Thermocouple potentiometer temperature, °C | Temperature difference,[c] % |
|---|---|---|---|---|
| 1 | ice bath | 32 | 32 | 0 |
| 2 | ambient | 75 | 73 | 2.6 |

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °C} + 273) - (\text{test thermom temp, °C} + 273)}{\text{ref temp, °C} + 273}\right] 100 \leq 1.5\%$.

# TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 8-4-88 Thermocouple number 4-I

Ambient temperature 75 °F Barometric pressure 29.58 in. Hg

Calibrator TM Reference: mercury-in-glass REF.

other

| Reference point number[a] | Source[b] (specify) | Reference thermometer temperature, °F | Thermocouple potentiometer temperature, °F | Temperature difference,[c] % |
|---|---|---|---|---|
| 1 | ice bath | 32 | 32 | 0 |
| 2 | ambient | 75 | 74 | 1.3 |

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °C} + 273) - (\text{test thermom temp, °C} + 273)}{\text{ref temp, °C} + 273}\right] 100 \leq 1.5\%$.

# APPENDIX G

## Project Participants and Activity Log

## PROJECT PARTICIPANTS

| Name | Title | Responsibility |
|---|---|---|
| Frank Clay | U.S. EPA Task Manager<br>Computer Center Coordinator<br>Test Observationist | Observed test activity and on-site data reduction and calculations |
| John Brown | U.S. EPA, Technician | Conducted Screening Methods tests |
| Helen Owens | PEER Consultants, P.C.<br>Project Leader | On-site analysis, coordinated test activity with plant and contractors |
| Andrew Weisman | PEER Consultants, P.C.<br>Technician | Assisted in site set-up, sampling, sample recovery |
| Eric Hollins | PEER Consultants, P.C.<br>Technician | Assisted in site set-up, sampling, sample recovery |
| Jim Blau | Pacific Environmental Services<br>Subcontractor Project Leader | Conducted emission sampling, sample train set-up and recovery |
| Tim Miller | Pacific Environmental Services<br>Technician | Conducted emission sampling, sample train set-up and recovery |
| Bruce Gerber | Pacific Environmental Services<br>Laboratory Assistant | Sample train set-up and recovery, assisted with chemical analysis and process sampling |
| Robin Barker | MRI<br>NSPS Contractor | Monitored process operation |

## ACTIVITY LOG

| | |
|---|---|
| 8/7 | Drive equipment to site |
| 8/8 | Test crew travels to Greenville and begin site set-up |
| 8/9 | Complete site set-up, conduct 1 MM13B test, Screening Methods and analysis |
| 8/10 | Conduct 2 MM13B tests, 2 Screening Methods and Analysis, and dismantle site |
| 8/11 | Collect final rinseate samples and travel |

# APPENDIX H

## Characterization of Cyclonic Flow and Analysis of Particulate Sampling Approaches at Asphalt Plants

# CHARACTERIZATION OF CYCLONIC FLOW AND ANALYSIS OF PARTICULATE SAMPLING APPROACHES AT ASPHALT PLANTS

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27709



ENTROPY
ENVIRONMENTALISTS, INC

CHARACTERIZATION OF CYCLONIC FLOW AND ANALYSIS OF PARTICULATE SAMPLING APPROACHES AT ASPHALT PLANTS, J. W. Peeler, F. J. Phoenix, and D. J. Grove, Entropy Environmentalists, Inc., P. O. Box 12291, Research Triangle Park, N. C. 27709.

The information presented in this paper is directed to those individuals responsible for conducting particulate emission tests at asphalt plants where cyclonic flow conditions occur in the stack. Characterization of cyclonic flow has been accomplished through axial and tangential velocity measurements in several stacks following inertial demisters. The axial and tangential velocities reach maximums at 82% and 43% of the stack radius, respectively. The angle between the flow direction and the stack axis varies from 41° to 66° across the stack. A theoretical formulation of particle behavior in cyclonic flow, incorporating the results of flow measurements, and a numerical solution to the resulting equations is employed to determine radial particle velocities. Results indicate that 25 micron diameter and larger particles will reach the stack wall before the sampling site. The radial velocity of 10 micron particles is small compared to axial and tangential velocities and these particles will be encountered at sampling sites located less than 8 diameters downstream of the starting point. The application of three sampling methods to cyclonic flow are discussed. The Blind Man's Approach should not be used. The Compensation Approach and Alignment Approach satisfy the requirements of proportional sampling, isokinetic sampling, and accurate volumetric flow rate measurements.

## Introduction

Cyclonic flow conditions often occur following inertial demisters in stacks at asphalt plants equipped with wet scrubber control systems. Where cyclonic flow conditions exist, the effluent gas flows in a spiral motion up the stack. At each point in the stack, the gases have both axial and tangential velocity components.

Measurements of volumetric flow and mass concentration are considerably more difficult under cyclonic flow conditions than under fully developed flow conditions. EPA Reference Methods 2 and 5 are not applicable to sampling cyclonic flow systems, since the average angle of the free stream velocity is inclined at greater than 10° to the stack axis. Thus, either an alternative sampling location, modifications to the source to eliminate the cyclonic flow, or alternate sampling methodology is necessitated.

This paper presents through empirical measurement a characterization of cyclonic flow systems typically encountered at asphalt plants. Particle velocities in a cyclonic flow system are determined through theoretical considerations. A description of several particulate sampling approaches for cyclonic flow systems and a discussion of some of the errors associated with these methods are provided.

## Characterization of Cyclonic Flow

Flow measurements were taken following inertial demisters in stacks at three asphalt plants considered to be representative of the industry.[1] These measurements were made at sampling points as specified by EPA Reference Method 1, with a United Sensor Corporation, three dimensional, type DA probe. Two 24-point traverses were conducted; however, no useful data were obtained at points 1, 2, 23, and 24, because there was an excessive amount of particulate and water droplets near the wall. The measurements made on the near side of the stack diameter were more stable and are considered more reliable than the measurements obtained on the far side of the stack diameter. Axial and tangential velocity components were determined as a function of stack radius, and are shown in Figure 1. Pitch angle measurements, corresponding to radial velocity components, were found to vary randomly across the stack, and were highly unstable with time. Since the pitch angles were small in comparison with the yaw angles, the cyclonic flow system is considered to have no radial velocity components.

## Characterization of Particulate Behavior in a Cyclonic Flow System

The behavior of particles in cyclonic flow is of fundamental importance in developing particulate sampling methodology. Large particles are of primary concern here, since these particles present the greatest difficulty in obtaining representative measurements due to the effects of the inertial forces imposed on these particles by the cyclonic flow. Small particles will behave much like gas molecules and are easily and accurately sampled.

The position of a particle in cylindrical co-ordinates at time t is given by R, 0, Z, and the radial velocity component ($u_r$) and tangential velocity component ($u_t$) of the particle are:

$$u_r = \frac{dR}{dt} \quad (1) \qquad u_t = R\,\frac{d\theta}{dt} \quad (2)$$

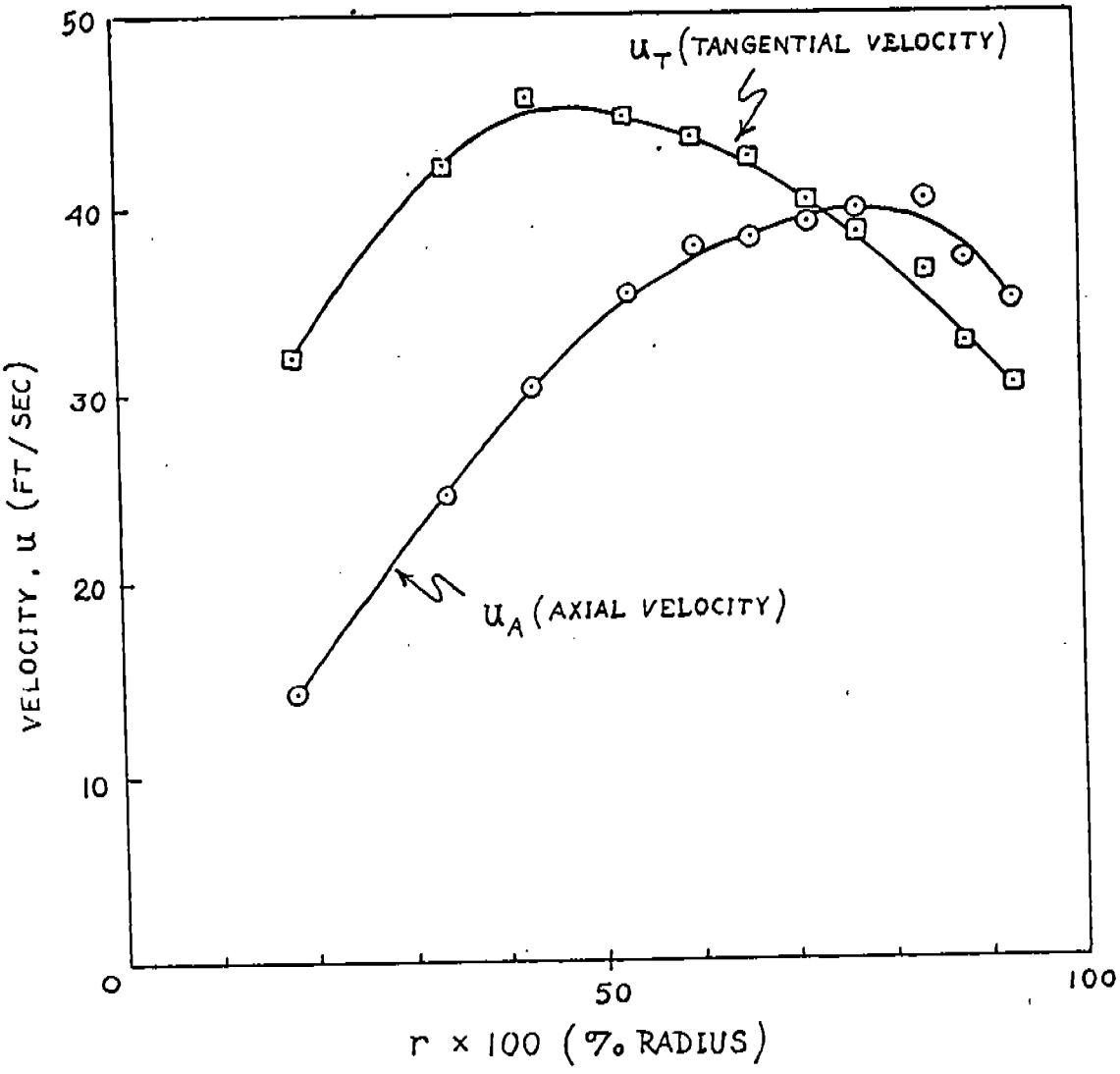


Figure 1. Axial and tangential fluid velocities along stack radius for cyclonic flow.

The radial and tangential accelerations of the particle are defined by the material derivative of the velocities,

$$\frac{d\underline{u}}{dt} = \frac{\partial \underline{u}}{\partial t} + \underline{u}\cdot\nabla\underline{u} \qquad (3)$$

Multiplying the component accelerations by the particle mass provides the inertial forces acting on the particle. These forces are resisted by viscous forces due to the relative motion of the particle moving through the surrounding fluid. The viscous forces can be described by Stokes law in terms of the viscosity of the fluid ($\mu$), particle diameter (d), and relative velocity between the particle and the fluid ($u_{rel}$):

$$F = 3\pi\mu d u_{rel} \qquad (4)$$

Thus, following the development of Strauss[2], force balances in the radial and tangential directions are

$$\frac{m}{3\pi\mu d}\left[\frac{d^2R}{dt^2} - R\left(\frac{d\theta}{dt}\right)^2\right] = -u_r = -\frac{dR}{dt} \qquad (5)$$

$$\frac{m}{3\pi\mu d}\left[R\,\frac{d^2\theta}{dt^2} + 2\,\frac{dR}{dt}\cdot\frac{d\theta}{dt}\right] = 0 \qquad (6)$$

where it is assumed that the tangential particle velocity is equal to the tangential fluid velocity. Since large particles following an inertial demister will be essentially particulate laden water droplets, the particles may be assumed to be spherical, and the particulate mass may be expressed in terms of the density ($\rho$) and the particle diameter. Employing this simplification, and expressing the above equations in dimensionless form, yields,

$$T\left[\frac{d^2r}{d\tau^2} - r\left(\frac{d\theta}{d\tau}\right)^2\right] = -\frac{dr}{d\tau} \qquad (7)$$

and

$$T\left[r\,\frac{d^2\theta}{d\tau^2} + 2\,\frac{dr}{d\tau}\cdot\frac{d\theta}{d\tau}\right] = 0 \qquad (8)$$

where:

$$T = \frac{d^2\rho u_{to}}{18\mu R_o}$$

$$r = R/R_o$$

$$u = u_r/u_{to}$$

$$\tau = tu_{to}/R_o$$

$u_{to}$ = tangential velocity at $r = 1$ ($R = R_o$)

Equation 8 can be rewritten as

$$\frac{T}{r}\frac{d}{d\tau}\left(r^2\frac{d\theta}{d\tau}\right) = 0 \qquad (9)$$

which requires

$$u_t r = \text{constant} \qquad (10)$$

The above equation is the free vortex equation. It can be seen from the tangential velocity measurements that the tangential velocity of the fluid is accurately described by the free vortex relation over the range $0.7 \leq r \leq 1.0$. Thus, the above formulation is an accurate description of the particle behavior over this range. The previous equations cannot be applied for values of r less than 70% of the stack radius; however, this is not a serious constraint since the larger particles will be in the outer portion of the stack if the demister is functioning at all.

Substituting equation 10 in equation 7 leads to Strauss' result[2]:

$$\frac{d^2r}{d\tau^2} + \frac{1}{T}\frac{dr}{d\tau} - r^{-3} = 0 \qquad (11)$$

The above equation is non-linear due to the $r^{-3}$ term. For our study, this equation was solved numerically by employing the Taylor Method and retaining fifth order terms. The Taylor Method was employed because it provides the particle's position, radial velocity, and radial acceleration directly as functions of time. Solutions were obtained for several values of T corresponding to particle diameters of 10, 25, 50, and 100 microns. For each case, it was assumed that the particle was initially located at r = .7 and had no initial radial velocity. These initial conditions represent worst case conditions in terms of the time required for the particles to reach the stack wall. The radial velocities of several particles as functions of the stack radius are presented in Figure 2.

From the results illustrated in Figure 2, it can be seen that the radial velocity component is small compared to the axial and tangential velocity components for particles with diameters equal to or less than 10 microns. Thus, particles less than 10 microns in diameter essentially move with the cyclonic gas stream. Also, by considering both the radial and axial particle velocities, for particles starting at r = .7 and with no initial radial drift, it can be shown that one stack diameter downstream of the starting point, all of the 100 and 50 micron particles will have reached the stack wall and that the 25 micron particles will have traveled outward to r = .94. In contrast, the 10 micron particles will have drifted outward from $r_o$ = .7 to only r = .7455. The 10 micron particles will have reached r = .84 four stack diameters downstream from the starting point and will not have reached the wall even after traveling axially for more than eight stack diameters. Thus, considering the typical length of stacks on inertial demisters in the asphalt industry, particles at least as large as 10 microns will be encountered at the sampling location.

The previous analysis assumes that the particles always have the same axial and tangential velocity components as the gas stream. These assumptions are approximately true for r greater than .7, since only in this region can the tangential velocity of the effluent stream be accurately described by the free vortex equation, and since only in this region is the axial velocity fairly constant. To determine the particle behavior for large particles initially located within the inner portion of the stack, it is necessary to consider relative

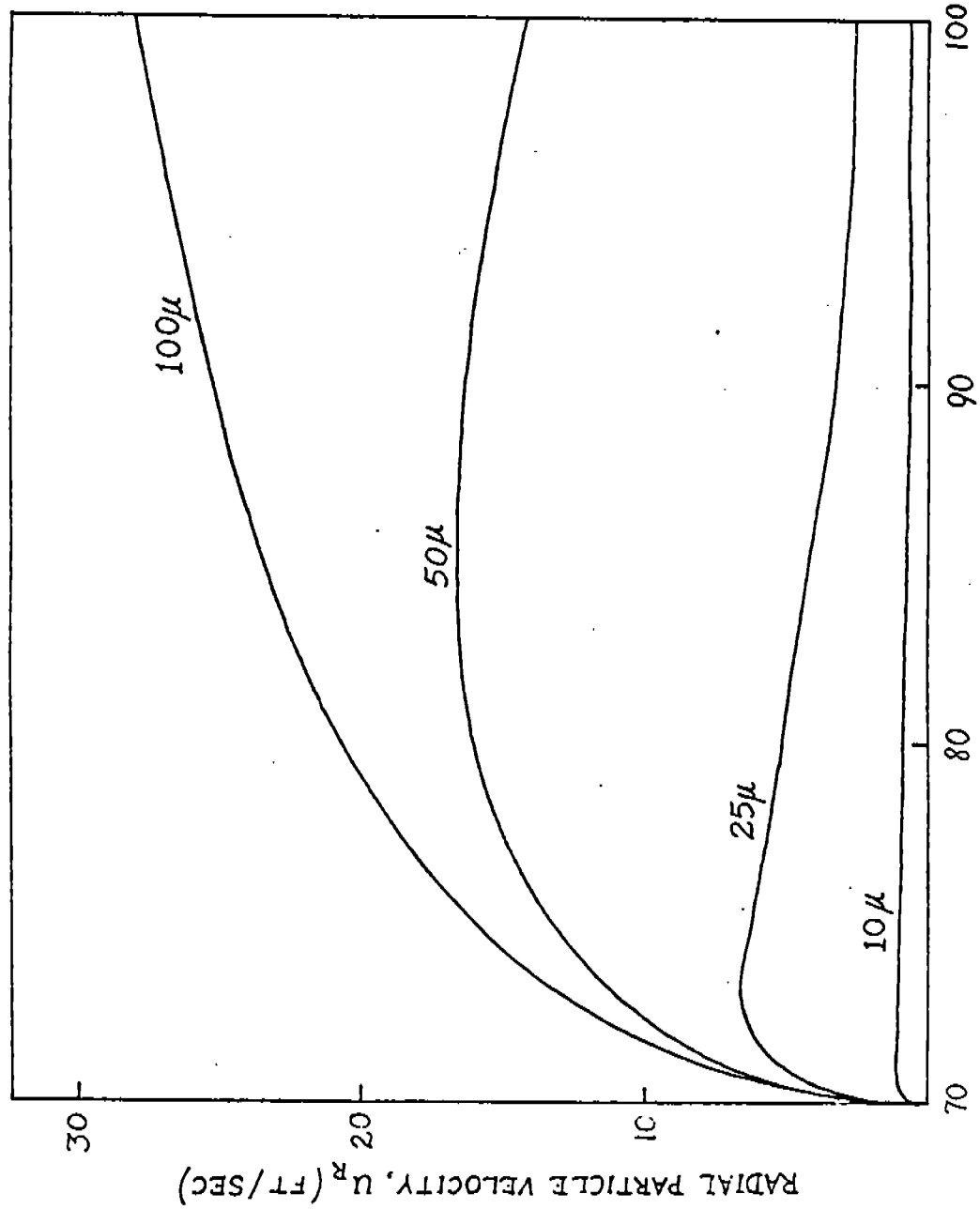


Figure 2. Radial particle velocities in cyclonic flow for particles starting at 70% of stack radius.

velocities between the particles and the fluid in both the tangential and axial directions. Such a formulation leads to a set of three simultaneous, non-linear, partial differential equations which describe the particle behavior. Solutions to these equations have not yet been obtained.

## Sampling Methods for Cyclonic Flow Systems

Stack sampling is usually conducted at asphalt plants to determine the particulate concentration of the effluent, and, in some cases, the volumetric flow rate, in order to compute mass emission rates. Several papers have been written which discuss various methods for sampling cyclonic flow systems.[1,3] Three general methods have been discussed: (1) Blind Man's Approach, (2) Compensation Approach, and (3) Alignment Approach. These methods are outlined below and some of the factors influencing these methods are discussed.

### Blind Man's Approach

In the Blind Man's Approach, standard sampling methodology is applied and the cyclonic flow is simply ignored. The sampling results obtained through this procedure are subject to multiple biasing effects. This approach is not recommended; it is only discussed here because of the frequency with which it is actually employed.

In the Blind Man's Approach, the sampling rate is based on the measured velocity which is neither the total velocity nor the axial velocity. For the axial and tangential velocities presented in Figure 1, the angle between the flow direction and the stack axis ($\Phi$) varies from a maximum of 66° at the innermost sampling point to a minimum of 41° at the outermost point. According to the data presented by Smith and Grove[4], the total velocity will be underestimated by about 20% at the innermost point and overestimated by about 2% at the outermost point. If the total velocity was accurately measured, the sampling rate would be overisokinetic, since the nozzle is not aligned with the flow and the effective area of the nozzle opening is reduced by cos $\Phi$. The combined biases resulting from velocity measurement errors and from the reduction in effective nozzle area will lead to overisokinetic sampling, where the sampling rate is too great by approximately 30% at the outermost point and by more than 100% at the innermost point. A low bias in the mass concentration will result from overisokinetic sampling.

To satisfy the constraints of proportional sampling, the sampling rate must be directly proportional to the axial velocity in the stack. In the Blind Man's Approach, the sampling rate is proportional to the indicated velocity; therefore, the requirements of proportional sampling are not satisfied. Since both the particulate concentration and axial velocity increase with increasing distance from the center of the stack, a low bias is expected in the measured mass concentration.

### Compensation Approach

The Compensation Approach requires determination of the magnitude and direction of flow at each sampling point. This may be accomplished through the use of a three dimensional pitot sensor or similar device, or by rotating an S-type pitot to obtain a null reading perpendicular to the flow direction, and then rotating the pitot 90° to measure the flow velocity. In the Compensation Approach, the sampling nozzle is aligned with the stack axis. Since the nozzle is not aligned with the flow direction, the effective nozzle area

is reduced by cos $\Phi$ where $\Phi$ is the angle between the flow direction and the stack axis. Due to the reduction in the nozzle effective area, the sampling rate must be reduced by cos $\Phi$ to maintain isokinetic sampling conditions. If isokinetic sampling conditions are maintained, the Compensation Approach satisfies the contraints of proportioned sampling, since the sampling rate is directly proportional to the axial velocity at each sampling point.

The Compensation Approach is subject to biases when the angle between the nozzle and flow stream becomes sufficiently large. For large angles, the flow around the nozzle will create aerodynamic interferences with isokinetic sampling. In general, the degree of the bias increases as the velocity increases and as the angle of misalignment increases. These effects are currently unquantified; however, these interferences will bias the measured mass concentration low. Also, for large angles between the flow direction and nozzle orientation, particulate agglomeration on both the inside and outside walls of the sampling nozzle should be expeçted. Care must be exercised in moving the sampling train to prevent accidental loss of material accumulated inside the nozzle, and in sample recovery to prevent material on the outside of the nozzle from being included in the particulate catch.

Alignment Approach .

The alignment approach involves determination of the flow direction at each sampling point by means of a three dimensional pitot sensor, or by obtaining a null reading normal to the flow direction with an S-type pitot. The sampling nozzle and pitot are then aligned with the flow direction at each sampling point.

In the alignment method, the sampling rate must be based on the total velocity at each sampling point in order to maintain isokinetic sampling conditions. Since the angle between the flow direction and stack axis varies across the stack, the sampling velocity is not weighted proportionally to the axial velocity component. Proportional sampling requirements can be satisfied by adjusting the sampling time for each sampling point such that the volume of sample collected at each point is related by a constant to the axial velocity component at each point. Thus,

$$t_2 = t_1 \cos \Phi \qquad (12)$$

where

$t_1$ = nominal sampling time per point

$t_2$ = actual sampling time per point

$\Phi$ = angle between flow direction and stack axis

Care should be exercised in selecting the nominal sampling time per point to ensure collection of sufficient sample volume to provide accurate mass concentration measurements since the application of the above weighting procedure will reduce the actual sampling time.

When sampling to determine a mass emission rate, the volumetric flow rate should be determined as:

$$Q = k_p C_p A_s \sqrt{\frac{T_s}{P_s M_s}} \frac{\sum_i^N (\sqrt{\Delta P_i} \cos \Phi_i)}{N} \qquad (13)$$

This procedure is applicable to both the Compensation and Alignment Approaches, since in both cases the angles $\Phi_i$ are known. If negative velocities are encountered at particular sampling points, then no sampling should be conducted at those points and the measured negative axial volume flow rate should be subtracted from the measured positive axial volume flow rate.

It has been suggested that when the angle between the particle velocities and the gas flow direction is large, errors in the mass concentration measurement will exist for both the Compensation and Alignment Approaches. It can be shown that no bias will exist if the particles have the same axial and tangential velocity components as the gas stream. Within these constraints, the differences in the effective area of the nozzle with respect to the particle flow direction and the gas flow direction will be exactly offset by the greater particle velocity due to the radial velocity component of the particles. Thus, based on the preceding theoretical description of particle behavior in cyclonic flow, no significant bias should be introduced in the results obtained by either method due to the differences between particle and gas flow directions when sampling after inertial demisters.

Recommendations

The following recommendations are provided for particulate sampling of cyclonic flow systems in stacks after inertial demisters at asphalt plants.

In order to minimize potential sampling problems due to the presence of large particles, the sampling site should be located as far downstream as possible: approximately one half diameter upstream of the stack exit. Where possible, four sampling ports should be installed to facilitate flow measurements and sampling on the near side of the stack diameter for each sampling port.

The Blind Man's Approach should not be employed. It is suggested that the Alignment Approach be employed to eliminate the potential aerodynamic interferences associated with the Compensation Approach where large angles between the flow direction and the stack axis are encountered. The Compensation Approach should be considered as an alternative method. Differences between the results obtained by the Alignment Approach and the Compensation Approach are expected to be small, particularly for asphalt plants operating at or below the EPA New Source Performance Standard for asphalt plants.

The complexity of both the Alignment Approach and the Compensation Approach compared to standard source sampling procedures will require more time to complete sampling runs. Asphalt plant operators should therefore allow for longer periods of operation at "representative operating conditions" in order to complete particulate emission tests.

References

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