LFG EFD AP42
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AIR POLLUTION EMISSION EVALUATION REPORT

FOR

GROUND FLARE

AT

BROWNING FERRIS INDUSTRIES
GREENTREE LANDFILL
KERSEY, PENNSYLVANIA

BCM NO. 00-7335-01

MAY 22, 1992

DRAFT COPY

PREPARED BY

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VICE PRESIDENT

BCM

Engineers, Planners, Scientists and Laboratory Services
5777 Baum Boulevard • Pittsburgh, PA 15206 • (412) 361-6000

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1.0 EXECUTIVE SUMMARY

Browning Ferris Industries (BFI) retained BCM Engineers Inc. (BCM) to perform an air pollution emission evaluation of the Ground Flare at the Greentree Landfill located in Kersey, Pennsylvania. The test results are to be used to demonstrate compliance with limitations set forth by the Pennsylvania Department of Environmental Resources (PADER).

The Ground Flare destruction efficiency based on a mass inlet loading and emission rate for total nonmethane hydrocarbons (TNMHC) as hexane was 100 percent assuming the Ground Flare exhaust emission rate to be 0.0 lb/hr and 95.6 percent based on using one half of the analytical detection limit. All Ground Flare exhaust analytical results for TNMHC were non-detectable. The destruction efficiency based on the inlet and outlet TNMHC concentrations was greater than 99.8 percent. PADER Plan Approval No. 24-322-001 allows a destruction efficiency for TNMHC of 98 percent or greater. The average nitrogen oxides (NO_x) emission rate was 2.69 lb/hour as nitrogen dioxide (NO_2).

2.0 SCOPE AND OBJECTIVES

The field sampling program was performed on April 23, 1992. The BCM test personnel consisted of Messrs. Paul Jadlowiec, James Phillippi, and John Scrabis. Mr. William Binnie served as the BFI liaison. Mr. William Jones was onsite as BFI's gas systems engineer.

Three one-hour samples were collected for the determination of the Ground Flare TNMHC destruction efficiency and NO_x emissions. The average of the three test runs constituted the compliance determination. The test protocol submittal to PADER is contained in Appendix A. For each test run a gas flow measurement was made. The following parameters were determined for this test program:

• Gas Flow	acfm and dscfm
• Gas Temperature	^oF
• Gas Moisture	% by Volume
• Carbon Dioxide	%
• Oxygen	%
• NO_x Emissions	lb/dscf, lb/hr, and ppm
• Inlet TNMHC Loading	lb/ft^3 and lb/hr
• TNMHC Emissions	lb/ft^3 and lb/hr
• TNMHC Destruction Efficiency	%

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3.0 PROCESS

3.1 PROCESS DESCRIPTION

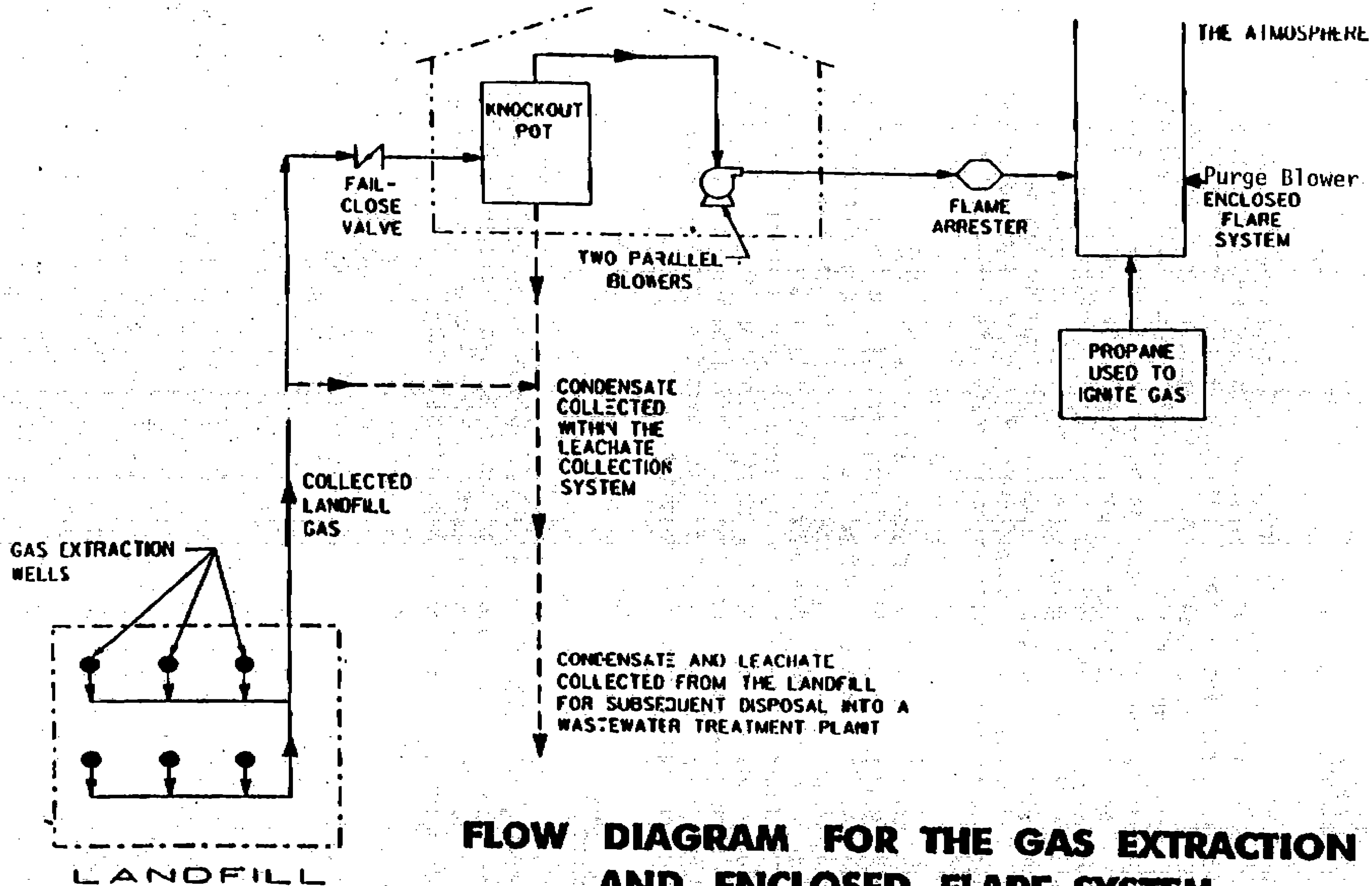
The Greentree Landfill is operated by BFI and is located in Kersey, Elk County, Pennsylvania. The landfill serves as a collection and disposal point for municipal waste and approved residual waste. The decomposing waste encapsulated within the landfill produces a gas, which is primarily composed of methane, carbon dioxide, and trace inerts. The gas is collected via a network system of extraction wells and pipes and routed through a fail-close valve, knock-out pot, one of two blowers, flame arrester, and enclosed flare system for combustion. When the saturated gas is extracted from the landfill, the decrease in pressure and temperature generates condensate throughout the piping system and knock-out pot. The condensate is transferred via gravity into dedicated sumps for subsequent disposal through an onsite wastewater treatment plant (see Figure 1).

Figure 2 details the enclosed flare system, which is 40 feet high. The flare is ignited by first purging the enclosed area with a blower located at the bottom of the flare system. After the flare has been evacuated of landfill gas, a pilot stream of propane at a rate of approximately 22 standard cubic feet per hour is released and ignited by a spark within the burner area. The landfill gas is then released through the tips of the burners which are located at the base of the enclosed flare, and the propane flame is transferred across the surrounding burners by a flame bridge and three flame burners. After the landfill gas is properly ignited, the propane startup stream is shut off.

3.2 PROCESS OPERATION

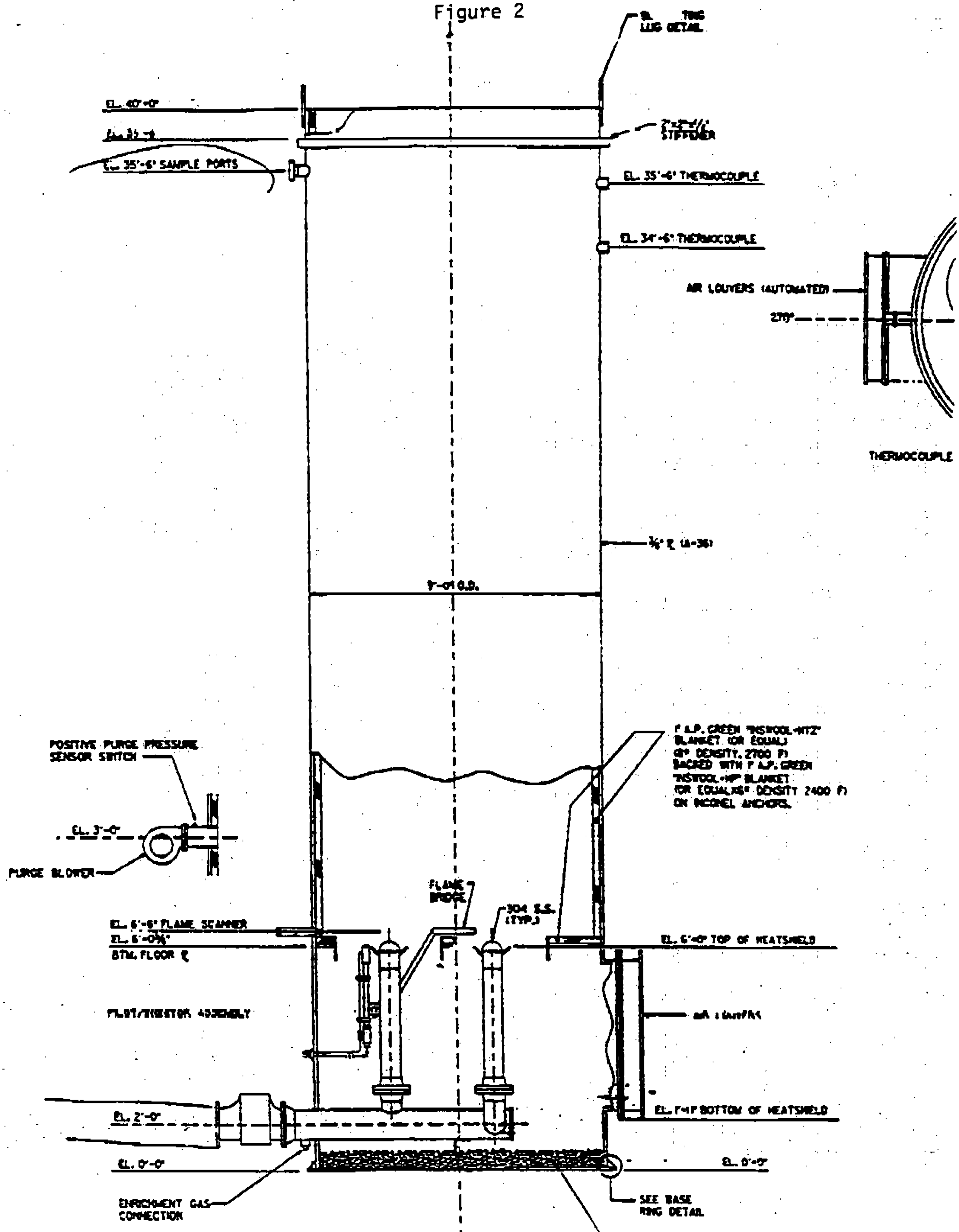
All of the incoming gas collected from the extraction wells was processed through the flare system. The amount of gas collected was approximately 524 standard cubic feet per minute (scfm). The Ground Flare system operating temperature was maintained at approximately 1550°F.

Figure 1



FLOW DIAGRAM FOR THE GAS EXTRACTION AND ENCLOSED FLARE SYSTEM AT THE GREENTREE LANDFILL BROWNING – FERRIS INDUSTRIES OF PENNSYLVANIA, INC.

Figure 2



SIDE ELEVATION

(NOT TRUE ORIENTATION)

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4.0 PROCEDURES

4.1 FIELD WORK

4.1.1 Field Data

All field data sheets are contained in Appendix B.

4.1.2 Testing Station and Traverse Locations

The ground flare stack exhaust is 40 feet above finished ground elevation and is 9 feet in diameter. There are 4 sample ports spaced 90 degrees to center. They are located 3-1/2 feet from the stack outlet and 29 feet downstream from the burners (see Figure 2). Twenty-four traverse points were selected according to EPA Method 1 to sample gas flow across two traverses (12 points per traverse).

The incoming landfill gas is received at the flare via approximately 12-inch pipe and is 2 feet above ground elevation. A 1/2-inch sample port on the pipe is located approximately 20 feet from the flare.

4.1.3 Gas Flow and Gas Temperature Measurements

The flow rate and temperature profiles for the Ground Flare stack gas stream were measured by conducting simultaneous velocity and temperature traverses. Gas velocity head was measured with a calibrated "S"-type pitot tube which was connected to an 0 to 0.25-inch inclined manometer. The static pressure was measured using the same pitot tube and manometer. A chrome-alumel thermocouple attached to a digital readout was used to measure the gas temperature at each of the traverse points. The gas flow and gas temperature measurements follow EPA Method 2.

The Ground Flare stack has existing thermocouples where the exhaust temperature is continuously recorded on a chart. A comparison between the BCM calibrated thermocouple and the BFI thermocouple indicated perfect agreement.

4.1.4 Molecular Weight Determination

A Fisher-Type B, No. 10-605, Orsat analyzer was used to determine the molecular weight of the flue gas for the calculation of gas flow during the sampling. A grab sample was collected during each sample run using EPA Method 3. The average of three analyses was used for the calculation of gas flow for each sample run. The following parameters were measured: volume percent carbon dioxide (CO_2), volume percent oxygen (O_2), and volume percent carbon monoxide (CO). The volume percent of nitrogen (N_2) was determined by difference.

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4.1.5 Determination of Nitrogen Oxides

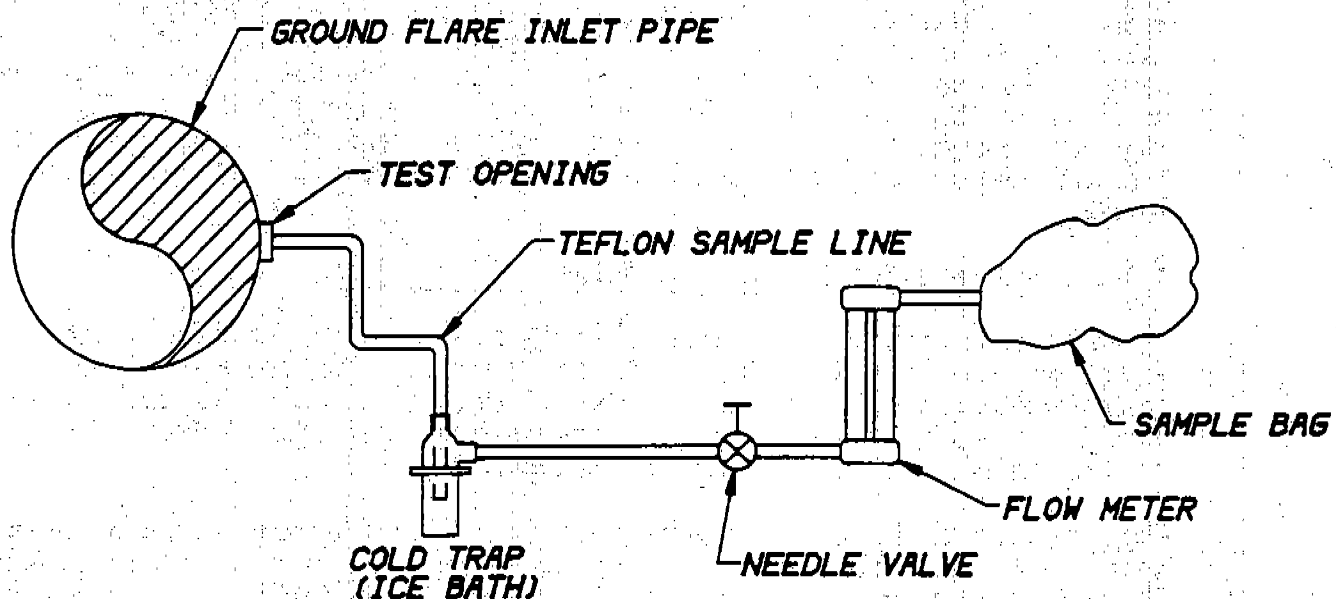
BCM collected three 1-hour samples at the flare outlet for NO_x using EPA Method 7D--Determination of Nitrogen Oxides From Stationary Sources (Alkaline-Permanganate/Ion Chromatographic Method). An integrated gas sample was extracted from the stack in alkaline-potassium permanganate solution: NO_x (NO and NO_2) emissions were oxidized to NO_3, then NO_3 was analyzed by ion chromatography and reported as NO_2 emissions. The average of the three samples collected constituted the emission test for NO_x.

4.1.6 Determination of Total Nonmethane Hydrocarbons

Three 1-hour integrated samples were collected in tedlar sample bags simultaneously at the flare inlet and outlet. The average of the three samples constituted the destruction efficiency test. The tedlar sample bags were analyzed by a photoionization detector for TNMHC. Collected condensate was analyzed by gas chromatography (GC).

The sampling train at the pressurized inlet location consisted of a short teflon tube connected to a 50 ml midget impinger with a shortened stem. The midget impinger was submersed in ice water to collect any condensate. At the completion of the sampling run, the condensate was volumetrically measured and poured into a 40 ml volatile organic analysis (VOA) bottle. The VOA bottle was then filled with distilled water so that no air space remained in the bottle. Another short teflon tube connected the impinger to a rotameter for the measurement of a sampling flow rate. The rotameter outlet was connected by teflon tubing to a 10-liter tedlar bag. The sampling rate was approximately 150 cubic centimeters. Figure 3 is a schematic diagram of the sampling train.

The sampling train at the outlet location was identical to the inlet location, with the exception that a leakless teflon diaphram pump was connected between the rotameter and sample bag to extract a sample at approximately 150 cubic centimeters per minute from the exhaust gas at one point. Figure 4 is a schematic diagram of the sampling train.

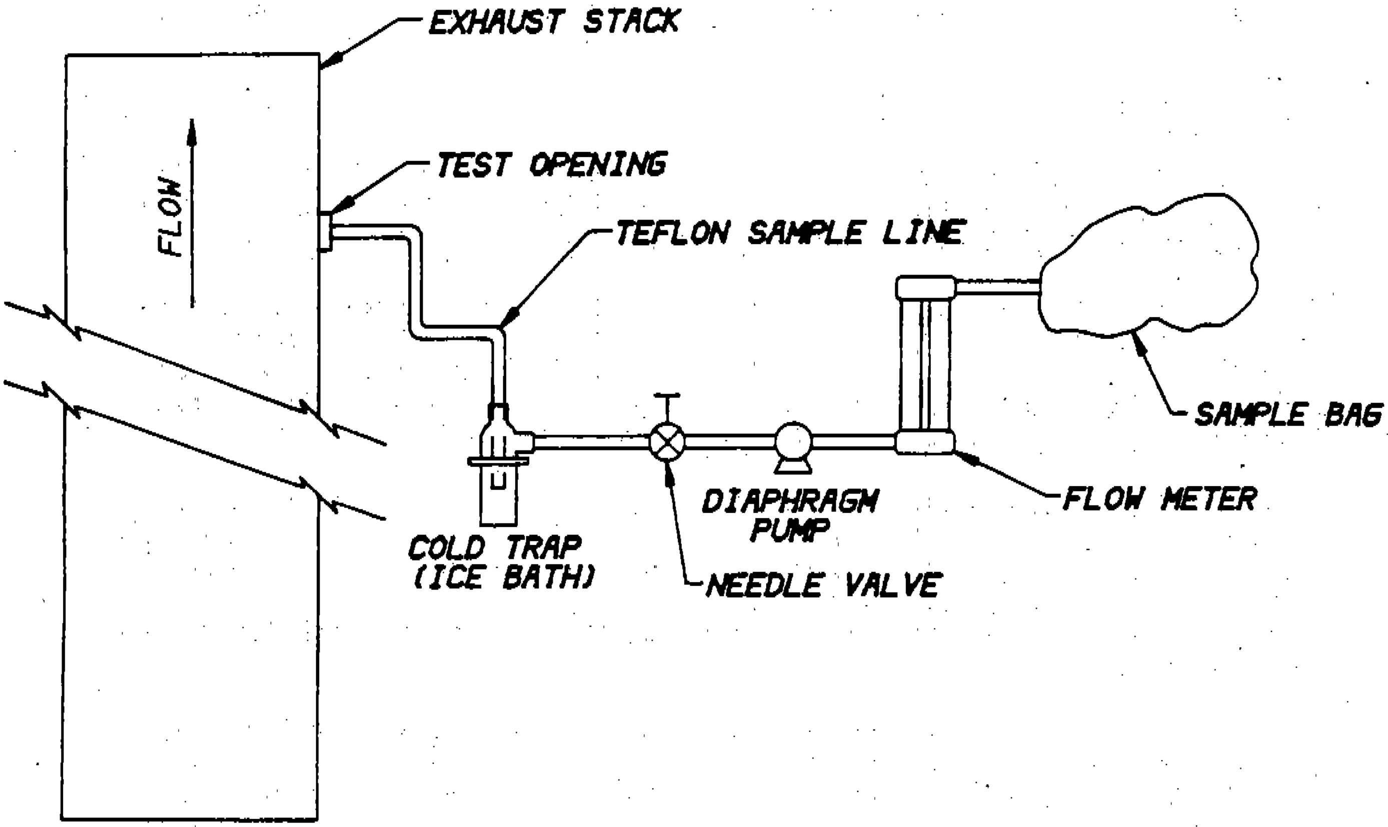


GROUND FLARE INLET SAMPLING TRAIN

PREPARED BY :

BCM Engineers

FIGURE 3



GROUND FLARE STACK SAMPLING TRAIN

PREPARED BY :

BCM Engineers
ENGINEERS, PLANNERS and SCIENTISTS
5777 Baum Blvd. Pittsburgh, PA 15206
One Plymouth Meeting Plymouth Meeting, PA 19462

FIGURE 4

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4.1.7 Sample Recovery

The sample recoveries were conducted in the BCM air van at the test site.

4.2 ANALYSIS

All sample analyses were conducted by Air Quality Services, Inc., 4527 Clairton Boulevard, Pittsburgh, Pennsylvania 15236, (412) 881-5630. The analytical report is presented in Appendix C.

The gas collected in the tedlar bags was analyzed for TNMHC with a direct reading photoionization detector. The instrument used was a Model 580 Organic Vapor Monitor manufactured by Analytical Instrument Development Company. This manufacturer is now part of Thermal Environmental Instruments, Inc., 8 West Forge Parkway, Franklin, MA 02038.

The photoionization detector uses a high energy ultra violet radiation source to ionize a portion of the sample which is introduced into the ionization chamber of the instrument. The ionization current formed is measured with the electrometer of the instrument. The current is displayed as the concentration of the sample as parts per million of the calibration gas.

The photoionization detector does not respond to oxygen, water, carbon dioxide, methane, carbon monoxide and nitrogen. The response then is total TNMHC expressed as hexane since hexane was used as the calibration gas.

The instrument was calibrated by injecting a known quantity of hexane vapor into a gas collection bag. Using a calibrated pump, the hexane vapor was diluted with air. Three concentrations of hexane vapor were prepared. The instrument was linear to 500 ppm, the maximum concentration of calibration gas prepared.

Each sample bag was attached to the inlet of the instrument and the sample pumped through the instrument until a steady reading was obtained. The gas bag was removed and the instrument allowed to return to zero before sampling the next bag. The limit of detection was 0.28 ppm.

The condensate samples were analyzed for TNMHC by GC using a SRI Model 8610 GC equipped with a flame ionization detector (FID). The entire sample, recovered in a 40 ml VOA bottle, was extracted with methylene chloride and diluted to 25 ml with methylene chloride.

The gas chromatograph was calibrated using known quantities of hexane diluted with methylene chloride. The GC was operated at a temperature program of 50°C for 5 minutes and a ramp of 8 degrees per minute to 75°C. This temperature was held for 5 minutes then ramped to 200°C at 10 degrees per minute. The limit of detection was 0.001 mg for the 25 ml extract.

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4.3 CALCULATIONS

The calculations for nitrogen oxide emissions, Ground Flare outlet gas flow and moisture content were calculated by a Lotus 123 spreadsheet format, which uses the equations referenced in EPA Methods 2, 3, 4, and 7D. The calculations for determining TNMHC concentrations and emission rates were completed by calculator. All calculations are presented in Appendix D.

4.4 CALIBRATIONS

Documentation of the following field equipment calibrations are contained in Appendix E:

- Thermocouples
- Dry Gas Meter
- Pitot Tube

4.5 PROCESS DATA

The Ground Flare exhaust temperature (°F) and the inlet gas flow (scfm) were recorded continuously with existing instrumentation and copies of the recording charts can be found in Appendix F.

5.0 SUMMARY OF RESULTS

5.1 NITROGEN OXIDE EMISSIONS

Table 5.1 presents a summary of the nitrogen oxide emissions. The emissions ranged from 2.20 lb/hr as NO_2 to 3.44 lb/hr as NO_2. The average emission rate was 2.69 lb/hr as NO_2.

TABLE 5.1
BFI GREENTREE LANDFILL
GROUND FLARE
NITROGEN OXIDE EMISSIONS

Emission Rate/Concentration	Run No. 1	Run No. 2	Run No. 3	Average
ppm	49	44	69	54
lb/dscf	5.88×10^{-6}	5.29×10^{-6}	8.26×10^{-6}	6.48×10^{-6}
lb/hr	2.44	2.20	3.44	2.69

5.2 TOTAL NONMETHANE HYDROCARBON DESTRUCTION EFFICIENCY

Table 5.2.1 presents a summary of the TNMHC Ground Flare inlet loading reported as hexane. The loading of TNMHC ranged from 0.2353 lb/hr to 0.4766 lb/hr. The average inlet loading was 0.3926 lb/hr.

TABLE 5.2.1
BFI GREENTREE LANDFILL
GROUND FLARE
INLET TNMHC LOADING

Run No.	Gas Phase (lb/ft^3)	Gas Phase (lb/hr)	Condensate Phase (lb/ft^3)	Condensate Phase (lb/hr)	Total (lb/ft^3)	Total (lb/hr)
1	8.811×10^{-6}	0.1851	1.387×10^{-5}	0.2915	2.268×10^{-5}	0.4766
2	8.811×10^{-6}	0.1866	1.318×10^{-5}	0.2792	2.199×10^{-5}	0.4658
3	8.347×10^{-6}	0.1766	2.775×10^{-6}	0.0587	1.112×10^{-5}	0.2353
Average	8.656×10^{-6}	0.1828	2.982×10^{-5}	0.2098	1.860×10^{-5}	0.3926

Table 5.2.2 presents a summary of the TNMHC Ground Flare exhaust emissions based on using one-half of the analytical detection limit. All analytical results were nondetectable for the Ground Flare exhaust. The average emission rate reported as hexane and using one-half of the analytical detection limit was 0.0156 lb/hr for the three sample runs.

TABLE 5.2.2
BFI GREENTREE LANDFILL
GROUND FLARE
EXHAUST TNMHC EMISSION RATE

Run No.	Gas Phase (lb/ft^3)	Gas Phase (lb/hr)	Condensate Phase (lb/ft^3)	Condensate Phase (lb/hr)	Total (lb/ft^3)	Total (lb/hr)
1	3.417×10^{-8}	0.0142	3.469×10^{-9}	0.0014	3.764×10^{-8}	0.0156
2	3.417×10^{-8}	0.0142	3.469×10^{-9}	0.0014	3.764×10^{-8}	0.0156
3	3.417×10^{-8}	0.0142	3.469×10^{-6}	0.0014	3.764×10^{-8}	0.0156
Average	3.417×10^{-8}	0.0142	3.469×10^{-9}	0.0014	3.764×10^{-8}	0.0156

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Table 5.2.3 presents a summary of the Ground Flare destruction efficiency for TNMHC. Based on using one-half of the analytical detection limit, the average TNMHC destruction efficiency was 95.6 percent. Based on concentration and using one-half of the analytical detection limit, the destruction efficiency was greater than 99.8 percent. Assuming a TNMHC emission rate of zero, the destruction efficiency was 100 percent.

TABLE 5.2.3
BFI GREENTREE LANDFILL
GROUND FLARE
TNMHC DESTRUCTION EFFICIENCY

Run No.	1/2 Detection Limit (based on emission rate)	1/2 Detection Limit (based on concentration)	Zero Emissions
1	96.7%	>99.8%	100.0%
2	96.6%	>99.8%	100.0%
3	93.4%	>99.7%	100.0%
Average	95.6%	>99.8%	100.0%

5.3 GAS FLOW DATA

Tables 5.3.1 and 5.3.2 present a summary of the Ground Flare inlet and outlet gas flow data collected during the sampling program. The data includes gas flow, temperature, oxygen, and carbon dioxide measurement results.

TABLE 5.3.1
BFI GREENTREE LANDFILL
GROUND FLARE
INLET GAS FLOW DATA

Parameter	Unit	Run No. 1	Run No. 2	Run No. 3	Average
Gas Flow	SCFM	520	528	524	524
Gas Flow	DSCFM	350	353	353	352
Temperature	°F	163	164	163	163
Moisture	%	32.7	33.1	32.7	32.8
Oxygen	%	1.1	1.3	3.1	1.8
Carbon Dioxide	%	36.6	35.8	30.6	34.3

CAL ≅ 31.1%

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TABLE 5.3.2
BFI GREENTREE LANDFILL
GROUND FLARE
OUTLET GAS FLOW DATA

Parameter	Unit	Run No. 1	Run No. 2	Run No. 3	Average
Gas Flow	ACFM	30,558	30,640	30,586	30,595
Gas Flow	DSCFM	6,907	6,920	6,937	6,921
Temperature	°F	1,548	1,555	1,549	1,551
Moisture	%	9.1	8.8	8.7	9.1
Oxygen	%	12.27	12.80	12.57	12.55
Carbon Dioxide	%	6.93	6.30	6.37	6.53

APPENDIX A

TEST PROTOCOL

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BCM Eastern Inc.
Pittsburgh

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COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
Post Office Box 2357
Harrisburg, Pennsylvania 17105-2357

April 28, 1992

717-772-2304

Bureau of Air Quality Control

Mr. Paul Jadlowiec
Section Manager
BCM Engineers, Inc.
5777 Baum Boulevard
Pittsburgh, PA 15206-3745

Dear Mr. Jadlowiec:

The test protocol submitted for the Browning-Ferris Industries' Greentree Landfill enclosed flare system for determining outlet NO_X emission rates and destruction efficiency of TNMHC is acceptable to the Department.

Final acceptance of the test report will be contingent upon fulfilling all applicable sections of Chapter 139 of the Department of Environmental Resources' Rules and Regulations and the Source Testing Manual.

Should you have any questions with regards to this matter, please feel free to contact me.

Sincerely,

Richard St. Louis, Chief
Source Testing Unit
Division of Technical Services and Monitoring

1X

BCM Engineers Inc.

BCM Engineers Inc.
Engineers, Planners, Scientists and Laboratory Services
5777 Baum Boulevard • Pittsburgh, PA 15206-3745 • (412) 361-6000 • FAX (412) 361-6243

April 3, 1992

Mr. Richard St. Louis, Chief
Pennsylvania Department of
Environmental Resources
Stack Testing Unit
Division of Technical Services
and Monitoring
Bureau of Air Quality Control
P.O. Box 2357
Harrisburg, PA 17105-2357

Subject: Landfill Gas Collection System Flare
BFI Greentree Landfill, Elk County, PA
Emission Evaluation
Pretest Procedural Submittal Revision
BCM No. 00-7335-01

Dear Mr. St. Louis:

On April 2, 1992, BCM Engineers Inc. (BCM) visited the Browning-Ferris Industries Greentree Landfill and inspected the sampling locations for the flare stack compliance test program. Based on the inspection, please note the following revisions to the Pretest Procedural Submittal related to the exhaust stack dimensions and gas flow sampling procedure:

1.3 EXHAUST STACK

The stack exhaust is 40 feet aboveground elevation and 9 feet in diameter. There are 4 sample ports spaced 90 degrees to center. They are located 3-1/2 feet from the stack outlet and 29 feet downstream from the burners (see Figure 2).

The incoming landfill gas is received by the flare by an approximately 12-inch pipe and is 2 feet aboveground elevation. A sample port on the pipe is located approximately 20 feet from the flare. The gas is under pressure, and the gas temperature and flow are measured electronically near the sample port.

2.3 GAS FLOWS

A temperature and velocity traverse will be conducted for each sampling run at the outlet location. Twenty-four sampling points will be selected according to EPA Method 2, twelve points across two 90-degree to center traverses. Carbon dioxide and oxygen will be measured for molecular weight determination using a Fyrite analyzer. EPA Method 4 will be used to determine the moisture content of the gas stream. The inlet gas flow will be determined by an existing flow meter.

If you have any questions, please do not hesitate to call.

Very truly yours,

Paul A. Jadlowiec

Paul A. Jadlowiec
Section Manager

PAJ/rh

cc: Mr. Larry Wonders, PADER
Ms. Kathy L. Fain, BFI
Mr. William Binnie, BFI

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PRETEST PROCEDURAL SUBMITTAL

TO

BROWNING-FERRIS INDUSTRIES
GREENTREE LANDFILL
FOX TOWNSHIP, ELK COUNTY, PENNSYLVANIA

FOR

LANDFILL GAS COLLECTION SYSTEM
EMISSION EVALUATION

BCM NO. 00-7335-01

PREPARED BY

PAUL JADLOWIEC
SECTION MANAGER

APPROVED BY

DAVID G. NICHOLS, P.E.
VICE PRESIDENT

BCM ENGINEERS INC.
5777 BAUM BOULEVARD
PITTSBURGH, PENNSYLVANIA 15206

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CONTENTS

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1.0 PROCESS

1.1 PROCESS DESCRIPTION

Greentree Landfill is operated by Browning-Ferris Industries, Inc. (BFI) and located in Kersey, Elk County, Pennsylvania. The landfill serves as a collection and disposal point for municipal waste and approved residual waste. The decomposing waste encapsulated within the landfill produces a gas, which is primarily composed of methane, carbon dioxide, and trace inerts. The gas is collected via a network system of extraction wells and pipes and routed through a fail-close valve, knock-out pot, one of two blowers, flame arrester, and enclosed flare system for combustion. When the saturated gas is extracted from the landfill, the decrease in pressure and temperature generates condensate throughout the piping system and knock-out pot. The condensate is transferred via gravity into dedicated sumps for subsequent disposal through an onsite wastewater treatment plant (see Figure 1).

Figure 2 details the enclosed flare system, which is 40 feet high. The flare is ignited by first purging the enclosed area with a blower located at the bottom of the flare system. After the flare has been evacuated of landfill gas, a pilot stream of propane at a rate of approximately 22 standard cubic feet per hour is released and ignited by a spark within the burner area. The landfill gas is then released through the tips of the burners which are located at the base of the enclosed flare, and the propane flame is transferred across the surrounding burners by a flame bridge and three flame burners. After the landfill gas is properly ignited, the propane startup stream is shut off.

1.2 PROCESS OPERATION

All of the incoming gas collected from the extraction wells will be processed through the flare system. The amount of gas currently being collected is approximately 500 actual cubic feet per minute. The system operating temperatures will be maintained at the conditions specified in Plan Approval No. 24-322-001 and a letter from Mr. Devandro Verna, dated March 6, 1992. Copies of chart recording indicating operating parameters such as temperature points and gas flows will be included in the test report.

1.3 EXHAUST STACK

The stack exhaust is 40 feet above ground elevation, and the rectangular-shaped stack is 9 feet by 40 feet in its outside dimensions. There are 4 evenly spaced sample ports located 3 1/2 feet from the stack outlet and 29 feet downstream from the burners (see Figure 2).

The incoming landfill gas is received by the flare by an approximately 12-inch pipe and is 2 feet above ground elevation. A sample port on the pipe is located a few feet from the flare. The gas is under pressure, and the gas temperature and flow are measured electronically near the sample port.

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2.0 SAMPLING PROCEDURES

2.1 NITROGEN OXIDES

BCM will collect three 1-hour samples at the flare outlet for nitrogen oxides (NO_x) using EPA Method 7D--Determination of Nitrogen Oxides From Stationary Sources (Alkaline-Permanganate/Ion Chromatographic Method). An integrated gas sample is extracted from the stack in alkaline-potassium permanganate solution: NO_x (NO and NO_2) emissions are oxidized to NO_3, then NO_3 is analyzed by ion chromatography and reported as NO_2 emissions. The three samples collected will constitute the emission test for NO_x.

2.2 TOTAL NONMETHANE HYDROCARBONS

BCM will use the principles of EPA Method 18-Measurement of Gaseous Organic Compound Emissions By Gas Chromatography to measure the emission concentration of total nonmethane hydrocarbons (TNMHC). Three 1-hour integrated samples will be collected in tedlar sample bags simultaneously at the flare inlet and outlet. The tedlar sample bags will be analyzed by gas chromatography for methane and all other nonmethane hydrocarbons. Any collected condensate will also be analyzed. From the chromatograms generated during the analysis, the total peak area for methane will be subtracted from all nonmethane hydrocarbon peak areas. The TNMHC concentration of each sample will then be quantified as hexane, utilizing calibration curves prepared from standard injections. The analytical data will be generated from one injection per sample bag and condensate sample. The purpose of the TNMHC sampling will be to demonstrate 98 percent destruction of TNMHC.

EPA Method 25--Determination of Total Gaseous Nonmethane Organic Emissions as carbon is not an appropriate method for this sampling application and was, therefore, not selected. Carbon dioxide (CO_2) and water vapor present together can produce a positive bias in the sample. The inlet gas stream to the flare can contain 50 percent CO_2 and the gas can be saturated with water vapor, causing a significant positive bias. In an effort to be consistent in a sampling approach at both the inlet and outlet locations, an alternative method was developed using EPA Method 18 sampling and analytical principles as outlined above.

The sampling train at the pressurized inlet location will consist of a short teflon tube to a 50 ml midget impinger with a shortened stem. The midget impinger will be submersed in ice water to collect any condensate. At the completion of the sampling run, the condensate will be volumetrically measured and poured into a 40 ml VOA bottle. The bottle will then be filled with distilled water so that no air space remains in the bottle. Another short teflon tube will connect the impinger to a rotameter for the measurement of a sampling flow rate. The rotameter outlet will be connected by teflon tubing to a 20-liter tedlar bag. The sampling rate will be approximately 0.3 liters per minute.

The sampling train at the outlet location will be identical to the inlet location, with the exception that a leakless pump will be connected between the rotometer and sample bag to extract a sample from the exhaust gas at one point.

Where applicable, sample lines will be heated to prevent condensation before the impinger knock-out trap. It may be necessary to use a water-cooled probe at the outlet location because of the expected 1800°F exhaust temperature.

2.3 GAS FLOWS

A temperature velocity traverse will be conducted for each sampling run at the outlet location. Four sample points will be selected at each sample port for a total of 16 velocity traverse points. This will constitute a 4 x 4 sampling matrix. Carbon dioxide and oxygen will be measured for molecular weight determination using a Fyrite analyzer. EPA Method 4 will be used to determine the moisture content of the gas stream. The inlet gas flow will be determined by an existing flow meter.

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3.0 LABORATORY ANALYSIS

3.1 NITROGEN OXIDES

The samples collected will be submitted to Air Quality Services, Pittsburgh, Pennsylvania. The analytical method will be according to EPA Method 7D procedures.

3.2 NONMETHANE HYDROCARBONS

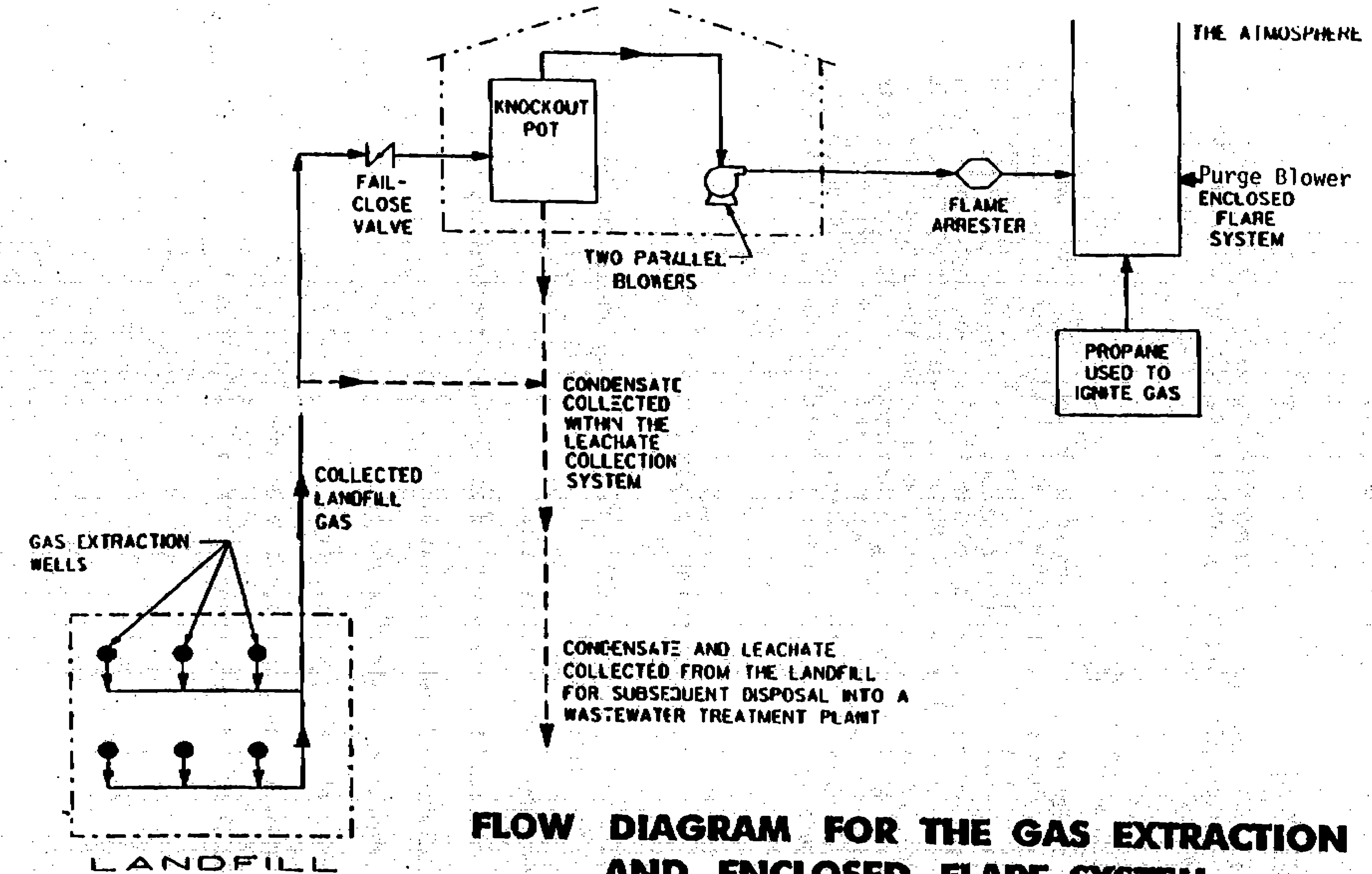
The samples collected will be submitted to Atlantic Analytical Laboratory, Whitehouse, New Jersey. A laboratory setting will allow for additional analytical safeguards and capabilities not possible in field analysis. Analysis will be performed within 48 hours after sample collection. A single analysis will be conducted on each sample. The bags samples will be heated prior to analysis, which will reduce the potential for organic losses in the tedlar bags. Standards, as well as the syringe used for injections, will also be heated. A gas chromatographic (GC) equipped with a flame ionization detector will be utilized for the analysis. The condensate analysis will be made by direct liquid injection into the GC. The sum of both analyses will provide the total nonmethane hydrocarbon content.

4.0 DATA EVALUATION AND REPORT

BCM personnel will review the testing data and incorporate the following information into a final report:

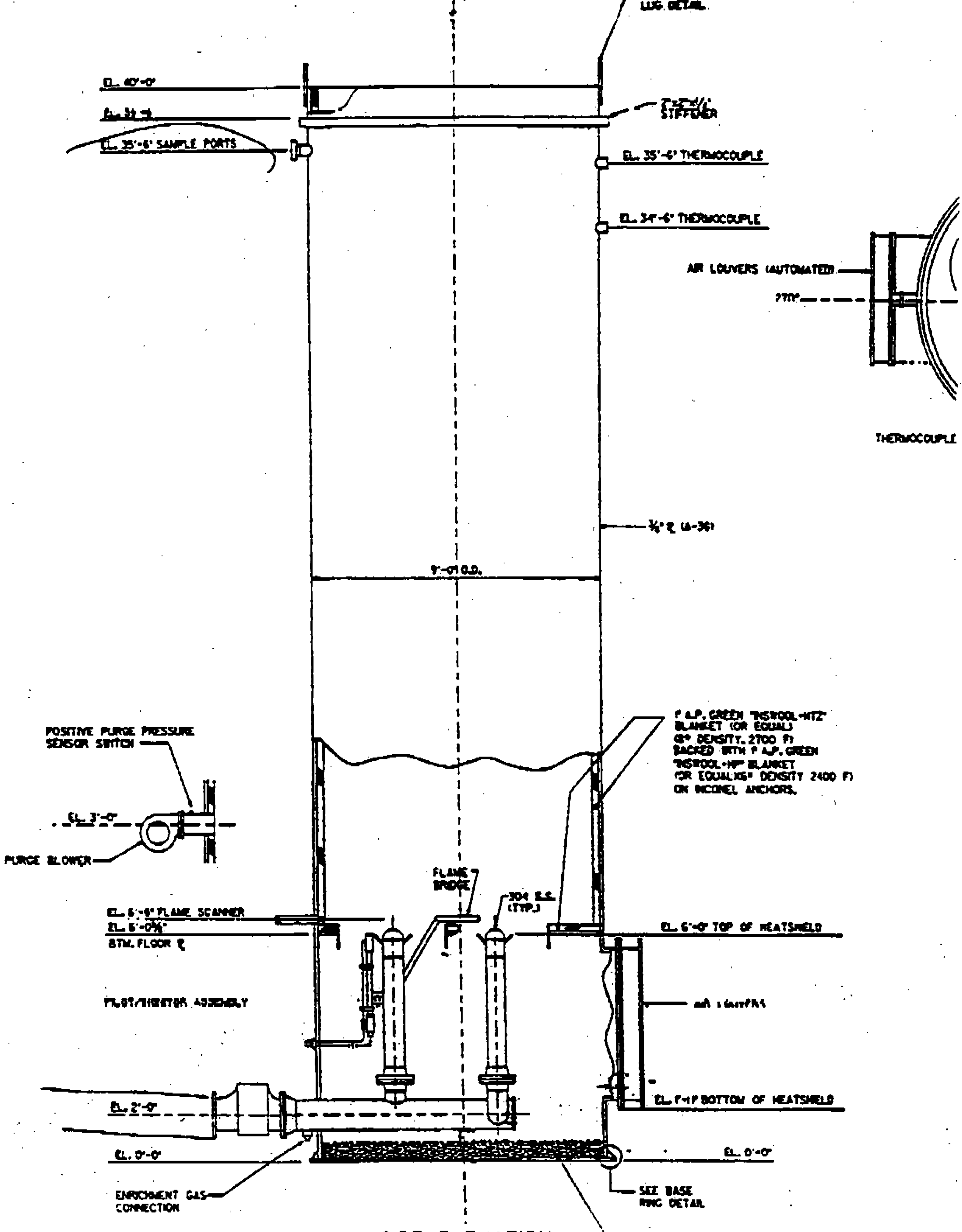
- Description of work undertaken;
- Discussion of the sampling and analytical techniques employed;
- Tabulation of field and laboratory data.
- Copies of all field data sheets;
- Copies of analytical results;
- Copies of pentinent process data; and
- Copies of field equipment calibration data.

Figure 1



FLOW DIAGRAM FOR THE GAS EXTRACTION AND ENCLOSED FLARE SYSTEM AT THE GREENTREE LANDFILL BROWNING – FERRIS INDUSTRIES OF PENNSYLVANIA, INC.

Figure 2



SIDE ELEVATION

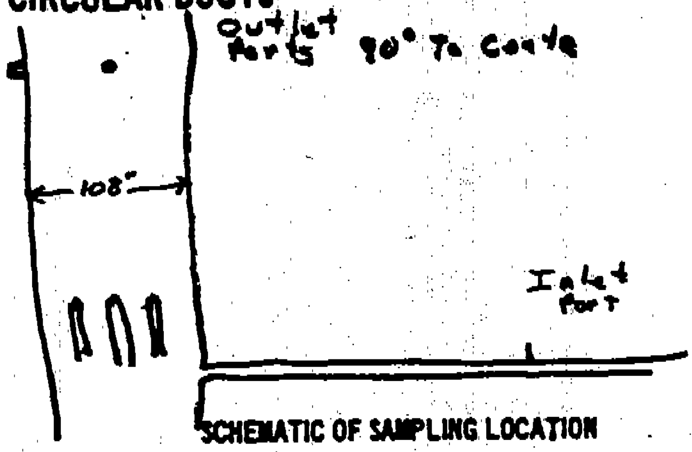
(NOT TRUE ORIENTATION)

APPENDIX B

FIELD DATA SHEETS

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

PLANT BFI - Greentree Landfill
DATE 4-22-92
SAMPLING LOCATION Flare Stack
INSIDE OF FAR WALL TO OUTSIDE OF NIPPLE, (DISTANCE A) 14.5
INSIDE OF NEAR WALL TO OUTSIDE OF NIPPLE, (DISTANCE B) 6.5
STACK I.D., (DISTANCE A - DISTANCE B) 108"
NEAREST UPSTREAM DISTURBANCE ~2.7'
NEAREST DOWNSTREAM DISTURBANCE ~293'
CALCULATOR Paul Jadlowiec



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	.021	108"	2.3	6.5	8.5
2	.067	↓	7.2	↓	13.7
3	.118		12.7		19.2
4	.177		19.1		25.6
5	.250		27.0		33.5
6	.356		38.4		44.9
7	.644		69.6		76.1
8	.750		81.0		87.5
9	.823		88.9		95.4
10	.882		95.2		101.7
11	.933		100.8		107.3
12	.979		105.7		112.2

EPA METHOD 2
VELOCITY TRAVERSE DATA

PLANT BFI Greentree landfill
LOCATION Flare Stack
DATE 4-23-92 RUN NO. 1
STACK INNER DIAMETER, m (in.) 108
BAROMETRIC PRESSURE, mm Hg (in. Hg) 28.30
CROSS SECTIONAL AREA, m^2 (ft^2) 63.617
OPERATORS PJ + JF
PITOT TUBE I.D. NO. 12 FT
AVG. COEFFICIENT, Cp = 0.84
LAST DATE CALIBRATED 4-22-92

SCHEMATIC OF STACK CROSS SECTION

ecked BCM
hermocouple
gainst BFI
hermocouple:
: 1548°F
FI: 1548°F

emp of
inlet
gas -
163°F

TRAVERSE PT. No.	VEL. Hd. Δp mm (in.) H_2O	STACK TEMPERATURE t_s °C (°F)	T_s, °K (°R)	P_g mm Hg (in. Hg) -.08" H_2O	$\sqrt{\Delta p}$
LT 1	.005	1548		28.30	
2	.005	1548			
3	.005	1548			
4	.005	1548			
5	.005	1549			
6	.005	1549			
7	.005	1549			
8	.005	1549			
9	.005	1550			
10	.005	1550			
11	.005	1550			
12	.005	1550			
Rt 1	.005	1550			
2	.005	1550			
3	.005	1550			
4	.005	1550			
5	.005	1548			
6	.005	1548			
7	.005	1548			
8	.005	1548			
9	.005	1546			
10	.005	1546			
11	.005	1546			
12	.005	1546			
		AVERAGE [illegible]			0.0707

EPA METHOD 2
VELOCITY TRAVERSE DATA

PLANT BFI Greentree
LOCATION Flare Stack
DATE 1-23-92 RUN NO. 2
STACK INNER DIAMETER, m (in.) 10'
BAROMETRIC PRESSURE, mm Hg (in. Hg) 28.28
CROSS SECTIONAL AREA, m^2 (ft^2) 53.617
OPERATORS PJ + JP
PITOT TUBE I.D. NO. 12'
AVG. COEFFICIENT, Cp = 0.84
LAST DATE CALIBRATED 4-22-92

SCHEMATIC OF STACK CROSS SECTION

Inlet Temperature: 164° F

TRAVERSE PT. No.	VEL. Hd. Δp mm (in.) H_2O	STACK TEMPERATURE t_s °C (°F)	STACK TEMPERATURE T_s, °K (°R)	P_g mm Hg (in. Hg)	$\sqrt{\Delta p}$
LT 1	.005	1556		28.28	
2	.005	1556			
3	.005	1556			
4	.005	1556			
5	.005	1556			
6	.005	1556			
7	.005	1555			
8	.005	1553			
9	.005	1555			
10	.005	1554			
11	.005	1554			
12	.005	1554			
Rt 1	.005	1554			
2	.005	1554			
3	.005	1554			
4	.005	1554			
5	.005	1554			
6	.005	1555			
7	.005	1555			
8	.005	1556			
9	.005	1556			
10	.005	1557			
11	.005	1557			
12	.005	1557			
		AVERAGE 1555			[illegible]

EPA METHOD 2
VELOCITY TRAVERSE DATA

PLANT BFI Green Tree
LOCATION Flare Stack
DATE 4-23-92 RUN NO. 3
STACK INNER DIAMETER, m (in.) 108
BAROMETRIC PRESSURE, mm Hg (in. Hg) 28.28
CROSS SECTIONAL AREA, m^2 (ft^2) 63.617
OPERATORS PJ + JP
PITOT TUBE I.D. NO. 12'
AVG. COEFFICIENT, Cp = 0.84
LAST DATE CALIBRATED 4-22-92

SCHEMATIC OF STACK CROSS SECTION

Inlet Temperature 163°F

TRAVERSE PT. No.	VEL. Hd. Δp mm (in.) H_2O	STACK TEMPERATURE t_s °C (°F)	T_s, °K (°R)	P_g mm Hg (in. Hg)	$\sqrt{\Delta p}$
Rt 1	~~1549~~ .005	1549		28.28	
2	.005	1549			
3	.005	1549			
4	.005	1549			
5	.005	1550			
6	.005	1550			
7	.005	1550			
8	.005	1550			
9	.005	1551			
10	.005	1551			
11	.005	1551			
12	.005 ~~1551~~	1551			
Lt 1	.005	1548			
2	.005	1548			
3	.005	1548			
4	.005	1548			
5	.005	1548			
6	.005	1548			
7	.005	1548			
8	.005	1548			
9	.005	1548			
10	.005	1548			
11	.005	1548			
12	.005	1548			
		AVERAGE			[illegible]

ORSAT ANALYSIS DATA SHEET

CLIENT: BFI Greentree

SAMPLING LOCATION: Flare Stack Inlet

RUN NO.: 1

DATE: 4-23-92

TIME: 1453

ANALYST: Paul Jadlowiec

GAS \ RUN	1		2		3		AVERAGE NET VOLUME
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET	
CO_2	36.8	36.8	36.2	36.2	36.6	36.6	36.53
O_2 (Net is Actual O_2 Reading Minus Actual CO_2 Reading)	38.0	1.2	37.2	1.0	37.6	1.0	1.07
CO (Net is Actual CO Reading Minus Actual O_2 Reading)	38.0	0.0	37.2	0.0	37.6	0.0	0.00
N_2 (Net is 100 Minus Actual CO Reading)							

ORSAT ANALYSIS DATA SHEET

CLIENT: BFI Greentree

SAMPLING LOCATION: Flare Inlet

RUN NO.: Run 2

DATE: 4-23-92

TIME: 1552

ANALYST: Paul Jadlowiec

GAS \ RUN	1		2		3		AVERAGE NET VOLUME
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET	
CO_2	35.8	35.8	36.6	36.6	35.8	35.8	36.13
O_2 (Net is Actual O_2 Reading Minus Actual CO_2 Reading)	37.4	1.6	37.8	1.2	37.0	1.2	1.33
CO (Net is Actual CO Reading Minus Actual O_2 Reading)	37.4	0.0	37.8	0.0	37.0 ~~0.0~~	0.0	0.00
N_2 (Net is 100 Minus Actual CO Reading)							

ORSAT ANALYSIS DATA SHEET

CLIENT: BFI Greentree

SAMPLING LOCATION: ~~Flow~~ Flare Inlet

RUN NO.: 3

DATE: 4-23-92

TIME: 1656

ANALYST: Paul Jadlowiec

GAS \ RUN	1		2		3		AVERAGE NET VOLUME
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET	
CO_2	32.6	32.6	31.0	31.0	30.6	30.6	31.40
O_2 (Net is Actual O_2 Reading Minus Actual CO_2 Reading)	35.8	3.2	33.6	2.6	34.2	3.6	3.13
CO (Net is Actual CO Reading Minus Actual O_2 Reading)	35.8	0.0	33.6	0.0	34.2	0.0	0.0
N_2 (Net is 100 Minus Actual CO Reading)							

ORSAT ANALYSIS DATA SHEET

CLIENT: BFI - Greentree Landfill

SAMPLING LOCATION: Flare Outlet

RUN NO.: 1

DATE: 4-23-92

TIME: 1230

ANALYST: Paul Jadlowiec

GAS \ RUN	1		2		3		AVERAGE NET VOLUME
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET	
CO_2	7.0	7.0	7.0	7.0	6.8	6.8	6.93
O_2 (Net is Actual O_2 Reading Minus Actual CO_2 Reading)	19.2	12.2 ~~19.2~~	19.2 ~~12.2~~	12.2	19.2	12.4	12.27
CO (Net is Actual CO Reading Minus Actual O_2 Reading)	19.2	0.0	19.2	0.0	19.2	0.0	0.0
N_2 (Net is 100 Minus Actual CO Reading)		80.80		80.80		80.80	80.80

ORSAT ANALYSIS DATA SHEET

CLIENT: BFI - Greentree Landfill

SAMPLING LOCATION: Flare Stack Outlet

RUN NO.: 2

DATE: 4-23-92

TIME: 1420

ANALYST: Paul Jadlowiec

RUN / GAS	1		2		3		AVERAGE NET VOLUME
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET	
CO_2	6.5	6.5	6.2	6.2	6.2	6.2	6.30
O_2 (Net is Actual O_2 Reading Minus Actual CO_2 Reading)	19.3	12.8	19.0	12.8	19.0	12.8	12.80
CO (Net is Actual CO Reading Minus Actual O_2 Reading)	19.3	0.0	19.0	0.0	19.0	0.0	0.0
N_2 (Net is 100 Minus Actual CO Reading)	80.7		81.0		81.0		80.9

ORSAT ANALYSIS DATA SHEET

CLIENT: BFI Greentree

SAMPLING LOCATION: ~~4-23-92~~ R Flare ~~Inlet~~ Outlet

RUN NO.: 3

DATE: 4-23-92

TIME: 1616

ANALYST: Paul Jadlowiec

GAS \ RUN	1		2		3		AVERAGE NET VOLUME
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET	
CO_2	6.2	6.2	6.4	6.4	6.5	6.5	6.37
O_2 (Net is Actual O_2 Reading Minus Actual CO_2 Reading)	19.0	12.8	19.2	12.8	18.6	12.1	12.57
CO (Net is Actual CO Reading Minus Actual O_2 Reading)	19.0	0.0	19.2	0.0	18.6	0.0	0.0
N_2 (Net is 100 Minus Actual CO Reading)		80.8		80.8		81.4	81.06

PLANT: BFI Greentree
DATE: 1-23-92
OPERATOR:
SAMPLING LOCATION: Flare Stack Outlet

BCM

METER ~~BOX~~ NUMBER DGM # 673569 $\Delta H_@$ ______ γ = 1.997
SAMPLE BOX NUMBER(S) ______
PROBE NUMBER ______ TYPE ______

METHOD 7D FIELD DATA SHEET

Smoke - Flare ~956

Run No 1

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m_{out}}$), °F	PUMP VACUUM, in. Hg	IMPINGER TEMPERATURE, °F
	0	0934	34.293					
	10	0944	34.364					
	20	0954	34.788			70	1	54
	30	1004	34.864			70	1	54
	40	1014	35.003			62	1	55
	50	1024	35.132			67	1	57
	60	1034	35.249			68	1	59
						69	1	61
			.956			64.3		

CO_2 ______
O_2 ______
CO ______
P_b 29.30

Run No. 2

	0	1151	35.584					
	10	1201	35.693			68	1	54
	20	1211	35.847			69	1	55
	30	1221	35.970			67	1	56
	40	1231	36.031			66	1	57
	50	1241	36.192			68	1	58
	60	1251	36.404			70	1	60
			.820			68.0		

CO_2 ______
O_2 ______
CO ______
P_b 29.28

Run No. 3

	0	1402	36.678					
	10	1412	36.875			75	1	55
	20	1422	37.057			75	1	56
	30	1432	37.205			76	1	54
	40	1442	37.337			76	1	54
	50	1452	37.470			78	1	55
	60	1502	37.599			76		
			.921			76.0		

CO_2 ______
O_2 ______
CO ______
P_b 29.28

PLANT: BFI Greentree

DATE: 4-23-92 OPERATOR: P. Jadlowiec

SAMPLING LOCATION: Flare Stack Outlet

BCM

METER BOX NUMBER: 582-128 $\Delta H_@$ 1.889 γ = 1.009

SAMPLE BOX NUMBER(S): —

PROBE NUMBER: 3 Ft TYPE: S.S

METHOD ~~5~~ 4 FIELD DATA SHEET

Run 1

Pre Leak Check 0.001 CFM at 15''Hg
Post Leak Check 0.001 CFM at 23''Hg

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	~~STACK TEMPERATURE (T_s), °F~~ ΔH	DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m_{out}}$), °F	PUMP VACUUM, in. Hg	IMPINGER TEMPERATURE, °F
	0	0930	230.236					
NA	10	0940	239.6	1.80	93	77	20	49
	20	0950	244.5	.97	93	78	22	49
	30	1000	249.5	1.00	97	78	23	49
	40	1010	254.8	.91	98	83	23	49
	50	1020	259.7	.92	103	87	23	49
	60	1030	264.762	.91	103	87	23	49
			34.526	1.085		89.8		

CO_2 —
O_2 —
CO —
P_b 28.32

Moisture Pickup!
155.0
100.0
12.5
0.0
267.5
- 200.0
067.5

Run 2

Pre Leak Check 0.003 CFM at 15''Hg
Post Leak Check 0.003 CFM at 20''Hg

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	ΔH	DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m_{out}}$), °F	PUMP VACUUM, in. Hg	IMPINGER TEMPERATURE, °F
	0	1120	265.143					
	10	1130	272.261	1.8	77	97	12	46
	20	1140	278.1	1.4	77	97	22	49
	30	1150	284.7	1.5	83	103	21	49
	40	1200	291.4	1.6	87	107	21	49
	50	1210	298.1	1.5	88	113	21	49
	60	120	304.995	1.5	93	113	21	49
			39.852	1.55		94.2		

CO_2 —
O_2 —
CO —
P_b 28.30

Moisture Pickup!
114.0
90.0
1.0
10.0
275.0
- 200.0
75.0

Run 3

Pre Leak Check 0.001 CFM @ 15''Hg
Post Leak Check 0.003 CFM @ 15''Hg

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	ΔH	DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m_{out}}$), °F	PUMP VACUUM, in. Hg	IMPINGER TEMPERATURE, °F
	0	1330	305.951					
	10	1340	312.250	1.8	93	73	12	57
	20	1350	319.8	1.8	103	77	13	51
	30	1400	325.1	1.0	103	83	9	51
	40	1410	330.6	1.0	107	87	9	51
	50	1420	335.9	1.0	106	87	9	52
	60	1430	341.583	1.0	113	93	9	52
			35.632	1.27		93.8		

CO_2 —
O_2 —
CO —
P_b 28.28

Moisture Pickup!
161.0
102.0
0.0
2.5
265.5
-200
65.5

BAG SAMPLING DATA SHEET

Client: BFI Greentree
Location: Flare Stack Inlet
Date: 4-23-92
Run No: 1
Operator: Paul Jadlowiec

Parameters: TNMHC
Bag Size and Type: 10 L Tedlar
Condensate: yes 1/2 ml
Bag No: 39
Condensate No: 46

TIME	FLOW RATE	TIME	FLOW RATE
0943			
0953	150 cc		
1003	150 cc		
1013	150 cc		
1023	150 cc		
1033	150cc		
1043	150cc		

BAG SAMPLING DATA SHEET

Client: BFI Greentree
Location: Flare Stack Inlet
Date: 4-23-92
Run No: 2
Operator: Paul Jadlowiec

Parameters: TNMHC
Bag Size and Type: 10 l Tedlar
Condensate: Yes < 1/4 ml
Bag No: 40
Condensate No: 46

TIME	FLOW RATE	TIME	FLOW RATE
1158			
1208	150 cc		
1218	150cc		
1228	150cc		
1238	150cc		
1248	150 cc		
1258	150cc		

BAG SAMPLING DATA SHEET

Client: BFI Green tree
Location: Flare Stack Inlet
Date: 4-23-92
Run No: 3
Operator: Paul Jablowiec

Parameters: TNMHC
Bag Size and Type: 10 l Tedlar
Condensate: Yes <¼ ml
Bag No: 41
Condensate No: 47

TIME	FLOW RATE	TIME	FLOW RATE
1405			
1415	150 cc		
1425	150 cc		
1435	150 cc		
1445	150 cc		
1455	150 cc		
1505	150 cc		

BAG SAMPLING DATA SHEET

Client: BFI GREENTREE
Location: FLARE STACK OUTLET
Date: APRIL 23, 1992
Run No: 1
Operator: JIM PHILLIPPI

Parameters: TNMOHC
Bag Size and Type: 10 L TEDLAR
Condensate: YES ½ ml
BAG # 42
CONDENSATE # 48

TIME	FLOW RATE	TIME	FLOW RATE
0943	150 cc/MIN		
0953	150 cc/MIN		
1003	150 cc/MIN		
1013	150 cc/MIN		
1023	150 cc/MIN		
1033	150 cc/MIN		
1043	150 cc/MIN		

BAG SAMPLING DATA SHEET

Client: BFI GREENTREE
Location: FLARE STACK OUTLET
Date: APRIL 23, 1992
Run No: 2
Operator: JIM PHILLIPPI

Parameters: TNMOHC
Bag Size and Type: 10L TEDLAR
Condensate: 7 mL
BAG # 43
CONTAINER # 49

TIME	FLOW RATE	TIME	FLOW RATE
1158	150 cc/min		
1208	150 cc/min		
1218	150 cc/min		
1228	150 cc/min		
1238	150 cc/min		
1248	150 cc/min		
1259	[illegible] cc/min		

BAG SAMPLING DATA SHEET

Client: BFI GREENTREE
Location: FLARE STACK OUTLET
Date: APRIL 23, 1992
Run No: 3
Operator: JIM PHILLIPPI

Parameters: TNMOHC
Bag Size and Type: 10 L TEDLAR
Condensate: 8 ML
BAG # 44
CONTAINER # 50

TIME	FLOW RATE	TIME	FLOW RATE
1405	150 cc/min		
1415	150 cc/min		
1425	150 cc/min		
1435	150 cc/min		
1445	150 cc/min		
1455	150 cc/min		
1505	150 cc/min		

APPENDIX C

ANALYTICAL REPORT

AIR QUALITY SERVICES, INC.

4527 Clairton Boulevard
Pittsburgh, PA 15236
(412) 881-5630

TABLE III
ANALYSIS OF SAMPLES NITROGEN DIOXIDE BY EPA METHOD 7D
BCM ENGINEERS
5777 BAUM BOULEVARD
PITTSBURGH, PA 15206
SAMPLES RECEIVED: APRIL 24, 1992

BCM SAMPLE NUMBER	AQS LABORATORY NUMBER	SAMPLE VOLUME MILLILITERS	NO2 TOTAL MICROGRAMS
38 BLANK	61286	1000	970 *
35 RUN #1	61283	1000	2600
36 RUN #2	61284	1000	1979
37 RUN #3	61285	1000	3421

* THE DATA HAS BEEN CORRECTED FOR THE BLANK

THE SAMPLES WERE ANALYZED ACCORDING TO THE ENVIRONMENTAL PROTECTION AGENCY METHOD 7D. THE CALCULATION OF THE TOTAL MICROGRAMS OF NO2 IS BASED ON EQUATION 6.2 IN METHOD 7D.

John O. Troklizer

AIR QUALITY SERVICES, INC

JOB 3361

AIR QUALITY SERVICES, INC.
4527 Clairton Boulevard
Pittsburgh, PA 15236
(412) 881-5630

TABLE II
ANALYSIS OF SAMPLES FOR TOTAL NON-METHANE HYDROCARBONS
EXPRESSED AS HEXANE BY PHOTOIONIZATION DETECTION
BCM ENGINEERS
5777 BAUM BOULEVARD
PITTSBURGH, PA 15206
SAMPLES RECEIVED: APRIL 24, 1992

BCM SAMPLE I.D.	AQS LABORATORY NUMBER	TOTAL NON-METHANE HYDROCARBONS PPM AS HEXANE
R1-INLET	61287	36.1
R2-INLET	61288	36.1
R3-INLET	61289	34.2
R1-OUTLET	61290	NONE DETECTED
R2-OUTLET	61291	NONE DETECTED
R3-OUTLET	61292	NONE DETECTED

THE SAMPLES WERE ANALYZED USING AN ORGANIC VAPOR ANALYZER EQUIPPED WITH A PHOTOIONIZATION DETECTOR.
THE LIMIT OF DETECTION IS 0.28 PARTS PER MILLION AS HEXANE.

John O. Frohliger
AIR QUALITY SERVICES, INC

JOB 3361

AIR QUALITY SERVICES, INC.

4527 Clairton Boulevard
Pittsburgh, PA 15236
(412) 881-5630

TABLE I-A
ANALYSIS OF SAMPLES FOR CONDENSABLE HYDROCARBONS
AS HEXANE BY GAS CHROMATOGRAPHY
BCM ENGINEERS
5777 BAUM BOULEVARD
PITTSBURGH, PA 15206
SAMPLES RECEIVED: APRIL 24, 1992
SAMPLES CORRECTED FOR THE BLANK

BCM SAMPLE I.D.	AQS LABORATORY NUMBER	EXTRACTION VOLUME ml	CONDENSED HYDROCARBONS ug/mL	CONDENSED HYDROCARBONS Mg
R1-INLET	61293	25.00	80.5	2.0
R2-INLET	61294	25.00	76.2	1.9
R3-INLET	61295	25.00	15.4	0.4
R1-OUTLET	61296	25.00	NONE DETECTED	
R2-OUTLET	61297	25.00	NONE DETECTED	
R3-OUTLET	61298	25.00	NONE DETECTED	

THE SAMPLES WERE ANALYZED BY GAS CHROMATOGRAPHY USING A FLAME IONIZATION DETECTOR. THE LIMIT OF DETECTION FOR THIS METHOD IS 0.001 MILLIGRAMS.

John O. Frollier

AIR QUALITY SERVICES, INC.

JOB 3361

APPENDIX D

CALCULATIONS

BROWNING-FERRIS INDUSTRIES
GREENTREE LANDFILL
FLARE STACK EMISSION TEST

4-23-92
RUN 1

MOISTURE CONTENT

SYMBOL		DESCRIPTION		VALUE
Theta	=	Duration of test, min.	=	60
Vm	=	Dry sample volume (meter conditions), dcf	=	34.026
dH	=	Orifice pressure drop, in. water	=	1.085
Tm	=	Average dry gas meter temperature, deg. F	=	89.8
Pbar	=	Barometric pressure, in. Hg	=	28.32
Y	=	Dry gas meter correction factor	=	1.005
Vlc	=	Volume of liquid collected in impingers and silica gel, ml	=	67.5
Vw(std)	=	Volume of liquid collected, cu. ft.	=	3.177
Vm(std)	=	Dry sample volume (standard conditions), dscf	=	31.743
Bws	=	Moisture content of the gas stream, %	=	9.1

BROWNING-FERRIS INDUSTRIES
GREENTREE LANDFILL
FLARE STACK EMISSION TEST

4-23-92
RUN 2

MOISTURE CONTENT

SYMBOL		DESCRIPTION		VALUE
Theta	=	Duration of test, min.	=	60
Vm	=	Dry sample volume (meter conditions), dcf	=	39.852
DH	=	Orifice pressure drop, in. water	=	1.55
Tm	=	Average dry gas meter temperature, deg. F	=	94.2
Pbar	=	Barometric pressure, in. Hg	=	28.30
Y	=	Dry gas meter correction factor	=	1.009
Vlc	=	Volume of liquid collected in impingers and silica gel, ml	=	75.0
Vw(std)	=	Volume of liquid collected, cu .ft.	=	3.530
Vm(std)	=	Dry sample volume (standard conditions), dscf	=	36.267
Bws %	=	Moisture content of the gas stream, %	=	8.8

BROWNING-FERRIS INDUSTRIES
GREENTREE LANDFILL
FLARE STACK EMISSION TEST

4-22-92
RUN 3

MOISTURE CONTENT

SYMBOL		DESCRIPTION		VALUE
Theta	=	Duration of test, min.	=	60
Vm	=	Dry sample volume (meter conditions), dcf	=	35.632
dH	=	Orifice pressure drop, in. water	=	1.27
Tm	=	Average dry gas meter temperature, deg. F	=	93.8
Pbar	=	Barometric pressure, in. Hg	=	28.28
Y	=	Dry gas meter correction factor	=	1.009
Vlc	=	Volume of liquid collected in impingers and silica gel, ml	=	65.5
Vw(std)	=	Volume of liquid collected, cu. ft.	=	3.083
Vm(std)	=	Dry sample volume (standard conditions), dscf	=	32.493
Bws	=	Moisture content of the gas stream, %	=	8.7

BROWNING-FERRIS INDUSTRIES
GREENTREE LANDFILL
FLARE STACK EMISSION TEST

4-22-92
Run 1

GAS FLOW
FOR
NMOHC AND NOx EMISSION TEST

SYMBOL		DESCRIPTION		VALUE
SQRT(dP)	=	Average of square roots of pitot pressure differential, in. H2O	=	0.0707
Ts	=	Average stack temperature, deg. F deg. F	=	1548.5
CO2	=	CO2 in stack gas, %	=	6.93
O2	=	O2 in stack gas, %	=	12.27
CO	=	CO in stack gas, %	=	0.00
N2	=	N2 in stack gas, %	=	80.80
Pbar		Barometric pressure, in. Hg	=	28.30
Ps	=	Stack pressure (absolute), in. Hg.	=	28.30
Cp	=	Pitot correction factor, dimensionless	=	0.84
Bws	=	Moisture content of the gas stream, %	=	[illegible]
As	=	Area of the stack, sq.ft.	=	63.62
Md	=	Dry molecular weight of stack gas, lb/lb-mole	=	29.60
Ms	=	Molecular weight of stack gas, lb/lb-mole	=	28.04
Vs	=	Stack velocity, ft/sec	=	8.01
Qs	=	Stack gas flow, acfm	=	30558
Qsd	=	Stack gas flow, dscfm	=	6907

BROWNING-FERRIS INDUSTRIES

[illegible] LANDFILL

FLARE STACK EMISSION TEST

4-[illegible]-92

RUN 2

GAS FLOW

FOR

NMOHC AND NOx EMISSION TEST

SYMBOL		DESCRIPTION		VALUE
SQRT(DP)	=	Average of square roots of pitot pressure differential, in. H2O	=	0.0707
TS	=	Average stack temperature, deg. F deg. F	=	1555.2
CO2	=	CO2 in stack gas, %	=	6.30
O2	=	O2 in stack gas, %	=	12.80
CO	=	CO in stack gas, %	=	0.00
N2	=	N2 in stack gas, %	=	80.90
Pbar		Barometric pressure, in. Hg	=	28.28
PS	=	Stack pressure (absolute), in. Hg.	=	28.28
Cp	=	Pitot correction factor, dimensionless	=	0.84
Bws	=	Moisture content of the gas stream, %	=	8.80
AS	=	Area of the stack, sq.ft.	=	63.62
Md	=	Dry molecular weight of stack gas, lb/lb-mole	=	29.52
Ms	=	Molecular weight of stack gas, lb/lb-mole	=	28.51
VS	=	Stack velocity, ft/sec	=	8.03
QS	=	Stack gas flow, acfm	=	30640
QSD	=	Stack gas flow, dscfm	=	6920

BROWNING-FERRIS INDUSTRIES
GREENTREE LANDFILL
FLARE STACK EMISSION TEST

4-23-92
RUN 3

GAS FLOW
FOR
TNMOHC AND NOX EMISSION TEST

SYMBOL		DESCRIPTION		VALUE
SQRT(dP)	=	Average of square roots of pitot pressure differential, in. H2O	=	0.0707
Ts	=	Average stack temperature, deg. F deg. F	=	1549.0
CO2	=	CO2 in stack gas, %	=	6.37
O2	=	O2 in stack gas, %	=	12.57
CO	=	CO in stack gas, %	=	0.00
N2	=	N2 in stack gas, %	=	81.06
Pbar		Barometric pressure, in. Hg	=	28.28
Ps	=	Stack pressure (absolute), in. Hg.	=	28.28
Cp	=	Pitot correction factor, dimensionless	=	0.84
Bws	=	Moisture content of the gas stream, %	=	6.70
As	=	Area of the stack, sq.ft.	=	63.62
Md	=	Dry molecular weight of stack gas, lb/lb-mole	=	29.52
Ms	=	Molecular weight of stack gas, lb/lb-mole	=	28.52
Vs	=	Stack velocity, ft/sec	=	8.01
Qs	=	Stack gas flow, acfm	=	30586
Qsd	=	Stack gas flow, dscfm	=	6937

BROWNING-FERRIS INDUSTRIES
GREENTREE LANDFILL
FLARE STACK EMISSION TEST

4-23-92
RUN 1

NITROGEN OXIDE EMISSIONS

SYMBOL	DESCRIPTION		VALUE
Vm	= Dry sample volume (meter conditions), cu. ft.	=	0.956
Theta	= Duration of test, minutes	=	60.00
Qsd	= Stack gas flow, dscfm	=	6907
Tm	= Average dry gas meter temperture deg. F	=	64.3
CO2	= Carbon dioxide analysis, percent	=	6.93
Y	= Meter correction factor	=	0.997
Pbar	= Barometric pressure, in. Hg	=	28.80
m	= Mass of NOx as NO2, in sample, ug	=	2600
Vm(std)	= Dry gas volume measured by the dry gas meter, dscf	=	0.975
Fr	= Sample gas flow rate, cc/min	=	460
Cnox(a)	= Concentration of NOx as NO2 dry, basis, corrected to standard conditions, lb/dscf	=	5.88E-06
Cnox(b)	= Concentration of NOx as NO2 dry, basis, corrected to standard conditions, ppm	=	49
Enox(a)	= Mass emission of NOx, lb/hr	=	2.44

BROWNING-FERRIS INDUSTRIES 4-23-92
GREENTREE LANDFILL RUN 2
FLARE STACK EMISSION TEST

NITROGEN OXIDE EMISSIONS

SYMBOL	DESCRIPTION		VALUE
Vm	= Dry sample volume (meter conditions), cu. ft.	=	0.880
Theta	= Duration of test, minutes	=	60.00
Qsd	= Stack gas flow, dscfm	=	6920
Tm	= Average dry gas meter temperture deg. F	=	66.0
CO2	= Carbon dioxide analysis, percent	=	6.30
Y	= Meter correction factor	=	0.997
Pbar	= Barometric pressure, in. Hg	=	28.28
m	= Mass of NOx as NO2 in sample, ug	=	1979
Vm(std)	= Dry gas volume measured by the dry gas meter, dscf	=	0.824
Fr	= Sample gas flow rate, cc/min	=	389
Cnox(a)	= Concentration of NOx as NO2 dry basis, corrected to standard conditions, lb/dscf	=	5.29E-06
Cnox(b)	= Concentration of NOx as NO2 dry basis, corrected to standard conditions, ppm	=	44
Enox(a)	= Mass emission of NOx, lb/hr	=	2.20

BROWNING-FERRIS INDUSTRIES 4-23-92

[illegible] RUN 3

FLARE STACK EMISSION TEST

NITROGEN OXIDE EMISSIONS

SYMBOL	DESCRIPTION		VALUE
Vm	= Dry sample volume (meter conditions), cu. ft.	=	0.921
Theta	= Duration of test, minutes	=	60.00
Qsd	= Stack gas flow, dscfm	=	6937
Tm	= Average dry gas meter temperature, deg. F	=	76.0
CO2	= Carbon dioxide analysis, percent	=	8.37
Y	= Meter correction factor	=	0.997
Pbar	= Barometric pressure, in. Hg	=	28.28
m	= Mass of NOx as NO2, in sample, ug	=	3421
Vm(std)	= Dry gas volume measured by the dry gas meter, dscf	=	[illegible]
Fr	= Sample gas flow rate, cc/min	=	431
CNOx(a)	= Concentration of NOx as NO2 dry basis, corrected to standard conditions, lb/dscf	=	8.26E-06
CNOx(b)	= Concentration of NOx as NO2 dry basis, corrected to standard conditions, ppm	=	[illegible]
ENOx(a)	= Mass emission of NOx, lb/hr	=	3.44

BCM

COMPUTATION SHEET

Sheet Number 1 Of 1
Date 5-21-92
Job Number 00-7335-01
Computed by PJ Checked by

Name of Client B.F.I.
Project Greentree Landfill Ground Flare
Description TNMHC Destruction Efficiency

Moisture Content

Run No 1

assume saturation at 163°F[1] - 34.5% moisture @ 29.921 in Hg

correction for pressure - $34.5\% \frac{28.33\text{"Hg}}{29.921\text{"Hg}} = \underline{\underline{32.66\%}}$

Run No 2

assume saturation at 164°F[1] - 35.0% moisture @ 29.921 in Hg

Correction for pressure - $35.0\% \frac{28.33\text{"Hg}}{29.921\text{"Hg}} = \underline{\underline{33.14\%}}$

Run No 3

assume saturation at 163°F[1] - 34.5% moisture @ 29.921 "Hg

Correction for pressure - $34.5\% \frac{29.35\text{"Hg}}{29.921} = \underline{\underline{32.69\%}}$

Gas Flow Conversion From SCFM to DSCFM

Run No 1

520 SCFM (1-0.3266) = **350.2 DSCFM**

Run No 2

528 SCFM (1-0.3314) = **353.0 DSCFM**

Run No 3

524 SCFM (1-0.3269) = **352.7 DSCFM**

1 High-temperature psychrometric chart for air-water vapor mixtures at 29.921 in Hg, Air Pollution Engineering Manual, U.S. Department of Health Education and Welfare 1967

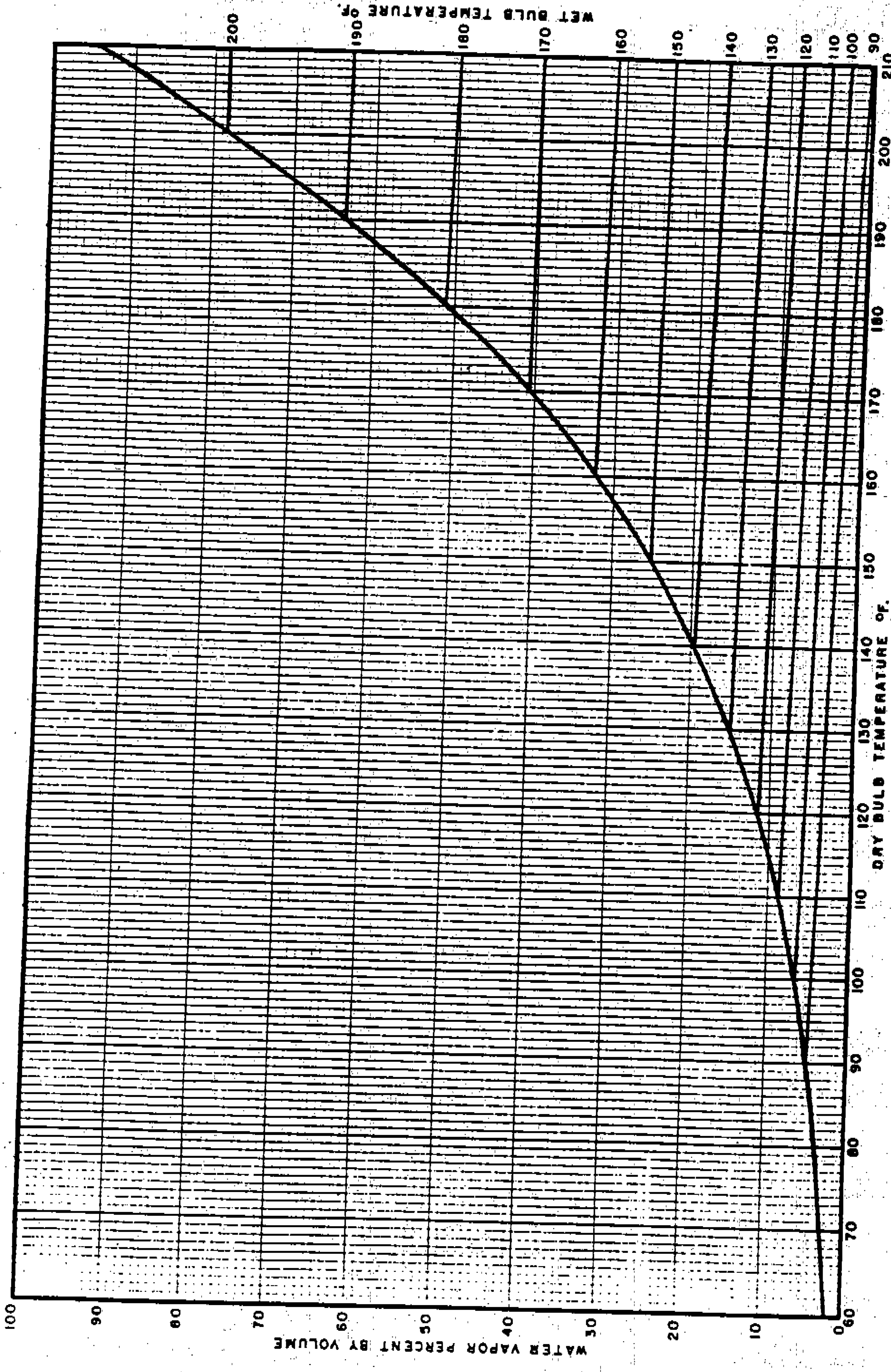


Figure D7. High-temperature psychrometric chart for air-water vapor mixtures at 1 atm (29.921 in. Hg).

COMPUTATION SHEET

BCM

Sheet Number 1 of 6
Date 5-20-92
Job Number 00-7??5-01
Computed by JMS Checked by PJ

Name of Client BFI
Project Greentree Landfill Ground Flare
Description TNMHC Destruction Efficiency

GROUND FLARE INLET GAS PHASE

Run No. 1

$$36.1\,ppm\left(\frac{1\,\mu l}{1\,L\,gas} \times \frac{1\times10^{-6}\,L}{\mu l} \times \frac{1\,mole}{22.042\,L} \times \frac{1\,lb.}{453.59\,g} \times \frac{28.32\,L\,gas}{ft^3\,gas} \times \frac{86.17\,g}{mole}\right) = 36.1\,ppm\left(\frac{2.44\times10^{-7}\,lb}{ft^3}\right)$$

$$= \underline{\underline{\frac{8.811\times10^{-6}\,lb}{ft^3}}} \times \frac{60\,min}{hr.} \times \frac{350.2\,ft^3}{min.}$$

$$= \underline{\underline{\frac{0.1851\,lb}{hr.}}}$$

Run No. 2

$$36.1\,ppm \times 2.44\times10^{-7}\frac{lb}{ft^3} = \underline{\underline{8.811\times10^{-6}\frac{lb}{ft^3}}} \times \frac{60\,min}{hr.} \times \frac{353.0\,ft^3}{min.}$$

$$= \underline{\underline{0.1866\,\frac{lb}{hr.}}}$$

Run No. 3

$$34.2\,ppm \times 2.44\times10^{-7}\frac{lb}{ft^3} = \underline{\underline{8.347\times10^{-6}\frac{lb}{ft^3}}} \times \frac{60\,min}{hr.} \times \frac{352.7\,ft^3}{min.}$$

$$= \underline{\underline{0.1766\,\frac{lb}{hr.}}}$$

BCM

COMPUTATION SHEET

Sheet Number 2 Of 6

Date 5-20-92

Job Number 0C-7335-01

Computed by JMS Checked by PJ

Name of Client BFI

Project Greentree Landfill Ground Flare

Description TNMHC Destruction Efficiency

GROUND FLARE INLET CONDENSATE PHASE

Run No. 1

$$\frac{2.0\ mg}{9\ L} \times \left(\frac{1\ L}{0.03531\ ft^3} \times \frac{1\ lb.}{453{,}593\ mg} \right)$$

$$= \frac{2.0\ mg}{9\ L} \times 6.244 \times 10^{-5} \frac{L\text{-}lb}{ft^3\text{-}mg}$$

$$= \underline{1.387 \times 10^{-5} \frac{lb}{ft^3}} \times 60 \frac{min}{hr.} \times 350.2 \frac{ft^3}{min.}$$

$$= \underline{0.2915 \frac{lb}{hr}}$$

Run No. 2

$$\frac{1.9\ mg}{9\ L} \times 6.244 \times 10^{-5} \frac{L\text{-}lb}{ft^3\text{-}mg} = \underline{1.318 \times 10^{-5} \frac{lb}{ft^3}}$$

$$\times 60 \frac{min}{hr.} \times 353.0 \frac{ft^3}{min} = \underline{\cancel{0.2791}\ 0.2792 \frac{lb.}{hr.}}$$

Run No. 3

$$\frac{0.4\ mg}{9\ L} \times 6.244 \times 10^{-5} \frac{L\text{-}lb}{ft^3\text{-}mg} = \underline{2.775 \times 10^{-6} \frac{lb}{ft^3}}$$

$$\times 60 \frac{min}{hr.} \times 352.7 \frac{ft^3}{min.} = \underline{0.0587 \frac{lb}{hr.}}$$

BCM

COMPUTATION SHEET

Sheet Number 3 Of 6

Date 5-20-92

Job Number EC-7335-01

Computed by JMS Checked by PJ

Name of Client RFI

Project Greentree Landfill Ground Flare

Description TNMHC Destruction Efficiency

TOTAL GROUND FLARE INLET LOADING

Run No. 1

Gas Phase + Condensate Phase

$$= 8.811\times10^{-6}\frac{lb}{ft^3} + 1.387\times10^{-5}\frac{lb}{ft^3} = \underline{\underline{2.268\times10^{-5}\frac{lb}{ft^3}}}$$

$$= 0.1851\frac{lb}{hr} + 0.2915\frac{lb}{hr} = \underline{\underline{0.4766\frac{lb}{hr}}}$$

Run No. 2

$$8.811\times10^{-6}\frac{lb}{ft^3} + 1.318\times10^{-5}\frac{lb}{ft^3} = \underline{\underline{2.199\times10^{-5}\frac{lb}{ft^3}}}$$

0.2792 PJ

0.4658 PJ

$$= 0.1866\frac{lb}{hr} + 0.\cancel{2791}\frac{lb}{hr} = \underline{\underline{0.\cancel{4657}\frac{lb}{hr}}}$$

Run No. 3

$$8.347\times10^{-6}\frac{lb}{ft^3} + 2.775\times10^{-6}\frac{lb}{ft^3} = \underline{\underline{1.112\times10^{-5}\frac{lb}{ft^3}}}$$

$$= 0.1766\frac{lb}{hr} + 0.0587\frac{lb}{hr} = \underline{\underline{0.2353\frac{lb}{hr}}}$$

BCM COMPUTATION SHEET

Name of Client: BFI

Project: Greentree Landfill Ground Flare

Description: TNMHC Destruction Efficiency

Sheet Number: 4 Of 6

Date: 5.20.92

Job Number: 00-7335-01

Computed by: JAS Checked by: PJ

GROUND FLARE EXHAUST GAS PHASE

Run No. 1

$$0.14\ ppm \times 2.44 \times 10^{-7} \frac{lb}{ft^3} = 3.417 \times 10^{-8} \frac{lb}{ft^3}$$

$$\times 60 \frac{min}{hr.} \times 6907 \frac{ft^3}{min.} = 0.0142 \frac{lb}{hr.}$$

Run No. 2

$$0.14\ ppm \times 2.44 \times 10^{-7} \frac{lb}{ft^3} = 3.417 \times 10^{-8} \frac{lb}{ft^3}$$

$$\times 60 \frac{min}{hr.} \times 6920 \frac{ft^3}{min.} = 0.0142 \frac{lb}{hr.}$$

Run No. 3

$$0.14\ ppm \times 2.44 \times 10^{-7} \frac{lb}{ft^3} = 3.417 \times 10^{-8} \frac{lb}{ft^3}$$

$$\times 60 \frac{min}{hr.} \times 6937 \frac{ft^3}{min} = 0.0142 \frac{lb}{hr.}$$

GROUND FLARE EXHAUST CONDENSATE PHASE

Run No. 1

$$\frac{0.0005\ mg}{9L} \times 6.244 \times 10^{-5} \frac{L\text{-}lb}{ft^3\text{-}mg} = 3.469 \times 10^{-9} \frac{lb}{ft^3}$$

$$\times 60 \frac{min}{hr.} \times 6907 \frac{ft^3}{min} = 0.0014 \frac{lb}{hr.}$$

Run No. 2

$$\frac{0.0005\ mg}{9L} \times 6.244 \times 10^{-5} \frac{L\text{-}lb}{ft^3\text{-}mg} = 3.469 \times 10^{-9} \frac{lb}{ft^3}$$

$$\times 60 \frac{min}{hr.} \times 6920 \frac{ft^3}{min.} = 0.0014 \frac{lb}{hr.}$$

BCM

COMPUTATION SHEET

Name of Client: BFI
Project: Greentree Landfill Ground Flare
Description: TNMHC Destruction Efficiency

Sheet Number: 5 Of 6
Date: 5-20-92
Job Number: 00-7335-01
Computed by: JMS Checked by: PJ

Run No. 3

$$\frac{0.0005\ mg}{9\ L} \times 6.244\times10^{-5}\ \frac{L\text{-}lb}{ft^3\text{-}mg} = \underline{\underline{3.469\times10^{-9}\ \frac{lb}{ft^3}}}$$

$$\times 60\ \frac{min}{hr.} \times 6937\ \frac{ft^3}{min.} = \underline{\underline{0.0014\ \frac{lb}{hr.}}}$$

TOTAL GROUND FLARE EXHAUST EMISSIONS

Run No. 1

$$3.417\times10^{-8}\ \frac{lb}{ft^3} + 3.469\times10^{-9}\ \frac{lb}{ft^3} = \underline{\underline{3.764\times10^{-8}\ \frac{lb}{ft^3}}}$$

$$= 0.0142\ \frac{lb}{hr} + 0.0014\ \frac{lb}{hr.} = \underline{\underline{0.0156\ \frac{lb}{hr.}}}$$

Run No. 2

$$3.417\times10^{-8}\ \frac{lb}{ft^3} + 3.469\times10^{-9}\ \frac{lb}{ft^3} = \underline{\underline{3.764\times10^{-8}\ \frac{lb}{ft^3}}}$$

$$= 0.0142\ \frac{lb}{hr.} + 0.0014\ \frac{lb}{hr.} = \underline{\underline{0.0156\ \frac{lb}{hr.}}}$$

Run No. 3

$$3.417\times10^{-8}\ \frac{lb}{ft^3} + 3.469\times10^{-9}\ \frac{lb}{ft^3} = \underline{\underline{3.764\times10^{-8}\ \frac{lb}{ft^3}}}$$

$$= 0.0142\ \frac{lb}{hr.} + 0.0014\ \frac{lb}{hr.} = \underline{\underline{0.0156\ \frac{lb}{hr.}}}$$

BCM

COMPUTATION SHEET

Name of Client: BFI
Project: Greentree Landfill Ground Flare
Description: TNMHC Destruction Efficiency

Sheet Number: 6 Of 6
Date: 5-20-92
Job Number: 00-7335-01
Computed by: JMS Checked by: DJ

GROUND FLARE DESTRUCTION EFFICIENCY

Run No. 1

$$\frac{\text{Inlet Loading} - \text{Outlet Loading}}{\text{Inlet Loading}} \times 100$$

$$= \left(\frac{2.268\times10^{-5}\ lb/ft^3 - 3.764\times10^{-8}\ lb/ft^3}{2.268\times10^{-5}\ lb/ft^3}\right)\times100 = \underline{\underline{99.8\%}}$$

$$\text{or} = \left(\frac{0.4766\ lb/hr. - 0.0156\ lb/hr.}{0.4766\ lb/hr.}\right)\times100 = \underline{\underline{96.7\%}}$$

Run No. 2

$$\left(\frac{2.199\times10^{-5}\ lb/ft^3 - 3.764\times10^{-8}\ lb/ft^3}{2.199\times10^{-5}\ lb/ft^3}\right)\times100 = \underline{\underline{99.8\%}}$$

$$\text{or} \left(\frac{0.4657\ lb/hr - 0.0156\ lb/hr}{0.4657\ lb/hr.}\right)\times100 = \underline{\underline{96.6\%}}$$

Run No. 3

$$\left(\frac{1.112\times10^{-5}\ lb/ft^3 - 3.764\times10^{-8}\ lb/ft^3}{1.112\times10^{-5}\ lb/ft^3}\right)\times100 = \underline{\underline{99.7\%}}$$

$$\text{or} \left(\frac{0.2353\ lb/hr. - 0.0156\ lb/hr.}{0.2353\ lb/hr.}\right)\times100 = \underline{\underline{93.4\%}}$$

AVERAGE GROUND FLARE DESTRUCTION EFFICIENCY

$$\frac{\text{Run No. 1} + \text{Run No. 2} + \text{Run No. 3}}{3}$$

$$= \frac{99.8\% + 99.8\% + 99.7\%}{3} = \underline{\underline{99.8\%}}$$ BASED ON CONCENTRATION

$$\text{or} = \frac{96.7\% + 96.6\% + 93.4\%}{3} = \underline{\underline{95.6\%}}$$ BASED ON EMISSION RATE

APPENDIX E

CALIBRATIONS

CONSTRUCTION STANDARDS :

1. Dt - between 0.48 and 0.95 centimeters

2. Pa = Pb $1.05\ Dt \leqq P \leqq 1.50\ Dt$

3. a1 , a2 < 10°

4. B1 , B2 < 5°

5. $Z \leqq 0.32$ cm

6. $W \leqq 0.08$ cm

PITOT ALIGNMENT STANDARDS :

1. $X \geqq 3/4$ in.

2. Ip must be higher than Np

3. $Z \geqq 1.90$ cm

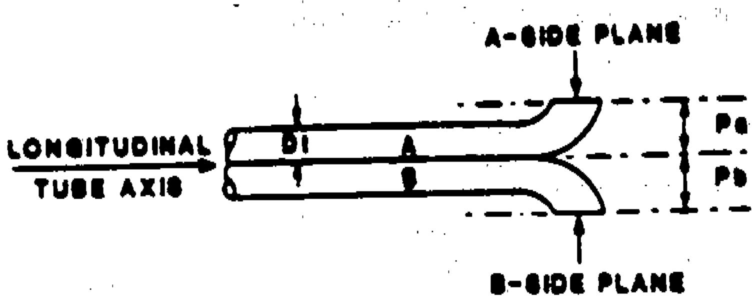
4. $Y \geqq 3$ in.

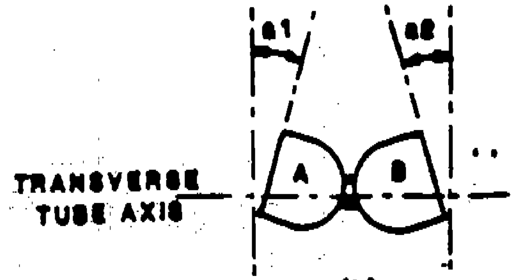
TYPE S PITOT
CALIBRATION STANDARDS

DRAWN BY: JSA	PROJECT NO:
SCALE: NONE	FILE NO: 12-1

BCM Engineers
Engineers Planners Scientists and Laboratory Services

CONSTRUCTION CALIBRATIONS





(b)

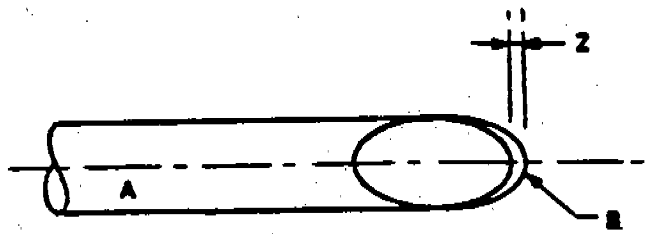
Dt = .95

Pa = 1.20

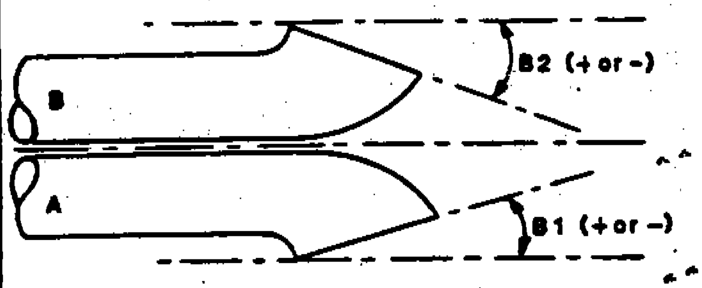
Pb = 1.20

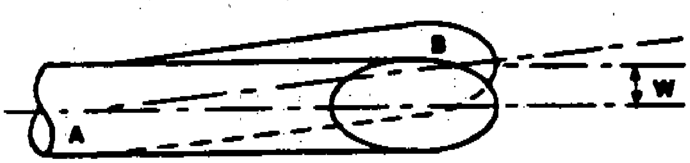
a1 = 0

a2 = 0



(f)





B1 = 0

B2 = 0

Z = 0

W = 0

Pitot I.D. No. 12-1 Date 12-4-91 Performed By DRP

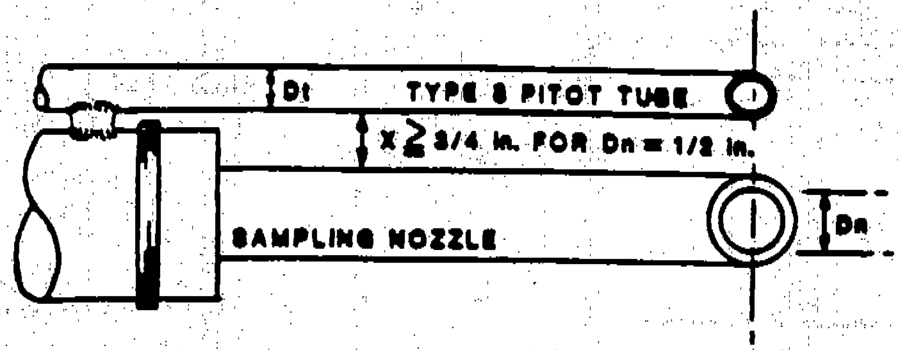
TYPE S PITOT CALIBRATION SHEET

BCM Engineers
Engineers Planners Scientists and Laboratory Services

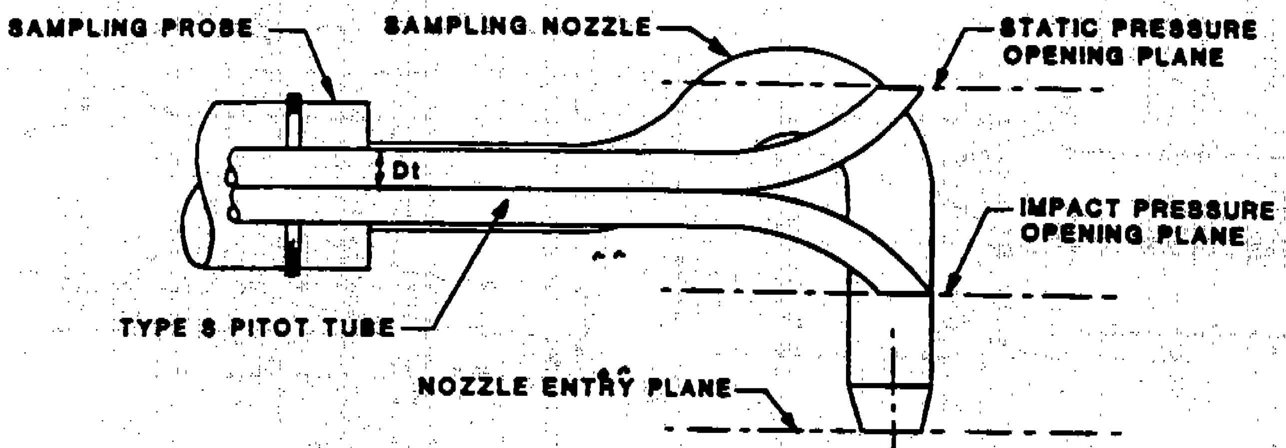
DRAWN BY: JSA
SCALE: NONE
DATE: SEPT. [illegible]

PROJECT NO:
FILE NO: 12-1
SHEET 2 OF 4

PITOT ALIGNMENT CALIBRATIONS



X = .75



Is Ip higher than Np = Yes

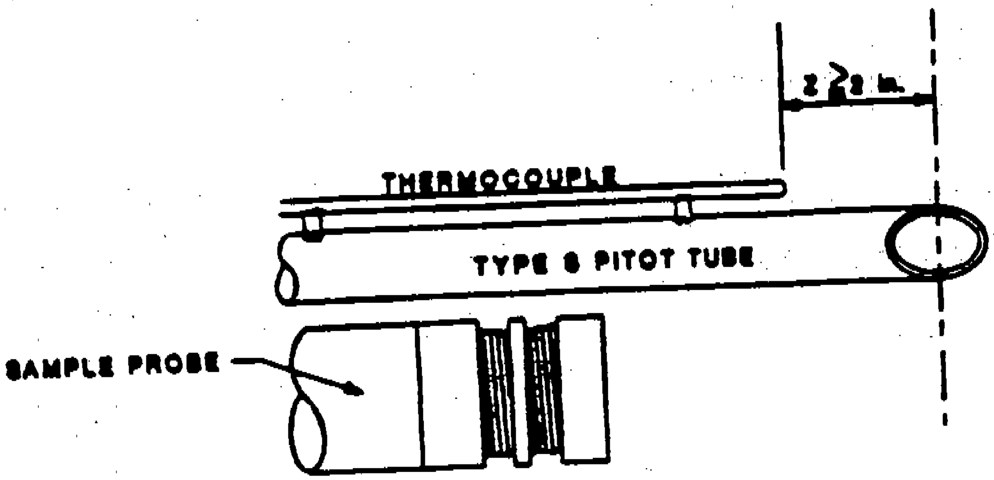
Pitot I.D. No. 12-1 Date 12-4-91 Performed By DRP

TYPE S PITOT TUBE
CALIBRATION SHEET

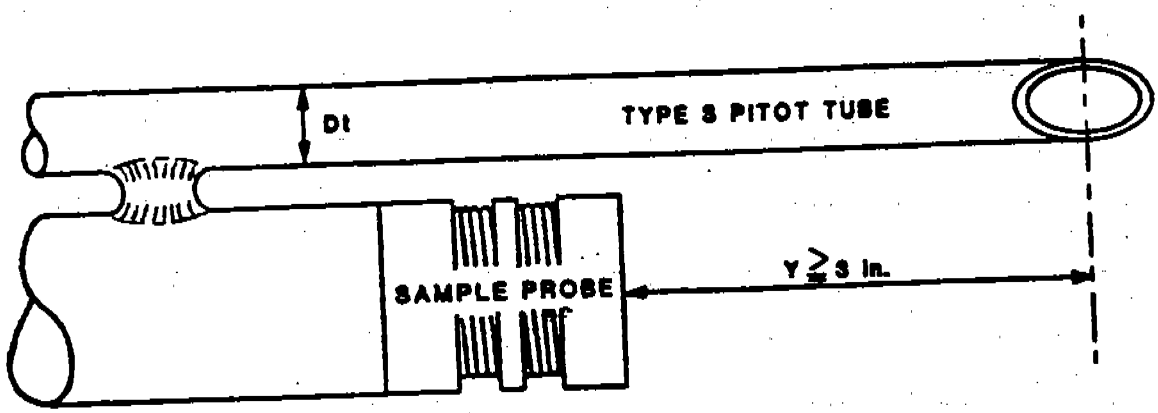
BCM Engineers
Engineers Planners Scientists and Laboratory Services

DRAWN BY: JSA PROJECT NO:
SCALE: NONE FILE NO: 12-1

PITOT ALIGNMENT CALIBRATIONS



Z = 2.0



Y = 3.0

Determined Coefficient 0.84

Pitot I.D. No. 12-1 Date 12-4-91 Performed By DRP

TYPE S PITOT TUBE
CALIBRATION SHEET

BCM Engineers
Engineers Planners Scientists and Laboratory Services

DRAWN BY: JBA
SCALE: NONE
DATE: SEPT. 1989

PROJECT NO:
FILE NO: 12-1
SHEET 4 OF 4

THERMOCOUPLE CALIBRATION DATA SHEET

Thermocouple No. : 12-1 Date: 12-4-91

Ambient Temperature: 72 °F Barometric Pressure: 28.93 Hg

Calibrator: DAN PETROVAY Reference: Mercury-in-glass: ✓

Other: ______

Reference Point No.	Source (Specify)	Reference Thermometer Temperature °F	Thermocouple Potentiometer Temperature °F	Difference %
1	H_2O	34.0	35.0	2.9
2	H_2O	210	208	.95
3	OIL	467	460	1.52
			Average % Difference	1.79%

THERMOCOUPLE CALIBRATION DATA SHEET

Thermocouple No. : 1 FOOT SPECIAL Date: MARCH 18, 1992

Ambient Temperature: 78 °F Barometric Pressure: 29.86 Hg

Calibrator: JP & JT Reference: Mercury-in-glass: ✓

Other:

Reference Point No.	Source (Specify)	Reference Thermometer Temperature °F	Thermocouple Potentiometer Temperature °F	Difference %
1	ICE WATER	33°	33°	0
–	BOILING WATER	212°	212°	0
	HOT OIL	467°	460°	1.52
			Average % Difference	.50

Dry Gas Meter and Orifice calibration

DATE:02/29/92 OPERATOR:J.P. CONSOLE: 582-128

Wet Test Meter Gas Volumes and Temperatures

Orifice Manometer Setting (in. H2O)	Initial Reading ft (cf) Vw	Initial Reading Temp. (deg F) Tw	Final Reading ft (cf) Vw	Final Reading Temp. (deg F) Tw	Net Volume (ft) Vw	Avg. Temp. (F) Tw
0.50	0.000	54.0	5.001	54.0	5.001	54.0
0.75	0.000	54.0	5.001	54.0	5.001	54.0
1.00	0.000	54.0	4.997	54.0	4.997	54.0
1.50	0.000	54.0	10.002	54.0	10.002	54.0
2.00	0.000	54.0	10.001	54.0	10.001	54.0

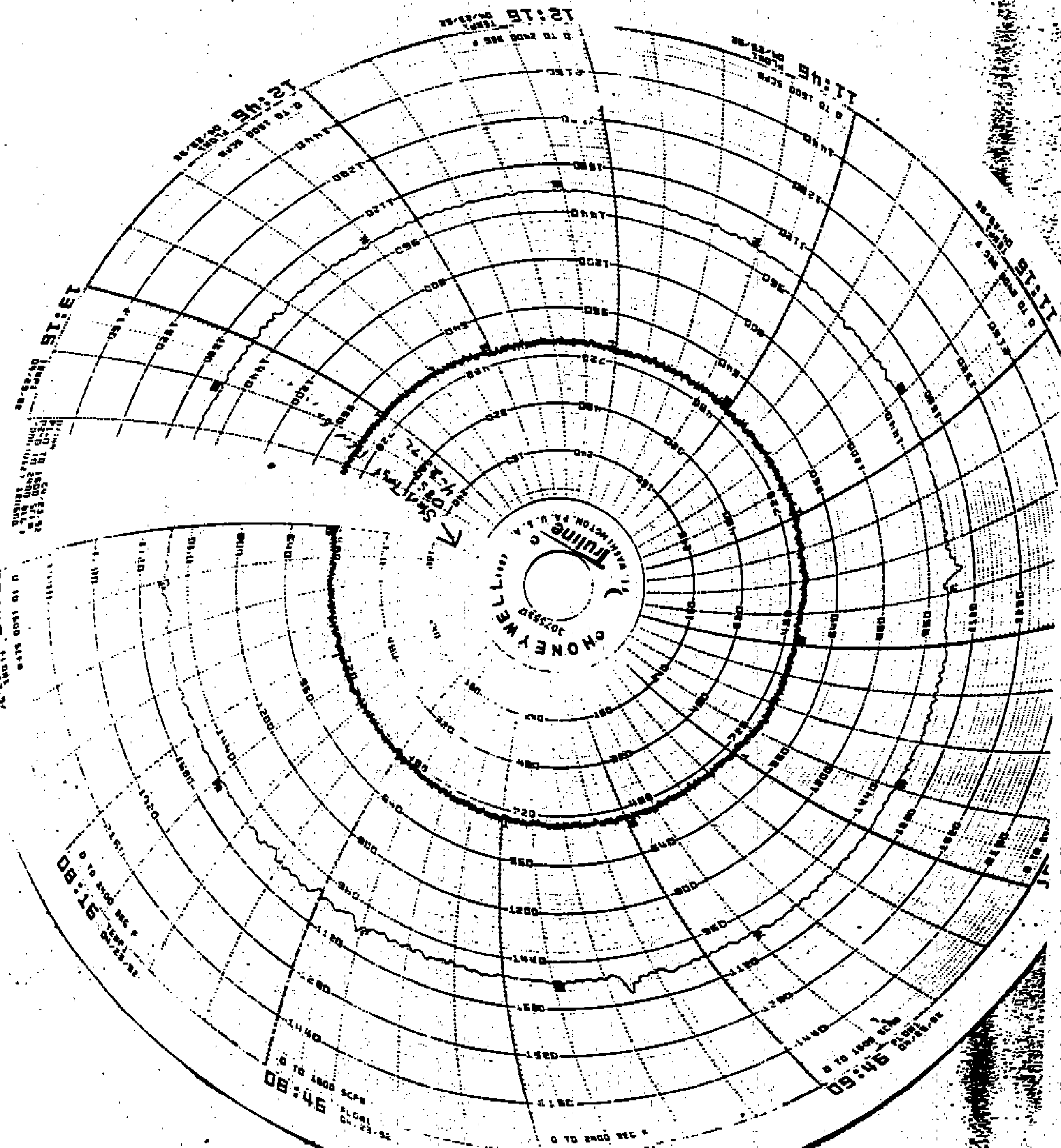
Dry Test Meter Gas Volumes and Temperatures

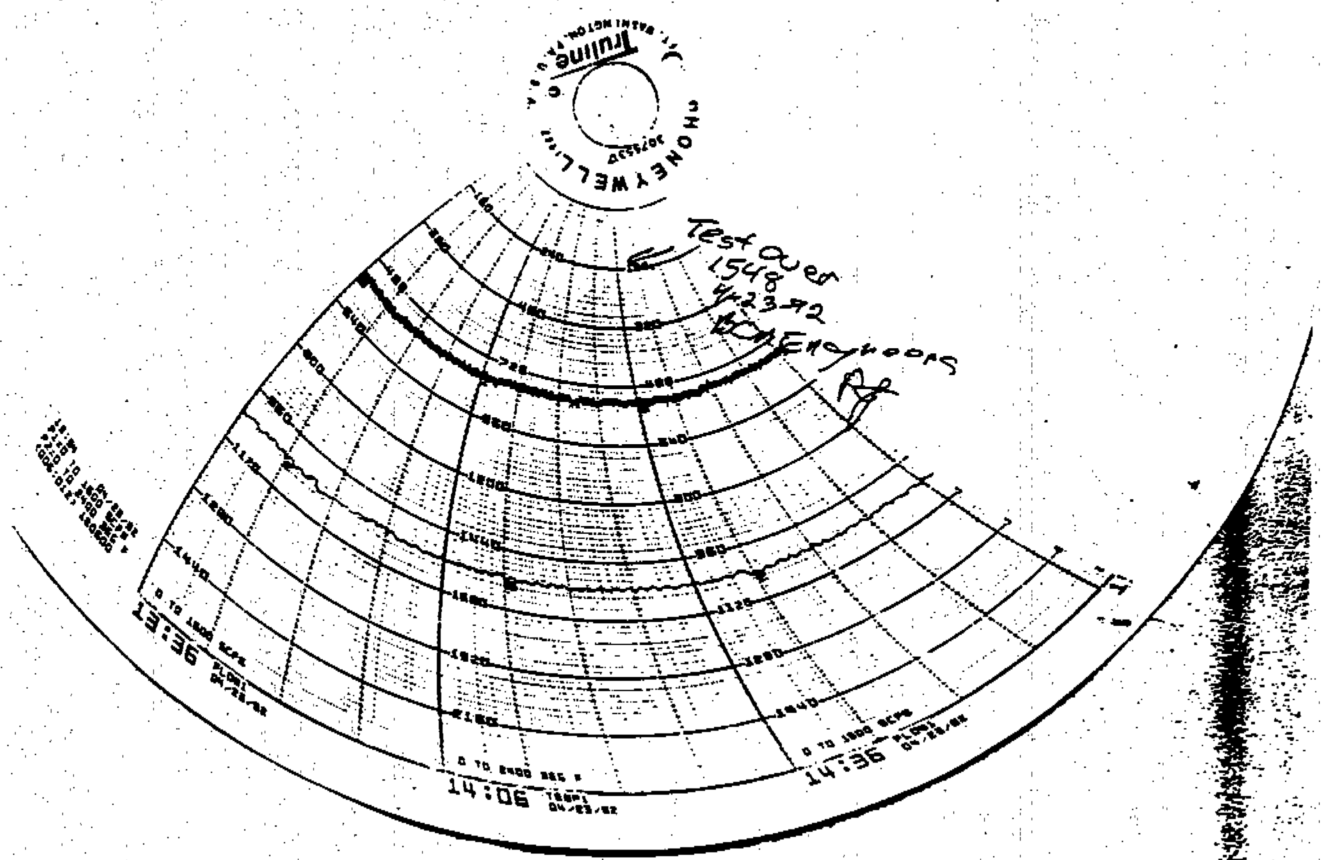
Orifice Manometer Setting (in. H2O)	Initial Reading (cf) Vd	Final Reading (cf) Vd	Temperature Inlet (deg f) Ti	Temperature Outlet (deg f) Td	Net Volume (ft) Vd	Avg. Temp. (deg f) Td
0.50	778.658	783.961	88.0	68.0	5.303	78.0
0.75	784.495	789.741	97.0	73.0	5.246	85.0
1.00	795.246	800.487	103.0	78.0	5.241	90.5
1.50	800.749	811.312	107.0	83.0	10.563	95.0
2.00	811.575	822.160	107.0	83.0	10.585	95.0

Orifice Manometer Setting (in. H2O)	Total Test Time (min.) Theta	Barometer Reading Inches ("Hg) Pb		Gamma	delta H
0.50	13.450	29.28		0.986	1.923
0.75	10.933	29.28		1.009	1.881
1.00	9.500	29.28		1.019	1.878
1.50	15.566	29.28		1.019	1.872
2.00	13.550	29.28		1.015	1.892
			Average	1.009	1.889

APPENDIX F

PROCESS DATA


HONEYWELL
Truline
08:46
0 TO 1800 SCFH
FLOW1
04/23/92
09:16
0 TO 2400 DEG F
TEMP1
09:46


HONEYWELL
truline
Test over
1548
4-23-92
Engineers
13:36
14:06
14:36