



# Research and Development

DEMONSTRATION OF FUEL CELLS TO RECOVER  
ENERGY FROM LANDFILL GAS

PHASE III. DEMONSTRATION TESTS, AND  
PHASE IV. GUIDELINES AND DEMONSTRATIONS

Volume 2. Appendices

## Prepared for

Office of Research and Development

## Prepared by

National Risk Management  
Research Laboratory  
Research Triangle Park, NC 27711



## FOREWORD

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory is the Agency's center for investigation of technological and management approaches for reducing risks from threats to human health and the environment. The focus of the Laboratory's research program is on methods for the prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites and groundwater; and prevention and control of indoor air pollution. The goal of this research effort is to catalyze development and implementation of innovative, cost-effective environmental technologies; develop scientific and engineering information needed by EPA to support regulatory and policy decisions; and provide technical support and information transfer to ensure effective implementation of environmental regulations and strategies.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

E. Timothy Oppelt, Director  
National Risk Management Research Laboratory

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**DEMONSTRATION OF FUEL CELLS TO RECOVER  
ENERGY FROM LANDFILL GAS**

**PHASE III. DEMONSTRATION TESTS, AND PHASE IV.  
GUIDELINES AND RECOMMENDATIONS**

**Volume 2. Appendices**

by

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Office of Research and Development  
Washington, D.C. 20460**

## ABSTRACT

This report summarizes the results of a four-phase program with the U. S. Environmental Protection Agency under Contract 68-D1-0008, "Demonstration of Fuel Cells to Recover Energy from Landfill Gas." The environmental impact of widespread use of this concept would be a significant reduction of global warming gas emissions (methane and carbon dioxide). This work was conducted over the period from January 1991 through June 1995.

International Fuel Cells Corporation (IFC) conducted the four-phase program to demonstrate that fuel cell energy recovery using a commercial phosphoric acid fuel cell is both environmentally sound and commercially feasible. Phase I, a conceptual design and evaluation study, addressed the technical and economic issues associated with operation of the fuel cell energy recovery system of landfill gas. Phase II includes design, construction and testing of a landfill gas pretreatment unit (GPU) to remove critical fuel poisons such as sulfur and halides from the landfill gas, and to design fuel cell modifications to permit operation on low heating value landfill gas. Phase III was the demonstration test of the complete fuel cell energy recovery system. Phase IV described how the commercial fuel cell power plant could be further modified to achieve full rated power on low heating value landfill gas.

The demonstration test successfully demonstrated operation of the energy recovery system, including the GPU and commercial phosphoric acid fuel cell modified for operation on landfill gas. Demonstration output included operation up to 137 kW; 37.1 percent efficiency at 120 kW; exceptionally low secondary emissions (dry gas, 15% O<sub>2</sub>) of 0.77 ppmV carbon monoxide, 0.12 ppmV nitrogen oxides, and undetectable sulfur dioxide; no forced outages with adjusted availability of 98.5 percent; and a total of 709 hours operation on landfill gas. The pretreatment (GPU) operated for a total of 2,297 hours, including the 709 hours with the fuel cell, and documented total sulfur and halide removal to much lower than specified <3 ppmV for the fuel cell. The GPU flare safely disposed of the removed landfill gas contaminants by achieving destruction efficiencies greater than 99 percent. An environmental and economic evaluation of a commercial fuel cell energy system concluded there is a large potential market for fuel cells in this application.



**TABLE OF CONTENTS – VOLUME 1**

<b>Section</b>	<b>Page</b>
ABSTRACT .....	ii
FIGURES .....	vii
TABLES .....	viii
REFERENCES .....	ix
ABBREVIATIONS .....	x
UNITS AND CONVERSION FACTORS .....	x
1.0 EXECUTIVE SUMMARY .....	1
2.0 INTRODUCTION .....	7
3.0 CONCEPTUAL DESIGN, COST AND EVALUATION STUDY .....	9
3.1 Requirement for Landfill Gas Application .....	9
3.1.1 Landfill Gas Availability .....	9
3.1.2 Landfill Gas Characteristics .....	9
3.1.3 Emission Requirements .....	10
3.1.4 Present Options for Methane Abatement from Landfill Gas .....	11
3.1.5 Requirements for Conceptual Design .....	11
3.2 Commercial Fuel Cell Landfill Gas to Energy System Conceptual Design .....	12
3.2.1 Overall System Description .....	12
Fuel Pretreatment System .....	13
Fuel Cell Power Plant .....	16
Overall System Performance .....	18
Impact of Heating Value on System Performance .....	19
3.2.2 Environmental and Economic Assessment on the Fuel Cell Energy Conversion System .....	20
Environmental Assessment .....	21
Economic Assessment Results .....	22
Comparison With Other Energy Conversion Options .....	24
Conclusions .....	25
3.2.3 Critical Issues .....	26
Marketing Issues .....	26
Technical Issues .....	26

## TABLE OF CONTENTS

Section	Page
4.0 DEMONSTRATION TEST DESIGN .....	27
4.1 Select Landfill Site .....	27
4.1.1 Site Selection Criteria .....	27
4.1.2 Characteristics of Candidate Sites and Selection .....	27
4.1.3 Description of Selected Site .....	30
4.2 Landfill Gas Pretreatment Unit Process Design and Description .....	34
4.2.1 Process Operation .....	35
4.2.1.1 Clean Gas Production Process .....	35
4.2.1.2 Regeneration Process .....	37
4.2.1.3 Refrigeration Process .....	37
4.3 PC25 Power Plant Design Modifications .....	40
4.3.1 Introduction and Background .....	40
4.3.2 Phase II Summary .....	40
4.3.2.1 Modify Control Software .....	41
4.3.2.2 Cathode Exit Orifice .....	41
4.3.2.3 Recycle Orifice .....	41
4.3.2.4 Inlet Fuel Controls .....	41
4.3.2.5 Halide Guard Bed .....	41
4.3.2.6 Startup .....	41
4.4 Site Specific Process Design .....	42
4.4.1 Overall System and Site Description .....	42
4.5 Site Specific Engineering Design .....	44
4.5.1 Site Location .....	44
4.5.2 Site Arrangement .....	44
4.5.3 Site Design Details .....	47
5.0 GPU VERIFICATION TEST .....	48
5.1 Landfill Gas Pretreatment Module Test Plan .....	48
5.2 Permitting .....	50
5.2.1 South Coast Air Quality Management District Permit .....	50
5.2.2 L.A. City Permits .....	50



## TABLE OF CONTENTS

Section	Page
5.3 Test Results .....	51
5.3.1 Factory Test Results .....	51
5.3.2 Site Checkout Test Results .....	51
5.3.3 Phase II, EPA Field Test .....	52
5.3.4 Conclusions from Phase II GPU Field Test .....	57
6.0 FUEL CELL DEMONSTRATION TEST .....	58
6.1 Test and Quality Assurance Project Plan (QAPP) .....	58
6.2 Test Preparation .....	58
6.2.1 Permitting .....	58
6.2.2 Site Preparation .....	58
6.2.3 Fuel Cell Installation and Checkout on Natural Gas .....	58
6.2.4 Modifications for Landfill Gas .....	60
6.2.5 Checkout for Landfill Gas Operation .....	60
6.3 Demonstration Test Results .....	61
6.3.1 GPU Performance .....	61
6.3.1.1 Operation and Reliability .....	61
6.3.1.2 GPU Contaminant Removal Performance .....	63
6.3.1.3 GPU Exit Gas Heat Content .....	65
6.3.2 Fuel Cell Performance .....	66
6.3.2.1 Fuel Cell Operation and Availability .....	66
6.3.2.2 Fuel Cell Power Plant Efficiency .....	67
6.3.2.3 Fuel Cell Maintenance and Operator Requirements .....	69
6.3.3 Emissions .....	70
6.3.4 Quality Assurance .....	71
7.0 PHASE IV GUIDELINES AND RECOMMENDATIONS .....	74
8.0 CONCLUSIONS .....	76

**TABLE OF CONTENTS – VOLUME 2**

<b>Section</b>	<b>Page</b>
<b>LIST OF APPENDICES</b>	
Appendix A (Summary of Detailed Site Design) .....	A-1
Appendix B (Landfill Gas Pretreatment Test Plan) .....	B-1
Appendix C (H <sub>2</sub> S Removal Over Westates Carbon) .....	C-1
Appendix D (Executive Summary of Landfill Gas Pretreatment Performance Test Report by TRC Environmental Corp.) .....	D-1
Appendix E (Properties of d-limonene Refrigerant) .....	E-1
Appendix F (Laboratory Data on Reaction of Hydrogen Sulfide to Carbonyl Sulfide) .....	F-1
Appendix G (Site Specific Test Plan and Quality Assurance Project Plan, Revision No. 2, December 1994) .....	G-1
Appendix H (System Performance and Emission Test Report, by TRC Environmental, May 1995) Phase III Fuel Cell/Landfill Gas Energy Recovery Demonstration, Penrose Landfill .....	H-1
Sub-Appendix A – Process Data .....	H-A1
Sub-Appendix B – GPU Exit Heat Content Analytical Data – ASTM Method .....	H-B1
Sub-Appendix C – Power Plant Emissions Data .....	H-C1
Sub-Appendix D – Flare Emission Data From Phase II .....	H-D1
Sub-Appendix E – GPU Exit Contaminant Measurement Data .....	H-E1
Sub-Appendix F – Calibration Data And Certifications .....	H-F1
Sub-Appendix G – ASTM Method Heat Content Analysis QA Replicates .....	H-G1
Sub-Appendix H – Halide And Sulfur Compound Audit Data ... ..	H-H1
Sub-Appendix I – Fuel Cell Emissions QA Data .....	H-I1
Sub-Appendix J – Fuel Cell Emissions Calibration Error Data .....	H-J1
Sub-Appendix K – Fuel Cell Exhaust Gas Flowrate Data .....	H-K1
Sub-Appendix L – ASTM Heat Content Analysis Audit Data .....	H-L1



## LIST OF FIGURES

Figure	Page
1-1. Fuel Cell Energy Conversion System Commercial Concept .....	2
1-2. Landfill Gas Pretreatment Unit (GPU) System .....	3
1-3. GPU Installation at Pacific Energy Landfill .....	4
1-4. PC25 Power Plant Installation at California Landfill Site .....	6
3-1. Commercial Fuel Cell Landfill Gas to Energy Conversion Concept .....	12
3-2. Simplified Block Diagram of Commercial LFG Pretreatment System .....	13
3-3. Staged Regeneration of Adsorbent Beds and Sample Regeneration Sequence .....	15
3-4. Functional Schematic Fuel Cell Landfill Gas Power Unit .....	17
3.5. Overall System Schematic and Performance Estimate for Fuel Cell LFG to Energy Conversion System .....	19
3-6. Impact of Landfill Gas Heating Value on Power Plant Power Output and Heat Rate .....	20
3-7. Comparison of Fuel Cell to Flare for Methane Mitigation Assuming Electric Revenues, Emission Credits and Thermal Recovery .....	23
3-8. Comparison of Fuel Cell to Flare for Methane Mitigation Assuming Electric Revenues and Emission Credits .....	23
3-9. Comparison of Fuel Cell to Flare for Methane Mitigation Assuming Electric Revenues Only .....	24
3-10. Comparison of Fuel Cell to I.C.E. Energy Conversion System .....	25
4-1. Penrose Plant Supplies Alternative Energy to Southern California Power Grid (Courtesy of Pacific Energy) .....	31
4-2. Landfill Gas to Electric Power (Courtesy of Pacific Energy) .....	32
4-3. Fuel Cell Site Options (Courtesy of Pacific Energy) .....	33
4-4. Landfill Gas Pretreatment Unit System .....	35
4-5. Gas Purification Process .....	36
4-6. Regeneration Process .....	38
4-7. Refrigeration Process Unit .....	39
4-8. LFG Fuel Cell Demonstration Program .....	42
4-9. Demonstration Project Processes .....	43
4-10. Fuel Cell Site Options: Site 2 Selected for Demonstration (Courtesy of Pacific Energy) .....	45
4-11. Site Layout .....	46
5-1. Phase II Gas Pretreatment Unit Sample Location .....	53
5-2. Landfill Gas Pretreatment Unit Sample Location for GPU Flare Tests .....	55
6-1. Installation of PC25 at Los Angeles Landfill .....	59
6-2. Photograph of the GPU and Power Plant Installed at the Penrose Site .....	60
6-3. GPU Exit Contaminant Concentration vs. Time .....	63
6-4. Demonstrator System Schematic .....	68
7-1. PC25 C Fuel Delivery Train .....	74
7-2. PC25 C Fuel Delivery Train Modified for Operation on Landfill Gas .....	74

## LIST OF TABLES

<b>Table</b>	<b>Page</b>
1-1. GPU Sulfur and Halide Contaminant Removal Performance and Specification . . . . .	5
3-1. Size Distribution of Landfills and Potential Power Output . . . . .	9
3-2. Landfill Gas Characteristics . . . . .	10
3-3. Key Features of Commercial Pretreatment System Conceptual Design . . . . .	15
3-4. Gas Pretreatment System Projected Performance . . . . .	16
3-5. Performance Comparison for Nominal 200 kW Output . . . . .	17
3-6. Estimated Fuel Cell Air Emissions . . . . .	18
3-7. Site Characteristics for Landfill Gas Assessment . . . . .	21
3-8. Emissions Impact of Fuel Cell Energy Recovery from Landfill Gas . . . . .	21
4-1 Pacific Energy Landfill Gas Sites . . . . .	28
4-2 Assessment of Candidates Sites vs. Evaluation Criteria . . . . .	29
4-3 Supplemental Landfill Data for Candidate Sites . . . . .	30
4-4 Raw Landfill Gas Contaminants and Concentration at Penrose Test Site . . . . .	34
4-5 Modification to PC25 A for Operation at 140 kW in Landfill Gas Demonstration . . . . .	40
4-6 Summary of Detail Site for EPA Landfill Gas Demonstration . . . . .	47
5-1 Test Protocol for Phase II EPA Field Test . . . . .	49
5-2 Permit Activities for EPA Gas Pretreatment . . . . .	50
5-3 Gas Pretreatment Unit Sulfur Removal Performance . . . . .	52
5-4 Summary of Phase II Testing of Gas Pretreatment Unit . . . . .	54
5-5 Landfill Gas Pretreatment Unit Field Test Results for GPU Flare . . . . .	55
6-1 GPU Validation Test Results Prior to Start of Fuel Demonstration Field Test . . . . .	61
6-2 GPU Run Summary . . . . .	62
6-3 GPU Contaminant Removal Performance During Phase III . . . . .	64
6-4 GPU Exit Gas Heat Content . . . . .	65
6-5 Summary of Fuel Cell Operations on Landfill Gas . . . . .	66
6-6 Fuel Cell Electrical Efficiency on Landfill Gas . . . . .	68
6-7 Operation and Maintenance Cost Factor for Commercial Applications . . . . .	69
6-8 Fuel Cell Emissions Summary on Landfill Gas . . . . .	70
6-9 Summary of Quality Assurance Goals and Test Results . . . . .	72
6-10 Typical Concentrations, Detection Limits, and Blank Results for Targeted Compounds in the Raw Landfill Gas at the Penrose Landfill . . . . .	73

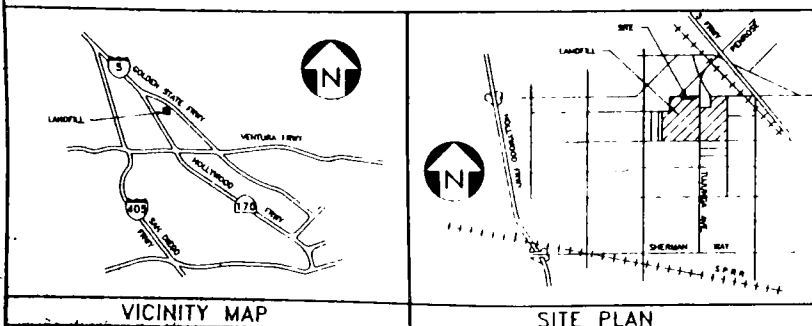


## **APPENDIX A**

### **Summary of Detailed Site Design for EPA Landfill Gas Demonstration**



NOTE: SEE FOUNDATION PLAN FOR EQUIPMENT LOCATION

[illegible]



## GENERAL

- THE GENERAL CONTRACTOR SHALL VERIFY CONTRACT DOCUMENTS, ALL DIMENSIONS AND SITE CONDITIONS BEFORE STARTING WORK. THE ENGINEER SHALL BE NOTIFIED OF ANY DISCREPANCY BEFORE PROCEEDING WITH THE WORK.
- IN CASE OF CONFLICT BETWEEN CONTRACT DOCUMENTS, THE ENGINEER SHALL PRECEDE WITH ANY WORK INVOLVED.
- NOTES AND DETAILS ON DRAWINGS SHALL TAKE PRECEDENCE OVER GENERAL NOTES AND TYPICAL DETAILS. WHERE NO DETAILS ARE SHOWN, CONSTRUCTION SHALL CONFORM TO SIMILAR WORK ON PROJECT AND CONTRACTOR SHALL NOTIFY THE ENGINEER.
- ALL WORK SHALL CONFORM TO THE MINIMUM STANDARDS OF THE 1988 EDITION OF THE UNIFORM BUILDING CODE AND ANY OTHER REGULATION AGENCIES THAT HAVE AUTHORITY OVER ANY PORTION OF THE WORK, INCLUDING THE STATE OF CALIFORNIA, DIVISION OF INDUSTRIAL SAFETY AND THOSE CODES AND STANDARDS LISTED IN THESE NOTES AND SPECIFICATIONS.
- THE CONTRACT STRUCTURAL DRAWINGS AND SPECIFICATIONS REPRESENT THE INTENDED STRUCTURE. THEY DO NOT INDICATE THE METHOD OF CONSTRUCTION. THE CONTRACTOR SHALL PROVIDE ALL MEASURES NECESSARY TO PROTECT THE STRUCTURE DURING CONSTRUCTION. SUCH MEASURES SHALL INCLUDE BUT NOT BE LIMITED TO BRACING, SHORING, OR LOADS DUE TO CONSTRUCTION EQUIPMENT. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO NOTIFY THE STRUCTURAL ENGINEER OF ANY INSPECTION OF THE ABOVE ITEMS.
- CONTRACTOR SHALL INVESTIGATE SITE DURING CLEARING AND EARTHWORK OPERATION FOR FLEED EXCAVATIONS OR BURIED STRUCTURES SUCH AS CESSPOOLS, CISTERNS, FOUNDATIONS, ETC. IF ANY STRUCTURES ARE FOUND, STRUCTURAL ENGINEER SHALL BE NOTIFIED IMMEDIATELY.
- THE GENERAL CONTRACTOR SHALL EXAMINE THE ARCHITECTURAL AND MECHANICAL DRAWINGS FOR REQUIRED OPENINGS AND PIPE SLEEVES IN THE JOB. VERIFY SIZE AND LOCATION OF ALL OPENINGS WITH MECHANICAL CONTRACTOR.
- GENERAL CONTRACTOR SHALL GIVE DUE AND LEGAL NOTICE TO ADJACENT PROPERTY OWNERS REGARDING THE PROTECTION OF THEIR PROPERTY AND STRUCTURES WHICH MAY BE NECESSARY DUE TO EXCAVATION AND CONSTRUCTION PLACED ON THESE DRAWINGS IN DUE TIME PRIOR TO START OF EXCAVATION.

## FOUNDATIONS

- THE ALLOWABLE SOIL BEARING IS PER THE UNIFORM BUILDING CODE 1981 EDITION AND IS LISTED BELOW.
- FOUNDATION SHALL CONSIST OF CONTINUOUS AND SPREAD FOOTING POURED ON UNDISTURBED SOIL (MINIMUM OF 12" WIDE AND 6" DEEP) ALLOWABLE SOIL BEARING PRESSURE:
    - SPREAD FOOTINGS 1000 PSI
    - CONTINUOUS FOOTINGS 1000 PSI
  - CONCRETE SLAB PLACEMENT SHALL BE 1200 PSI MINIMUM OR 40'-0" LONG MAXIMUM. ADJACENT SLAB SHOULD NOT BE PLACED IN 48 HOURS.
  - ALL REQUIRED FILL AND BACKFILL SHALL BE COMPACTED TO 95% OF THE MAXIMUM DENSITY.
  - FILL AND FOUNDATION EXCAVATION SHALL BE INSPECTED AND APPROVED BY THE SOIL ENGINEER PRIOR TO POURING.
  - WATER SHALL BE REMOVED FROM FOUNDATION EXCAVATION PRIOR TO POURING OF CONCRETE. FOOTING SHALL BE POURED IMMEDIATELY AT EXCAVATION.

DATE	DESCRIPTION	BY	CHKD	DATE
1	PLAN CHECK COMMENTS	ELW	PAB	6/1/94
2	INCORPORATED CLIENT COMMENTS	ELW	BC	6/1/94
3	CHANGED LOCATION PER CLIENT	ELW	BC	6/1/94
4	FOR APPROVAL	ELW	BC	6/1/94
5	DESCRIPTION	ELW	BC	6/1/94

## WORK IN PLACE CONCRETE

- ALL PHASES OF WORK PERTAINING TO THE CONCRETE CONSTRUCTION SHALL CONFORM TO THE BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE (ACI 318 LATEST APPROVED EDITION) WITH MODIFICATIONS AS NOTED IN THE DRAWINGS OR SPECIFICATION.
- CONCRETE MIXES SHALL BE DESIGNED BY A QUALIFIED TESTING LABORATORY APPROVED BY LOCAL BUILDING OFFICIALS AND CONFORM TO ASTM C 94.
- THE MINIMUM ULTIMATE COMPRESSIVE STRENGTH OF CONCRETE AT 28 DAYS SHALL BE AS FOLLOWS:
- | LOCATION           | STRENGTH |
|--------------------|----------|
| CONTINUOUS FOOTING | 2000 PSI |
| SPREAD FOOTING     | 2000 PSI |
| SLAB ON GRADE      | 2000 PSI |
| GRADE BEAM         | 2000 PSI |
| ALL OTHERS         | 2000 PSI |
- ALL CEMENT SHALL CONFORM TO ASTM C-150 TYPE I OR TYPE II.
  - AGGREGATE FOR MASS CONCRETE SHALL CONFORM TO ALL REQUIREMENTS AND TESTS OF ASTM C-33 AND PROJECT SPECIFICATIONS. EXCEPTIONS MAY BE USED ONLY WITH PERMISSION OF THE STRUCTURAL ENGINEER.
  - POURING OF CONCRETE SHALL CONFORM TO ACI STANDARDS 304 AND PROJECT SPECIFICATIONS. BOMBAST ALL CONCRETE SURFACES AGAINST WHICH CONCRETE IS TO BE PLACED.
  - ALL REINFORCING BARS, ANCHOR BOLTS AND OTHER CONCRETE INSERTS SHALL BE WELL SECURED IN POSITION PRIOR TO POURING CONCRETE.
  - PROVIDE SLEEVES FOR PLUMBING AND ELECTRICAL OPENINGS IN CONCRETE BEFORE POURING. DO NOT CUT ANY REINFORCING WHICH MAY COMPLECT CORING IN CONCRETE. IF NOT PERMITTED EXCEPT AS SHOWN, NOTIFY THE STRUCTURAL ENGINEER IN ADVANCE OF CONDITIONS NOT SHOWN ON THE DRAWINGS.
  - CONCRETE SHALL BE MAINTAINED IN A MOIST CONDITION FOR A MIN. OF 8 DAYS AFTER POURING.
  - LOCATION OF CONSTRUCTION JOINTS AND OTHER TYPES OF JOINTS, OTHER THAN SPECIFIED OR DETAILED ON DRAWINGS, SHALL BE APPROVED BY THE ENGINEER BEFORE POURING.
  - ALL CONCRETE IN A 28 DAY STRENGTH GREATER THAN 1500 PSI AND REINFORCING STEEL SHALL BE INSPECTED BY A REGISTERED DEPUTY INSPECTOR PER UBC SECTION 306.
  - CRACK USED UNDER STEEL COLUMN BASE PLATES SHALL BE OF NON-DIFFERENCE JARITY WITH MINIMUM COMPRESSIVE STRENGTH OF 8000 PSI IN 28 DAYS.

## REINFORCING STEEL

- ALL REINFORCING STEEL SHALL BE DEFORMED BARS CONFORMING TO ASTM A615 GRADE 60 UNLESS NOTED OTHERWISE.
- WELDED WIRE FABRIC SHALL CONFORM TO ASTM A185.
- DETAILING, FABRICATION AND ERECTION OF REINFORCING BARS SHALL CONFORM TO THE LATEST EDITION OF THE ACI MANUAL OF STANDARD PRACTICE FOR DETAILING REINFORCED STRUCTURES.
- BARS SHALL BE CLEAN OF RUST, GREASE OR OTHER MATERIAL LIKELY TO IMPAIR BOND.
- ALL BAR BENDS SHALL BE MADE COLD.
- PRIOR TO POURING CONCRETE, REINFORCING STEEL AND EMBEDDED ITEMS SHALL BE WELL SECURED IN POSITION.
- REINFORCING BARS SHALL NOT BE WELDED WITHOUT APPROVAL OF THE STRUCTURAL ENGINEER.
- THE LAPS ON WWP SHOULD BE ON MESH PLUS IT.
- BAR LAPS SHALL BE MADE AWAY FROM POINTS OF MAXIMUM STRESS OR AT LOCATIONS SHOWN ON THE DRAWINGS. THE LAP LENGTH SHALL BE AS INDICATED BELOW UNLESS NOTED OTHERWISE:
  - COLUMNS: 36 BAR DIAMETERS
  - ALL CONTINUOUS BARS SHALL HAVE MINIMUM LAP OF C TYPE AT SPICES
  - CONCRETE BLOCK MASONRY: NO BAR DIAMETERS
- CONCRETE COVER OVER REINFORCING STEEL BARS SHALL BE AS FOLLOWS:
  - POURED AGAINST EARTH 1" CLEAR
  - EXPOSED TO EARTH IN 1" POURED AGAINST FORMS 1" CLEAR
  - STRUCTURAL SLAB 1" CLEAR
  - INTERIOR FACE OF WALLS 1" CLEAR

## SITE PREPARATION

### 2.1 GENERAL REQUIREMENTS

THE POWER PLANT MUST BE SITED IN A WELL DRAINED AREA EITHER INDOORS OR OUTDOORS. THE AREA AROUND THE POWER PLANT MUST BE FREE OF COMBUSTIBLE MATERIALS AND ADEQUATE CLEARANCES PROVIDED. AIRFLOWS, AIR SUPPLY, VENTILATION AND EXHAUST OPENINGS, USUALLY AN 8'-FT ACCESSIBILITY AREA AROUND THE POWER PLANT IS ADEQUATE. FOR OUTDOOR LOCATIONS, A SECURITY FENCE AROUND THE POWER PLANT IS RECOMMENDED TO PREVENT UNAUTHORIZED ACCESS. FOR POWER PLANTS SITED INDOORS, A LOCKED AREA IS RECOMMENDED. LOCAL CODES SHOULD BE REVIEWED TO ESTABLISH ANY ADDITIONAL REQUIREMENTS.

THE POWER PLANT WAS DESIGNED TO ACCOMMODATE EITHER ABOVE GROUND OR UNDERGROUND ACCESS TO ALL PLUMBING AND ELECTRICAL INTERFACES. THE STANDARD POWER PLANT ENCLOSURE, HOWEVER, WAS DESIGNED FOR UNDERGROUND ACCESS. IF ABOVE GROUND SITE ENTRY IS PREFERRED, NOTIFY ONCE SO THAT THE PROPER ENCLOSURE PANELS AND DIRECTIONS CAN BE PROVIDED AT THE TIME OF POWER PLANT DELIVERY.

### 2.2 FOUNDATION

THE POWER MODULE MUST BE PLACED ON A NON-COMBUSTIBLE FLAT SURFACE SUCH AS A POURED CONCRETE SLAB CAPABLE OF SUPPORTING A TOTAL LOAD OF APPROXIMATELY 80,000 LBS. THE SUPPORT AREA IN CONTACT WITH THE BASE SHOULD BE SUCH THAT THE POWER PLANT CAN BE INSTALLED PLUMB AND LEVEL. THE TOP OF THE PAD SHOULD BE LOCATED ABOVE GRADE TO PREVENT THE ACCUMULATION OF WATER WITHIN THE ENCLOSURE.

### 2.3 ACCESSIBILITY REQUIREMENTS

A MINIMUM OF EIGHT FEET OF CLEAR SPACE SHOULD BE MAINTAINED AROUND THE PERIMETER OF THE POWER PLANT TO FACILITATE MAINTENANCE. IN THE EVENT IT BECOMES NECESSARY TO REMOVE A LARGE COMPONENT, A SMALL VERTICAL LIFT OF 12 INCHES IS REQUIRED, FOLLOWED BY SIDE REMOVAL OF THE COMPONENT FROM THE POWER PLANT FRAME. ENCLOSURE SECTIONS AND FRAME MEMBERS WERE DESIGNED TO BE REMOVABLE TO ACCOMMODATE MAINTENANCE OF THIS TYPE. ROUTINE MAINTENANCE FROM THE POWER PLANT TOP REQUIRES MINIMUM HEADROOM OF 50 FEET.

PREPARED

JUN 01 1994

BOCK ENGINEERING, INC.

200KW FUEL CELL DEMONSTRATION PLANT  
8301 TUJUNGA AVE., PENROSE LANDFILL, SUN VALLEY, CA

PACIFIC ENERGY



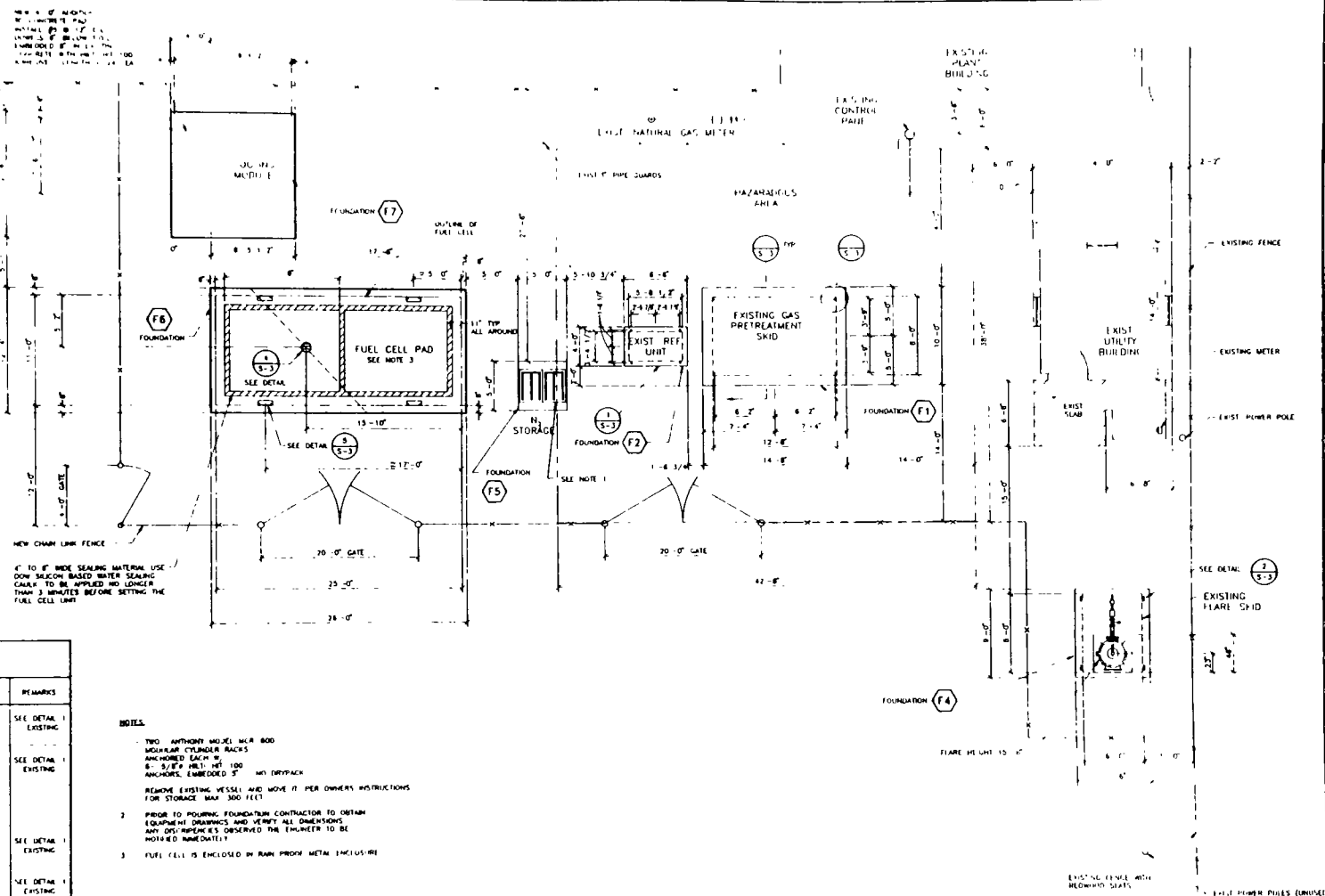
BOCK ENGINEERING, INC.  
STRUCTURAL ELECTRICAL MECHANICAL

6055 E WASHINGTON BLVD  
COMMERCIAL, CALIFORNIA 90040

174-827-1544  
FAX: 174-827-1544

DATE	9/20/96
TIME	9:05:08
USER	3

A-4



FOUNDATION PLAN



3, 16' 0"

<b>NOTES:</b> 1. CENTER OF GRAVITY OF ALL EQUIPMENT AND THEIR FOUNDATION SHALL BE IN A VERTICAL PLANE. 2. GRADE BELOW FOUNDATION SHALL BE VIRGIN SOIL OR A MINIMUM 12" (3'00") FILL EXTENDING 5 FEET BEYOND FOUNDATION BOUNDARIES. 3. $P_c = 2000$ PSI; $P_y = 60$ PSI. 4. PROVIDE 1" DRY PACK BELOW SAID BASE PLATES UNLESS NOTED OTHERWISE. 5. PAD HEIGHT ABOVE GRADE SHALL NOT EXCEED 2'.				<b>REVISIONS:</b> 1. INSTALLATION OF FUEL CELL/COOLING MODULE 2. INCORPORATED CLIENT COMMENTS 3. INCORPORATED CLIENT COMMENTS 4. CHANGED LOCATION PER CLIENT 5. FOR APPROVAL				<b>PROJECT:</b> 200KW FUEL CELL DEMONSTRATION PLANT 8301 TUJUNGA AVE, PENROSE LANDFILL, SUN VALLEY, CA <b>CLIENT:</b> PACIFIC ENERGY 6055 E WASHINGTON BLVD COMMERCE, CALIFORNIA 90040				<b>BOCK ENGINEERING, INC.</b> 4500 ARROW HIGHWAY, SUITE 100 MONTECLAIR, CALIFORNIA 91763 TEL: 909-731-0544 FAX: 909-731-0545 WWW: WWW.BOCKENGINEERING.COM				<b>PROJECT NO:</b> 92058 <b>DATE:</b> JUN 01 1994 <b>REV:</b> 2 <b>BY:</b> 5			
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A-5

DETAIL

N.T.S. 1

DETAIL

N.T.S. 2

DETAIL

N.T.S. 3

DETAIL

N.T.S. 7

DETAIL

N.T.S. 4

DETAIL

N.T.S. 5

DETAIL

N.T.S. 6

DETAIL

N.T.S. 8

STRUCTURAL STEEL

STRUCTURAL STEEL SHALL CONFORM TO THE FOLLOWING ASTM DESIGNATIONS

ASTM A36 - ALL STEEL FRAMING

ASTM A325 - ALL BOLTS USED FOR CONNECTING STRUCTURAL MEMBERS

ASTM A307 - ALL ANCHOR BOLTS

2. ALL STRUCTURAL STEEL SHALL BE FABRICATED IN THE SHOP OF A LICENSED FABRICATOR AND SHOP DRAWINGS SHALL BE SUBMITTED TO THE STRUCTURAL ENGINEER FOR APPROVAL PRIOR TO FABRICATION

3. WELDING SHALL BE DONE IN AN APPROVED FABRICATION SHOP BY WELDERS QUALIFIED AS REQUIRED BY THE BUILDING DEPARTMENT CONFORMING TO THE LATEST AWS SPECIFICATIONS AND STANDARDS. ELECTRODES SHALL BE AS FOLLOWS

E-70 ELECTRODES - A-36 STRUCTURAL STEEL

4. FIELD WELDING SHALL BE DONE BY A LOS ANGELES CERTIFIED WELDER. ALL FIELD WELDS SHALL BE INSPECTED BY AN APPROVED SPECIAL INSPECTOR PER U.B.C. SECTION 304

5. CONTINUOUS INSPECTION IS REQUIRED FOR ALL FIELD WELDING AND HIGH STRENGTH BOLTS

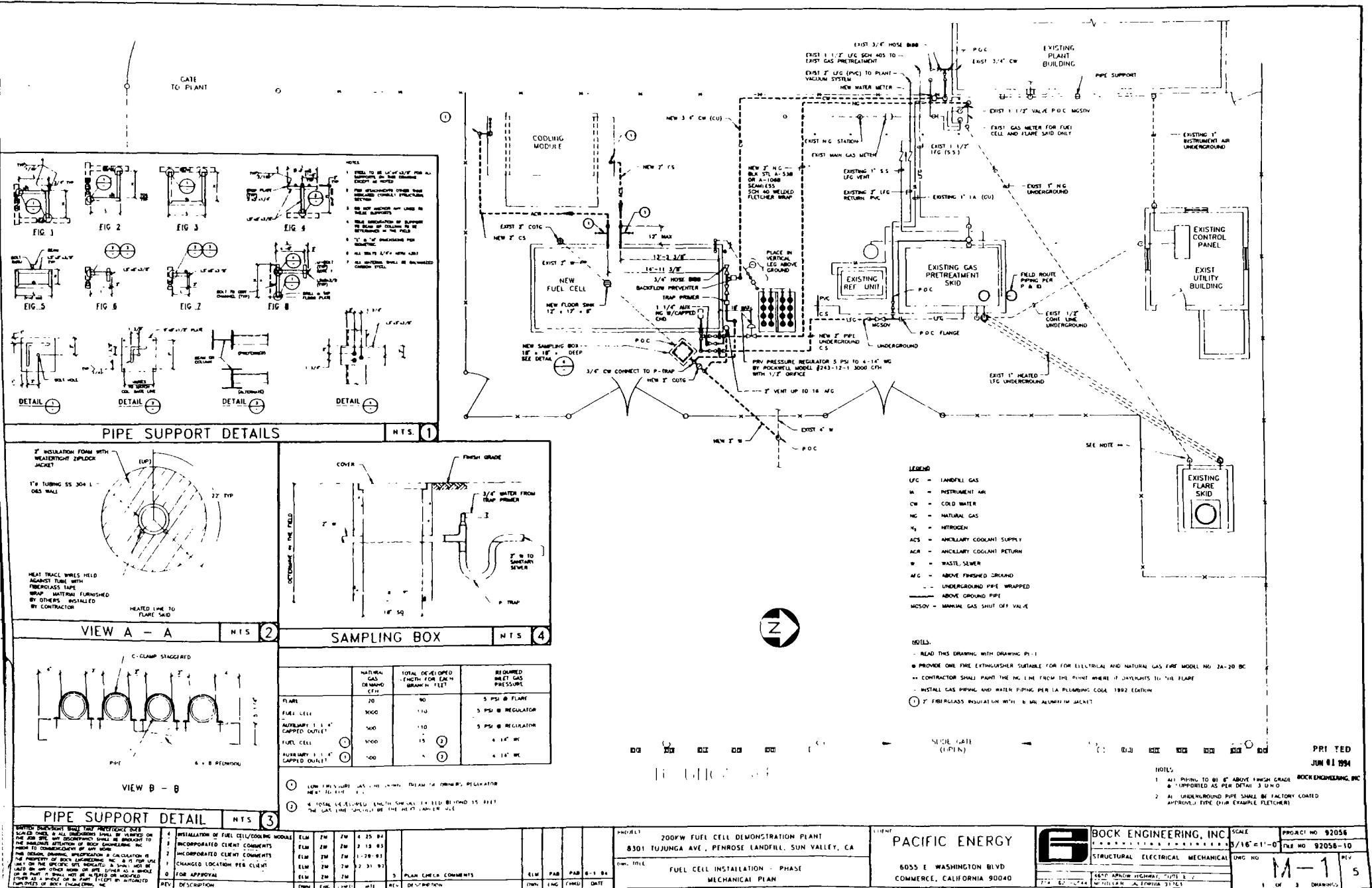
6. ALL STEEL SHALL BE POWER TOOL CLEANED AND PRIME COATED WITH MIL-G-4506 PRIMER AND ONE FINISH PAINT COAT PER OWNER SPECIFICATIONS

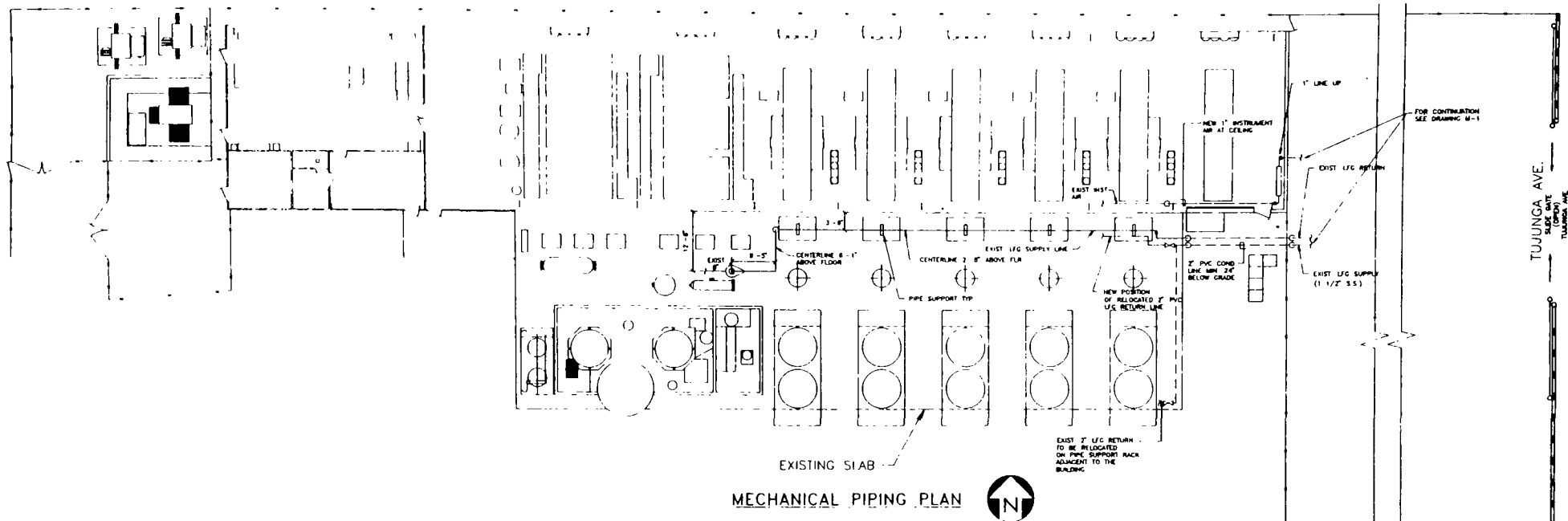
PRI: TED

JUN 01 1994

BOCK ENGINEERING, INC.

CLIENT	PROJECT	SCALE	PROJECT NO.
PACIFIC ENERGY	200KW FUEL CELL DEMONSTRATION PLANT 8301 TUJUNGA AVE., PENROSE LANDFILL, SUN VALLEY, CA	NOTED	02058
6055 E WASHINGTON BLVD COMMERCE, CALIFORNIA 90040	FUEL CELL INSTALLATION - PHASE III STRUCTURAL DETAILS	DWG. NO.	FILE NO. 02058-15
714 871-0544		REV	S-3 5
		OF 2 DRAWINGS	






# MECHANICAL PIPING PLAN

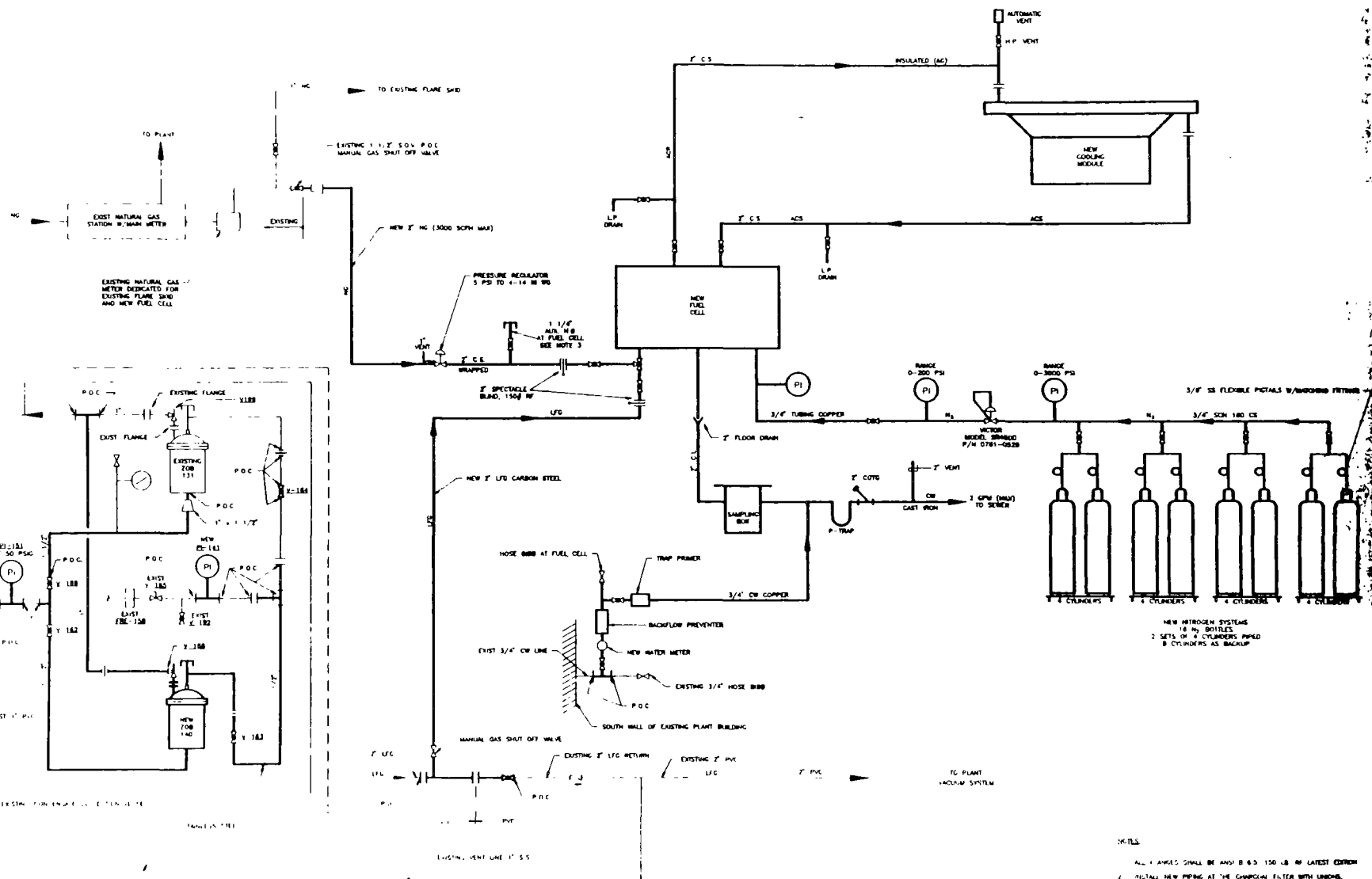


## NOTES

- FABRICATION HEREINAFTER SHALL INCLUDE FABRICATION AND ERECTION OF ALL SHOP-FABRICATED AND FIELD-FABRICATED PIPING, WHICH SHALL INCLUDE ALL COMPONENT PARTS NECESSARY TO COMPLETE FINAL PIPING INSTALLATION WITH ALL LINES CLEANED, SUPPORTED, TESTED AND READY FOR PLANT OPERATION.
- THIS SPECIFICATION COVERS, BUT IS NOT LIMITED TO, THE FOLLOWING OPERATIONS:  
FABRICATION AND ERECTION OF ALL FIELD-FABRICATED PIPING INCLUDING CUTTING, THREADING, BENDING, WELDING, BOLTING AND THE LIKE.  
ASSEMBLY AND ERECTION OF ALL SHOP-FABRICATED PIPING SUBASSEMBLIES.  
FABRICATION AND ERECTION OF MISCELLANEOUS ITEMS AS FOLLOWS: ALL PIPING SPECIALTIES.  
IN LINE AND VESSEL ATTACHED INSTRUMENTATION WHICH CLOSSES UP ANY OPENINGS IN LINES OR VESSELS INCLUDING, BUT NOT LIMITED TO, THERMOWELLS, PRESSURE GAUGE VALVING, ORifice VALVING, LEVEL INSTRUMENTS, AND THE LIKE.  
FABRICATION AND ERECTION OF PIPE SUPPORTS, GUIDES, HANGERS AND AUXILIARY STEEL AS DETAILED IN PIPING SUPPORT & SUPPORTS FOR ALL PIPING. ALL SIZES OF PIPE RACK PIPING AS WELL AS PIPE ATTACHED TRIMMINGS.  
INSPECTION AND TESTING OPERATIONS.
- SPECIFICATIONS AND DRAWINGS INCLUDE ARRANGEMENT, MATERIAL AND SIZES OF FABRICATED PIPING.
- BEFORE STARTING FABRICATION OPERATIONS, CONTRACTOR SHALL SUBMIT COMPLETE WELDING PROCEDURE SPECIFICATIONS, INCLUDING DETAILED WELDING METHODS AND CHEMICAL COMPOSITION OF PURGE GAS, IF USED, TO PURCHASER FOR APPROVAL.
- ALL METALLIC PIPING TO BE WRAPPED WITH 1/2" WALL PLASTIC PIPEWRAP AND EXTENDED A MINIMUM 12" ABOVE AND BEYOND UNIT LEVEL.
- CAUTION SHALL BE TAKEN FOR TRENCHING OF NEW PIPING. ANY DAMAGE TO EXISTING UNDERGROUND PIPE SHALL BE CONNECTED TO THE SATISFACTION OF OWNER AT THE CONTRACTOR'S EXPENSE.  
ALL PIPING SHALL BE FIELD TESTED TO MATCH ALL EQUIPMENT, FUTURE DEVICES, TUNING AND TO EXISTING EXISTING OBSTACLES.
- ALL PIPING SHALL BE PAINTED AS FOLLOWS:  
A. 1" THROUGH 4"  
B. 4" THROUGH 6"  
C. 6" THROUGH 12"  
D. 12" THROUGH 24"  
E. 24" THROUGH 48"  
F. 48" THROUGH 72"  
G. 72" THROUGH 96"  
H. 96" THROUGH 120"  
I. 120" THROUGH 144"  
J. 144" THROUGH 168"  
K. 168" THROUGH 192"  
L. 192" THROUGH 216"  
M. 216" THROUGH 240"  
N. 240" THROUGH 264"  
O. 264" THROUGH 288"  
P. 288" THROUGH 312"  
Q. 312" THROUGH 336"  
R. 336" THROUGH 360"  
S. 360" THROUGH 384"  
T. 384" THROUGH 408"  
U. 408" THROUGH 432"  
V. 432" THROUGH 456"  
W. 456" THROUGH 480"  
X. 480" THROUGH 504"  
Y. 504" THROUGH 528"  
Z. 528" THROUGH 552"  
AA. 552" THROUGH 576"  
AB. 576" THROUGH 600"  
AC. 600" THROUGH 624"  
AD. 624" THROUGH 648"  
AE. 648" THROUGH 672"  
AF. 672" THROUGH 696"  
AG. 696" THROUGH 720"  
AH. 720" THROUGH 744"  
AI. 744" THROUGH 768"  
AJ. 768" THROUGH 792"  
AK. 792" THROUGH 816"  
AL. 816" THROUGH 840"  
AM. 840" THROUGH 864"  
AN. 864" THROUGH 888"  
AO. 888" THROUGH 912"  
AP. 912" THROUGH 936"  
AQ. 936" THROUGH 960"  
AR. 960" THROUGH 984"  
AS. 984" THROUGH 1008"  
AT. 1008" THROUGH 1032"  
AU. 1032" THROUGH 1056"  
AV. 1056" THROUGH 1080"  
AW. 1080" THROUGH 1104"  
AX. 1104" THROUGH 1128"  
AY. 1128" THROUGH 1152"  
AZ. 1152" THROUGH 1176"  
BA. 1176" THROUGH 1200"  
BB. 1200" THROUGH 1224"  
BC. 1224" THROUGH 1248"  
BD. 1248" THROUGH 1272"  
BE. 1272" THROUGH 1296"  
BF. 1296" THROUGH 1320"  
BG. 1320" THROUGH 1344"  
BH. 1344" THROUGH 1368"  
BI. 1368" THROUGH 1392"  
BJ. 1392" THROUGH 1416"  
BK. 1416" THROUGH 1440"  
BL. 1440" THROUGH 1464"  
BM. 1464" THROUGH 1488"  
BN. 1488" THROUGH 1512"  
BO. 1512" THROUGH 1536"  
BP. 1536" THROUGH 1560"  
BQ. 1560" THROUGH 1584"  
BR. 1584" THROUGH 1608"  
BS. 1608" THROUGH 1632"  
BT. 1632" THROUGH 1656"  
BU. 1656" THROUGH 1680"  
BV. 1680" THROUGH 1704"  
BW. 1704" THROUGH 1728"  
BX. 1728" THROUGH 1752"  
BY. 1752" THROUGH 1776"  
BZ. 1776" THROUGH 1800"  
CA. 1800" THROUGH 1824"  
CB. 1824" THROUGH 1848"  
CC. 1848" THROUGH 1872"  
CD. 1872" THROUGH 1896"  
CE. 1896" THROUGH 1920"  
CF. 1920" THROUGH 1944"  
CG. 1944" THROUGH 1968"  
CH. 1968" THROUGH 1992"  
CI. 1992" THROUGH 2016"  
CJ. 2016" THROUGH 2040"  
CK. 2040" THROUGH 2064"  
CL. 2064" THROUGH 2088"  
CM. 2088" THROUGH 2112"  
CN. 2112" THROUGH 2136"  
CO. 2136" THROUGH 2160"  
CP. 2160" THROUGH 2184"  
CQ. 2184" THROUGH 2208"  
CR. 2208" THROUGH 2232"  
CS. 2232" THROUGH 2256"  
CT. 2256" THROUGH 2280"  
CU. 2280" THROUGH 2304"  
CV. 2304" THROUGH 2328"  
CW. 2328" THROUGH 2352"  
CX. 2352" THROUGH 2376"  
CY. 2376" THROUGH 2400"  
CZ. 2400" THROUGH 2424"  
DA. 2424" THROUGH 2448"  
DB. 2448" THROUGH 2472"  
DC. 2472" THROUGH 2496"  
DD. 2496" THROUGH 2520"  
DE. 2520" THROUGH 2544"  
DF. 2544" THROUGH 2568"  
DG. 2568" THROUGH 2592"  
DH. 2592" THROUGH 2616"  
DI. 2616" THROUGH 2640"  
DJ. 2640" THROUGH 2664"  
DK. 2664" THROUGH 2688"  
DL. 2688" THROUGH 2712"  
DM. 2712" THROUGH 2736"  
DN. 2736" THROUGH 2760"  
DO. 2760" THROUGH 2784"  
DP. 2784" THROUGH 2808"  
DQ. 2808" THROUGH 2832"  
DR. 2832" THROUGH 2856"  
DS. 2856" THROUGH 2880"  
DT. 2880" THROUGH 2904"  
DU. 2904" THROUGH 2928"  
DV. 2928" THROUGH 2952"  
DW. 2952" THROUGH 2976"  
DX. 2976" THROUGH 3000"  
DY. 3000" THROUGH 3024"  
DZ. 3024" THROUGH 3048"  
EA. 3048" THROUGH 3072"  
EB. 3072" THROUGH 3096"  
EC. 3096" THROUGH 3120"  
ED. 3120" THROUGH 3144"  
EE. 3144" THROUGH 3168"  
EF. 3168" THROUGH 3192"  
EG. 3192" THROUGH 3216"  
EH. 3216" THROUGH 3240"  
EI. 3240" THROUGH 3264"  
EJ. 3264" THROUGH 3288"  
EK. 3288" THROUGH 3312"  
EL. 3312" THROUGH 3336"  
EM. 3336" THROUGH 3360"  
EN. 3360" THROUGH 3384"  
EO. 3384" THROUGH 3408"  
EP. 3408" THROUGH 3432"  
EQ. 3432" THROUGH 3456"  
ER. 3456" THROUGH 3480"  
ES. 3480" THROUGH 3504"  
ET. 3504" THROUGH 3528"  
EU. 3528" THROUGH 3552"  
EV. 3552" THROUGH 3576"  
EW. 3576" THROUGH 3600"  
EX. 3600" THROUGH 3624"  
EY. 3624" THROUGH 3648"  
EZ. 3648" THROUGH 3672"  
FA. 3672" THROUGH 3696"  
FB. 3696" THROUGH 3720"  
FC. 3720" THROUGH 3744"  
FD. 3744" THROUGH 3768"  
FE. 3768" THROUGH 3792"  
FF. 3792" THROUGH 3816"  
FG. 3816" THROUGH 3840"  
FH. 3840" THROUGH 3864"  
FI. 3864" THROUGH 3888"  
FJ. 3888" THROUGH 3912"  
FK. 3912" THROUGH 3936"  
FL. 3936" THROUGH 3960"  
FM. 3960" THROUGH 3984"  
FN. 3984" THROUGH 4008"  
FO. 4008" THROUGH 4032"  
FP. 4032" THROUGH 4056"  
FQ. 4056" THROUGH 4080"  
FR. 4080" THROUGH 4104"  
FS. 4104" THROUGH 4128"  
FT. 4128" THROUGH 4152"  
FU. 4152" THROUGH 4176"  
FV. 4176" THROUGH 4200"  
FW. 4200" THROUGH 4224"  
FX. 4224" THROUGH 4248"  
FY. 4248" THROUGH 4272"  
FZ. 4272" THROUGH 4296"  
GA. 4296" THROUGH 4320"  
GB. 4320" THROUGH 4344"  
GC. 4344" THROUGH 4368"  
GD. 4368" THROUGH 4392"  
GE. 4392" THROUGH 4416"  
GF. 4416" THROUGH 4440"  
GG. 4440" THROUGH 4464"  
GH. 4464" THROUGH 4488"  
GI. 4488" THROUGH 4512"  
GJ. 4512" THROUGH 4536"  
GK. 4536" THROUGH 4560"  
GL. 4560" THROUGH 4584"  
GM. 4584" THROUGH 4608"  
GN. 4608" THROUGH 4632"  
GO. 4632" THROUGH 4656"  
GP. 4656" THROUGH 4680"  
GQ. 4680" THROUGH 4704"  
GR. 4704" THROUGH 4728"  
GS. 4728" THROUGH 4752"  
GT. 4752" THROUGH 4776"  
GU. 4776" THROUGH 4800"  
GV. 4800" THROUGH 4824"  
GW. 4824" THROUGH 4848"  
GX. 4848" THROUGH 4872"  
GY. 4872" THROUGH 4896"  
GZ. 4896" THROUGH 4920"  
HA. 4920" THROUGH 4944"  
HB. 4944" THROUGH 4968"  
HC. 4968" THROUGH 4992"  
HD. 4992" THROUGH 5016"  
HE. 5016" THROUGH 5040"  
HF. 5040" THROUGH 5064"  
HG. 5064" THROUGH 5088"  
HH. 5088" THROUGH 5112"  
HI. 5112" THROUGH 5136"  
HJ. 5136" THROUGH 5160"  
HK. 5160" THROUGH 5184"  
HL. 5184" THROUGH 5208"  
HM. 5208" THROUGH 5232"  
HN. 5232" THROUGH 5256"  
HO. 5256" THROUGH 5280"  
HP. 5280" THROUGH 5304"  
HQ. 5304" THROUGH 5328"  
HR. 5328" THROUGH 5352"  
HS. 5352" THROUGH 5376"  
HT. 5376" THROUGH 5400"  
HU. 5400" THROUGH 5424"  
HV. 5424" THROUGH 5448"  
HW. 5448" THROUGH 5472"  
HX. 5472" THROUGH 5496"  
HY. 5496" THROUGH 5520"  
HZ. 5520" THROUGH 5544"  
IA. 5544" THROUGH 5568"  
IB. 5568" THROUGH 5592"  
IC. 5592" THROUGH 5616"  
ID. 5616" THROUGH 5640"  
IE. 5640" THROUGH 5664"  
IF. 5664" THROUGH 5688"  
IG. 5688" THROUGH 5712"  
IH. 5712" THROUGH 5736"  
II. 5736" THROUGH 5760"  
IJ. 5760" THROUGH 5784"  
IK. 5784" THROUGH 5808"  
IL. 5808" THROUGH 5832"  
IM. 5832" THROUGH 5856"  
IN. 5856" THROUGH 5880"  
IO. 5880" THROUGH 5904"  
IP. 5904" THROUGH 5928"  
IQ. 5928" THROUGH 5952"  
IR. 5952" THROUGH 5976"  
IS. 5976" THROUGH 6000"  
IT. 6000" THROUGH 6024"  
IU. 6024" THROUGH 6048"  
IV. 6048" THROUGH 6072"  
IW. 6072" THROUGH 6096"  
IX. 6096" THROUGH 6120"  
IY. 6120" THROUGH 6144"  
IZ. 6144" THROUGH 6168"  
JA. 6168" THROUGH 6192"  
JB. 6192" THROUGH 6216"  
JC. 6216" THROUGH 6240"  
JD. 6240" THROUGH 6264"  
JE. 6264" THROUGH 6288"  
JF. 6288" THROUGH 6312"  
JG. 6312" THROUGH 6336"  
JH. 6336" THROUGH 6360"  
JI. 6360" THROUGH 6384"  
JJ. 6384" THROUGH 6408"  
JK. 6408" THROUGH 6432"  
JL. 6432" THROUGH 6456"  
JM. 6456" THROUGH 6480"  
JN. 6480" THROUGH 6504"  
JO. 6504" THROUGH 6528"  
JP. 6528" THROUGH 6552"  
JQ. 6552" THROUGH 6576"  
JR. 6576" THROUGH 6600"  
JS. 6600" THROUGH 6624"  
JT. 6624" THROUGH 6648"  
JU. 6648" THROUGH 6672"  
JV. 6672" THROUGH 6696"  
JW. 6696" THROUGH 6720"  
JX. 6720" THROUGH 6744"  
JY. 6744" THROUGH 6768"  
JZ. 6768" THROUGH 6792"  
KA. 6792" THROUGH 6816"  
KB. 6816" THROUGH 6840"  
KC. 6840" THROUGH 6864"  
KD. 6864" THROUGH 6888"  
KE. 6888" THROUGH 6912"  
KF. 6912" THROUGH 6936"  
KG. 6936" THROUGH 6960"  
KH. 6960" THROUGH 6984"  
KI. 6984" THROUGH 7008"  
KJ. 7008" THROUGH 7032"  
KK. 7032" THROUGH 7056"  
KL. 7056" THROUGH 7080"  
KM. 7080" THROUGH 7104"  
KN. 7104" THROUGH 7128"  
KO. 7128" THROUGH 7152"  
KP. 7152" THROUGH 7176"  
KQ. 7176" THROUGH 7200"  
KR. 7200" THROUGH 7224"  
KS. 7224" THROUGH 7248"  
KT. 7248" THROUGH 7272"  
KU. 7272" THROUGH 7296"  
KV. 7296" THROUGH 7320"  
KW. 7320" THROUGH 7344"  
KX. 7344" THROUGH 7368"  
KY. 7368" THROUGH 7392"  
KZ. 7392" THROUGH 7416"  
LA. 7416" THROUGH 7440"  
LB. 7440" THROUGH 7464"  
LC. 7464" THROUGH 7488"  
LD. 7488" THROUGH 7512"  
LE. 7512" THROUGH 7536"  
LF. 7536" THROUGH 7560"  
LG. 7560" THROUGH 7584"  
LH. 7584" THROUGH 7608"  
LI. 7608" THROUGH 7632"  
LJ. 7632" THROUGH 7656"  
LK. 7656" THROUGH 7680"  
LL. 7680" THROUGH 7704"  
LM. 7704" THROUGH 7728"  
LN. 7728" THROUGH 7752"  
LO. 7752" THROUGH 7776"  
LP. 7776" THROUGH 7800"  
LQ. 7800" THROUGH 7824"  
LR. 7824" THROUGH 7848"  
LS. 7848" THROUGH 7872"  
LT. 7872" THROUGH 7896"  
LU. 7896" THROUGH 7920"  
LV. 7920" THROUGH 7944"  
LW. 7944" THROUGH 7968"  
LX. 7968" THROUGH 7992"  
LY. 7992" THROUGH 8016"  
LZ. 8016" THROUGH 8040"  
MA. 8040" THROUGH 8064"  
MB. 8064" THROUGH 8088"  
MC. 8088" THROUGH 8112"  
MD. 8112" THROUGH 8136"  
ME. 8136" THROUGH 8160"  
MF. 8160" THROUGH 8184"  
MG. 8184" THROUGH 8208"  
MH. 8208" THROUGH 8232"  
MI. 8232" THROUGH 8256"  
MJ. 8256" THROUGH 8280"  
MK. 8280" THROUGH 8304"  
ML. 8304" THROUGH 8328"  
MN. 8328" THROUGH 8352"  
MO. 8352" THROUGH 8376"  
MP. 8376" THROUGH 8400"  
MQ. 8400" THROUGH 8424"  
MR. 8424" THROUGH 8448"  
MS. 8448" THROUGH 8472"  
MT. 8472" THROUGH 8496"  
MU. 8496" THROUGH 8520"  
MV. 8520" THROUGH 8544"  
MW. 8544" THROUGH 8568"  
MX. 8568" THROUGH 8592"  
MY. 8592" THROUGH 8616"  
MZ. 8616" THROUGH 8640"  
NA. 8640" THROUGH 8664"  
NB. 8664" THROUGH 8688"  
NC. 8688" THROUGH 8712"  
ND. 8712" THROUGH 8736"  
NE. 8736" THROUGH 8760"  
NF. 8760" THROUGH 8784"  
NG. 8784" THROUGH 8808"  
NH. 8808" THROUGH 8832"  
NI. 8832" THROUGH 8856"  
NJ. 8856" THROUGH 8880"  
NK. 8880" THROUGH 8904"  
NL. 8904" THROUGH 8928"  
NM. 8928" THROUGH 8952"  
NO. 8952" THROUGH 8976"  
NP. 8976" THROUGH 9000"  
NQ. 9000" THROUGH 9024"  
NR. 9024" THROUGH 9048"  
NS. 9048" THROUGH 9072"  
NT. 9072" THROUGH 9096"  
NU. 9096" THROUGH 9120"  
NV. 9120" THROUGH 9144"  
NW. 9144" THROUGH 9168"  
NX. 9168" THROUGH 9192"  
NY. 9192" THROUGH 9216"  
NZ. 9216" THROUGH 9240"  
OA. 9240" THROUGH 9264"  
OB. 9264" THROUGH 9288"  
OC. 9288" THROUGH 9312"  
OD. 9312" THROUGH 9336"  
OE. 9336" THROUGH 9360"  
OF. 9360" THROUGH 9384"  
OG. 9384" THROUGH 9408"  
OH. 9408" THROUGH 9432"  
OI. 9432" THROUGH 9456"  
OJ. 9456" THROUGH 9480"  
OK. 9480" THROUGH 9504"  
OL. 9504" THROUGH 9528"  
OM. 9528" THROUGH 9552"  
ON. 9552" THROUGH 9576"  
OO. 9576" THROUGH 9600"  
OP. 9600" THROUGH 9624"  
OQ. 9624" THROUGH 9648"  
OR. 9648" THROUGH 9672"  
OS. 9672" THROUGH 9696"  
OT. 9696" THROUGH 9720"  
OU. 9720" THROUGH 9744"  
OV. 9744" THROUGH 9768"  
OW. 9768" THROUGH 9792"  
OX. 9792" THROUGH 9816"  
OY. 9816" THROUGH 9840"  
OZ. 9840" THROUGH 9864"  
PA. 9864" THROUGH 9888"  
PB. 9888" THROUGH 9912"  
PC. 9912" THROUGH 9936"  
PD. 9936" THROUGH 9960"  
PE. 9960" THROUGH 9984"  
PF. 9984" THROUGH 10008"  
PG. 10008" THROUGH 10032"  
PH. 10032" THROUGH 10056"  
PI. 10056" THROUGH 10080"  
PJ. 10080" THROUGH 10104"  
PK. 10104" THROUGH 10128"  
PL. 10128" THROUGH 10152"  
PM. 10152" THROUGH 10176"  
PN. 10176" THROUGH 10200"  
PO. 10200" THROUGH 10224"  
PP. 10224" THROUGH 10248"  
PQ. 10248" THROUGH 10272"  
PR. 10272" THROUGH 10296"  
PS. 10296" THROUGH 10320"  
PT. 10320" THROUGH 10344"  
PU. 10344" THROUGH 10368"  
PV. 10368" THROUGH 10392"  
PW. 10392" THROUGH 10416"  
PX. 10416" THROUGH 10440"  
PY. 10440" THROUGH 10464"  
PZ. 10464" THROUGH 10488"  
QA. 10488" THROUGH 10512"  
QB. 10512" THROUGH 10536"  
QC. 10536" THROUGH 10560"  
QD. 10560" THROUGH 10584"  
QE. 10584" THROUGH 10608"  
QF. 10608" THROUGH 10632"  
QG. 10632" THROUGH 10656"  
QH. 10656" THROUGH 10680"  
QI. 10680" THROUGH 10704"  
QJ. 10704" THROUGH 10728"  
QK. 10728" THROUGH 10752"  
QL. 10752" THROUGH 10776"  
QM. 10776" THROUGH 10800"  
QN. 10800" THROUGH 10824"  
QO. 10824" THROUGH 10848"  
QP. 10848" THROUGH 10872"  
QQ. 10872" THROUGH 10896"  
QR. 10896" THROUGH 10920"  
QS. 10920" THROUGH 10944"  
QT. 10944" THROUGH 10968"  
QU. 10968" THROUGH 10992"  
QV. 10992" THROUGH 11016"  
QW. 11016" THROUGH 11040"  
QX. 11040" THROUGH 11064"  
QY. 11064" THROUGH 11088"  
QZ. 11088" THROUGH 11112"  
RA. 11112" THROUGH 11136"  
RB. 11136" THROUGH 11160"  
RC. 11160" THROUGH 11184"  
RD. 11184" THROUGH 11208"  
RE. 11208" THROUGH 11232"  
RF. 11232" THROUGH 11256"  
RG. 11256" THROUGH 11280"  
RH. 11280" THROUGH 11304"  
RI. 11304" THROUGH 11328"  
RJ. 11328" THROUGH 11352"  
RK. 11352" THROUGH 11376"  
RL. 11376" THROUGH 11400"  
RM. 11400" THROUGH 11424"  
RN. 11424" THROUGH 11448"  
RO. 11448" THROUGH 11472"  
RP. 11472" THROUGH 11496"  
RQ. 11496" THROUGH 11520"  
RR. 11520" THROUGH 11544"  
RS. 11544" THROUGH 11568"  
RT. 11568" THROUGH 11592"  
RU. 11592" THROUGH 11616"  
RV. 11616" THROUGH 11640"  
RW. 11640" THROUGH 11664"  
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RZ. 11712" THROUGH 11736"  
SA. 11736" THROUGH 11760"  
SB. 11760" THROUGH 11784"  
SC. 11784" THROUGH 11808"  
SD. 11808" THROUGH 11832"  
SE. 11832" THROUGH 11856"  
SF. 11856" THROUGH 11880"  
SG. 11880" THROUGH 11904"  
SH. 11904" THROUGH 11928"  
SI. 11928" THROUGH 11952"  
SJ. 11952" THROUGH 11976"  
SK. 11976" THROUGH 12000"  
SL. 12000" THROUGH 12024"  
SM. 12024" THROUGH 12048"  
SN. 12048" THROUGH 12072"  
SO. 12072" THROUGH 12096"  
SP. 12096" THROUGH 12120"  
SQ. 12120" THROUGH 12144"  
SR. 12144" THROUGH 12168"  
SS. 12168" THROUGH 12192"  
ST. 12192" THROUGH 12216"  
SU. 12216" THROUGH 12240"  
SV. 12240" THROUGH 12264"  
SW. 12264" THROUGH 12288"  
SX. 12288" THROUGH 12312"  
SY. 12312" THROUGH 12336"  
SZ. 12336" THROUGH 12360"  
TA. 12360" THROUGH 12384"  
TB. 12384" THROUGH 12408"  
TC. 12408" THROUGH 12432"  
TD. 12432" THROUGH 12456"  
TE. 12456" THROUGH 12480"  
TF. 12480" THROUGH 12504"  
TG. 12504" THROUGH 12528"  
TH. 12528" THROUGH 12552"  
TI. 12552" THROUGH 12576"  
TJ. 12576" THROUGH 12600"  
TK. 12600" THROUGH 12624"  
TL. 12624" THROUGH 12648"  
TM. 12648" THROUGH 12672"  
TN. 12672" THROUGH 12696"  
TO. 12696" THROUGH 12720"  
TP. 12720" THROUGH 12744"  
TQ. 12744" THROUGH 12768"  
TR. 12768" THROUGH 12792"  
TS. 12792" THROUGH 12816"  
TU. 12816" THROUGH 12840"  
TV. 12840" THROUGH 12864"  
TW. 12864" THROUGH 12888"  
TX. 12888" THROUGH 12912"  
TY. 12912" THROUGH 12936"  
TZ. 12936" THROUGH 12960"  
UA. 12960" THROUGH 12984"  
UB. 12984" THROUGH 13008"  
UC. 13008" THROUGH 13032"  
UD. 13032" THROUGH 13056"  
UE. 13056" THROUGH 13080"  
UF. 13080" THROUGH 13104"  
UG. 13104" THROUGH 13128"  
UH. 13128" THROUGH 13152"  
UI. 13152" THROUGH 13176"  
UJ. 13176" THROUGH 13200"  
UK. 13200" THROUGH 13224"  
UL. 13224" THROUGH 13248"  
UM. 13248" THROUGH 13272"  
UN. 13272" THROUGH 13296"  
UO. 13296" THROUGH 13320"  
UP. 13320" THROUGH 13344"  
UQ. 13344" THROUGH 13368"  
UR. 13368" THROUGH 13392"  
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VT. 14040" THROUGH 14064"  
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VV. 14088" THROUGH 14112"  
VW. 14112" THROUGH 14136"  
VX. 14136" THROUGH 14160"  
VY. 14160" THROUGH 14184"  
VZ. 14184" THROUGH 14208"  
WA. 14208" THROUGH 14232"  
WB. 14232" THROUGH 14256"  
WC. 14256" THROUGH 14280"  
WD. 14280" THROUGH 14304"  
WE. 14304" THROUGH 14328"  
WF. 14328" THROUGH 14352"  
WG. 14352" THROUGH 14376"  
WH. 14376" THROUGH 14400"  
WI. 14400" THROUGH 14424"  
WJ. 14424" THROUGH 14448"  
WK. 14448" THROUGH 14472"  
WL. 14472" THROUGH 14496"  
WM. 14496" THROUGH 14520"  
WN. 14520" THROUGH 14544"  
WO. 14544" THROUGH 14568"  
WP. 14568" THROUGH 14592"  
WQ. 14592" THROUGH 14616"  
WR. 14616" THROUGH 14640"  
WS. 14640" THROUGH 14664"  
WT. 14664" THROUGH 14688"  
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WV. 14712" THROUGH 14736"  
WW. 14736" THROUGH 14760"  
WX. 14760" THROUGH 14784"  
WY. 14784" THROUGH 14808"  
WZ. 14808" THROUGH 14832"  
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XC. 14880" THROUGH 14904"  
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XI. 15024" THROUGH 15048"  
XJ. 15048" THROUGH 15072"  
XK. 15072" THROUGH 15096"  
XL. 15096" THROUGH 15120"  
XM. 15120" THROUGH 15144"  
XN. 15144" THROUGH 15168"  
XO. 15168" THROUGH 15192"  
XP. 15192" THROUGH 15216"  
XQ. 15216" THROUGH 15240"  
XR. 15240" THROUGH 15264"  
XS. 15264" THROUGH 15288"  
XT. 15288" THROUGH 15312"  
XU. 15312" THROUGH 15336"  
XV. 15336" THROUGH 15360"  
XW. 15360" THROUGH 15384"  
XX. 15384" THROUGH 15408"  
XY. 15408" THROUGH 15432"  
XZ. 15432" THROUGH 15456"  
YA. 15456" THROUGH 15480"  
YB. 15480" THROUGH 15504"  
YC. 15504" THROUGH 15528"  
YD. 15528" THROUGH 15552"  
YE. 15552" THROUGH 15576"  
YF. 15576" THROUGH 156



- LFG - LAND FILL GAS
- NB - NATURAL GAS
- ACS - ANKILLARY COOLANT SUPPLY
- ACR - ANKILLARY COOLANT RETURN
- H<sub>2</sub> - HYDROGEN
- OW - COLD WATER
- P.O.C - POINT OF CONNECTION
- PI** - PRESSURE INDICATOR
-  - PRESSURE RELIEF VALVE
- [B] - BALL VALVE
- [S] - DIAPHRAGM SEAL VALVE OR GLOBE VALVE
- - EXISTING PIPING
- - NEW PIPING



NOTES

- ALL ANGLES SHALL BE AND 1/8 150 LB OR LATEST EDITION
- INSTALL NEW PIPING AT THE CHAMBERLAIN FILTER WITH UNIONS TO FACILITATE COMPLETE REMOVING OF THE HEAD AND OF THE CHAMBERLAIN FILTERS INSIDE
- NO INTERCONNECTION EXISTS INSIDE THE FUEL CELL BETWEEN THE AUXILIARY AIR FLOW AND LFC

PRI. TED  
JUN 01 1994


NOTHING HEREIN SHALL CONSTITUTE OR BE  
DECLARED OR BE A CONTRACT AND SHALL BE VOIDED ON  
THE DAY THE SPECIFIC INFORMATION SHALL BE BROUGHT TO  
THE IMMEDIATE ATTENTION OF BOCK ENGINEERING, INC.  
PRIOR TO COMMENCEMENT OF ANY WORK.

THIS DESIGN, DRAWING, SPECIFICATION OR CALCULATION IS  
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BE PART OF ANY OTHER WORK, IN WHOLE OR MODIFIED  
OTHER AS A WHOLE OR IN PART, UNLESS BY AUTHORIZED  
EMPLOYEES OF BOCK ENGINEERING, INC.

1	PLAN CHECK COMMENTS	ELW	PAB	PAB	8-1-84								
2	INSTALLATION OF FUEL CELL COOLING MODULES	ELW	RMJ	JW	4-25-84								
REV	DESCRIPTION	CHNG	BY	APPD	DATE	REV	DESCRIPTION	CHNG	BY	APPD	DATE		

PROJECT	200KW FUEL CELL DEMONSTRATION PLANT 8301 TUJUNGA AVE. PENROSE LANDFILL, SUN VALLEY, CA
W. NO.	FUEL CELL INSTALLATION - PHASE III P & I D

PACIFIC ENERGY  
6055 E WASHINGTON BLVD  
COMMERCE, CALIFORNIA 90040

	<b>BOCK ENGINEERING, INC.</b>	
	CONSULTING ENGINEERS	
	STRUCTURAL ELECTRICAL MECHANICAL	
	4650 ARROW HIGHWAY SUITE 117 MONTCLAIR, CALIFORNIA 91763	
809	821-0544	

SCALE	PROJECT NO 92058
N.T.S.	FILE NO 92058-17
DRG NO	REV
PI-1	
DRAWING	

**APPENDIX B**

**LANDFILL GAS PRETREATMENT MODULE TEST PLAN  
FCR-12706A, DATED  
MAY 1993 (REVISED JULY 1993)**

**DEMONSTRATION OF FUEL CELLS TO RECOVER  
ENERGY FROM LANDFILL GAS**

**Landfill Gas Pretreatment Module Test And Quality Assurance Plan**

**May 1993**

**Revised July 1993**

**Contract 68-D1-0008**

**FCR-12706A**

**Prepared for**

**AEERL  
Global Warming Control Branch (MD-63)  
Research Triangle Park, NC 27711**

**International  
Fuel Cells**

## TABLE OF CONTENTS

Section	Page
1.0 OBJECTIVE .....	B-4
2.0 QUALIFICATION OF LFG PRETREATMENT UNIT PROCESS CONDITIONS .....	B-5
1 Factory Test (Completed) .....	B-5
2 Site Check-Out Test .....	B-5
3 Phase II EPA Field Test .....	B-5
3.0 PHASE II EPA FIELD TEST AND QUALITY ASSURANCE PLAN .....	B-6
3.1 Scope .....	B-6
3.2 Phase II Testing/Schedule .....	B-6
3.3 Sampling and Analysis Methods .....	B-11
3.4 QA/QC Procedures .....	B-13
4.0 FIELD TEST PLAN FOR SCAQMD AIR QUALITY PERMIT REQUIREMENTS .....	B-15
4.1 Background .....	B-15
4.2 Test Operation/Schedule .....	B-15
4.3 Sampling and Analysis Methods .....	B-15
4.4 QA/QC Procedures for Special SCAQMD .....	B-16
 ATTACHMENTS	
ATTACHMENT A      FCCS 5736 .....	B-19
ATTACHMENT B      PROCESS DESCRIPTION .....	B-30
ATTACHMENT C      FACTORY TEST DATA .....	B-45
ATTACHMENT D      SCAQMD PERMITS REQUIREMENTS .....	B-51

## **LANDFILL GAS PRETREATMENT MODULE TEST AND QUALITY ASSURANCE PLAN**

### **1.0 OBJECTIVE**

The Test Plan details the EPA Phase II Field Test of the Gas Pretreatment Unit (GPU) to confirm the functionality of the gas pretreatment module for the fuel cell power plant field demonstration. It also describes the additional emissions testing that will be conducted to satisfy the requirements of the South Coast Air Quality Management District (SCAQMD) permit. Included is: a) a schedule and all operating conditions under which tests will be made, b) all parameters to be measured, recorded, and observed, c) a detailed description of the sampling and testing techniques to be used, and d) specifications for all test equipment and instrumentation required to make the necessary measurements. This plan addresses the quality assurance/quality control requirements of EPA/Air and Energy Engineering Research Laboratory's Category IV projects. The verification criteria will be the demonstration of the performance parameters of the Landfill Gas Pretreatment System specification (FCCS5736). The key parameters of this specification are removal of sulfur and halide contaminants to 3 ppmv each. A copy of FCCS5736 is provided in Attachment A for reference.

IFC's philosophy is to demonstrate a potential commercial gas pretreatment module, that is designed to be factory assembled and checked out, then delivered to any landfill with confidence the process will meet the fuel specification. The Phase II Field Test will also address the flexibility of the gas pretreatment process to clean landfill gas as a variety of different sites. Confirmation of this includes a challenge test of the gas pretreatment module with dichlorodifluoromethane. Dichlorodifluoromethane was selected because it is a light halogenated hydrocarbon which is difficult to remove. This challenge will be conducted once the desired operating parameters have been selected. Implementation of the Test Plan to validate the operation of the gas pretreatment unit represents a major step toward completion of that demonstration.



## **2.0 QUALIFICATION OF LFG PRETREATMENT UNIT PROCESS CONDITIONS**

The initial test effort is to qualify the gas pretreatment unit process operating conditions. The Landfill Gas (LFG) pretreatment unit process design and operating conditions were selected by IFC and Bio-Gas Development Inc., using chemical industry and landfill gas purification experience and adsorbent and heat exchanger vendor recommendations. A detailed description of the process design is provided in Attachment B. Qualifications of the process design and conditions will be done in three steps:

### **1 Factory Test (Completed)**

Factory Test was conducted to verify the thermal, mechanical, and electrical operability of the LFG pretreatment unit. The test was completed in February 1993. The unit was operated for 16 hours (one complete adsorption-regeneration cycle on both sets of adsorption beds) at rated flow conditions on N<sub>2</sub> gas. The operating features of the unit, excluding the condensation and adsorption of LFG water vapor and contaminants, and excluding operation of the flare were verified.

Included in this Verification Test was the operation of the refrigeration system, the first and second stage condenser-cooler heat exchangers, regeneration gas heater, thermal cycling of the regenerable dehydration and activated carbon beds, automatic valve sequencing programmable controller, pneumatic actuator and actuating valves, operation of all mechanical and electrical and components, and verification of all process flows, system pressure, pressure drops, and temperatures throughout the system consistent with the process design.

Factory Test data are provided in Attachment C.

### **2 Site Check-Out Test**

The site check-out test will follow similar procedures used during the factory N<sub>2</sub> test but will include rated flow operation on landfill gas, water vapor and contaminant removal by condensation and by the regenerable adsorbent beds, and operation of the flare which destroys contaminants regenerated from the adsorbent beds. The gas pretreatment unit will be operated for a complete 16 hour cycle. Inlet and exit gas samples will be obtained periodically during the check out test for analysis off-site. These, along with samples of the raw LFG, will be returned to TRC Environmental Consultants Inc.<sup>1</sup> for preliminary analysis.

Condensates from the first stage and second stage condensers will be analyzed for the presence of hydrocarbons. Specifically, we will determine if the second stage condenser removes light hydrocarbons.

All critical temperatures, including a continuous recording of all regenerable bed thermal cycles, will be recorded. As in the factory test, process flows, pressures, and pressure drops will also be recorded. These data and the results of the gas analyses will be reviewed following the check-out test to determine if adjustments to the programmable controller are required for the Field Test.

### **3 Phase II EPA Field Test**

The Field Test will be conducted at the process conditions derived during the site check-out test. Some tuning of the regeneration timing (shortening of the adsorption-regeneration cycle) may be required if analyses of the product gas samples indicates any significant landfill gas contaminant specie breakthrough near the end of the adsorption cycle. Gas pretreatment unit performance verification, including the flare destruction efficiency will be documented according to the test plans described in Section 3 and 4 of this report and air quality permit requirements. A copy of the South Coast Quality Management District permit requirements are provided in Attachment D.

1. Corporate Headquarters: 5 Waterside Crossing, Windsor, Ct 06095 , (203) 289-8631

### 3.0 PHASE II EPA FIELD TEST AND QUALITY ASSURANCE PLAN

#### 3.1 Scope

The testing chain-of-custody and schedule to be performed is provided in Table 3.1. IFC will analyze the landfill gas entering the pretreatment unit, exiting the unit, condensates, and inlet and exit flare gases. Operation of each dual regenerable beds (designated Bed "A" and "B") will be monitored. Additionally, Bed A will undergo a special Challenge Test, involving "spiking" the LFG with approximately 50 ppm of dichlorodifluoromethane to evaluate the performance of the unit on a more highly contaminated gas typical of some landfill sites. To accomplish this, the gas pretreatment unit will be analyzed as described above, in the following modes:

- Pre-challenge – Air analyzed of Bed A characteristics before dichlorodifluoromethane injection.
- Challenge – Air analyzed during dichlorodifluoromethane injection and landfill gas.
- 24 hours after challenge on Penrose to judge the ability of the system to recover from the Challenge Test.

The Phase II tests and schedule will be described in Section 3.1.2 below. Additionally, a separate battery of tests, required by the SCAQMD air quality permit, will also be performed. These will be discussed in Section 4.

#### 3.2 Phase II Testing/Schedule

The Phase II testing will be performed over a three-day period. The day prior to the test, initiation on-line measurements and instrument calibrations will be conducted. At least two weeks prior to Field Test program, a TRC engineer will inspect the site and collect Tedlar bag samples which will be analyzed off-site to resolve any analytical problems prior to the field program. The program goal is to operate the LFG pretreatment unit for 500 hrs.

The following description assumes an eight-hour cycle time. If, as a result of the check-out testing described in Section 2, it is determined that this should be adjusted, the following would change according to the modified cycle schedule. Testing will begin on 0800 of Day one when Bed A will be started and run for a short period of time ( $\sim 1/2$  hour) on LFG. This is the pre-challenge test of Bed A. Inlet gases will be analyzed for the following:

- Total and individual sulfur compounds shown as Table 3.2-1.
- Volatile priority hydrocarbon and halohydrocarbon pollutants shown in Table 3.2-2.
- Phenol
- Elemental silicon for silanes and siloxanes in shown as Table 3.2-3.

Outlet gases will be monitored for total sulfur and individual halides. Condensate from Vessel 1 will also be tested for total organics (as carbon).

At approximately 0830 of Day one the dichlorodifluoromethane challenge test will begin by injecting the challenge gas to the inlet of the pretreatment unit. From 0830-0900, both the inlet and outlet gas will be tested for dichlorodifluoromethane. After proper calibration of the dichlorodifluoromethane additive is confirmed, testing for dichlorodifluoromethane will be performed on the outlet gases only from 0900-1500. For the last hour of the eight hour cycle, from 1500-1600, outlet gases will be tested for total sulfur, individual halides as well as dichlorodifluoromethane. Additionally, the condensate from Vessel 2 will be tested for total organics (as carbon). At approximately 1600, Bed A will be switched to the regeneration mode and Bed B will be started for an eight hour "make" cycle.

At 0000 hours of Day two, Bed B will be switched for an eight-hour regenerative cycle. Bed A will be put back into the “make” mode, running on straight LFG (without dichlorodifluoromethane “spiking”).

At 0800 hours of Day two, normal testing of Bed B will begin. Bed B will be switched to the make mode and run on LFG. From 0800 to 0900 inlet gases will be tested for the following:

- Total and individual sulfur (per Table 3.2-1)
- Volatile priority gases (per Table 3.2-2)
- Phenol
- Silicon (see Table 3.2-3)

The outlet gas of Bed B will be tested for total particulates. Condensate from Vessel 1 will also be tested for total organics (as carbon).

At approximately 0900 of Day two, after calibration of the inlet gases is completed, the outlet gases will be tested for H<sub>2</sub>S and total particulates. This will continue to approximately 1500 hours. For the final hour of the eight-hour cycle, from 1500-1600, the outlet gas will be tested for the following:

- Total sulfur
- H<sub>2</sub>S
- Individual halides
- Total particulates

Condensate from Vessel 2 will also be analyzed.

At 1600 hours, Bed B will be regenerated for eight-hours and Bed A will be switched to the “make” mode on LFG.

At 0000 hours of Day three, Bed B is switched to “make” and Bed A is “regenerated.” Final day testing begins at 0800. This test will determine how Bed A responds to normal operation, 24 hours after the challenge test. For the first hour (0800–0900) inlet gases will be tested for:

- Total and individual sulfur (see Table 3.2-1)
- Volatile priority gases (see Table 3.2-2)
- Phenol
- Silicons (see Table 3.2-3)

Outlet gas measurements will be taken of the following:

- Total Sulfur
- H<sub>2</sub>S
- Individual Halides
- Total Particulates

Condensate from Vessel 2 will be tested for total organics (as carbon).

The final hour of testing (from 1500-1600) we will analyze only outlet gases. The tests will be performed as described above.

Table 3.1-1

OFF-GAS PRETREATMENT UNIT (PTU) GAS ANALYSIS TESTING REQUIREMENTS

DAY	TIME PERIOD (HR)	OPERATING BED	INLET GAS CONDITIONS	OUTLET GAS MEASUREMENTS -- (PTU TO FUEL CELL)						INLET GAS MEASUREMENTS -- (LANDFILL TO PTU)				CONDENSATES		FLARE TESTING			COMMENTS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
				TOTAL SULFUR ONLY	H <sub>2</sub> S ONLY	INDIVIDUAL HALIDES	R-12 ONLY	TOTAL PARTICULATE	SPECIAL SCAGND TESTING (TABLE B)	R-12 ONLY	TOTAL & INDIVIDUAL SULFUR COMPOUNDS (TABLE A)	VOLATILE PRIORITY, HC + R-12 POLLUTANTS (TABLE C)	PHENOL	ELEMENTAL SILICON for SILANES & SILOXANES (TABLE D)	SPECIAL SCAGND TESTING (TABLE E)	TOTAL ORGANICS (as carbon)		* SPECIAL SCAGND TESTING *																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
																VESSEL 1	VESSEL 2	FLARE INLET (TABLE B)		FLARE EXHAUST (TABLE E)	AMBIENT (TABLE F)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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Note: R-12 = Dichlorodifluoromethane

**TABLE 3.2-1  
INDIVIDUAL SULFUR COMPOUNDS**

<b>Sulfur Constituent (ppm<sub>v</sub>)</b>		<b>Typical Value in LFG</b>
1.	H <sub>2</sub> S	1.03
2.	Methyl Mercaptan	3.0
3.	Ethyl Mercaptan	0.5
4.	Dimethyl Sulfide	8.0
5.	Dimethyl Disulfide	0.02
6.	Carbonyl Sulfide	<0.5
7.	Carbon Disulfide	<0.5
8.	Total Sulfur, as H <sub>2</sub> S (ppm)	114.5

**TABLE 3.2-2  
VOLATILE PRIORITY POLLUTANTS AND HYDROCARBONS**

<b>VOLATILE PRIORITY POLLUTANTS (PPM<sub>v</sub>)</b>		<b>Typical Values in LFG</b>
1.	Dichloroethene	0-33
2.	Dichlorethane	0-0.25
3.	Benzene	0.41-2.0
4.	Chlorobenzene	0.1-1.0
5.	Ethylbenzene	3.5-13.0
6.	Methylene Chloride	0-12.0
7.	Styrene	0-0.5
8.	Trichloroethene	0.6-2.8
9.	Trichlorofluoromethane	0-0.6
10.	Toluene	4.7-35.0
11.	Tetrachloroethene	1.0-6.3
12.	Vinyl Chloride	0.4-1.4
13.	Xylene Isomers	6.9-22.0
14.	CIS-1, s-Dichloroethane	4.1-5.1
15.	Total Organic Chloride as Cl (ppm <sub>v</sub> )	14.5-67.1
16.	Total Volatile Priority Pollutants (ppm <sub>v</sub> )	21.7-105.3



**TABLE 3.2-2 (Continued)**  
**VOLATILE PRIORITY POLLUTANTS AND HYDROCARBONS**

<b>Major Hydrocarbon Species (%)</b>		<b>Typical Values in LFG</b>
17.	Methane	41-48
18.	Ethane	0
19.	Propane	0
20.	Isobutane	0-0.01 (100 ppm <sub>v</sub> )
21.	N-Butane	0
22.	150 Pentane	0-0.097 (970 ppm <sub>v</sub> )
23.	N-Pentane	0-0.018 (180 ppm <sub>v</sub> )
24.	Hexanes	0.0040-0.039 (390 ppm <sub>v</sub> )
<b>Hydrocarbons</b>		<b>Typical Values in LFG</b>
25.	Alpha Pinene	Unknown
26.	d-Limonene	
27.	Ethyl Butyrate	
28.	Ethyl Acetate	
29.	Methyl Ethyl Ketone	
30.	Methyl Isobutyl Ketone	
31.	Acetone	
32.	Butanol	
33.	CIS 13 Dichloropropene	
34.	Naphthene	
35.	Tetrahydrofuran	
36.	Nitrobenzene	
<b>Halohydrocarbons</b>		<b>Typical Values in LFG</b>
37.	Dichlorofluoromethane	Unknown
38.	Dichlorodifluoromethane	
39.	Chlorodifluoromethane	
40.	Bromodichloromethane	

**TABLE 3.2-3**  
**SILICONES AND SILOXANES**

<b>Silanes</b>		<b>Typical Values in LFG</b>
1.	Methoxytrimethyl Silane	Unknown
<b>Siloxanes</b>		<b>Typical Values in LFG</b>
2.	Octamethyl Cyclosiloxane	Unknown
3.	Decamethyl Cycosiloxane	Unknown

### 3.3 Sampling and Analysis Methods

#### 3.3.1 Pretreatment Unit Inlet Gas Measurements

**3.3.1.1 Volatile Organic Compounds and Sulfur Compounds** – TRC will collect two 30-minute integrated samples in Tedlar bags from 0800 to 0830 on each day of the three day test. One bag sample will be analyzed by TRC on-site for total sulfur, halohydrocarbons and the target halides, and for the individual sulfur compounds. (Table 3.2-1)

The second bag sample will be analyzed by a TRC sub-contract laboratory for the following compound classes (Table 3.2-2):

- Volatile priority pollutants by gas chromatography/mass spectroscopy (GC/MS).
- C<sub>1</sub> to C<sub>6</sub> hydrocarbon species by gas chromatography/flame ionization detection (GC/FID).
- Twelve additional volatile organic compounds and four halohydrocarbons compounds by GC/MS. This analysis excludes phenol.

**3.3.1.2 Phenol** – TRC will collect triplicate one-hour gas samples on a solid sorbent tube during each test day. This sample will be analyzed by a TRC sub-contract laboratory (Environmental Health Laboratory of Hartford, CT) for phenol by High Pressure Liquid Chromatography (HPLC).

**3.3.1.3 Silicone Compounds** – TRC will collect triplicate gas samples in a liquid absorbing reagent or on a solid sorbent tube during each test day. These samples will be analyzed by a TRC sub-contract laboratory (Environmental Health Laboratory of Hartford, CT) for elemental silicon by Atomic Absorption Spectroscopy (AAS) or by a colorimetric analytical procedure. The elemental silicon data will be used as a measure of the presence of silanes and siloxanes.

#### 3.3.2 Outlet Gas Measurements

Concurrently with the inlet gas measurements, TRC will collect and analyze samples of the outlet gas as follows:

**3.3.2.1 Total Sulfur** – TRC will measure Total Sulfur (TS) concentration in the PTU outlet gas stream continuously. The TS concentration will be measured in accordance with EPA Method 6C, modified by the use of a hydrogen sulfide-to-SO<sub>2</sub> catalytic converter. The modified analyzer converts H<sub>2</sub>S to SO<sub>2</sub>, and then measures the SO<sub>2</sub> with a pulsed fluorescent Thermo Environmental Model 43 SO<sub>2</sub> analyzer. The result is a continuous measurement of total sulfur with a detection limit of approximately 10 ppb. Analyzer output will be recorded on a data logger and a strip chart.

The TS sampling system will consist of a stainless steel probe, Teflon sample line, pump, and the analyzer. The analyzer will respond to all sulfur-containing compounds, and will be calibrated with certified hydrogen sulfide (H<sub>2</sub>S) compressed gas standards, and thus the TS data will be expressed as H<sub>2</sub>S.

**3.3.2.2 ON-Line Halides** – TRC will measure Halogenated Organic Compound (HOC) concentrations in the outlet gas stream semi-continuously with a Gas Chromatograph/Electron Capture Detector (GC/ECD). The GC/ECD will be calibrated with the halohydrocarbon isomer used as the spiking agent and at least five additional halogens listed in Table 3.2-2. The system will be operated for eight hours each day, over the three-day program. The HOC sampling system will consist of a probe, heated Teflon sample line, heated pump, and the GC/EDC analyzer. The pump will continuously purge the analyzer sample loop, and an automatic sampling valve will periodically be activated to inject the sample loop contents into the analyzer.

**3.3.2.3 Halides and Freon (GC/MS Method)** – TRC will collect gas samples in Tedlar bags and analyze the samples for halohydrocarbons and the halogenated organic compounds listed in Table 3.2-2. The purpose is to provide confirmation for the analyses described in Section 3.3.2.2, to quantify the complete list of Table 3.2-2 target halides, and to identify any significant non-target halides.

A 30-minute sample will be collected at the start of the first cycle, and a 60-minute sample will be collected for subsequent samples. The five samples will be shipped to a off-site laboratory under and analyzed by low resolution Gas Chromatography/Mass Spectrometry (GC/MS).

**3.3.2.4 Reduced Sulfur Compounds** – TRC will conduct on-line semi-continuous gas analysis for reduced sulfur compounds according to a modified EPA Method 16. The individual sulfur compound analysis will be performed with a Gas Chromatograph/Flame Photometric Detector (GC/FPD), which will be calibrated with compressed gas standards containing a mixture of the sulfur compounds. A Hewlett-Packard 5890 gas chromatograph equipped with an air actuated automatic gas sampling valve will be used. The system will analyze the gas at approximately 15-minute intervals over each of the three eight-hour test periods.

**3.3.2.5 Particulate Matter Measurements** – TRC will measure the Total Particulate Matter (TPM) concentration in the PTU outlet gas stream once during each 8-hour bed cycle. The TPM concentration will be measured using a modification of EPA Method 5. A portion of the gas stream will be drawn through a filter (99.5% efficient at 0.3 microns) at approximately 0.75 cfm for the full eight-hours of each bed cycle. The filters will be returned to the TRC laboratory, and the TMP catch on the filter will be determined gravimetrically. We expect the TPM catch to be very low and for this reason particle sizing will not be feasible. Three eight-hour samples will be analyzed.

**3.3.2.6 Volumetric Flow Measurements** – TRC will measure volumetric flow rate of the outlet gas stream with a hot-wire anemometer, the output of which will be recorded continuously on a strip chart.

**3.3.2.7 Gas Pretreatment Unit Condensate Samples** – TRC will collect two liquid condensate samples during each test day. These samples will be analyzed by a TRC contract laboratory for total organic content. The results will be expressed in weight percent as carbon.

### 3.4 QA/QC PROCEDURES

#### 3.4.1 Quality Commitment

The TRC Quality Assurance program (QA) is designed to ensure that emission measurement work is performed by qualified people using proper equipment following written procedures in order to provide accurate, defensible data. This program is based upon the EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III (EPA-600/4-77-027b).

At the beginning of each test day, a meeting will be held to orient personnel to the activities scheduled for that day, to discuss results from the previous day, and to determine if any special considerations will be appropriate for the day's work.

#### 3.4.2 QA/QC Procedures

##### 3.4.2.1 Emission Measurement Methods

Sampling and measurement equipment including continuous analyzers, recorders, pilot tubes, dry gas meters, orifice meters, thermocouples, nozzles, and any other pertinent apparatus are uniquely identified, undergo preventive maintenance, and will be calibrated before and after the test program. Most calibrations will be performed with standards traceable to the National Institute of Standards and Technology (NIST) or other appropriate references. These standards include wet test meters and NIST Standard Reference Materials. Records of all calibration data are maintained in TRC files and will be available on site prior to the first test period.

During the field tests, sampling performance and progress will be continually evaluated, and deviations from sampling method criteria will be reported to the Field Team Leader who then can assess the validity of the test run. All field data will be recorded on prepared data sheets. The Field Team Leader will maintain a written log describing the events of each day. Field samples including field blanks will be transported from the field in shock-proof, secure containers. Sample integrity will be controlled through the use of prepared data sheets, positive sample identification, and chain-of-custody forms as shown in Table 3.1-1. All sampling trains will be leak-checked before and after each test.

##### 3.4.2.1.1 Methods 1, 2, 4, 26

All Method related sampling runs will be maintained at  $100 \pm 10$  percent isokinetic. Probe and hotbox temperatures will be maintained within  $25^{\circ}\text{F}$  of the temperatures specified.

Prior to the field test programs, full clean-up (background) evaluations of all sampling equipment are periodically performed at the TRC laboratories. This procedure will ensure the accuracy of the chosen equipment and procedures.

##### 3.4.2.1.2 Continuous Emission Monitoring System

The CEM system will be calibrated, leak, and bias checked at the beginning and end of each emission test. In addition, manual mea-

measurements of O<sub>2</sub> and CO<sub>2</sub> concentrations will be made on a regular basis in accordance with EPA Method 3 as a comparison to the CEM data. All calibration gases will be Protocol I or equivalent ( $\pm 1\%$ ). Multipoint calibrations will be performed on the analyzers prior to the field program to establish linearity.

#### 3.4.2.1.3 Analysis

All samples preparation and sample analyses will be performed at or under the direction of the TRC Environmental Laboratories. Standards of QA set forth in the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III (EPA-600/4-7-027b) and the Handbook for Analytical Quality Control in Water and Wastewater Laboratories (EPA-600/4-79-019, March 1979) will be strictly followed.

In the analytical laboratories, all quality control samples including field blank samples, reagents, and filter blanks will be analyzed with the actual test samples. Blank values will be subtracted from actual sample values.

The TRC Laboratory maintains a continuous QC program to monitor instrument response and analyst proficiency, and to ensure the precision and accuracy of all analytical results. This program has been developed in consultation with EPA, NIOSH, and State regulatory agencies.

TRC participates in the audit programs of the EPA Environmental Monitoring Systems Laboratory (source and ambient air) and the EPA Environmental Monitoring and Support Laboratory (water). TRC will provide a compressed gas cylinder audit to the subcontract laboratories conducting the toxic air analyses. Audit results are reviewed by the Chemistry Laboratory Manager and the Emission Measurement Section Manager, and corrective action is initiated when acceptance criteria are not met.

During the data reduction processes, all calculations will be reviewed initially by a person intimately associated with emission test program, and finally by a senior scientist or engineer not associated with the program. These QC checks will provide a means to ensure that the calculations are performed correctly and that the data are reasonable.

#### 3.4.2.1.4 Laboratory Subcontractors

Subcontract laboratories have been selected by TRC to provide analytical support not available at TRC. They offer state-of-the-art laboratory services and professional staff experience with the rigorous requirements of method development, sample analysis, and quality control. Toxic organic samples will be analyzed by two separate laboratories to provide additional quality assurance.



## **4.0 FIELD TEST PLAN FOR SCAQMD AIR QUALITY PERMIT REQUIREMENTS**

### **4.1 Background**

In addition to the EPA Phase II testing described in Section 3.0 above, emission testing will be conducted to satisfy the requirements of the SCAQMD permit. Samples will be collected from the gas pretreatment unit inlet and outlet as well as the flare inlet and outlet. In addition, ambient air samples will be collected to assess the background. A single 60-minute sample will be collected for each pollutant in the inlet and outlet LFG and triplicate samples will be collected on the flare inlet and outlet. This testing will be conducted on the second test day. One series of tests are planned to meet the permit requirements.

### **4.2 Test Operation/Schedule**

These tests will be performed on Bed B, operating in the “make” mode. The following gases will be analyzed:

- Gas Pretreatment Unit Inlet Gas
- Outlet Gas
- Flare Inlet
- Flare Outlet
- Ambient Air

The specific schedule is shown in Section 3 (See Table 3.1-1).

### **4.3 Sampling and Analysis Methods**

#### **4.3.1 Gas pretreatment unit Inlet and Outlet Gas Measurements**

TRC will conduct the following tests on the PTU inlet and outlet to measure the emissions of the compounds listed in Table 4.3.1-1.

**Methane and Non-Methane Hydrocarbons (CARB Method 25.2)** – TRC will collect a pair of cold trap samples according to CARB Method 25.2 from the PTU inlet and outlet. A single 60-minute sample pair will be collected from each location on the second test day only. Each sample will be analyzed for methane and non-methane hydrocarbons.

**Reduced Sulfur Compounds (See Table 3.2-1)** – Reduced sulfur compounds will be analyzed for the AEERL demonstration and that data will be used for the SCAQMD requirement.

**Carbon Dioxide and Oxygen** – will be analyzed according to EPA Method 3 using an Orsat analyzer. A single set of 60-minute Tedlar bag samples will be collected and analyzed on site.

**Flowrate** – will be measured at both locations with a Sierra hot wire anemometer.

**Toxic Air Contaminants** – will be measured on the AEERL program and the data will be applied to the SCAQMD requirements. See Section 3.3 for sampling and analysis methods.

#### 4.3.2 Flare Inlet and Exit Measurements

The flare inlet and outlet emissions will also be tested to demonstrate compliance with the SCAQMD permit. Also analyze the filter and backshelf (liquid droplets). Triplicate 60-minute test runs will be conducted for each compound listed in Table 4.3.1-1 for the flare inlet and Table 4.3.2-1 for the flare outlet as outlined above. Samples will be collected from 0800 to 0900, 0900 to 1200 and 1500 to 1600 on the second day of the Field Test Program.

In addition to the pollutants listed above, particulates, nitric oxides and carbon dioxide will be measured at the flare outlet only. Triplicate 60-minute samples will be collected according to EPA Methods 5, 7E and 10 respectively during the first hour of bed operation, the middle six hours and the final hour.

#### 4.3.3 Ambient Air Measurements

Concurrently with the flare testing, TRC will sample the ambient air for the pollutants listed in Table E. This will include a single 60-minute sample collected and analyzed as described above for each Table 5.2.2-2 constituent with the exception of particulates. Ambient particulates will be measured with a single high volume sample collected over an eight hour period.

#### 4.4 QA/QC Procedures for Special SCAQMD

TRC plans to follow and conform to a similar set of QA/QC procedures for the special SCAQMD testing as it will follow for the EPA Phase II testing. These procedures were described in Section 3.4.

**TABLE 4.3.1-1**  
**SCAQMD SPECIAL TEST OF PRETREATMENT UNIT**  
**INLET AND OUTLET GAS, FLARE INLET GAS**

The performance tests will be conducted at the maximum permitted steady state flow rates and will include a test of the inlet gas to the treatment system, the product gas, and flare inlet gas for:

- 1 Methane
- 2 Total Non-Methane Organics
- 3 Hydrogen Sulfide
- 4 C1 through C3 Sulfur Compounds
- 5 Carbon Dioxide
- 6 Toxic Air Contaminants, including but not limited to:

TOXIC AIR CONTAMINANTS	
1.	Benzene
2.	Chlorobenzene
3.	1, 2 Dichloroethane
4.	Dichloromethane
5.	Tetrachloroethylene
6.	Tetrachloromethane
7.	Toluene
8.	1, 1, 1 Trichloroethane
9.	Trichloroethylene
10.	Trichloromethane
11.	Vinyl Chloride
12.	Xylene

- 7 Oxygen
- 8 Nitrogen
- 9 Moisture Content
- 10 Temperature
- 11 Flow Rate

**TABLE 4.3.2-1**  
**SCAQMD SPECIAL TEST OF FLARE OUTLET GAS**

The performance tests will be conducted at the maximum permitted steady state flow rates and will include a test of the flare inlet gas for:

- 1 Methane
- 2 Total Non-Methane Organics
- 3 Oxides of Nitrogen
- 4 Carbon Monoxide
- 5 Total Particulates
- 6 Carbon Dioxide
- 7 Toxic Air Contaminants, including but not limited to:

TOXIC AIR CONTAMINANTS	
1.	Benzene
2.	Chlorobenzene
3.	1, 2 Dichloroethane
4.	Dichloromethane
5.	Tetrachloroethylene
6.	Tetrachloromethane
7.	Toluene
8.	1, 1, 1 Trichloroethane
9.	Trichloroethylene
10.	Trichloromethane
11.	Vinyl Chloride
12.	Xylene

- 8 Oxygen
- 9 Nitrogen
- 10 Moisture Content
- 11 Temperature
- 12 Flow Rate

**ATTACHMENT A**

**FCCS 5763**

**LANDFILL GAS PRETREATMENT SYSTEM  
COMPONENT SPECIFICATION**

TITLE:

LANDFILL GAS  
PRETREATMENT SYSTEM  
COMPONENT SPECIFICATION

REV LTR	AUTHOR	RELEASE NO.	DATE
—	J.L. PRESTON	D91FL273	5-3-88

PRODUCT FILE ADDRESS:

POWER PLANT/PROGRAM	SYSTEM & TAG NO.	PART NO.	DOCUMENT NO.
PC25/LANDFILL	FPRS		FCCS 5736
			PAGE <u>1</u> OF <u>8</u>

# REVISION RECORD

(DASH No.) LTR	REL NO.	LTR	DESCRIPTION	DATE
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ORIGINAL ISSUE

5/15/91

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FCCS 5736

REVISION

PAGE

2

## 1.0 SCOPE AND DESCRIPTION:

This specification defines the requirements for a landfill gas pretreatment system (pretreatment system) for an EPA landfill-gas-to-energy demonstration utilizing a commercially available 200kW fuel cell power plant. The pretreatment system will remove sulfur and halide contaminants, water, and particulates present in raw landfill gas. Removal of the landfill gas diluents, including carbon dioxide, nitrogen, and oxygen, are not required.

The pretreatment system shall include means for contaminant removal, on-site destruction of contaminants removed from the system, delivery pressure regulation of pretreated landfill gas fuel to the fuel cell power plant, and all controls. It is anticipated that the system will be a complete skid-mounted and truck-transportable unit designed for exposed weather installation and unattended operation with safety controls to provide automatic shutdown. It is desirable to apply a process operating at a pressure as close to atmospheric as possible.

## 2.0 APPLICABLE DOCUMENTS:

At the time of contract, the latest version of the applicable documents with any amendments shall apply.

### 2.1 NATIONAL STANDARDS:

This system must be suitable for siting in an industrial setting in the city of Los Angeles. It therefore must be designed and built to recognize industrial standards such as ANSI B31 Code for Pressure Piping, ASME Boiler and Pressure Vessel Code, NFPA, FM, AGA and NEMA.

### 2.2 STATE AND LOCAL CODES:

City of Los Angeles Unified Building Code,

City of Los Angeles Electrical Code,

City of Los Angeles Bureau of Fire Prevention Code,

City of Los Angeles Health Department Code,

California State Industrial Code: Title 8,

South Coast Air Quality Management District, Rules & Specifications

DOCMT. NO.

FCCS 5736

REVISION

PAGE

3



### 3.0 REQUIREMENTS:

#### 3.1 SUMMARY:

The gas pretreatment system will accept compressed raw landfill gas available at 80 to 95 psig from an existing site supply and will supply clean landfill gas of an appropriate temperature, pressure, humidity, and contaminant specification limit to the fuel cell on demand at a flow rate of up to 120,000 standard cubic feet per day (5000 SCFH). The system will provide the functions of water and particulate removal, contaminant removal, contaminant incineration, and supply pressure regulation on an automatic basis once operation is initiated.

#### 3.2 INTERFACES:

##### 3.2.1 Input Gas

The landfill gas feed to the pretreatment system will be available at up to 84 SCFM (5000 SCFH) and will have the following nominal properties:

- Temperature 80-100°F
- Pressure 80-95 PSIG
- CH<sub>4</sub> 42-50%
- CO<sub>2</sub> 38-48%
- N<sub>2</sub> 10-20%
- Oxygen at less than or equal to 1%
- Water vapor: saturated at nominal delivery conditions
- Heating value 425-510 BTU/SCF on a higher heating value basis
- Total non-methane organic compounds (NMOC) of 862 ppmv

For the pretreatment system design the total halides as chloride is 264 ppmv and total sulfur of 42 ppmv. These values are based on two times the EPA average compositional analysis for 48 quantifications at 23 different sites shown in Appendix A. Detailed compositional analysis for these values is given in Appendix B.

DOCMT. NO.

FCCS 5736

REVISION

PAGE 4

### 3.2.2 Output Gas Requirements to Fuel Cell Power Plant

	<u>Min</u>	<u>Max</u>	<u>Units</u>
Flow	0	5000	SCFH
Pressure	4	14	Inches of Water (Column W.C.)
Temperature	30	130	°F
Dew Point	—	20	°F
Total Sulfur	—	3	PPMv
Total Halides	—	3	PPMv
Particulates	—	Particulate removal of 100% at 1 micron or larger and 98% removal at 0.4 microns or larger	

### 3.2.3 Other Site Interfaces

- Location: Los Angeles, CA
- Site Services Available
  - Landfill Gas Supply
  - Electricity
  - Natural Gas
  - Water
  - Other site services to be defined by Pretreatment System Supplier

## 3.3 OPERATING CONDITIONS:

### 3.3.1 Start-Up

The pretreatment system design should be compatible with eventual automatic start-up. Manual start-up is acceptable for the demonstration program. Start-Up Time: 1 shift.

### 3.3.2 Shutdown

Normal shutdown can be accomplished manually.

In the event of malfunction in the fuel pretreatment system, the pretreatment system shall have provisions for automatic shutdown which protects the pretreatment system and does not exceed any site emissions limitations.

DOCMT. NO.

FCCS 5736

REVISION

PAGE

5

### 3.3.3 Normal Operation

The operation of the pretreatment system shall not be linked with the fuel cell power plant except that it can accept a shutdown signal from the fuel cell power plant. The pretreat system should be capable of checkout and operation without the fuel cell. A landfill gas pipeline operating at subatmospheric pressure (10 to 60 inches W.C. vacuum) is available to accept pretreated landfill gas during trials without the fuel cell.

### 3.4 PRESSURE REGULATION:

Provide to the fuel cell power plant on demand pretreated landfill gas at up to 120,000 SCFD (5000 SCFH) on a continuous, and uninterrupted basis at a delivery pressure of 4 to 14" W.C. Pretreatment system shall provide rapid flow response to changes in the fuel cell demand. Delivery pressure shall not fall below 4" W.C. during increased demand from 0 to 5000 SCFH in 15 seconds.

### 3.5 CONTAMINANT DISPOSAL:

The pretreatment system shall not collect and store hazardous contaminants on site for later shipment off site. All contaminants regenerated from the pretreatment system shall be disposed of on-site using an incinerator which shall preclude dioxin formation, and shall be consistent with the current South Coast Air Quality Management District design specifications.

### 3.6 LIFE:

The pretreatment system adsorbents and absorbents shall be designed for a minimum life of 1 year. Quarterly filter replacement is allowable only if this can be accomplished without shutdown of the unit. Active components (solenoid valves, pumps, etc.) may be serviced on an annual basis.

### 3.7 PERMITTING:

The design specifications and stampings of the pretreatment system shall be consistent with all national, state and local codes and regulations as listed in Section 2.

DOCMT. NO.

FCCS 5736

REVISION

PAGE 6

### 3.8 DESIGN AND CONSTRUCTION:

The pretreatment system shall be modular, self-contained, and skid mounted. Materials of construction should be compatible with the operating environment and operating schedule to insure a minimum of two years of uninterrupted service. The system shall be designed to operate outdoors in the Los Angeles, California area.

### 3.9 DOCUMENTATION:

- Installation Manual and Drawings including Point of Connection Interface Locations
- Operating Manual
- Overhaul and Maintenance Manual
- P&I Diagram
- Electrical Diagram
- Process Flow Diagram
- Equipment Drawings
- Vendor Supplied Literature for Purchased Equipment
- Foundation Loading Calculation Document

### 4.0 QUALITY ASSURANCE:

#### 4.1 QUALITY CONTROL SYSTEM:

The supplier shall have a Quality Control System that will ensure that parts are manufactured to the requirements of this specification. IFC reserves the right to review the supplier's system prior to contract award and to inspect parts and witness tests during manufacture and prior to shipment. IFC or its representatives will act as the authorized inspector required by ANSI B31 Codes for Pressure Piping.

#### 4.2 TESTING:

All testing required by applicable codes (e.g., ASME Code vessel pressure testing) will be identified upon completion of the design, including a 24 hour pneumatic static test at 100% of rated pressure.

#### 4.3 REPORTS:

All test and code required documentation will be provided to IFC prior to delivery of the pretreatment system.

DOCMT. NO.

FCCS 5736

REVISION

PAGE

7

5.0 PREPARATION FOR DELIVERY:

5.1 IDENTIFICATION:

The pretreatment system shall have a metal identification plate attached with the following information at a minimum:

- LANDFILL GAS PRETREATMENT SYSTEM
- IFC FCCS-5736
- vendor part number
- vendor serial number
- property of U.S. EPA under contract 68-D1-0008

6.0 APPENDICES:

- A. Landfill Gas Contaminant Composition for Pretreatment System Design
- B. EPA Average Landfill Gas Contaminant Composition Analysis

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REVISION

PAGE 8

# APPENDIX A

## LANDFILL GAS CONTAMINANT COMPOSITION FOR PRETREATMENT SYSTEM DESIGN

	<u>CONTAMINANT CONCENTRATION (PPMV)</u>				
	<u>TOTAL NON-METHANE ORGANIC COMPOUNDS (NMOG)</u>	<u>SATURATED ORGANIC COMPOUNDS (C<sub>2</sub>, C<sub>3</sub>, ETC)</u>	<u>UNSATURATES, AROMATICS, HALIDE AND SULFUR COMPOUNDS, ETC.</u>	<u>TOTAL SULFUR AS S</u>	<u>TOTAL HALIDE AS CL</u>
EPA AVERAGE * (48 QUANTIFICATIONS, 23 SITES)	431	157	274	21	132
PRETREATMENT SYSTEM DESIGN BASIS (2 X EPA AVERAGE)	862	314	548	42	264

# APPENDIX B

## EPA AVERAGE LANDFILL GAS CONTAMINANT COMPOSITION ANALYSIS

CHEMICAL NAME	No. of Times Quantified	Average Conc. ppm	CHEMICAL NAME	No. of Times Quantified	Average Conc. ppm
ETHANE	7	138.26	1,2 - DICHLOROETHANE	21	1.01
TOLUENE	41	49.33	CHLOROETHANE	23	0.93
HYDROGEN SULFIDE	3	15.01	TRICHLOROFLUOROMETHANE	48	0.96
METHYLENE CHLORIDE	36	14.48	2,3 DIMETHYL FURAN	1	0.83
ETHYLBENZENE	31	14.17	2 - METHYL FURAN	1	0.83
XYLENE	2	13.91	METHYL ISOBUTYL KETONE	19	0.77
1,2 - DIMETHYL BENZENE	1	12.25	CHLORODIFLUOROMETHANE	13	0.76
TOTAL XYLENE ISOMERS	27	10.12	PROPENE	1	0.75
LIMONENE	1	9.79	ETHYL MERCAPTAN	3	0.75
- PINENE	1	9.29	1,1,1 - TRICHLOROETHANE	31	0.72
DICHLORODIFLUOROMETHANE	23	8.56	DICHLOROFLUOROMETHANE	24	0.70
ETHYLESTER BUTANOIC ACID	1	8.29	TETRAHYDROFURAN	1	0.63
PROPANE	18	7.28	ETHYLESTER PROPANOIC ACID	1	0.54
TETRACHLOROETHENE	41	7.08	BROMODICHLOROMETHANE	7	0.43
VINYL CHLORIDE	43	6.91	3 - METHYLHEXANE	1	0.42
METHYLESTER BUTANOIC ACID	1	6.35	ETHYL ACETATE	1	0.42
ETHYLESTER ACETIC ACID	1	5.88	CHLOROBENZENE	9	0.38
PROPYLESTER BUTANOIC ACID	1	5.27	C10H16 UNSATURATED HYDROCARBON	1	0.31
1,2 - DICHLOROETHENE	35	5.03	METHYLPROPANE	1	0.25
METHYL ETHYL KETONE	24	5.01	2 - CHLOROETHYL VINYL ETHER	2	0.24
THIOBISMETHANE	1	4.38	1,1,2,2 - TETRACHLOROETHANE	8	0.18
METHYLCYCLOHEXANE	2	4.15	ACRYLONITRILE	2	0.17
TRICHLOROETHENE	46	3.72	1,1 - DICHLOROETHENE	20	0.15
NONANE	1	3.48	METHYLETHYLPROPANOATE	1	0.15
BENZENE	45	3.41	METHYL MERCAPTAN	3	0.12
ACETONE	18	3.35	1,2 - DICHLOROPROPANE	10	0.07
ETHANOL	1	3.27	1 - PROPYL MERCAPTAN	2	0.06
2 - BUTANOL	1	3.17	CHLOROFORM	8	0.06
OCTANE	1	3.17	1 - BUTYL MERCAPTAN	2	0.03
PENTANE	17	3.00	DICHLOROTETRAFLUOROETHANE	1	0.02
1 - METHOXY - 2 - METHYL PROPANE	1	2.83	DIMETHYL DISULFIDE	2	0.02
METHYLESTER ACETIC ACID	1	2.83	DIMETHYL SULFIDE	2	0.02
2 - BUTANONE	1	2.69	CARBONYL SULFIDE	1	0.02
HEXANE	17	2.60	1,1,2-TRICHLORO 1,2,2-TRIFLUOROETHANE	1	0.01
BUTANE	13	2.51	METHYL ETHYL SULFIDE	1	0.01
1,1 - DICHLOROETHANE	27	2.39	BROMOMETHANE	1	0.01
1 - BUTANOL	1	2.08	1,1,2 - TRICHLOROETHANE	1	0.00
4 - METHYL - 2 - PENTANONE	1	1.85	1,3 - BROMOCHLOROPROPANE	1	0.00
CHLOROMETHANE	23	1.78	1,2 - DIBROMOETHANE	1	0.00
2 - METHYL PROPANE	1	1.75	ACROLEIN	7	0.00
1 - METHYLETHYLESTER BUTANOIC ACID	1	1.44			
2 - METHYL, METHYLESTER PROPANOIC ACID	1	1.44			
CARBON TETRACHLORIDE	11	1.43			
1,1,3 TRIMETHYL CYCLOHEXANE	1	1.19			
2 - METHYL - 1 - PROPANOL	1	1.06			

**ATTACHMENT B**  
**PROCESS DESCRIPTION**



## DESCRIPTION OF PROCESS

### Process Chemistry

The process chemistry of the Landfill Gas Pretreatment System gas cleaning process is dictated by the composition of the incoming landfill gas and its complex mixture of trace contaminants. The fuel cell gas quality must be free of water and all contaminants so as to consist of a mixture of methane, nitrogen, oxygen and carbon dioxide. Raw landfill gas trace contaminants and their concentration levels used as a basis for the Landfill Gas Pretreatment System Process design are shown in Table 1. The raw landfill gas consists of a mixture of hydrocarbons, aromatics, halogenated hydrocarbons, and sulfide gases at very low concentrations.

Two-stage, low temperature condensation followed by activated carbon absorption are the process steps used to clean the landfill gas. Overall, all contaminants except butane and pentane are removed from the raw landfill gas at a total 100% cleaning effectiveness. The process-specific removal efficiencies shown in Table 2 are based on experimental data from a comparative facility on the East coast and related laboratory and bench-scale tests. As noted in the process flow sheet, the first and second stage condensation processes are designed to operate at +33°F and -25°F respectively. Hexane and octane, aromatics, trichloroethylene, and tetrachloroethylene, and dimethyl disulfide are condensed out at 99.5% and above. Part of the

initial testing of the pretreatment system will be to determine the effectiveness of the second stage condenser in removing contaminants by condensation. The remaining contaminants, mainly sulfides, and chlorinated hydrocarbons (including any heavy hydrocarbons or contaminants not removed by condensation) are removed by activated carbon adsorption at 99.9% removal and above.

TABLE 1 .

Raw Landfill Gas Contaminants and  
Concentrations for Penrose Test Site

<u>Landfill Gas Trace Contaminants</u>	<u>Design Raw Gas Concentration Level (ppm - by volume)</u>
<u>Hydrocarbons</u>	
Isobutane	95
Isopentane	963
n-Pentane	198
Hexane	297
Octane	81
<u>Aromatics</u>	
Benzene	2
Ethylbenzene	13
Chlorobenzene	1
Toluene	35
Xylenes	22
Styrene	0.5
<u>Halogenated Hydrocarbons</u>	
Dichloroethene	3
Dichloroethane	3
Methylene Chloride	12
Cis-1, 2-Dichloroethene	5
Trichlorofluroethane	0.6
Trichloroethylene	70
Tetrachlorethylene	6
Vinyl Chloride	1.4
<u>Sulfides</u>	
Hydrogen Sulfide	103
Methyl Mercaptan	5
Ethyl Mercaptan	5
Dimethyl Sulfide	8
Dimethyl Disulfide	0.02

TABLE 2

Trace Contaminant Removal Efficiencies  
for Gas Cleaning Process Steps

REMOVAL EFFICIENCIES OF PROCESS STEPS					
	1st Stage Condenser	Activated Alumina/ Molecular Sieve	2nd Stage Condenser	Activated Carbon Beds	TOTAL
<u>Hydrocarbons</u>					
<u>(HC's)</u>					
Methane	0	0	0	0	0
Isobutane	0	0	15.4	80.0	83.1
Isopentane	0	0	44.8	90.9	95.0
n-Pentane	0	0	60.0	91.9	96.8
Hexane	0	0	99.0	100.0	100.0
Octane	96.0	0	99.3	100.0	100.0
<u>Aromatics</u>					
Benzene	0.05	0	99.99	100.0	100.0
Ethylbenzene	97.4	0	100.0	--	100.0
Chlorobenzene	96.0	0	100.0	--	100.0
Toluene	87.8	0	99.99	100.0	100.0
Xylenes	92.0	0	100.0	--	100.0
Styrene	94.4	0	100.0	--	100.0
<u>Halogenated Hydrocarbons</u>					
Dichloroethene	30.4	0	85.0	100.0	100.0
Dichloroethane	29.8	4.0	90.0	100.0	100.0
Methylene Chloride	0	0.2	83.0	99.9	100.0
Cis-1,2-Dichloroethene	0	0.2	85.0	100.0	100.0
Trichlorofluoroethane	2.0	0	85.0	100.0	100.0
Trichloroethylene	0	0	99.5	100.0	100.0
Tetrachloroethylene	50.0	0	99.99	100.0	100.0
Vinyl Chloride	0	0	80.1	99.6	99.9
<u>Sulfides</u>					
Hydrogen Sulfide	0	0	0	100.0	100.0
Methyl Mercaptan	30.0	0	80.0	100.0	100.0
Ethyl Mercaptan	60.7	0	90.0	100.0	100.0
Dimethyl Sulfide	60.3	0	91.3	100.0	100.0
Dimethyl Disulfide	99.0	0	100.0	--	100.0
<u>Inorganics &amp; Other</u>					
Nitrogen	0	0	0	0	0
Oxygen	0	0	0	0	0
Carbon Dioxide	0	0	0	0	0
Water	61.5	100.0	--	--	100.0

In summary, the process chemistry of the Landfill Gas Pretreatment System gas cleaning process relies on the contaminants' physical phase separation (eg. condensation) and on chemisorption or physical adsorption characteristic's to produce an ultra clean product gas.

### Process Operation

The Landfill Gas Pretreatment System is comprised of the following three processes:

- Clean Gas Production Process
- Regeneration Process
- Refrigeration Process

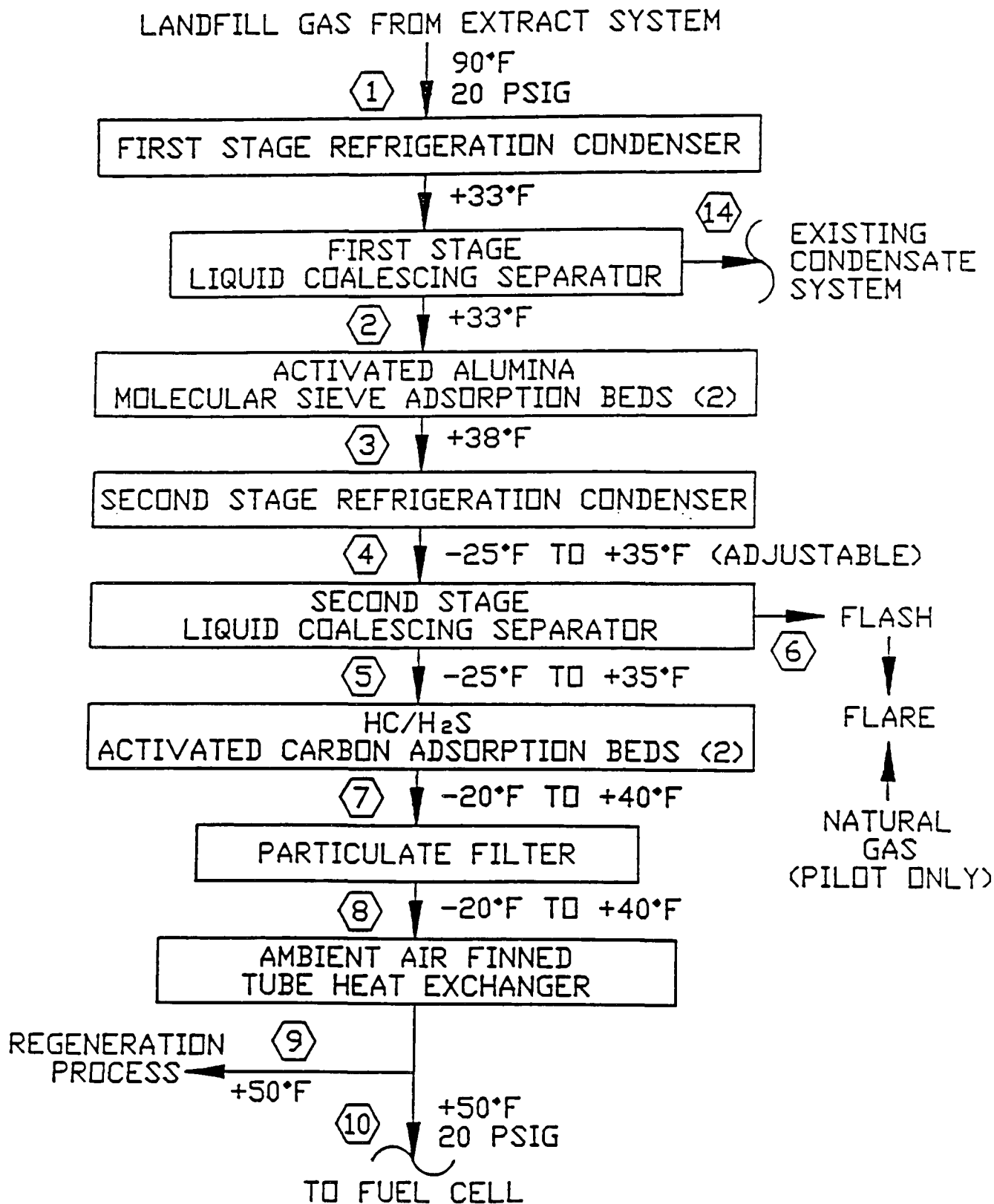
Clean Gas Production Process. The Landfill Gas Pretreatment System clean gas production process is represented in a block flow diagram as shown in Figure 1. This process incorporates refrigerated condensation and activated carbon process units to remove trace organic contaminants from the landfill gas.

The first and second stage refrigeration condensers operate at +33°F and -25°F, respectively.

The first stage refrigerated condenser removes water, aromatics, and sulfides which are discharged as condensate to the Penrose plant's existing gas condensate pre-treatment system. All remaining water in the landfill gas is removed in the next process unit which consists of two activated alumina and molecular sieve modules which have a high capacity for adsorbing the remaining water vapor in the

# FIGURE 1

## CLEAN GAS PRODUCTION PROCESS



landfill gas. The two activated alumina and molecular sieve modules operate in parallel so that one is always operational when the second is being regenerated. The dry landfill gas is then fed to the second stage refrigeration condenser. This condenser can be operated as low as  $-25^{\circ}\text{F}$  and potentially condense out a mixture of hydrocarbons, aromatics, halogenated hydrocarbons, and sulfides. Any condensate is collected and flashed to a vapor state (by dropping pressure and by indirect heating by ambient air) and transferred to the enclosed flare for thermal destruction. In the event that the second stage condenser is ineffective in removing hydrocarbon contaminants, the downstream carbon adsorption unit whose temperature is controlled by the second stage condenser has been conservatively sized to remove all heavy hydrocarbon, sulfur and halogen contaminant species. The partially clean landfill gas then passes through the activated carbon adsorption unit. Two beds operate in parallel so one is always operational when the other bed is being regenerated. The gas then passes through a particulate filter and warmed indirectly by an ambient air finned tube heat exchanger before being fed to the fuel cell unit. The process operating pressure is designed to remain steady at 20 psig with the only nominal pressure loss across the equipment. Thus the process can be controlled easily without any critical pressure control problems.

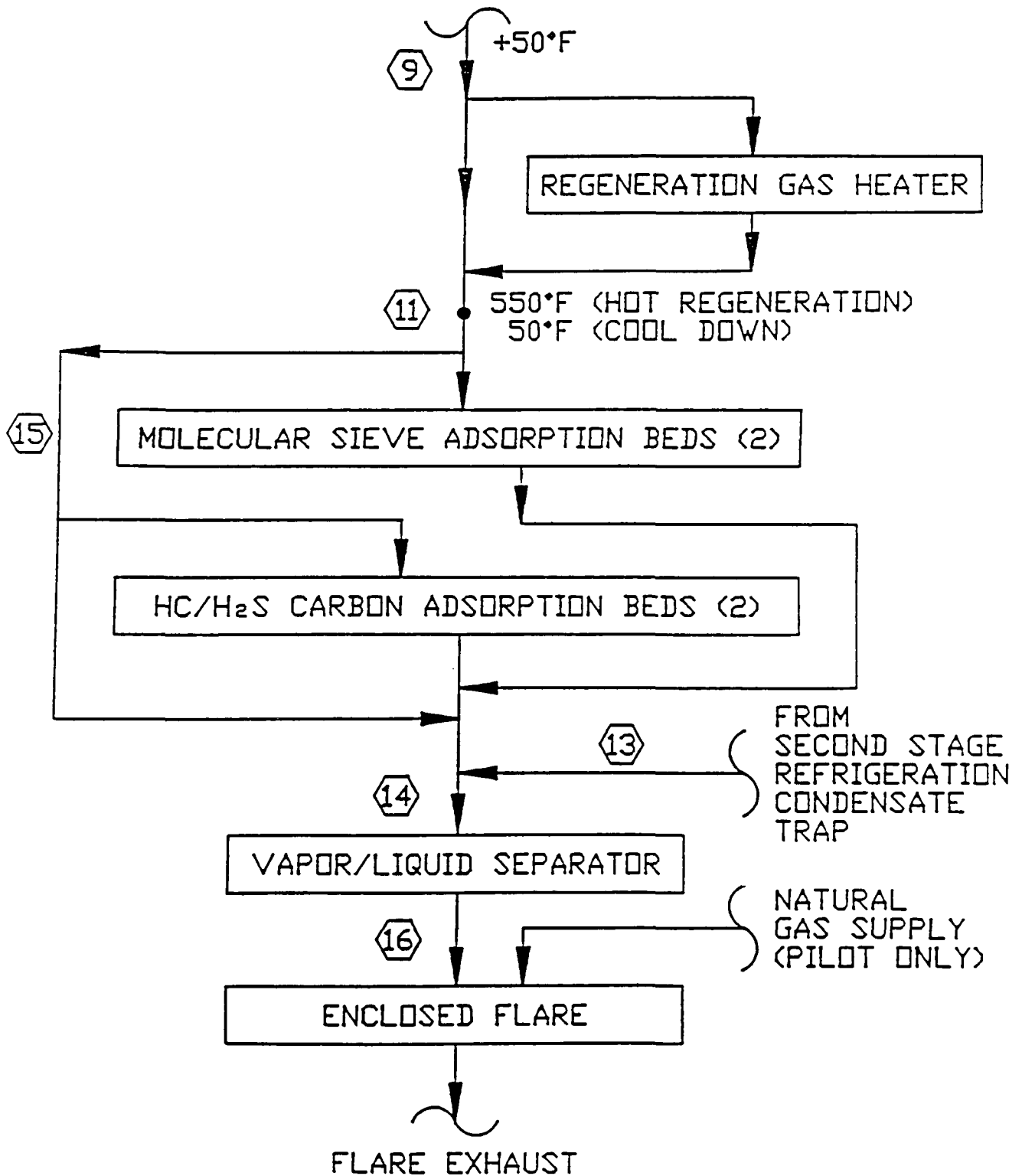
Regeneration Process. The regeneration process is represented in a block diagram shown in Figure 2. This process heats clean product landfill gas from the production process and regenerates the activated alumina/molecular sieve and activated carbon adsorption beds in the reverse flow direction during their regeneration cycle and destructs the spent regenerant gas in an enclosed flare. Two parallel bed design provides operating flexibility for reliable operation of the activated alumina/molecular sieve and activated carbon units during regeneration and/or maintenance. An electric gas heater is used to heat the recycled clean landfill gas to 550°F. This heated, regenerant gas is used first to regenerate the activated carbon bed. Second, the activated alumina/molecular sieve bed is regenerated. Third, the regeneration gas heater is bypassed and the activated alumina/molecular sieve bed is cooled down with cold regeneration gas. Lastly, the activated carbon bed is cooled down. During transition from adsorption to regeneration modes the regeneration gas is bypassed around the beds. At all times the regeneration gas flows to the enclosed flare ensuring continuous operation of the flare and continuous thermal destruction of the contaminants and regeneration gas prior to atmospheric dispersion.

Refrigeration Process. The refrigeration process shown in Figure 3 uses R-22 refrigerant in the cycle which provides refrigerated Limonene coolant at a nominal 33°F to the first



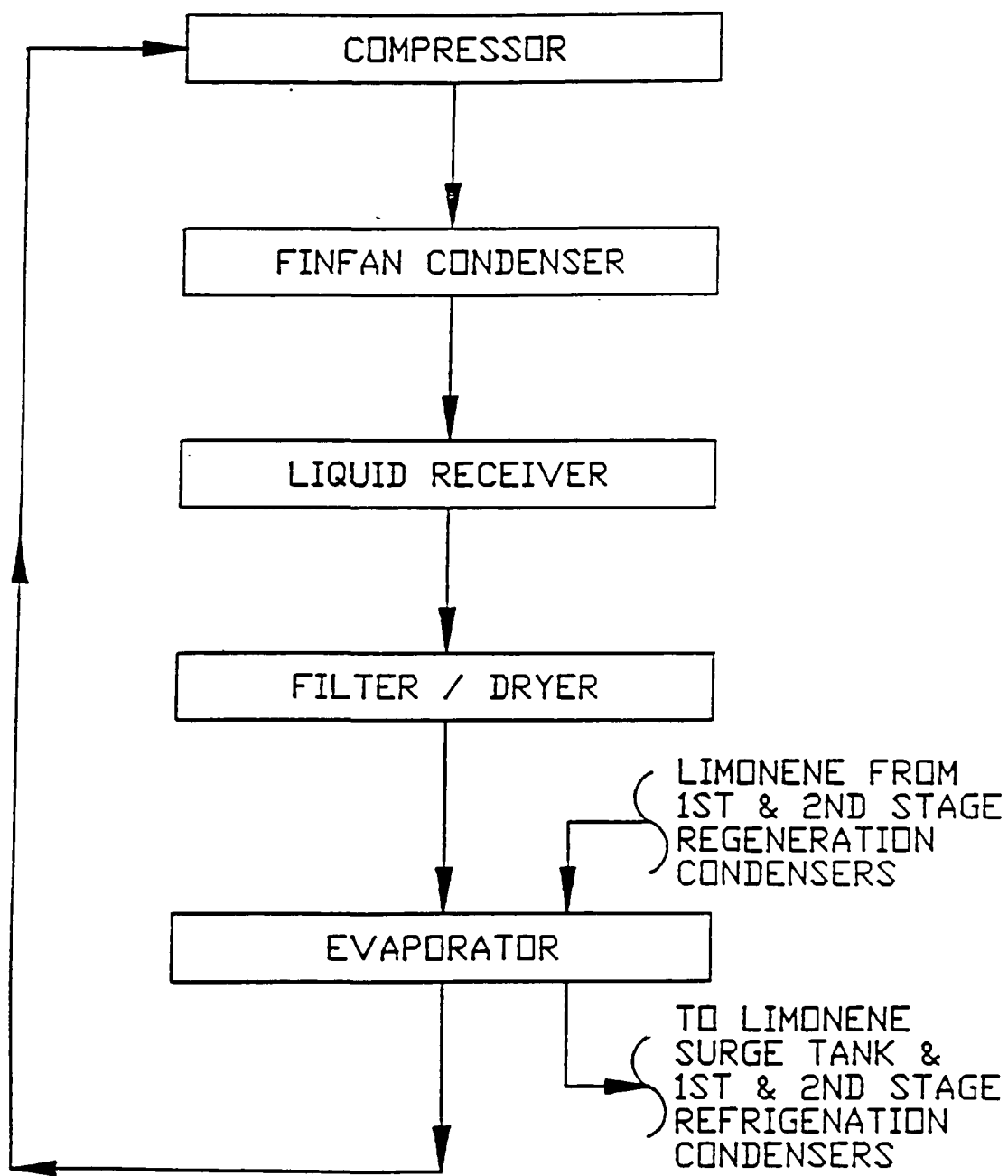
# FIGURE 2 REGENERATION PROCESS

FROM LFG PRODUCTION PROCESS



and an adjustable -25°F to +35°F to the second stage refrigeration condensers. The refrigeration process incorporates a double-stage hermetically-sealed compressor and plate-type evaporator. The refrigeration cycle operates to maintain the Limonene coolant temperature setting at its discharge from the evaporator. The compressor is driven by a 10 HP motor drive and operates continuously to recirculate R-22 refrigerant in the refrigeration process. The process operates with greater than 99% reliability based on past operating experience. Both refrigerant R-22 and Limonene coolant are completely recycled and are not purged or vented from the process.

FIGURE 3  
REFRIGERATION PROCESS UNIT



## PROCESS WEIGHT

The total weight of each material in the 90.0 scfm of raw landfill gas charged into the Landfill Gas Pretreatment System facility and which has been used as the design basis for the Landfill Gas Pretreatment System research operation, is specified below:

<u>Material</u>	<u>Pounds/hour</u>
<u>Hydrocarbons</u>	
Methane	104.999325
Isobutane	0.082714
Isopentane	0.995952
n-Pentane	0.184816
n-Hexane	0.367876
Octane	0.146294
<u>Aromatics</u>	
Benzene	0.008247
Ethylbenzene	0.019849
Chlorobenzene	0.001619
Toluene	0.046381
Xylenes	0.033585
Styrene	0.000149
<u>Halogenated Hydrocarbons</u>	
Dichloroethene	0.004600
Dichloroethane	0.000356
Methylene Chloride	0.008711
CIS-1,2-Dichloroethene	0.006772
Trichlorofluoroethane	0.001180
Trichloroethylene	0.005292
Tetrachloroethylene	0.015003
Vinyl Chloride	0.001258
<u>Sulfides</u>	
Hydrogen Sulfide	0.050492
Methyl Mercaptan	0.002074
Ethyl Mercaptan	0.000442
Dimethyl Sulfide	0.007149
Dimethyl Disulfide	0.000027
<u>Inorganics &amp; Other</u>	
Nitrogen	55.784094
Oxygen	1.530065
Carbon Dioxide	247.386467
Water	2.454545

### **H<sub>2</sub>S Polishing**

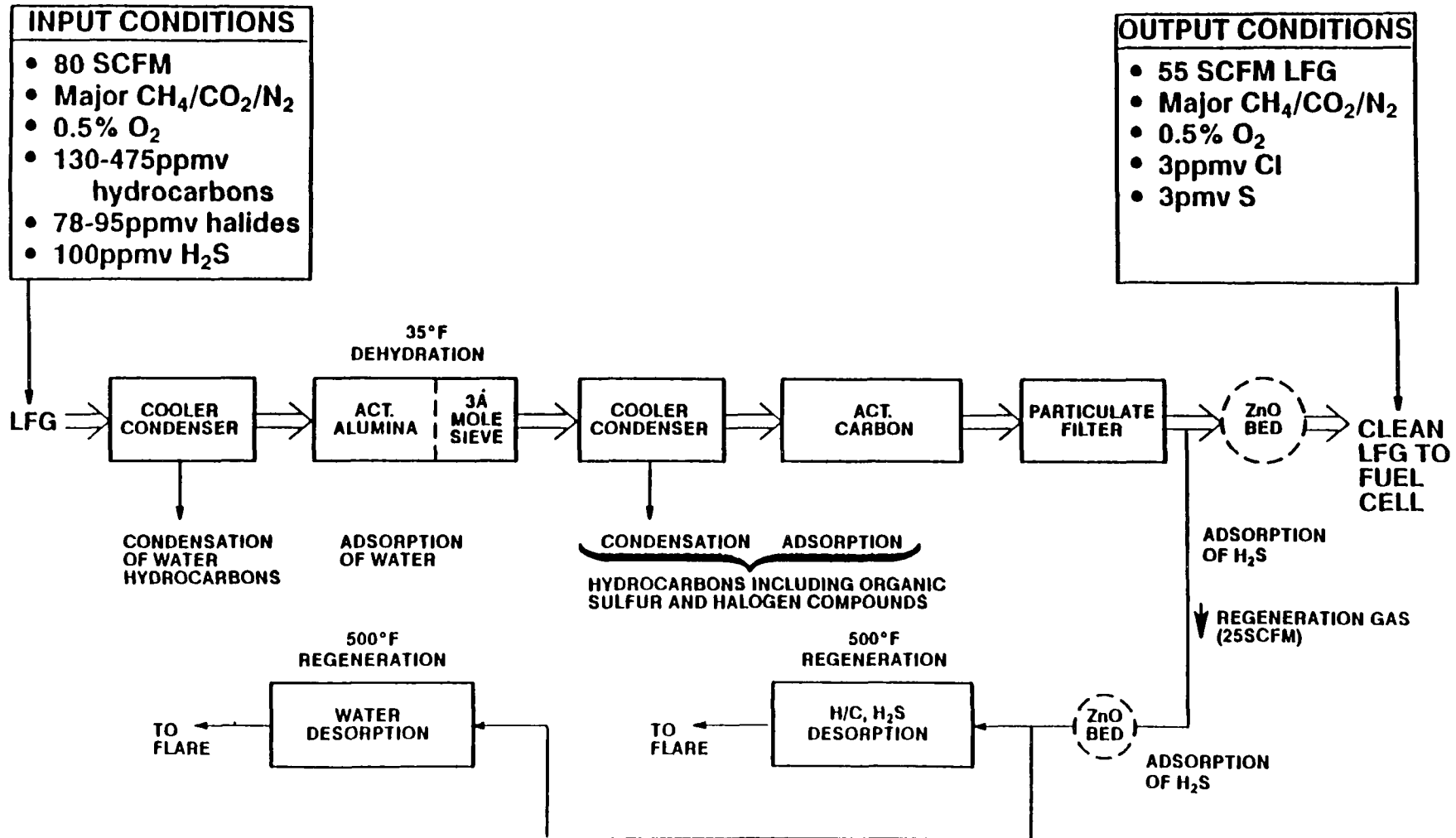
Due to possible high levels of Hydrogen Sulfide (H<sub>2</sub>S) in landfill gas that could potentially slip through the pretreatment system, zinc oxide beds have been placed downstream to effect removal of H<sub>2</sub>S from both landfill gas feeding the fuel cell and the landfill gas being returned to the pretreatment system for regeneration of the absorption beds. This added feature is shown in Figure 4.

FIGURE 4

# LFG PRETREATMENT SYSTEM

MODIFICATIONS FOR H<sub>2</sub>S POLISHING

B-44



**ATTACHMENT C**  
**FACTORY TEST DATA**

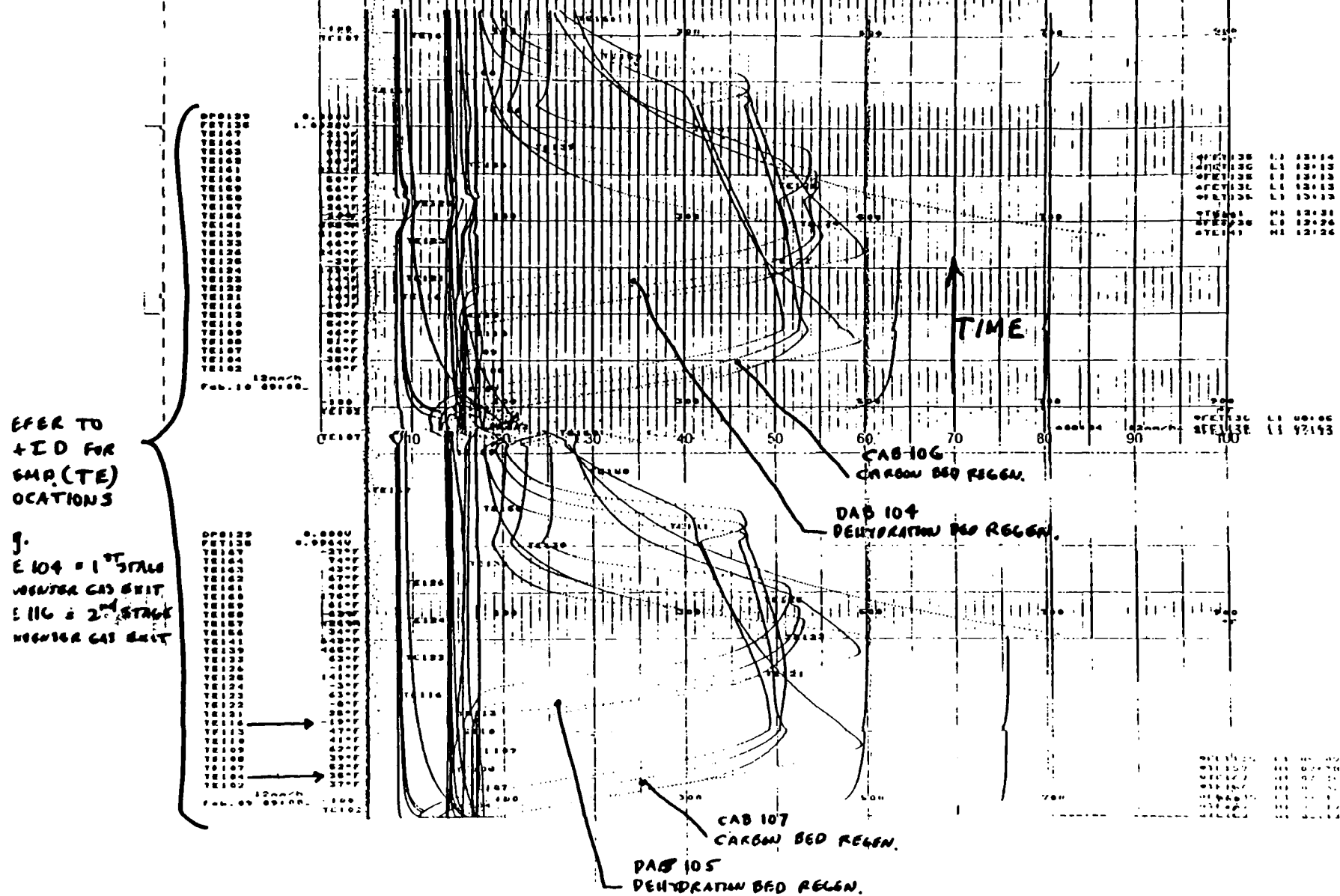
### **ATTACHMENT C - GAS PRETREATMENT UNIT FACTORY TEST DATA**

The LFG pretreatment unit bed temperature strip chart record for the N<sub>2</sub> factory test is shown in Figure 1. This record shows the heating and cooling of the dehydration and activated carbon beds during regeneration. While the dehydration bed (DAB 105) and carbon bed (CAB 107) are being regenerated, dehydration bed 104 and carbon bed 106 are in the adsorption mode and vice versa. Other sample temperatures are shown to the left of the regeneration plots. For example, the first and second stage condenser gas exit were operated at 35°F and -19°F, respectively. This test demonstrated that the pretreatment unit can be operated and controlled at its design temperature. The pretreatment unit controls allow flexibility in adjusting those conditions as needed.

Figure 2 contains a record of critical pressures and flows during the N<sub>2</sub> factory test. (Note that the flow meters FE103, 135, and 134 are calibrated for fuel gas and therefore only show approximate values on N<sub>2</sub> gas which was also supplied to the pretreatment unit at significantly lower temperatures than the landfill gas would be supplied. Also, refer to the P&ID for the locations of the appropriate pressure gages and gas flow meter). The factory test verified the volumetric flow capability of the pretreatment unit at design flow is approximately 6 psid with N<sub>2</sub> gas. This favorably compares with the design value of 5 psid with landfill gas.



FIGURE 1  
SAMPLE LFG PRETREATMENT UNIT TEMPERATURES



B-48

SYSTEM COND- TIONS	TIME	FE- 103 INLET	PE- 135 RECY- CLE	FE- 134 EXIT	FANUC VALVE STATUS	PI-105 FIRST REGUL. INLET EXIT	PI-101 SECOND REGUL. INLET EXIT	PI-130 FIRST STAGE FILTER EXIT	PI-111 BED DAB- 104	PI-112 BED DAB- 105	PI-127 BED CAB- 106	PI-128 BED CAB- 107	PI-106 FIRST REGUL. EXIT IN.W.C.	PI-132 SECOND REGUL. EXIT IN.W.C.	PI-138 REC- ZLF FIM	PI-136 BED ZOB-131 EXIT	PI-120 FIRST STAGE COND. LUMIN.	PI-119 SECOND STAGE COND. LUMIN.	OPT-129 EXIT FILTER DIFF PRESS.	PI-102 HOUSE WALL SUPPLY
S-1	0815	84	30	79	✓	21.8	19.8	18.4	18	18	16	16.1	29	14.2	2.3	13.5	21.6	15.6	—	84
S-5	0826	84	30+	79	✓	21.8	19.8	18.4	1.8	18	2	16.2	29	14.2	3.2	13.6	21.6	15.6	—	84
	0840		Readjusted			Inlet	Press	To	85	PSI					3-	13.7				
S-5	0845	84	30	79	✓	21.8	19.8	18.3	1.6	18	2	16.2	29.2	14.4	3.7	13.7	21.6	15.6	—	85
S-5	0900	84	30	79	✓	21.8	19.8	18.3	1.6	18	2	16.2	29.4	14.4	3.8	13.7	21.6	15.6	—	84
	0915		READJUSTED			INLET	PRESS	TO	85	PSI						13.7			—	
S-5	0915	84	30	79	✓	21.8	19.8	18.3	1.6	18	2.1	16.1	29.2	14.5	3.8	13.6	21.6	15.6	—	85
S-5	0930	84	30	79	✓	21.8	19.8	19.2	1.6	18	2.3	16.1	29.2	14.5	4.2	13.6	21.6	15.6	—	85
S-5	0945	86	30	79	✓	21.8	19.8	18.1	1.8	18	2.3	16	29.2	14.5	4.4	13.6	21.6	15.6	—	84
	0955		Re Set			Wall	Inlet	Pressure	To	85	PSI									
S-5	1000	87	30	78	✓	21.9	19.8	18.2	2	18	2.9	16	29	14.4	4.8	13.5	21.6	15.6	—	85
S-5	1015	87	30	78	✓	21.8	19.8	18.1	2.1	17.8	3.0	15.9	29	14.4	5.0	13.4	21.6	15.6	—	84
	1020		Re set			WALL	Inlet	Press.	To	85	PSI									
S-5	1030	88	30	78	✓	21.8	19.7	18.0	2.2	17.8	3.2	15.8	29.1	14.4	5.2	13.4	21.6	15.6	—	85
	1035		Re Set			PSI	101	To	20.0	PSI										
S-6	1045	87	30	78	✓	22	20.0	18.4	3.0	18.0	2.1	16.0	29.2	14.5	4.7	13.7	21.6	15.6	—	85
S-6	1100	88	30	78	✓	22.0	20.0	18.3	3.0	18.0	2.1	16.0	29.2	14.4	4.7	13.5	21.6	15.6	—	84
S-6	1115	89	30	78	✓	22.0	20.0	18.3	3.0	18.0	2.1	16.0	29.2	14.5	4.7	13.6	21.6	15.6	—	83
S-6	1130	89	30	78	✓	22.0	19.9	18.2	3.0	18.0	2.1	16.0	29.2	14.5	4.9	13.5	21.6	15.6	—	83
	1135		Re set			WALL	Inlet	Press	To	85	PSI									
S-6	1145	90	30	78	✓	22.0	20.0	18.2	3.1	18.0	2.2	15.9	29.2	14.5	4.9	13.5	21.6	15.6	—	85
S-6	1200	90	30	78	✓	22.1	20.0	18.4	3.4	18.0	2.3	16.0	29.2	14.5	5.2	13.6	21.6	15.6	—	85
S-6	1215	90	30	78	✓	22.2	20.0	18.5	3.8	18.2	2.5	16.1	29.0	14.5	5.5	13.7	21.6	15.6	—	85
S-6	1230	91	30	78	✓	22.2	20.0	18.3	4.1	18.0	2.8	16.0	29.0	14.5	6.0	13.5	21.6	15.6	—	85
S-7	1245	88	30	78	✓	22.2	20.1	18.5	4.0	18.4	2.7	16.4	29.2	14.5	4.0	14.0	21.6	15.6	—	85
	1250		Re set			WALL	Inlet	Press	To	85	PSI									
S-7	1300	89	30+	78	✓	22.2	20	18.5	3.9	18.3	2.7	16.4	29.4	14.5	4.0	14.0	21.6	15.6	—	85

FIGURE 2

SYSTEM COND. TIONS	TIME	FE- 103 INLET	FE- 135 RECY- CLE	FE- 134 EXIT	FANUC VALVE STATUS	PI-105 FIRST REGUL. INLET EXIT	PI-101 SECOND REGUL. INLET EXIT	PI-130 FIRST STAGE FILTER EXIT	PI-111 B2B DAB- 104	PI-112 B2B DAB- 105	PI-127 B2B CAB- 106	PI-128 B2B CAB- 107	PI-106 FIRST REGUL. EXIT IN.W.C.	PI-132 SECOND REGUL. EXIT IN.W.C.	PI-138 REC- ZLR FIM	PI-136 B2B DAB-131 EXIT	PI-120 FIRST STAGE COND. LWON.	PI-119 SECOND STAGE COND. LWON.	DPT-129 EXIT FILTER DIFF. PRESS.	PI-102 HOUSE WALL SUPPLY
S-7	13:15	88	30+	78	✓	22.1	20.0	18.4	4.0	18.3	2.7	16.4	29.5	14.5	4.2	13.9	21.6	15.6	—	84
S-7	1330	88	30+	78	✓	22.1	20.0	18.4	4.0	18.0	2.7	16.2	29.2	14.5	4.2	13.8	21.6	15.6	—	85
S-7	1345	89	30+	78	✓	22.1	20.0	18.4	4.0	18.0	2.7	16.2	29.2	14.5	4.2	13.8	21.6	15.6	—	85
S-7	1400	89	30+	78	✓	22.1	20.0	18.4	4.0	18.0	2.7	16.2	29.2	14.5	4.2	13.8	21.6	15.6	—	85
S-7	1415	89	30+	78	✓	22.1	20.0	18.4	4.0	18.0	2.7	16.2	29.2	14.5	4.2	13.9	21.6	15.6	—	85
S-7	1430	89	30+	78	✓	22.1	20.0	18.5	3.8	18.0	2.6	16.4	29.2	14.4	3.9	14.0	21.6	15.6	—	85
S-7	1445	88	30+	78	✓	22.2	20.0	18.5	3.3	18.2	2.3	16.4	29.2	14.5	3.5	14.0	21.6	15.6	—	85
	1455		ADJUSTED WALL PRESSURE To 85 PSI																	
S-8	1500	87	30+	78	✓	22.2	20.0	18.6	2.0	18.4	2.5	16.5	29.0	14.5	3.3	14.2	21.6	15.6	—	85
S-8	1515	87	3+	78	✓	22.2	20.0	18.4	2.0	18.3	2.9	16.4	29.0	14.5	3.7	14.0	21.6	15.6	—	85
S-8	1540	87	30+	78	✓	22.2	20.1	18.5	2.0	18.3	2.9	16.5	29.0	14.5	3.6	14.1	21.6	15.6	—	86
S-8	1600	86	30+	78	✓	22.2	20.1	18.6	2.0	18.3	2.6	16.5	29.0	14.5	3.2	14.2	21.6	15.6	—	86
S-8	1615	86	30+	78	✓	22.2	20.1	18.6	2.0	18.3	2.5	16.6	29.0	14.5	3.1	14.2	21.6	15.6	—	87
S-8	1640	85	30+	78	✓	22.2	20.1	18.6	2.0	18.3	2.4	16.6	29.0	14.5	3.0	14.3	21.6	15.6	—	88
S-14	1700	85	30+	78	✓	22.2	20.1	18.6	2.0	18.2	1.0	16.2	29.0	14.5	2.1	14.0	21.6	15.6	—	88
	0800				FEB. 10TH 1993															
S-14	0815	84	30	80	✓	21.9	20.0	18.5	18.0	0	16.2	1.0	29.0	14.3	2.1	13.9	21.4	15.4	—0	85
S-14	0830	84	30	80	✓	21.9	20.0	18.5	18.0	0	16.4	1.0	29.0	14.4	3.9	14.0	21.4	15.4	—0	85
S-14	0845	86	30	80	✓	21.9	20.0	18.4	18.0	1.4	16.1	2.5	29.0	14.5	4.9	13.7	22.0	15.4	—0	85
S-14	0900	87	30	79	✓	21.9	20.0	18.3	18.0	1.4	16.0	3.6	29.0	14.5	5.0	13.5	22.0	15.4	—0	85
S-14	0915	87	30	79	✓	22.0	20.0	18.3	18.0	1.5	16.0	3.0	29.0	14.5	5.2	13.5	22.0	15.4	—0	85
S-14	0930	88	30	79	✓	22.0	20.0	18.3	18.0	3.7	16.0	3.2	29.0	14.5	5.5	13.5	22.1	15.4	—0	85
S-14	0945	88	30	79	✓	22.0	19.9	18.3	18.0	2.0	16.0	3.5	29.0	14.5	5.9	13.5	22.1	15.4	—0	85
S-14	1000	88	30	79	✓	22.0	20.0	18.3	18.0	2.1	16.1	3.7	29.0	14.5	6.1	13.5	22.1	15.4	—0	85
S-14	1015	89	30	79	✓	22.2	20.0	18.5	18.0	2.3	16.0	4.0	29.2	14.5	6.4	13.5	22.1	15.4	—0	85
S-15	1030	87	30	79	✓	22.1	20.0	18.5	18.0	2.6	16.0	2.0	29.2	14.5	4.9	13.7	22.1	15.4	—0	85
S-15	1045	87	30	79	✓	22.2	20.0	18.6	18.3	.9	16.4	0.5	29.5	14.5	3.1	14.2	22.1	15.4	—0	85

FIGURE 2 (CONT.)

SYSTEM COND- ITIONS	TIME	FE- 103 INLET	FE- 135 RECY- CLE	FE- 134 EXIT	FANVC VALVE STATUS	PI-105 FIRST REGUL. INLET EXIT	PI-101 SECOND REGUL. INLET EXIT	PI-130 FIRST STAGE FILTER EXIT	PI-111 GED DAB- 104	PI-112 1320 DAB- 105	PI-127 B20 CAB- 106	PI-128 BED CAB- 107	PI-106 FIRST REGUL. EXIT IN.W.C.	PI-132 SECOND REGUL. EXIT IN.W.C.	PI-138 REC- ZLF FIM	PI-136 BED 208-131 EXIT	PI-120 FIRST STAGE COND. LIMIN.	PI-119 SECOND STAGE COND. LIMIN.	DAT-129 EXIT FILTER DIFF PRESS.	PI-102 HOUSE WALL SUPPLY
S-15	1100	88	30	78	✓	22.1	20.0	18.4	18.0	3.7	16.0	2.1	29.2	14.5	5.0	13.7	22.1	15.4	-0	85
S-15	1115	88	30	79	✓	22.2	20.0	18.4	18.0	2.7	16.1	2.1	29.2	14.4	5.1	13.7	22.1	15.4	-0	85
S-15	1130	89	30	78	✓	22.1	20.0	18.3	18.0	3.0	16.0	2.3	29.2	14.5	5.2	13.5	22.1	15.4	-0	85
S-15	1145	90	30	78	✓	22.1	20.0	18.3	18.0	3.1	16.0	2.4	29.0	14.5	5.4	13.5	22.1	15.4	-0	85
S-15	1200	91	30	78	✓	22.1	20	18.3	18.0	3.4	16.0	2.6	29.0	14.5	5.8	13.5	22.1	15.4	-0	84
	1202		Re Set		Wall Pressure					85 PSI										
S-15	1215	92	30	78	✓	22.1	20.0	18.2	17.8	4.0	15.8	3.0	29.0	14.5	6.5	13.4	22.1	15.4	-0	85/43
S-16	1230	0	-	0	✓	20.0	20.0	19.0	17.8	3.1	16.2	2.0	6	0	0	0	22.1	15.4	-0	130/0
	1315		Restart		Slows			After		Shut Down										
S-16	1315	87	22	78	✓	22.1	20.0	18.5	18.3	3.0	16.4	2.3	29.0	14.5	3.7	14.4	22.1	15.4	-0	85(41)
S-16	1330	88	22	78	✓	22.1	20.0	18.5	18.0	3.4	16.4	2.5	29.0	14.5	4.0	14.0	22.1	15.4	-0	85(42)
S-16	1345	89	23	78	✓	22.1	20.0	18.4	18.0	3.7	14.1	2.7	29.0	14.5	4.3	13.9	22.1	15.4	-0	85(42)
S-16	1400	89	23	78	✓	22.1	20.0	18.4	18.0	3.8	16.2	2.7	29.0	14.5	4.5	13.9	22.1	15.4	-0	85(42)
S-16	1415	89	23	78	✓	22.1	20.0	18.4	18.0	3.7	16.2	2.6	29.0	14.5	4.5	13.9	22.1	15.4	-0	85(42)
S-16	1430	90	23	78	✓	21.1	20.0	18.4	18.0	3.9	16.1	2.9	29.0	14.5	4.5	13.8	22.4	15.4	-0	85(42)
S-16	1445	89	23	78	✓	22.1	20.0	18.5	18.4	3.8	16.2	2.8	29.0	14.5	4.5	14.0	22.1	15.4	-0	85(42)
S-16	1500	89	23	78	✓	22.1	20.0	18.5	18.1	3.5	16.2	2.5	29.0	14.5	4.1	14.0	22.1	15.4	-0	85(42)
S-16	1515	88	23	78	✓	21.1	20.0	18.5	18.2	3.0	16.2	2.3	29.0	14.5	3.6	14.1	21.1	15.4	-0	85(42)
S-17	1555	88	23	78	✓	22.1	20	18.4	18	1.8	16.2	3.4	29	14.5	4.2	14	22.2	15.4	-0	85(42)
S-17	1625	88	23	78	✓	22.2	20.1	18.4	18	1.9	16.2	3.4	29	14.5	4.2	14	22	15.4	-0	85(42)
S-17	1655	87	23	78	✓	22.2	20.2	18.4	18	1.5	16.2	2.8	29	14.5	3.6	14	22	15.4	-0	85-42
S-17	1715	86	23	78	✓	22.2	20.2	18.5	18	1.4	16.2	2.8	29	14.5	3.5	14.2	22	15.5	-0	85-42
S-18									15 SEC.	15.2	6.4									
S-19									2 1/2 MIN	16.1	14.4									
	1727		Shut Down																	

FIGURE 2 (CONT.)

**ATTACHMENT D**  
**SCAQMD PERMIT REQUIREMENT**



**South Coast  
AIR QUALITY MANAGEMENT DISTRICT**

21865 E. Copley Drive, Diamond Bar, CA 91765-4182 (714) 396-2000

December 7, 1992  
A/N 271694

EPA, Air and Energy Environ Research Lab  
6055 East Washington Blvd.  
Commerce, California 90040

Attention: Mr. Andrew Washington

Gentlemen:

**PERMIT TO CONSTRUCT AND OPERATE  
EXPERIMENTAL RESEARCH OPERATIONS**

The equipment described below is granted a Permit to Construct and Operate (Application Number 271694) as allowed by and under the conditions set forth by Rule 441 of the Rules and Regulations of the District and is subject to the special conditions listed.

**LANDFILL GAS TREATING SYSTEM CONSISTING OF:**

1. FIRST STAGE REFRIGERATION CONDENSER, 10" DIA. X 5'-0" H.
2. LIQUID COALESCING SEPARATOR, 6 5/8" DIA X 1'-4" L.
3. CONDENSATE COLLECTION TANK, 4 1/2" DIA. X 2'-6" L
4. TWO MOLECULAR SIEVE ADSORPTION BEDS, EACH 1'-6" DIA. X 2'-6" H.
5. SECOND STAGE REFRIGERATION CONDENSER, 10" DIA. X 5'-0" H.
6. LIQUID COALESCING CONDENSER, 6 5/8 " DIA. X 1'-4" L.
7. TWO HC/H2S CARBON ADSORPTION BEDS, EACH 1'-6" DIA X 2'-6" H.
8. PARTICULATE FILTER, LANDFILL GAS
9. PROCESS GAS HEATER
10. REGENERATION GAS HEATER, ELECTRIC
11. CONDENSATE TRAP, 3 1/2" DIA. X 2'-0" L
12. FLARE, 2'-0" DIA. X 15'-0" H., WITH AN AUTOMATIC COMBUSTION AIR CONTROL AND AN AUTOMATIC SHUT-OFF AND RESTART SYSTEM
13. COMPRESSOR, REFRIGERATION UNIT, 10 H.P.
14. AIR COOLED CONDENSER, REFRIGERANT
15. LIQUID RECEIVER, REFRIGERANT
16. FILTER DRIER, REFRIGERANT
17. EVAPORATOR, REFRIGERANT, ALFA-LAVAL, PLATE TYPE, 0'-4" W X 0'-5" L X 1'-0" H.
18. D-LIMONENE SURGE TANK
19. TWO SULFUR REMOVAL BEDS
20. FIRST STAGE COOLANT PUMP
21. SECOND STAGE COOLANT PUMP

Located at 8301 Tujunga Avenue, Sun Valley, California.

EPA

2

December 7, 1992

**PERMIT CONDITIONS**

1. CONSTRUCTION AND OPERATION OF THIS EQUIPMENT SHALL BE CONDUCTED IN COMPLIANCE WITH ALL DATA AND SPECIFICATIONS SUBMITTED WITH THE APPLICATION UNDER WHICH THIS PERMIT TO CONSTRUCT IS ISSUED UNLESS OTHERWISE NOTED BELOW.
2. THIS EQUIPMENT SHALL BE PROPERLY MAINTAINED AND KEPT IN GOOD OPERATING CONDITION AT ALL TIMES.
3. THIS EQUIPMENT SHALL BE OPERATED AND MAINTAINED BY PERSONNEL PROPERLY TRAINED IN ITS OPERATION.
4. OPERATION OF THIS EQUIPMENT SHALL NOT RESULT IN THE EMISSION OF RAW LANDFILL GAS TO THE ATMOSPHERE.
5. RECORDS SHOWING TOTAL DAILY VOLUME OF LANDFILL GAS PROCESSED, LANDFILL GAS FLARED AND PRODUCT GAS SHALL BE MAINTAINED AS APPROVED BY THE DISTRICT AND SHALL BE MADE AVAILABLE TO DISTRICT PERSONNEL UPON REQUEST.
6. THE TOTAL VOLUME OF PROCESSED GAS BURNED IN THE FLARE SHALL NOT EXCEED 60 CUBIC FEET PER MINUTE.
7. ALL RECORDS MUST BE KEPT FOR TWO YEARS AND MADE AVAILABLE TO THE EXECUTIVE OFFICER UPON REQUEST.
8. A SET OF TWO SAMPLING PORTS SHALL BE INSTALLED IN THE FLARE SHROUD AND LOCATED AT LEAST TWO FEET ABOVE THE FLAME ZONE AND AT LEAST THREE FEET BELOW THE TOP OF THE FLARE SHROUD. EACH PORT SHALL BE INSTALLED AT 90 DEGREES APART, AND SHALL CONSIST OF FOUR INCH COUPLINGS WITH PLUGS. ADEQUATE AND SAFE ACCESS TO ALL TEST PORTS SHALL BE PROVIDED.
9. A SAMPLING PORT, OR OTHER METHOD APPROVED BY THE DISTRICT, SHALL BE INSTALLED AT THE INLET GAS LINE TO THE FLARE, THE INLET GAS LINE TO THE TREATMENT SYSTEM AND AT THE OUTLET GAS LINE OF THE TREATMENT SYSTEM
10. THE FLARE SHALL BE EQUIPPED WITH A TEMPERATURE INDICATOR AND RECORDER WHICH MEASURES AND RECORDS THE GAS TEMPERATURE IN THE FLARE STACK. THE TEMPERATURE INDICATOR AND RECORDER SHALL OPERATE WHENEVER THE FLARE IS IN OPERATION.

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3

December 7, 1992

11. WHENEVER THE FLARE IS IN OPERATION, A TEMPERATURE OF NOT LESS THAN 1400 DEGREES F AS MEASURED BY THE TEMPERATURE INDICATOR SHALL BE MAINTAINED IN THE FLARE STACK. THE THERMOCOUPLE USED TO MEASURE THE TEMPERATURE SHALL BE ABOVE THE FLAME ZONE AND AT LEAST 3 FEET BELOW THE TOP OF THE FLARE SHROUD AND AT LEAST 0.6 SECONDS DOWNSTREAM OF THE BURNER.
12. A FLARE FAILURE ALARM WITH AUTOMATIC BLOWER AND LANDFILL GAS SUPPLY VALVE SHUT-OFF SYSTEM APPROVED BY THE EXECUTIVE OFFICER SHALL BE INSTALLED.
13. PRIOR TO OPERATING THIS EQUIPMENT, SIGHT GLASS WINDOWS SHALL BE INSTALLED IN THE FLARE TO ALLOW VISUAL INSPECTION OF THE FLAME WITHIN THE FLARE AT ALL TIMES. PERMANENT AND SAFE ACCESS SHALL BE PROVIDED FOR ALL SIGHT GLASS WINDOWS.
14. THE SKIN TEMPERATURE OF THE FLARE SHROUD WITHIN FOUR FEET OF ALL THE SOURCE TEST PORTS SHALL NOT EXCEED 250 DEGREES F. IF A HEAT SHIELD IS REQUIRED TO MEET THIS REQUIREMENT, ITS DESIGN SHALL BE APPROVED BY THE DISTRICT PRIOR TO CONSTRUCTION. THE HEAT SHIELD, IF REQUIRED TO MEET THE TEMPERATURE REQUIREMENT, SHALL BE IN PLACE WHENEVER A SOURCE TEST IS CONDUCTED BY THE DISTRICT.
15. ANY BREAKDOWN OR MALFUNCTION OF THE LANDFILL GAS FLARE RESULTING IN THE EMISSION OF RAW LANDFILL GAS SHALL BE REPORTED TO THE SCAQMD MANAGER OF THE PUBLIC FACILITIES BRANCH WITHIN ONE HOUR AFTER OCCURRENCE, AND IMMEDIATE REMEDIAL MEASURES SHALL BE UNDERTAKEN TO CORRECT THE PROBLEM AND PREVENT FURTHER EMISSIONS INTO THE ATMOSPHERE.



EPA

4

December 7, 1992

16. WITHIN SIXTY (60) DAYS OF INITIAL OPERATION, THE APPLICANT SHALL CONDUCT PERFORMANCE TESTS IN ACCORDANCE WITH SCAQMD TEST PROCEDURES AND FURNISH THE SCAQMD A WRITTEN RESULT OF SUCH PERFORMANCE TESTS WITHIN THIRTY (30) DAYS AFTER THE TESTS ARE CONDUCTED. WRITTEN NOTICE OF THE PERFORMANCE TESTS SHALL BE PROVIDED TO THE SCAQMD SEVEN (7) DAYS PRIOR TO THE TESTS SO THAT AN OBSERVER MAY BE PRESENT. ALL SOURCE TESTING AND ANALYTICAL METHODS SHALL BE SUBMITTED TO THE DISTRICT FOR APPROVAL AT LEAST SIXTY (60) DAYS PRIOR TO THE START OF THE TESTS.

THE PERFORMANCE TESTS SHALL BE CONDUCTED AT THE STEADY STATE FLOW RATE AND SHALL INCLUDE, BUT MAY NOT BE LIMITED TO, A TEST OF THE INLET LANDFILL GAS FLARE, THE FLARE EXHAUST, THE INLET GAS TO THE TREATMENT SYSTEM AND THE PRODUCT GAS FOR:

- A. METHANE
- B. TOTAL NON-METHANE ORGANICS
- C. OXIDES OF NITROGEN (FLARE EXHAUST ONLY)
- D. CARBON MONOXIDE (FLARE EXHAUST ONLY)
- E. TOTAL PARTICULATES (FLARE EXHAUST ONLY)
- F. HYDROGEN SULFIDE (EXCEPT FLARE EXHAUST)
- G. C1 THROUGH C3 SULFUR COMPOUNDS (EXCEPT FLARE EXHAUST)
- H. CARBON DIOXIDE
- I. TOXIC AIR CONTAMINANTS, INCLUDING BUT NOT LIMITED TO:
  - BENZENE
  - CHLOROBENZENE
  - 1,2 DICHLOROETHANE
  - DICHLOROMETHANE
  - TETRACHLOROETHYLENE
  - TETRACHLOROMETHANE
  - TOLUENE
  - 1,1,1 TRICHLOROETHANE
  - TRICHLOROETHYLENE
  - TRICHLOROMETHANE
  - VINYL CHLORIDE
  - XYLENE
- J. OXYGEN
- K. NITROGEN
- L. MOISTURE CONTENT
- M. TEMPERATURE
- N. FLOW RATE

17. THE DATE OF INITIAL OPERATION SHALL BE SUBMITTED TO THE DISTRICT IN WRITING WITHIN THREE DAYS AFTER INITIAL OPERATION.

18. THIS PERMIT SHALL EXPIRE JANUARY 1, 1994. AN EXTENSION OF TIME MAY BE REQUESTED IN WRITING. SUCH A REQUEST SHALL INCLUDE THE REASON FOR THE EXTENSION, THE LENGTH OF THE EXTENSION AND THE STATUS OF THE RESEARCH OPERATION.

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5

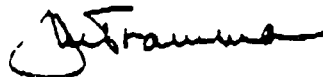
December 7, 1992

It is your responsibility to comply with all laws, ordinances and regulations of other governmental agencies which are applicable to this equipment.

THIS PERMIT TO CONSTRUCT AND OPERATE WILL EXPIRE ON JANUARY 1, 1994.

If you have any questions regarding this matter, please call, Mr. Ted Kowalczyk at (714) 396-2592.

Very truly yours,



Joseph Tramma  
AQAC Supervisor

TK

## **APPENDIX C**

### **H<sub>2</sub>S REMOVAL OVER WESTATES CARBON UOC-HKP. TESTS PERFORMED AT IFC AND WESTATES CARBON**

IFC laboratory test data for the removal of H<sub>2</sub>S using potassium hydroxide in preganated activated carbon.

#### H2S HISTORY OF TWO INCH LOCATION IN KOH CARBON BED

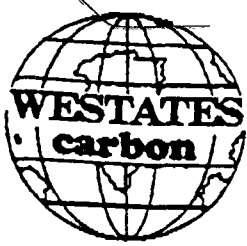
DATE	RUN TIME (hours)	H2S INLET CONC (ppm)	H2S EXIT CONC. (ppm)	PRESS (psig)	SAT TEMP (F)	REACTOR TEMP (F)
7-16-93	0.9	99	0	20	69	70
	2.6	99	0	20	69	71
	4.2	99	0.6	20	69	70
	5	99	1	20	69	71
	6	99	0	20	69	71
7-19-93	10.3	98	20	50	68	70
	11.4	98	23	50	68	71
	13.5	98	29	50	69	71
7-20-93	17	98	38	20	65	67
	21.4	97	38	20	67	71
7-21-93	26	98	49	20	67	69
	29.5	98	49	50	68	70
	31.9	98	49	50	68	72
7-22-93	34.9	94	52	50	65	66
	37.5	94	52	50	66	67
	42.1	92	58	50	67	70
7-23-93	57.9	97	70	50	63	65
	63.5	96	68	50	66	70
7-26-93	72.4	95	72	50	66	67
7-28-93	77.7	95	66	50	68	72
7-29-93	82.1	96	66	50	69	70
7-30-93	94	84	55	50	88	75

#### H2S HISTORY OF 4.76 INCH LOCATION IN KOH CARBON BED

DATE	RUN TIME (hours)	H2S INLET CONC (ppm)	H2S EXIT CONC. (ppm)	PRESS (psig)	SAT. TEMP (F)	REACTOR TEMP (F)
7-16-93	4.6	99	0	20	69	71
7-19-93	10.7	99	0	50	68	70
7-20-93	22.7	97	1.3	20	67	71
7-21-93	26.1	98	2.7	20	67	70
	30.2	98	5.2	50	68	71
7-22-93	35.5	94	9	50	65	67
	42.9	92	12.5	50	67	70
7-23-93	58.8	97	23	50	64	66
	64.4	96	24	50	67	70
7-26-93	72.9	95	26	50	66	67
7-28-93	78.6	90	32	50	69	73
7-29-93	82.9	95	38	50	69	70
7-30-93	93.3	84	19	50	87	74

#### H2S HISTORY OF 10.6 INCH LOCATION IN KOH CARBON BED

DATE	RUN TIME (hours)	H2S INLET CONC (ppm)	H2S EXIT CONC. (ppm)	PRESS (psig)	SAT TEMP (F)	REACTOR TEMP (F)
7-16-93	4.6		<1			
7-19-93	12.1		<1			
7-21-93	27.5		<1			
7-22-93	36.4		<1			
7-23-93	59.6		<1			
7-26-93	73.6		<1			
7-28-93	79.1		<1			
7-29-93	83.5		<1			
7-30-93	92.4		<1			



2130 LEO AVENUE • LOS ANGELES, CALIFORNIA • 90040-1634  
TELEPHONE (213) 722-7500 • TWX 910-321-2355 • FAX (213) 722-8207

A Wheelabrator Technologies Company

APPC 1/4

July 26, 1993

Mr. Roger Lesieur  
International Fuel Cells  
195 Governors Highway  
P.O. Box 739  
South Windsor, Connecticut 06074

RE: H2S Breakthrough Test Results

Dear Roger:

We have completed work on the H2S breakthrough testing of UOCH-KP using as close as possible the conditions described in your FAX dated July 12, 1993. Two breakthrough tests were carried out. The breakthrough tests were carried using the gas compositions listed below and the breakthrough apparatus and adsorption tube shown in the attached drawings.

	<u>Test 1</u>	<u>Test 2</u>
H2S	1.0 vol.%	0.2 vol.%
O2	1.0 vol.%	1.0 vol.%
CO2	39.3 vol.%	47.5 vol.%
CH4	39.3 vol.%	47.5 vol.%
Balance N2	19.4 vol.%	3.8 vol.%
Rel. Humidity	40 - 45 %	45 - 48 %
Total Gas Flow	1,450 cc/min	1,450 cc/min
Time to Breakthrough	48 minutes	7,446 minutes
H2S Breakthrough Capacity	0.009 gH2S/ccC	0.28 gH2S/ccC

$\frac{200 \text{ g/liter}}{\text{ft}^3} \sim 37\% \text{ for } C_2 = 45 \frac{1}{2} \left( \frac{759}{\text{cc}} \right)$

Using the first set of test conditions, very rapid H2S breakthrough was observed. The observed results indicate no catalytic oxidation of H2s to elemental sulfur was occurring under these high H2S and low oxygen concentration conditions. The test was then repeated using a lower H2S concentration and an excellent H2S breakthrough capacity was measured. These results indicate the UOCH-KP will operate very well using the proposed conditions and should give a

H2S breakthrough capacity that exceeds the specifications for UOCH-KP. The presence of CO2 and methane and the lower than normal relative humidity do not seem to adversely affect the performance of the UOCH-KP.

Following is a brief description of how the tests were carried out:

The H2S breakthrough apparatus consists of four rotameters and flow control vales for metering the CO2, Methane, H2S and oxygen into the apparatus. The methane was passed through a constant temperature bubbler to produce a saturated stream which upon blending with the other gases yield the desired relative humidity of approximately 40 % that was required for the tests.

The UOCH-KP was contained in a reactor tube (see attached figure) that held a bed of carbon that was 9" in length and 1" in diameter. The outlet from the reactor tube was connected to an H2S monitor which detected the breakthrough of H2S. A H2S breakthrough to the level of 50 ppmv was used to determine completion of the test. The H2S monitor made use of a high level alarm which shut off a timer when 50 ppmv H2S was reached giving the exact time to reaching breakthrough.

The UOCH-KP was pre-conditioned for 24 hours prior to the starting of the test by running the humidified methane, CO2 and oxygen through the system and the sample held in the reactor. After the pre-conditioning was complete, the proper H2S flow was established to begin the test run. The H2S breakthrough of the UOCH-KP sample was calculated as follows:

$$\text{H2S capacity (gH2S/ccC)} = \frac{(1.53 \times 10^{-3})(C)(F)(t_b)}{(V)}$$

Where: C = Concentration of H2S in test stream, vol. %  
F = Total system flow rate, cc/min  
t<sub>b</sub> = Time to 50 ppmv breakthrough, minutes  
V = Volume of UOCH-KP used

Please give me a call at (213) 724-8565 if you have any questions concerning the interpretation of results from this study or how the testing was conducted. It has been our pleasure being of service to International Fuel Cells.

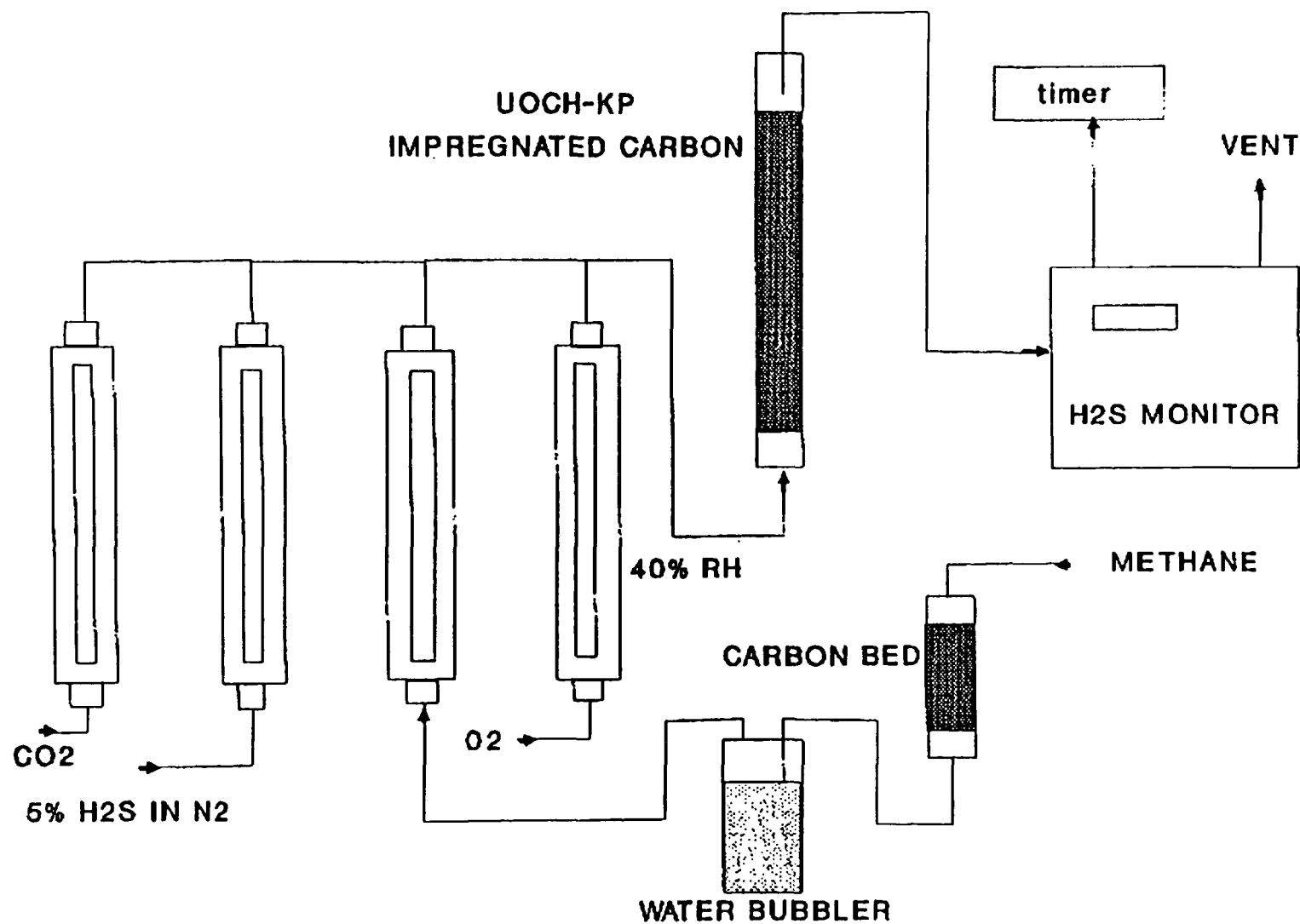
Sincerely,  
WESTATES CARBON, Inc.

*James R. Graham*

James R. Graham, Ph.D.  
Technical Director

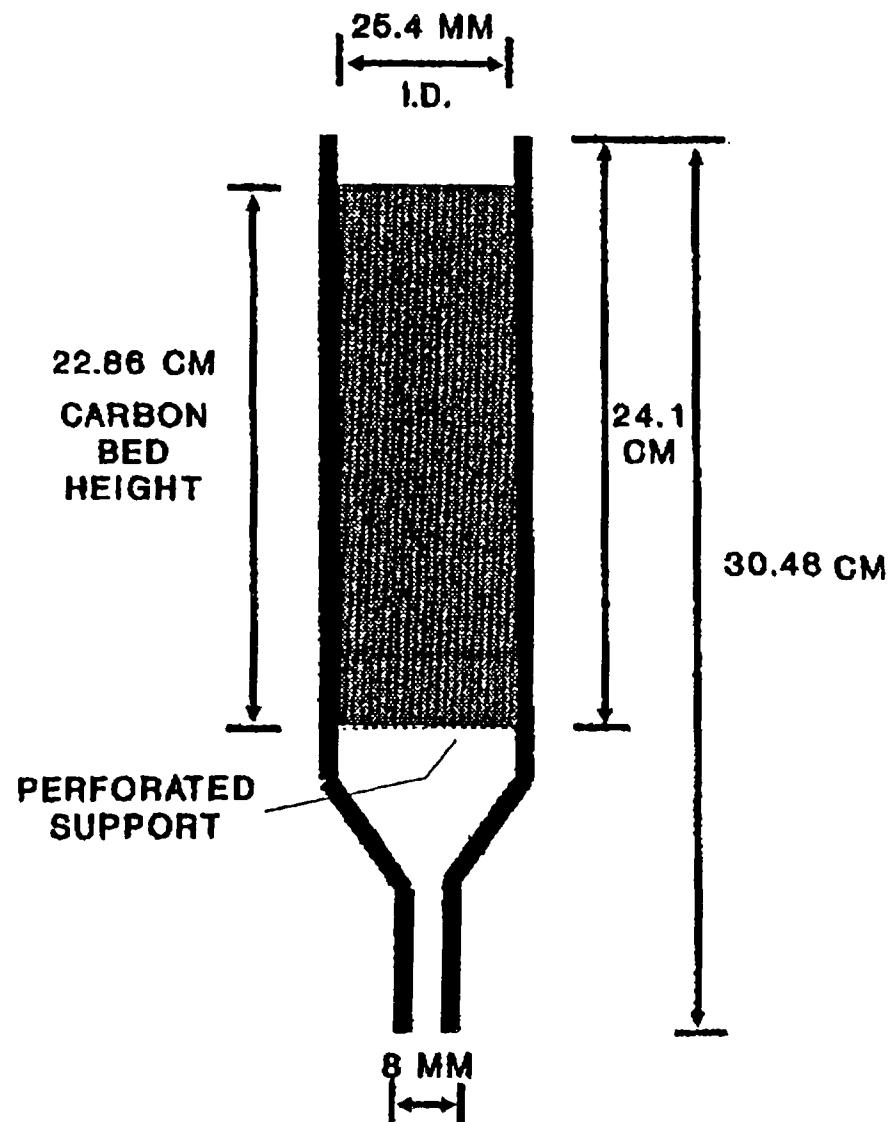
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# MODIFIED H<sub>2</sub>S BREAKTHROUGH APPARATUS



C-5

FIGURE 2. H<sub>2</sub>S ADSORPTION TUBE





**APPENDIX D**

**EXECUTIVE SUMMARY OF LANDFILL GAS PRETREATMENT UNIT  
PERFORMANCE TEST REPORT,  
BY  
JIM CANORA, TRC ENVIRONMENTAL CORPORATION,  
TRC PROJECT NO. 20300, MAY 1994**

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# ***Landfill Gas Pretreatment Unit Performance Test Report***

*International Fuel Cells, Inc.  
South Windsor, Connecticut*

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**TRC**

TRC Environmental Corporation

# Landfill Gas Pretreatment Unit Performance Test Report

Penrose Landfill – Sun Valley, California

International Fuel Cells, Inc.  
South Windsor, Connecticut

Prepared by:

TRC ENVIRONMENTAL CORPORATION

James E. Canora  
Project manager

TRC Project No. 20300

May 1994

**TRC**

TRC Environmental Corporation

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# Table of Contents

<u>SECTION</u>	<u>PAGE</u>
1.0 INTRODUCTION . . . . .	D-6
1.1 Program Objectives . . . . .	D-6
1.2 Scope of Work . . . . .	D-6
1.3 Report Organization . . . . .	D-11
2.0 EXECUTIVE SUMMARY . . . . .	D-12
2.1 Recommendations for Phase III Program Emission Measurements . . . . .	D-13
3.0 SUMMARY AND DISCUSSION OF RESULTS . . . . .	D-14
3.1 GPU Dichlorodifluoromethane Challenge Test . . . . .	D-14
3.2 GPU Removal of Volatile Organic Compounds . . . . .	D-16
3.3 GPU Removal of Reduced Sulfur Compounds . . . . .	D-20
3.4 GPU Removal of Nonmethane Organics . . . . .	D-21
3.5 GPU Outlet Particulate Matter Concentration . . . . .	D-21
3.6 GPU Inlet Phenol Concentration . . . . .	D-21
3.7 Silanes and Siloxanes – GPU Inlet Concentration . . . . .	D-22
3.8 Flare Efficiency Test . . . . .	D-22
3.8.1 Flare Destruction of VOCs . . . . .	D-24
3.8.2 Flare Destruction of Sulfur Compounds . . . . .	D-24
3.8.3 Flare Destruction of Total Nonmethane Organics . . . . .	D-24
3.8.4 Flare Outlet Concentration of NO <sub>x</sub> , CO, and Particulate Matter . . . . .	D-25
3.9 Ambient Concentrations of NO <sub>x</sub> , CO, and Particulate Matter . . . . .	D-25
3.10 Condensate Analyses . . . . .	D-25
4.0 SAMPLING AND ANALYTICAL METHODS . . . . .	D-27
4.1 GPU Inlet Measurements . . . . .	D-27
4.1.1 GPU Inlet Volatile Organic Compounds . . . . .	D-27
4.1.2 GPU Inlet Reduced Sulfur Compounds . . . . .	D-29
4.1.3 GPU Inlet Phenol . . . . .	D-30
4.1.4 GPU Inlet Silicon Compounds . . . . .	D-30
4.1.5 GPU Inlet Total Nonmethane Hydrocarbons . . . . .	D-30
4.2 GPU Outlet Gas Measurements . . . . .	D-30
4.2.1 GPU Outlet On-line Halides . . . . .	D-30
4.2.2 GPU Outlet Off-site Halides and Dichlorodifluoromethane Analysis (GC/MS Method) . . . . .	D-31
4.2.3 GPU Outlet Continuous Total Reduced Sulfur . . . . .	D-32
4.2.4 GPU Outlet On-line Sulfur Compounds (GC/FPD Method) . . . . .	D-32
4.2.5 GPU Outlet Reduced Sulfur Compounds (Off-site GC/FPD Method) . . . . .	D-32
4.2.6 GPU Outlet Volumetric Flowrate . . . . .	D-33
4.2.7 GPU Outlet Total Nonmethane Hydrocarbons . . . . .	D-33

## Table of Contents (continued)

<u>SECTION</u>		<u>PAGE</u>
4.3	Flare Emission Tests .....	D-33
4.3.1	Flare Inlet and Outlet VOC Emission Concentration .....	D-33
4.3.2	Flare Inlet and Outlet Reduced Sulfur Compounds Concentration .	D-33
4.3.3	Flare Outlet Particulate Emissions .....	D-34
4.3.4	Flare Outlet NO <sub>x</sub> , CO, and O <sub>2</sub> Emission Concentrations .....	D-34
4.3.5	Flare Outlet Volumetric Flowrate .....	D-34
4.4	Ambient Monitoring for Particulate, NO <sub>x</sub> , and CO .....	D-34
5.0	QUALITY ASSURANCE .....	D-35
5.1	Emission Measurement Methods .....	D-35
5.2	Analysis .....	D-36
5.3	Program-Specific Quality Control Discussion .....	D-37

## List of Figures, Tables, and Appendices

Figure 1-1	Phase II Field Test Sample Locations and Test Results .....	D-8
Figure 4-1	Preparation of Solvent Standards – EPA Method 18 .....	D-28
Table 3-1	GPU Inlet/Outlet Emission Test Summary: Test No. 1 .....	D-15
Table 3-2	GPU Inlet/Outlet Emission Test Summary: Test No. 2 .....	D-17
Table 3-3	GPU Inlet/Outlet Emission Test Summary: Test No. 3 .....	D-18
Table 3-4	C1–C6 Hydrocarbons Emission Data .....	D-19
Table 3-5	Flare Inlet/Outlet Emission Test Summary .....	D-23
Table 3-6	Condensate Analyses .....	D-26
Table 5-1	Summary of Results – Audit to Resolve Discrepancy Between GC/ECD and GC/MS Analyses of Landfill Gas Samples .....	D-38
Table 5-2	Effect of Humidity on GC/MS Analyses – Audit to Resolve Discrepancy Between GC/ECD and GC/MS Analyses of Landfill Gas Samples .....	D-39

## 1.0 INTRODUCTION

TRC Environmental Corporation (TRC) was retained by International Fuel Cells, Inc. (IFC) to conduct emission tests associated with the U.S. Environmental Protection Agency (EPA) Phase II Field Performance Test program at the Penrose Landfill in Sun Valley, California. The test was designed to demonstrate the performance of a landfill gas purification system for application to fuel cell power plants.

The gas purification system, identified as the Gas Pretreatment Unit (GPU), was tested over three complete cycles during a three-day period from October 20 to October 22, 1993. Additional emission tests were also conducted to satisfy the requirements of a South Coast Air Quality Management District (SCAQMD) permit. The test program was conducted under the direction of Mr. Jim Canora of TRC and Mr. Dick Sederquist of IFC. No personnel from EPA or SCAQMD were present to observe the tests.

### 1.1 Program Objectives

The program objectives included a demonstration of GPU performance and flare performance. The specific objectives are outlined below:

- Demonstrate that **total sulfur** emission concentration at the GPU outlet was below 3 parts per million volume (ppmv).
- Demonstrate that **total halide** emission concentration at the GPU outlet was below 3 ppmv.
- Demonstrate compliance with the 3 ppmv total halide limit when the GPU is challenged with dichlorodifluoromethane at the GPU inlet.
- Demonstrate the performance of the GPU and the flare as required in the SCAQMD permit.

### 1.2 Scope of Work

GPU emission tests were conducted at the beginning, middle, and end of the regenerative bed cycles to evaluate performance over normal eight-hour cycles on each of the two regenerative beds in the GPU. Gaseous emission measurements for sulfur compounds, halides, and other target compounds were conducted at the GPU inlet and outlet simultaneously, at specific times in the bed cycles. In addition, samples of liquid condensate from the first GPU

condenser were also collected and analyzed for sulfur and halides. Gas samples were collected from sampling manifolds located at the GPU inlet, the exit of the first condenser, the GPU outlet, and the flare inlet. See **Figure 1-1** for sampling locations. Three eight-hour cycles were tested.

Emission tests for key parameters were conducted on-site to provide real-time data for an immediate assessment of GPU performance. The program strategy was to use on-site continuous and semicontinuous methods as process monitoring data, and off-site laboratory analysis of integrated samples for a formal demonstration of performance according to EPA test methods. The on-site measurements included gas chromatography/flame photometric detection (GC/FPD) for sulfur compounds, a continuous gas analyzer for total sulfur, and gas chromatography/electron capture detection (GC/ECD) for target halides. The quantification accuracy of the on-site GC/ECD analysis was suspect because of the landfill gas matrix, and, as a result, those results are not reported. The off-site methods, used to formally demonstrate performance, included gas chromatography/mass spectrometry (GC/MS) analysis for target volatile organic compounds (VOCs) and GC/FPD analysis for target sulfur compounds.

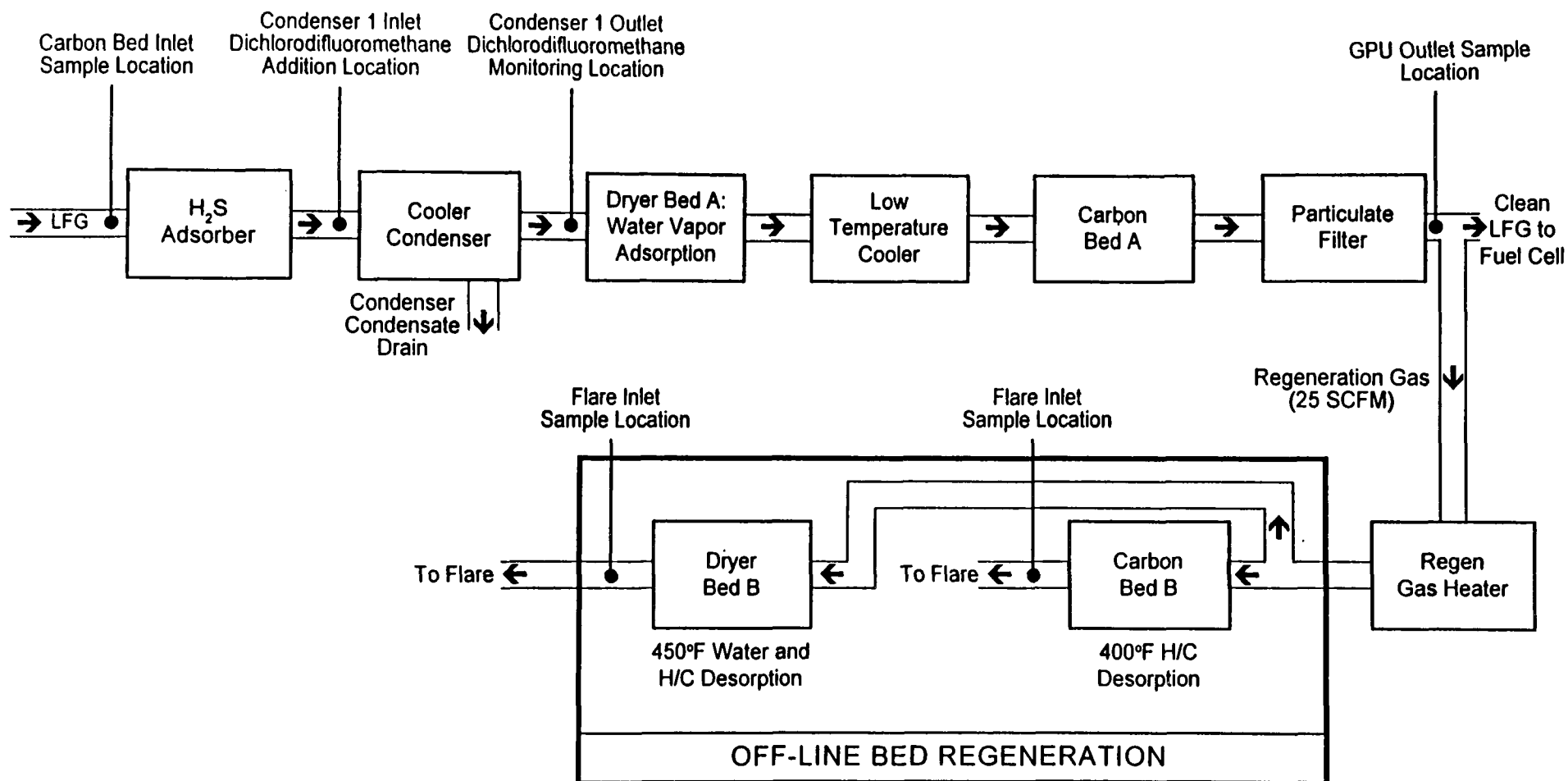
During the first test cycle, Bed A was challenged by injecting pure dichlorodifluoromethane prior to the GPU regenerative beds while the dichlorodifluoromethane concentration was measured in the GPU outlet gas stream by both on-line GC/ECD and off-site GC/MS. The dichlorodifluoromethane test was designed to demonstrate the flexibility of the GPU for any landfill gas application by challenging the unit with high concentrations of a light, difficult to remove, halogenated hydrocarbon. The second and third test cycles did not include dichlorodifluoromethane spiking.

The test matrix and target compound list is included in **Appendix A**. Test parameters and methods used for VOCs and sulfur compounds during the GPU demonstration test are outlined below. Additional test parameters were also measured to provide a more complete characterization of the GPU inlet and outlet gas streams, and those methods are also listed below.

#### GPU Outlet Measurements

- **Sulfur Compounds (on-site)**—On-line GC/FPD according to EPA Methods 15 and 16.
- **Total Sulfur (on-site)**—Continuous monitoring of total sulfur using a chemical cell-type analyzer and a digital data logger.

D-8.



Clean Gas Production Process - This process incorporates H<sub>2</sub>S removal by the Claus reaction, refrigerated cooling and condensation, drying, cooling and hydrocarbon adsorption process units to remove contaminants from the landfill gas.

The H<sub>2</sub>S removal bed reacts H<sub>2</sub>S with O<sub>2</sub> found in the landfill gas to produce elemental sulfur. This bed is non-regenerable and is replaced periodically. The first and second stage refrigeration coolers operate at approximately +35°F and -20°F, respectively.

<b>TRC</b> TRC Environmental Corporation	5 Waterside Crossing Windsor, CT 06095 (203) 289-8631
	INTERNATIONAL FUEL CELLS INC. EPA/AEERL PHASE II FUEL CELL/LANDFILL GAS ENERGY RECOVERY PROGRAM
<b>FIGURE 1-1.</b> <b>PHASE II FIELD TEST SAMPLE LOCATIONS          AND TEST RESULTS</b>	
Date: 5/95	Drawing No. 02030-05



- **Halogenated Volatile Organic Compounds (on-site)**—On-line GC/ECD according to EPA Method 18.
- **Sulfur Compounds (off-site)**—GC/FPD analysis of Tedlar bag samples according to EPA Methods 15, 16, and 18.
- **Target Volatile Organic Compounds (off-site)**—GC/MS analysis of Tedlar bag samples according to EPA Method TO-14 using the test protocol target compound list.
- **Particulate Matter**—EPA Method 5.
- **Total Nonmethane Hydrocarbons/Methane**—A Tedlar bag sample was analyzed by total combustion analysis and flame ionization detector analysis according to California Air Resources Board (CARB) Method 25.2.
- **Gas Volumetric Flowrate**—A calibrated process monitor was used.

#### GPU Inlet Measurements

- **Halogenated Volatile Organic Compounds (on-site)**—GC/ECD analysis of Tedlar bag samples according to EPA Method 18.
- **Sulfur Compounds (off-site)**—GC/FPD analysis of Tedlar bag samples according to EPA Methods 15, 16, and 18.
- **Target Volatile Organic Compounds (off-site)**—GC/MS analysis of Tedlar bag samples according to EPA Method TO-14 using the test protocol target compound list.
- **Phenol**—Samples collected on solid sorbent tubes, solvent extraction and analysis by GC/MS.
- **Silanes and Siloxanes**—Collection in absorbing solution and total silicon measurement by elemental analysis.
- **Total Nonmethane Hydrocarbons/Methane**—A Tedlar bag sample was analyzed by total combustion analysis and flame ionization detector analysis according to CARB Method 25.2.

#### GPU Liquid Condensate Measurements

- **Sulfur Compounds (off-site)**—GC/FPD analysis of water samples was conducted for target sulfur compounds using a purge and trap system.
- **Target Volatile Organic Compounds (off-site)**—Purge and trap, and GC/MS analysis of water samples were conducted according to EPA Method 8260 using the test protocol target compound list.

During the second bed cycle test series, emission tests were also performed at the flare inlet and outlet, to provide data for the SCAQMD permit. The flare is used to control emissions from the GPU during bed regeneration. Triplicate flare tests were conducted with sampling times correlating to specific events in the bed regeneration cycles. Flare inlet and outlet samples were collected during the carbon bed hot regeneration, the dehydration bed hot regeneration, and the dehydration bed cold regeneration. The scope of work for the flare test is outlined below.

#### Flare Inlet Measurements

- **Target Volatile Organic Compounds (off-site)**—GC/MS analysis of triplicate one-hour Tedlar bag samples were conducted according to EPA Method TO-14 using the test protocol target compound list.
- **Sulfur Compounds (off-site)**—Triplicate one-hour Tedlar bag samples were analyzed by GC/FPD according to EPA Methods 15, 16, and 18.
- **Total Nonmethane Hydrocarbons/Methane**—Triplicate one-hour Tedlar bag samples were analyzed by total combustion analysis and flame ionization detector analysis according to CARB Method 25.2.
- **Gas Volumetric Flowrate**—Process monitor data was used.

#### Flare Outlet Measurements

- **Target Volatile Organic Compounds (off-site)**—GC/MS analysis of triplicate one-hour Tedlar bag samples were conducted according to EPA Method TO-14 using the test protocol target compound list.
- **Sulfur Compounds (off-site)**—Triplicate one-hour Tedlar bag samples were analyzed by GC/FPD according to EPA Methods 15, 16, and 18 using the test protocol target compound list.
- **Total Nonmethane Hydrocarbons/Methane**—Triplicate one-hour Tedlar bag samples were analyzed by total combustion analysis and flame ionization detector analysis according to CARB Method 25.2.
- **Particulate Matter**—Triplicate tests were conducted according to EPA Methods 5 and 202.
- **Nitric Oxides, Carbon Monoxide, and Diluents**—Triplicate one-hour tests were conducted according to EPA Methods 7E, 10, and 3A.
- **Gas Volumetric Flowrate**—The gas flowrate was calculated on the basis of stoichiometric combustion and measured excess air.

### 1.3 Report Organization

Section 2.0 presents an executive summary, which includes a discussion applying the results to demonstrate compliance with the GPU performance specifications. The test results are presented in tables and discussions in Section 3.0 of this report. The test procedures are outlined in Section 4.0, and Section 5.0 presents an overview of quality assurance. Included in Section 5.3 is a discussion of the quality control results and how those results effect the data uncertainty. The report appendices contain copies of sampling and analytical data and descriptions of the GPU and associated equipment.

## 2.0 EXECUTIVE SUMMARY

Measured GPU outlet emission concentrations of halides and sulfur compounds were below or only marginally above the method detection limits. The method detection limits demonstrated that the GPU met the total halides and total sulfur performance standards during all times of the normal eight-hour cycles on each of the two regenerative beds. The dichlorodifluoromethane challenge test demonstrated that dichlorodifluoromethane was effectively removed; dichlorodifluoromethane was nondetected at the GPU outlet, with greater than 7 ppmv in the inlet.

GPU outlet sulfur measurements were performed with two types of on-site, on-line measurements and off-site analyses of integrated samples. All three measurements demonstrated compliance with the performance standard of 3 ppmv total sulfur.

The GPU outlet halide measurements were performed with both on-line GC/ECD measurements and off-site GC/MS analyses of integrated samples. The on-line halide measurements were conducted as a process monitoring tool and were not designed to demonstrate compliance with the performance limit. The on-line method measured selected halide compounds as a general indicator of GPU performance. The off-site GC/MS halide method was used to demonstrate compliance with the GPU performance specification. Methylene chloride was the only halogenated compound detected in the GPU outlet at a maximum concentration of 0.032 ppmv, and the GC/MS method detection limit for all other halogenated compounds was 0.002 ppmv. This data clearly demonstrated compliance with the 3 ppmv total halide limit.

There was a discrepancy between on-line GC/ECD and off-site GC/MS measurements which raised an uncertainty on the halide removal performance demonstration. As a result, an audit was conducted using cylinder gases prepared in a landfill gas matrix. The results of that audit indicated that the GC/ECD data may have been biased high due to the effect of the landfill gas matrix. The GC/MS method measured two audit gases within 2% of the certified value. The audit results minimized the GC/MS uncertainty and supported the use of the GC/MS method to demonstrate compliance with the halide performance specification.

Pollutant measurements conducted on the flare for the SCAQMD permit requirement demonstrated that the flame destruction efficiency was 99.2% for nonmethane organics and greater than 99.2% for sulfur compounds. Nitrogen oxides (NO<sub>x</sub>) emission concentration

averaged 10.4 ppmv and carbon monoxide (CO) emission concentration averaged 3 ppmv. Total particulate matter, including back-half organic and inorganic fractions, averaged 0.015 grains per dry standard cubic foot (grains/dscf).

## 2.1 Recommendations for Phase III Program Emission Measurements

Increased quality control measurements should be conducted for the Phase III program to minimize the potential for problems such as the disparity between the GC/ECD and GC/MS measurements that occurred in Phase II. The disparity between the two measurements occurred on each of the GPU inlet samples; dichlorodifluoromethane, trichloroethene, and tetrachloroethene concentrations were consistently higher according to the GC/ECD measurements. An audit was conducted to resolve the differences, and the results indicated that the GC/ECD data may have been biased high. A detailed discussion of the disparity between GC/ECD and GC/MS methods and the audit results is presented in Section 5.3.

Phase III testing will also include GC/MS measurements for halogenated compounds at the GPU outlet. This method can be used effectively to demonstrate compliance with the 3 ppmv performance standard as demonstrated during Phase II. The GC/MS method detection limits are sufficient to demonstrate that the GPU is greater than 100 times more efficient than required by the performance specification. However, additional audits should be conducted, using cylinder gas audits prepared in a landfill gas matrix, to minimize the uncertainty associated with the measurements.

### 3.0 SUMMARY AND DISCUSSION OF RESULTS

Emission tests were conducted in accordance with the test protocol during three complete GPU cycles, with the SCAQMD permit tests conducted during the second cycle. Results are summarized in the following discussions and tables; all sampling and analytical data are included in the appendices.

#### 3.1 GPU Dichlorodifluoromethane Challenge Test

The dichlorodifluoromethane challenge test was conducted on Bed A on October 20 from 0840 to 1640. The test consisted of metering a known quantity of pure gas into the inlet of the first condenser with a calibrated rotometer. The spiking began after the first 30 minutes of operation on Bed A and continued throughout the entire eight-hour cycle. Samples of the spiked gas stream were collected in Tedlar bags prior to spiking at 0855, during the first 30 minutes at 0930, again at 1255, and during the last hour of Bed A operation at 1530. GPU outlet bag samples were also collected concurrently with the exception of the 0930 sample. The GPU outlet gas stream was also analyzed by on-line GC/ECD at approximately one-hour intervals. The test results are summarized in Table 3-1.

Dichlorodifluoromethane was injected at a rate designed to provide 50 ppmv in the landfill gas stream entering the first condenser. Injection at the first condenser inlet was used because the pressure at the true GPU inlet (Westates carbon bed inlet) is high enough to potentially condense dichlorodifluoromethane vapors. The entire active system was challenged with this method.

The inlet dichlorodifluoromethane concentration was measured on-site by analyzing the landfill gas downstream of the injection point with GC/ECD to verify the spike rate; however, off-site GC/MS analysis of the same sample indicated that dichlorodifluoromethane concentration was much lower. An audit was conducted several months after the completion of the field program to resolve the difference between the two methods. The audit demonstrated that the on-site GC/ECD may have been biased by the landfill gas matrix and that the GC/MS data was more accurate. As a result, the actual dichlorodifluoromethane spike concentration averaged 8.0 ppmv. This rate was below the 50 ppmv specified in the protocol, but is representative of halogenated organic compound concentrations found in landfill gas.

TABLE 3-1  
GPU INLET/OUTLET EMISSION TEST SUMMARY:  
TEST NO. 1 - DICHLORODIFLUOROMETHANE SPIKING

International Fuel Cells  
Penrose Landfill  
October 20, 1993

Pretreatment Bed A  
Inlet Flowrate: 81 scfm  
Regeneration Flowrate: 25 scfm  
Output Flowrate: 56 scfm  
Flare Temperature: 1600 oF

Time	0840-0910		0910-0940		0940-1540		1540-1640	
Cycle Time	Hour 1		Hour 1		Hour 2-7		Hour 8	
Dichlorodifluoromethane Spike Status (on/off)	Off		On		On		On	
Sampling Location	Condenser 1 Outlet	GPU Outlet	Condenser 1 Outlet	GPU Outlet	Condenser 1 Outlet	GPU Outlet	Condenser 1 Outlet	GPU Outlet
Total Sulfur-Continuous Analyzer (ppmv)		< 0.2		< 0.2		< 0.2		< 0.2
Reduced Sulfur-GC/FPD (ppm v/v)								
Sample Type	bag	bag		on-line	bag	bag	bag	on-line
hydrogen sulfide	0.39	<0.004		<0.01	<0.08	<0.004	0.47	<0.01
carbonyl sulfide	0.079	<0.004		<0.01	<0.08	<0.004	<0.08	<0.01
methyl mercaptan	<0.04	<0.004		<0.01	<0.08	<0.004	<0.08	<0.01
ethyl mercaptan	<0.04	<0.004		<0.01	<0.08	<0.004	<0.08	<0.01
dimethyl sulfide	6.2	<0.004		<0.01	5.76	<0.004	5.7	<0.01
carbon disulfide	0.05	<0.002		<0.01	0.082	0.004	0.065	<0.01
dimethyl disulfide	0.11	<0.002		<0.01	0.14	0.004	0.11	<0.01
Total Reduced Sulfur - see note	7.71	<0.004		<0.01	6.76	0.008	7	<0.01
Volatile Organic Halogens- GC/MS Analysis (ppm v/v)								
Sample Type	bag	bag			bag	bag	bag	
dichlorodifluoromethane	0.6	<0.002			7.4	<0.002	8.7	
vinyl chloride	1.1	<0.002			0.09	<0.002	0.85	
methylene chloride	5.1	0.004			4	<0.002	3.5	
cis-1,2-dichloroethene	5.7	<0.002			4.8	<0.002	3.9	
1,1-dichloroethane	2.4	<0.002			1.9	<0.002	1.7	
trichloroethene	1.8	<0.002			1.7	<0.002	1.4	
tetrachloroethene	2.4	<0.002			4.4	<0.002	3.7	
chlorobenzene	0.58	<0.002			1.2	<0.002	1.1	
Total Halogens (as halide) - see note	46.6	0.008			75.1	< 0.002	74.8	
Volatile Organic Compounds - GC/MS Analysis (ppm v/v)								
benzene	1.5	<0.002			1.3	<0.002	1.1	
toluene	31	0.0035			46	0.0025	38	
xylenes	5.45	<0.002			17	<0.002	17.3	
ethyl benzene	4.5	<0.002			11	<0.002	10	
styrene	0.54	<0.002			0.97	<0.002	0.6	
acetone	16	<0.005			11	0.042	14	
2-butanone	7	<0.004			7.7	<0.004	6.3	
ethyl acetate	8.1	<0.002			8.1	<0.002	8.1	
ethyl butyrate	4.2	<0.002			8.4	<0.002	6.3	
alpha-pinene	9	<0.002			18	<0.002	16.2	
d-limonene	1.8	<0.002			5.4	<0.002	9	
tetrahydrofuran	1.6	<0.002			1.6	<0.002	1.3	
Phenol-GC/MS (ppm v/v)					<0.06			
Silanes/Siloxanes (mg/dscm)					< 0.28			
Particulate Matter (grains/dscf)						<0.0008		

NOTES:

- Total reduced sulfur is calculated as the sum of target compound concentrations as sulfur, plus the sum of any unknown sulfur compounds quantified as hydrogen sulfide.
- Total halogen is calculated as follows: multiply each compound concentration by the number of halide atoms and total.

The GPU outlet dichlorodifluoromethane concentration, measured by both on-line GC/ECD and off-site GC/MS, was below detection limits throughout each eight-hour cycle. The detection limit for the on-line GC/ECD was 0.4 ppmv and the GC/MS detection limit was 0.002 ppmv. The GC/MS method was 200 times more sensitive than the GC/ECD method for dichlorodifluoromethane and demonstrated that the GPU removal efficiency was greater than 99.97%. The dichlorodifluoromethane spike test, using the GC/MS detection limit, also demonstrated that total halide emissions from the GPU were less than 0.008 ppmv or less than 0.3% of the 3 ppmv performance specification.

### 3.2 GPU Removal of Volatile Organic Compounds

Volatile organic compound (VOC) removal was measured over three bed cycles using on-site GC/ECD analyses and off-site GC/MS analyses. Six target halides were analyzed by GC/ECD and the VOC target compounds listed in the protocol (Table 3.2-2) were analyzed by GC/MS. The results from the three cycles (identified as Tests 1-3) are summarized in Tables 3-1, 3-2, 3-3, and 3-4.

The GPU outlet concentration of the target compounds was below or only marginally above method detection limits as measured with both the GC/ECD and GC/MS methods. The GC/MS method was more sensitive than the GC/ECD and showed that halide target compounds were below 0.002 ppmv with the exception of methylene chloride, which was measured at trace levels (below 0.02 ppmv) in two samples. Both measurement methods demonstrated that the GPU met the performance specification of 3 ppmv over the entire eight-hour cycle of both beds.

The inlet concentrations of target VOCs measured by GC/MS were typical of landfill gas. Halide concentrations over 1 ppmv in the inlet gas stream included vinyl chloride, methylene chloride, cis-1,2-dichloroethene, 1,1-dichloroethane, trichloroethene, tetrachloroethene, and chlorobenzene. Additional VOCs measured in the inlet gas stream included toluene averaging 37.6 ppmv, xylenes at 17.3,  $\alpha$ -pinene at 15.0, acetone at 14.8, ethyl acetate at 9.0, ethyl benzene at 8.8, and ethyl butyrate at 7.0.

In summary, the off-site GC/MS measurements at the GPU inlet and outlet indicated that the GPU efficiently removed halogenated and other VOCs to comply with the performance specification. Only trace levels (less than 0.02 ppmv) of methylene chloride were detected in the GPU outlet by GC/MS.



TABLE 3-2  
GPU INLET/OUTLET EMISSION TEST SUMMARY:  
TEST NO. 2

International Fuel Cells  
Penrose Landfill  
October 21, 1993

Pretreatment Bed B  
Inlet Flowrate: 80 scfm  
Regeneration Flowrate: 25 scfm  
Output Flowrate: 55 scfm  
Flare Temperature: -1600 oF

Time Cycle Time	1000-1100 Hour 1		1100-1700 Hour 2-7		1700-1800 Hour 8
Sampling Location	Carbon Bed Inlet	GPU Outlet	Carbon Bed Inlet	GPU Outlet	GPU Outlet
Methane (ppm v/v)			472000	483000	
Total Non-Methane Organics (ppm v/v as carbon)			5700	13.8	
Total Sulfur-Continuous Analyzer (ppmv)		< 0.2		< 0.2	< 0.2
Reduced Sulfur-GC/FPD (ppm v/v)					
Sample Type	bag	bag		on-line	on-line
Compound					
hydrogen sulfide	108	<0.004		<0.01	<0.01
carbonyl sulfide	0.16	0.017		<0.01	0.047
methyl mercaptan	2.79	<0.004		<0.01	<0.01
ethyl mercaptan	0.44	<0.004		<0.01	<0.01
dimethyl sulfide	6.57	<0.004		<0.01	<0.01
carbon disulfide	<0.04	<0.002		<0.01	<0.01
dimethyl disulfide	<0.04	<0.002		<0.01	<0.01
Total Reduced Sulfur - see note	117	0.017		<0.01	0.047
Volatile Organic Halogens GC/MS Analysis (ppm v/v)					
Sample Type	bag	bag			
Compound					
dichlorodifluoromethane	0.26	<0.002			
vinyl chloride	1.4	<0.002			
methylene chloride	4.1	<0.002			
cis-1,2-dichloroethene	5.8	<0.002			
1,1-dichloroethane	2.8	<0.002			
trichloroethene	2.4	<0.002			
tetrachloroethene	4.8	<0.002			
chlorobenzene	1.4	<0.002			
Total Halogens (as halide) - see note	57.0	< 0.002			
Volatile Organic Compounds - GC/MS Analysis					
benzene	1.7	<0.002			
toluene	47	<0.002			
xylene	28.2	<0.002			
ethyl benzene	12	<0.002			
styrene	1.1	<0.002			
acetone	15	<0.005			
2-butanone	3.7	<0.004			
ethyl acetate	10.8	<0.002			
ethyl butyrate	8.4	<0.002			
alpha-pinene	18	<0.002			
d-limonene	18	<0.002			
tetrahydrofuran	2	<0.002			
Phenol-GC/MS (ppm v/v)			<0.03		
Silanes/Siloxanes (mg/dscm)			<0.14		
Particulate Matter (grains/dscf)				<0.0004	

NOTES:

1. Total reduced sulfur is calculated as the sum of target compound concentrations as sulfur, plus the sum of any unknown sulfur compounds quantified as hydrogen sulfide.
2. Total halogen is calculated as follows: multiply each compound concentration by the number of halide atoms and total.

TABLE 3-3  
GPU INLET/OUTLET EMISSION TEST SUMMARY  
TEST NO. 3

International Fuel Cells  
Penrose Landfill  
October 21-22, 1993

Pretreatment Bed A  
Inlet Flowrate: 80 scfm  
Regeneration Flowrate: 25 scfm  
Output Flowrate: 55 scfm  
Flare Temperature: 1600 oF

Time Cycle Time	1800-1900 Hour 1		1900-0100 Hour 2-7		0100-0200 Hour 8
Sampling Location	Carbon Bed Inlet	GPU Outlet	Carbon Bed Inlet	GPU Outlet	GPU Outlet
Total Sulfur-Continuous Analyzer (ppmv)		< 0.2		< 0.2	< 0.2
Reduced Sulfur Compounds (ppm v/v)					
Sample Type	bag	bag	bag	on-line	on-line
hydrogen sulfide	92.7	<0.004	107	<0.01	<0.01
carbonyl sulfide	0.197	0.017	0.164	0.035	0.026
methyl mercaptan	2.91	<0.004	2.96	<0.01	<0.01
ethyl mercaptan	0.48	<0.004	0.47	<0.01	<0.01
dimethyl sulfide	6.51	<0.004	6.52	<0.01	<0.01
carbon disulfide	<0.07	<0.002	<0.07	<0.01	<0.01
dimethyl disulfide	<0.07	<0.002	<0.07	<0.01	<0.01
Total Reduced Sulfur - see note	104	0.017	118	0.035	0.026
Volatile Organic Halogens- GC/MS Analysis (ppm v/v)					
Sample Type	bag	bag	bag	bag	bag
Compound					
dichlorodifluoromethane	0.83	<0.002	0.95	<0.002	<0.002
vinyl chloride	1.1	<0.002	1.2	<0.002	<0.002
methylene chloride	6.6	0.016	11	<0.002	<0.002
cis-1,2-dichloroethene	4.3	<0.002	5.9	<0.002	<0.002
1,1-dichloroethane	1.9	<0.002	2.7	<0.002	<0.002
trichloroethene	1.3	<0.002	1.8	<0.002	<0.002
tetrachloroethene	2.7	<0.002	3.6	<0.002	<0.002
chlorobenzene	0.91	<0.002	1.4	<0.002	<0.002
Total Halogens (as halide) - see note	46.7	0.032	66.6	< 0.002	< 0.002
Volatile Organic Compounds - GC/MS Analysis (ppm v/v)					
benzene	1.1	<0.002	1.4	<0.002	<0.002
toluene	28	0.005	36	<0.002	<0.002
xylenes	14.9	<0.002	21.2	<0.002	<0.002
ethyl benzene	6.1	<0.002	9	<0.002	<0.002
styrene	0.6	<0.002	0.81	<0.002	<0.002
acetone	<1.2	0.01	18	<0.005	<0.005
2-butanone	5.2	<0.004	6.6	<0.004	<0.004
ethyl acetate	8.1	<0.002	10.8	<0.002	<0.002
ethyl butyrate	6.3	<0.002	8.4	<0.002	<0.002
alpha-pinene	10.8	<0.002	18	<0.002	<0.002
d-limonene	12.6	<0.002	36	<0.002	<0.002
tetrahydrofuran	1.3	<0.002	1.6	<0.002	<0.002
Phenol-GC/MS (ppm v/v)			<0.06		
Silanes/Siloxanes (mg/dscm)			<0.08		
Particulate Matter (grains/dscf)				<0.0002	

NOTES:

1. Total reduced sulfur is calculated as the sum of target compound concentrations as sulfur, plus the sum of any unknown sulfur compounds quantified as hydrogen sulfide.
2. Total halogen is calculated as follows: multiply each compound concentration by the number of halide atoms and total.

TABLE 3-4  
C1 - C6 HYDROCARBONS EMISSIONS DATA

International Fuel Cells, Inc  
Penrose Landfill  
October 20-21, 1993

Location	Date	Time	Emission Concentrations Measured By GC/FID (ppm v/v)						
			ethane	n-propane	isobutane	n-butane	isopentane	pentane	n-hexane
Condenser No. 1 Inlet	10-20	0840-0910	<0.5	27	18	11	12	13	6.1
Condenser No. 1 Inlet	10-20	1255-1330	<0.5	25	16	9.7	11	18	6
Condenser No. 1 Inlet	10-20	1540-1640	<0.5	26	16	9.7	11	16	5.1
GPU Outlet	10-20	0840-0910	<0.5	<0.4	<0.3	<0.3	<0.3	<0.3	<0.2
GPU Outlet	10-20	1255-1330	<0.5	<0.4	<0.3	<0.3	<0.3	<0.3	<0.2

### 3.3 GPU Removal of Reduced Sulfur Compounds

Reduced sulfur compounds were measured at the inlet and outlet of the GPU simultaneously using on-line GC/FPD at the outlet and Tedlar bag samples with off-site GC/FPD analyses at the inlet. Total reduced sulfur was also continuously monitored with a continuous analyzer (Interscan wet chemical type) and data logger at the GPU outlet. Additional Tedlar bag samples were collected from the outlet gas stream and analyzed off-site for confirmation of the on-line measurements. The data is summarized in Tables 3-1, 3-2, and 3-3. The total reduced sulfur in the GPU outlet was below the detection limit of the continuous analyzer ( $< 0.2$  ppmv) at all times. All measurements indicated that the GPU was efficiently removing reduced sulfur compounds and complying with the performance standard of 3 ppmv during the entire eight-hour cycle on both beds.

The inlet concentrations of total reduced sulfur averaged 113 ppmv during Test 2 and Test 3. During the dichlorodifluoromethane challenge test (Test 1), the inlet sample was collected downstream of the carbon bed where the pressure was lower and, as a result, hydrogen sulfide ( $H_2S$ ) was removed prior to sampling. The GPU inlet sulfur data from Test 1 is not representative of the actual input to the GPU and is not included in the following averages:  $H_2S$  was the primary sulfur compound in the GPU inlet gas stream averaging 102 ppmv, followed by dimethyl sulfide averaging 6.5 ppmv and methyl mercaptan averaging 2.9 ppmv.

Only trace levels of sulfides were detected in the GPU outlet gas stream with both on-line GC/FPD and Tedlar bag sampling. Carbonyl sulfide was detected at levels ranging from below the detection limit of 0.01 ppmv to 0.047 ppmv with the on-line GC/FPD. Carbon disulfide and dimethyl disulfide were detected in one GPU outlet Tedlar bag sample at 0.004 ppmv each.

In summary, the data demonstrated that the reduced sulfur compound concentrations entering the GPU were typical of landfill gas and that the GPU removed these contaminants effectively. The GPU outlet concentrations were either below detection limits (detection limits were 0.01 ppmv for the on-line method and 0.004 for the off-site analyses) or in the part per billion concentration range which demonstrated that the unit was performing approximately 100 times better than the performance specification.

### 3.4 GPU Removal of Nonmethane Organics

During the second test cycle, methane and nonmethane organic compounds were measured according to CARB Method 25.2 in the GPU inlet and outlet gas streams. Single simultaneous samples were collected and the results are reported in **Table 3-2**. The results indicated that the inlet concentration of nonmethane organic compounds was 5700 ppmv as carbon and the outlet concentration was 13.8 ppmv. These data indicate a removal efficiency of 99.8% based on an inlet gas flowrate of 80 standard cubic feet per minute (scfm) and an outlet gas flowrate of 55 scfm.

### 3.5 GPU Outlet Particulate Matter Concentration

Particulate matter was measured during each of the three test cycles with single eight-hour samples collected during each cycle. The concentration measured at the GPU outlet was below 0.0008 grains/dscf on Test 1, below 0.0004 grains/dscf on Test 2, and below 0.0002 grains/dscf on Test 3. These low concentrations represented the sum of the material weights collected on the filters and back-half organic and inorganic fractions. Each filter had less than 1.0 milligram (mg) of particulate matter which was the analytical detection limit. Some trace levels were detected in the back-half fractions. Since no particulate matter was detected on the filters, the results are reported as “less than” values.

In summary, the particulate emissions at the GPU outlet were extremely low, as would be expected in a landfill gas stream. The measured concentrations were trace level and were below the Method 5 detection limit.

### 3.6 GPU Inlet Phenol Concentration

Three phenol samples were collected from the GPU inlet gas stream during the middle of each of the three test cycles. The samples were collected on XAD-2 solid sorbent tubes and analyzed by GC/MS off-site. Phenol was below the detection limit in each sample. The detection limit was 0.06 ppmv on Tests 1 and 3 and 0.03 ppmv on Test 2.

### 3.7 Silanes and Siloxanes – GPU Inlet Concentration

Silanes and siloxanes concentrations were measured in triplicate at the GPU inlet during each test cycle with an experimental test method. Samples were collected in potassium hydroxide absorbing solution and analyzed for silicon by elemental analysis.

The results reported in Tables 3-1, 3-2, and 3-3 are averages of the three test runs. The silicon concentrations were less than 0.278 mg/dry standard cubic meter (dscm), 0.145 mg/dscm, and 0.072 mg/dscm on the respective test cycles.

### 3.8 Flare Efficiency Test

The flare was tested during the regeneration of Bed A. Samples were collected during three phases of regeneration including the carbon bed hot regeneration, the dehydration bed hot regeneration, and the dehydration bed cold regeneration. The highest concentrations of VOCs and sulfur compounds were measured during the hot regeneration of the dryer bed. The data demonstrated that the flare effectively destroyed VOCs and sulfur compounds during all phases of regeneration including the worst-case hot dehydration bed regeneration.

The flare destruction efficiency was determined for key parameters using a calculated volumetric gas flowrate at the flare exhaust. The gas flow was below the detection limit of EPA Method 2; as a result, the calculation was required to determine destruction efficiency. The gas flowrate was calculated based on the sum of the methane and nonmethane gas entering the flare, the stoichiometric combustion air to oxidize the methane entering the flare, and a measured excess air factor of 2.3 based on the O<sub>2</sub> content of the flare exhaust. The calculated flare exhaust flowrate was 368 scfm based on 25 scfm total gas flow entering the flare at 44.8% methane concentration, the stoichiometric air, and the excess air. The airflow calculation is outlined in Appendix H. Based on these calculations, there was 14.7 times more gas flow at the outlet sampling location than there was at the inlet sampling location; a factor of 14.7 was used to calculate the destruction efficiency.

The flare test data is summarized in Table 3-5, and discussions of the data are included in the following subsections.

**TABLE 3-5  
FLARE INLET/OUTLET EMISSION TEST SUMMARY**

International Fuel Cells, Inc.  
Penrose Landfill  
October 21, 1993

GPU Inlet Flowrate: 81 scfm  
Regeneration Flowrate: 25 scfm  
GPU Output Flowrate: 56 scfm  
Flare Temperature: 1600 oF

Time Process Activity	1030-1130 Carbon Bed Regeneration		1230-1330 Dryer Bed Regeneration		1730-1830 Dryer Bed Cold Regeneration	
Flare Sampling Location	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET
Methane (ppm v/v)	440000	<1	448000	<1	463000	<1
Total Non-Methane Organics (ppm v/v as carbo	1860	11.7	21100	11.5	250	6.8
Oxides of Nitrogen (ppm v/v)		7.5		8.9		14.9
Carbon Monoxide (ppm v/v)		5.8		1.7		1.6
Total Particulates (gr/dscf)		0.0182		0.0178		0.0088
Front half		0.0069		0.0135		0.0072
Back half (organic)		0.0005		0.001		0.0011
Back half (inorganic)		0.0108		0.0033		0.0005
Oxygen (%)		14.9		15.03		13.5
Moisture (%)	<0.1	9.2	<0.1	9.1	<0.1	8.6
Temperature (oF)	80	1186	80	929	79	990
Flowrate (scfm)	25		25		25	
Reduced Sulfur Compounds (ppm v/v)						
Sample Type	bag	bag	bag	bag	bag	bag
hydrogen sulfide	<0.004	<0.004	<0.016	0.327	<0.004	<0.004
carbonyl sulfide	0.061	<0.004	<0.016	<0.04	0.014	0.06
methyl mercaptan	<0.004	<0.004	0.087	<0.04	<0.004	<0.004
ethyl mercaptan	<0.004	<0.004	0.016	<0.04	<0.004	<0.004
dimethyl sulfide	0.042	<0.004	73.9	<0.04	0.031	<0.004
carbon disulfide	0.146	<0.002	<0.008	<0.02	<0.002	<0.002
dimethyl disulfide	<0.002	<0.002	0.908	<0.02	0.005	<0.002
Total Reduced Sulfur - see note	0.254	<0.004	80.4	0.327	0.05	0.06
Volatile Organic Compounds- GC/MS Analysis (ppm v/v)						
Sample Type	bag	bag	bag	bag	bag	bag
Compound						
dichlorodifluoromethane	3.6	<0.002	<2.0	<0.002	<0.03	<0.002
vinyl chloride	1.5	<0.002	<3.9	<0.002	<0.05	<0.002
methylene chloride	0.28	<0.002	110	<0.002	0.07	<0.002
cis-1,2-dichloroethene	<0.02	<0.002	62	<0.002	<0.04	<0.002
1,1-dichloroethane	<0.02	<0.002	32	<0.002	<0.04	<0.002
trichloroethene	0.02	<0.002	17	<0.002	<0.03	<0.002
tetrachloroethene	0.17	<0.002	19	<0.002	0.1	<0.002
chlorobenzene	<0.02	<0.002	3.8	<0.002	0.07	<0.002
benzene	0.03	<0.002	16	<0.002	<0.04	<0.002
toluene	1.2	0.007	230	0.004	0.83	0.0025
xylene	0.04	<0.002	43.8	<0.002	1.8	<0.002
ethyl benzene	0.04	<0.002	25	<0.002	0.76	<0.002
styrene	<0.02	<0.002	<2.4	<0.002	<0.03	<0.002
acetone	<0.07	<0.005	150	0.065	<0.12	0.02
2-butanone	<0.06	<0.004	28	<0.004	<0.99	<0.004
ethyl acetate	<0.04	<0.002	5.4	<0.002	<0.04	<0.002
ethyl butyrate	<0.04	<0.002	2.1	<0.002	<0.04	<0.002
alpha-pinene	0.05	<0.002	3.6	<0.002	1.8	<0.002
d-limonene	0.07	<0.002	1.4	<0.002	3.6	<0.002
tetrahydrofuran	<0.04	<0.002	0.99	<0.002	<0.04	<0.002

**NOTES:**

1. Total reduced sulfur is calculated as the sum of target compound concentrations as sulfur, plus the sum of any unknown sulfur compounds quantified as hydrogen sulfide.

### 3.8.1 Flare Destruction of VOCs

As previously stated, the highest VOC concentration entering the flare occurred during the dryer bed hot regeneration. One-hour Tedlar bag samples were collected simultaneously at the inlet and outlet during each phase of regeneration. The samples were analyzed for target VOC compounds by GC/MS according to EPA Method TO-14.

Toluene and acetone were the highest concentration VOCs entering the flare, at 230 ppmv and 150 ppmv. Inlet halide concentrations were also significant with methylene chloride at 110 ppmv; cis-1,2-dichloroethene at 62 ppmv; 1,1-dichloroethane at 32 ppmv; trichloroethene at 17 ppmv; tetrachloroethene at 19 ppmv, and chlorobenzene at 3.8 ppmv. Flare outlet concentrations of these compounds were below the GC/MS detection limit of 0.002 ppmv, indicating that the flare was completely oxidizing these compounds.

The destruction efficiency of the flare was calculated using the calculated flare exhaust gas flowrate (airflow in the flare exhaust was below the detection limit of EPA Method 2 and could not be measured). The destruction efficiency of methylene chloride was greater than 99.97% based on 368 scfm at the flare exhaust and 25 scfm at the flare inlet. The destruction efficiency of tetrachloroethene, which is difficult to oxidize, was greater than 99.85%.

### 3.8.2 Flare Destruction of Sulfur Compounds

As with VOCs, the highest concentrations of sulfur compounds entering the flare occurred during hot regeneration of the dehydration bed. Dimethyl sulfide was the highest concentration compound at 73.9 ppmv. The outlet concentration of dimethyl sulfide was below the detection limit of 0.04 ppmv. The destruction efficiency of dimethyl sulfide was greater than 99.2%.

### 3.8.3 Flare Destruction of Total Nonmethane Organics

The highest concentration of nonmethane organics was also measured during the hot regeneration of the dehydration bed. The inlet concentration was 21,100 ppmv as carbon and the outlet concentration was 11.5 ppmv. Based on a 14.7-fold increase in air flow at the outlet, the destruction efficiency was 99.2%.



#### 3.8.4 Flare Outlet Concentration of NO<sub>x</sub>, CO, and Particulate Matter

The nitrogen oxides (NO<sub>x</sub>) and carbon monoxide (CO) concentrations at the flare outlet averaged 10.4 ppmv and 3.0 ppmv, respectively, over the three test periods. Particulate matter, based on the front-half catch, averaged 0.009 grains/dscf over the three test runs. Particulate matter, based on front-half and back-half catches, averaged 0.013 grains/dscf.

#### 3.9 Ambient Concentrations of NO<sub>x</sub>, CO, and Particulate Matter

The ambient concentrations of NO<sub>x</sub> and CO were below the detection limits of the analyzers. The detection limits were 1.0 ppmv for each compound. Particulate matter was measured with one eight-hour sample collected within 20 feet of the flare on the day of the flare emission testing. The particulate matter concentration was 267 micrograms per cubic meter (µg/m<sup>3</sup>).

#### 3.10 Condensate Analyses

One condensate sample was collected from the first cooler condenser during the first hour of each cycle for a total of three samples. There was no condensate in the second condenser; as a result, no sample could be collected. Each sample was analyzed for the target sulfur compounds by GC/FPD and the target VOCs by GC/MS. The results are reported in Table 3-6.

The highest concentration VOCs were acetone and 2-butanone, which were detected in each sample. The average concentrations were 16,700 micrograms/liter (µg/ℓ) of acetone and 12,700 µg/ℓ of 2-butanone. The highest concentration of a target sulfur compound was 1,720 µg/ℓ of dimethyl sulfide. However, an unknown sulfur compound was also detected in each sample which increased the average total sulfur concentration to 33,000 µg/ℓ.

**TABLE 3-6  
CONDENSATE ANALYSES**

International Fuel Cells, Inc.  
Penrose Landfill  
October 20-21, 1993

Date	10-20	10-21	10-21
Sampling Time	0900	1000	1800
Sampling Location	First Condenser	First Condenser	First Condenser
<b>Reduced Sulfur Compounds (ug/liter)</b>			
hydrogen sulfide	<56	<56	<56
carbonyl sulfide	<98	<98	<98
methyl mercaptan	<79	<79	<79
ethyl mercaptan	123	<100	<100
dimethyl sulfide	1760	1720	1720
carbonyl sulfide	97.2	<62	<62
dimethyl disulfide	99.9	135	132
Total Reduced Sulfur - see note 1	22700	39000	37300
<b>Volatile Organic Compounds - GC/MS Analysis (ug/liter) - see note 2</b>			
acetone	160000	150000	190000
2-butanone	100000	140000	140000
methylene chloride	1600	2100	2100
4-methyl-2-pentanone	15000	20000	17000
toluene	3200	6100	5700
2-hexanone	1000	1900	3100
xylenes	2620	3800	4000
ethyl benzene	990	1800	1400

**NOTES:**

1. Total reduced sulfur is calculated as the sum of target compound concentrations as sulfur, plus the sum of any unknown sulfur compounds quantified as hydrogen sulfide. Each condensate sample contained a large unknown peak.
2. Additional target volatile organic compounds were below the 2500 ug/L detection limit.

#### 4.0 SAMPLING AND ANALYTICAL METHODS

The following discussions outline the test methods used for both the EPA demonstration and the SCAQMD permit compliance test.

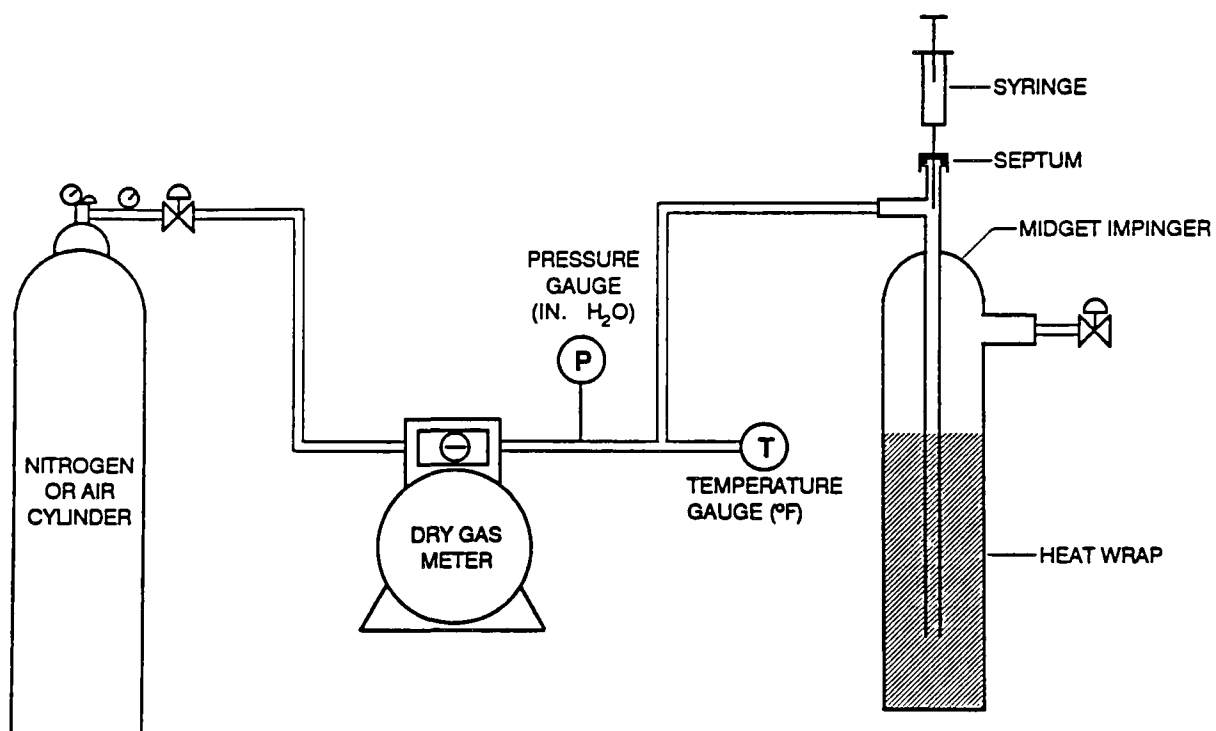
#### 4.1 GPU Inlet Measurements

##### 4.1.1 GPU Inlet Volatile Organic Compounds

GPU inlet samples were collected in Tedlar bags and analyzed on-site for six target compounds by GC/ECD and off-site by GC/MS. The strategy of the on-site and off-site measurements was to have an immediate indicator of performance on-site for key target compounds such as dichlorodifluoromethane and to use the off-site GC/MS analyses to provide a complete characterization of the full target compound list.

The sampling location was prior to the first condenser (downstream of the Westates carbon bed) on the first test cycle and at the inlet to the Westates carbon bed for the second and third test cycles. The bags were filled through a needle valve with the positive pressure in the gas stream. During the dichlorodifluoromethane challenge test, one sample was collected and analyzed prior to initiation of the spike and three samples were collected during the spiking. One sample was collected during the first hour of the second test. Two samples were collected during the third test cycle. Each sample was collected over approximately 30 minutes.

The samples were analyzed on-site for six target halides including dichlorodifluoromethane by GC/ECD according to EPA Method 18. A Hewlett-Packard 5890 with a Model 3396A integrator was used for the analysis. The GC was equipped with a 75 meter (m) by 0.45 millimeter (mm) DBVRX column purchased from J&W Scientific, Inc. Sample gas was injected through a 0.5 milliliter (mℓ) loop with a gas sampling valve. The GC/ECD was calibrated with gas standards prepared from liquid stock solutions purchased from a chemical standards supply company. The gas standards were prepared according to EPA Method 18 using the device depicted in Figure 4-1. Each of these standards contained the six target halides, and the external multipoint calibration was programmed into the integrator. During the challenge test (Test No. 1), dichlorodifluoromethane was quantified with a second calibration conducted by analyzing three standards prepared by dilution of pure dichlorodifluoromethane gas.



**TRC**

TRC Environmental Corporation

5 Waterside Crossing  
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FIGURE 4-1

**PREPARATION OF SOLVENT STANDARDS  
EPA METHOD 18**

The reason for the additional dichlorodifluoromethane calibration was that the dichlorodifluoromethane concentration during the challenge test exceeded the original calibration. In addition, the reliability of standards prepared from a liquid (the dichlorodifluoromethane stock solution was in methanol) was considered less reliable due to the gaseous state of this compound at ambient temperatures.

The on-site GC/ECD method was also audited with two gases containing 10.0 ppmv and 1.0 ppmv dichlorodifluoromethane, respectively, prepared by a specialty gas manufacturer. The analysis of the higher gas was 12.5 ppmv and the lower gas was 1.7 ppmv.

The off-site GC/MS analyses was conducted on the same day as sampling by Performance Analytical, Inc., of Canoga Park, California. The samples were analyzed by gas injections on a GC/MS according to EPA Method TO-14. The samples were concentrated with a cryogenic trap prior to analysis. The target compound list is presented in the protocol in Appendix A (Table 3.3-2 excluding the C1–C6 hydrocarbons). Twenty of these compounds were quantitated by external calibration curves prepared from gas standards. The remaining 10 compounds were identified by ion matching and quantified by internal standard. The internal standard method is less accurate and is usually referred to as a semi-quantitative method. The 10 compounds measured by internal standard are listed below:

chlorodifluoromethane	ethyl butyrate	tetrahydrofuran
dichlorofluoromethane	$\alpha$ -pinene	1-butanol
ethyl acetate	d-limonene	naphthalene
nitrobenzene		

In addition, the GPU inlet bag samples were analyzed for C1–C6 hydrocarbons by GC/flame ionization detector (GC/FID). These analyses were also conducted off-site by Performance Analytical, Inc.

#### 4.1.2 GPU Inlet Reduced Sulfur Compounds

The same GPU inlet bag samples collected for VOC were also analyzed by GC/FPD for seven target compounds. Samples were analyzed by gas injection on a Hewlett-Packard 5890 GC/FPD equipped with a 60 m by 0.53 mm ID capillary column (crossbonded 100% dimethyl polysiloxane). These analyses were conducted off-site by Performance Analytical, Inc. A multilevel calibration was performed for each compound.

#### 4.1.3 GPU Inlet Phenol

Triplicate phenol samples were collected during each of the three test cycles and analyzed off-site by GC/MS. The samples were collected on ORBO®-47 solid adsorbent tubes using an EPA Method 6 sampling system and analyzed according to Occupational Safety & Health Administration (OSHA) Method 32. The samples were analyzed by Mayfly Environmental. Each tube was desorbed in 0.5 ml of methanol and 1.0 microliter ( $\mu\text{l}$ ) was injected into the GC/MS. A 50-nanogram spiked ORBO-47 tube was also analyzed, with 95% recovery.

#### 4.1.4 GPU Inlet Silicon Compounds

The silicon target compounds including silanes and siloxanes were measured using an OSHA experimental method. The samples were collected using an EPA Method 6 sampling system with mini-impingers containing 20 ml of 0.01 N potassium hydroxide. Triplicate samples were collected during each of the three test cycles. The samples were extracted in nitric acid and analyzed by inductively coupled argon plasmography (ICAP).

#### 4.1.5 GPU Inlet Total Nonmethane Hydrocarbons

Total nonmethane hydrocarbons and methane concentrations were measured with a single Tedlar bag sample, collected during the second test cycle, according to CARB Method 25.2. Analysis was conducted by ATMAA, Inc., of Chatsworth, California, using total combustion analysis/flame ionization detector (TCA/FID) analysis.

### 4.2 GPU Outlet Gas Measurements

#### 4.2.1 GPU Outlet On-line Halides

The concentrations of six target halides were monitored according to EPA Method 18 with a GC/ECD. Samples were analyzed at approximately one-hour intervals throughout each cycle. The target compounds included:

dichlorodifluoromethane  
trichlorofluoromethane  
vinyl chloride

1,1,1-trichloroethane  
trichloroethene  
tetrachloroethene

A Hewlett-Packard 5890 with a Model 3396A integrator was used for the analysis. The GC was equipped with a 75 m by 0.45 mm DBVRX column purchased from J&W Scientific, Inc. Sample gas was injected through a 0.5 mL loop with a gas sampling valve. Teflon tube was used to transport the sample gas from the GPU to the analyzer. The sample gas was under pressure; as a result, no sample pump was required.

The GC/ECD was calibrated with gas standards prepared from liquid stock solutions purchased from a chemical standards supply company. The gas standards were prepared according to EPA Method 18 using the device depicted in **Figure 4-1**. Each of these standards contained the six target halides, and the external multipoint calibration was programmed into the integrator.

The on-site GC/ECD method was also audited with two gases containing 10.0 ppmv and 1.0 ppmv dichlorodifluoromethane, respectively, prepared by a specialty gas manufacturer. The analysis of the higher gas was 12.5 ppmv and the lower gas was 1.7 ppmv.

#### 4.2.2 GPU Outlet Off-site Halides and Dichlorodifluoromethane Analysis (GC/MS Method)

The off-site GC/MS analyses were conducted on the same day as sampling by Performance Analytical, Inc., of Canoga Park, California. The samples were analyzed by gas injections on a GC/MS according to EPA Method TO-14. A one-liter sample was concentrated with a cryogenic trap prior to analysis. The target compound list is presented in the protocol in **Appendix A** (Table 3.3-2 excluding the C1–C6 hydrocarbons). Twenty of these compounds were quantitated by external calibration curves prepared from gas standards. The remaining 10 compounds were identified by ion matching and quantified by internal standard. The internal standard method is less accurate and is usually referred to as a semi-quantitative method. The 10 compounds measured by internal standard are listed below:

chlorodifluoromethane	ethyl butyrate
dichlorodifluoromethane	$\alpha$ -pinene
ethyl acetate	d-limonene
tetrahydrofuran	naphthalene
1-butanol	nitrobenzene

#### 4.2.3 GPU Outlet Continuous Total Reduced Sulfur

Total reduced sulfur was monitored continuously with an Interscan hydrogen sulfide ( $\text{H}_2\text{S}$ ) analyzer calibrated on the 0–1 ppmv scale with EPA Protocol I gas. Sample gas was transported from the GPU outlet with Teflon tubing, with the system positive pressure, to a manifold. The analyzer drew sample gas from the manifold at ambient pressure. Data was recorded with a Yokogawa digital data logger programmed for five-minute and one-hour averages.

The Interscan analyzer measures sulfur compounds with a wet chemical cell designed for  $\text{H}_2\text{S}$ . The analyzer also detects other reduced sulfur compounds; however, the calibration was based on  $\text{H}_2\text{S}$ . A multipoint calibration was conducted with a 22.5-ppm EPA Protocol I gas and a dilution calibrator.

#### 4.2.4 GPU Outlet On-line Sulfur Compounds (GC/FPD Method)

The concentrations of six reduced sulfur compounds were measured semi-continuously with a GC/FPD according to EPA Methods 15, 16, and 18. Sample gas was transported from the GPU outlet through Teflon tubing with the system positive pressure to a manifold, and continuously pumped through an automatic gas sampling loop on a Hewlett-Packard GC/FPD. Samples were analyzed automatically at approximately one-hour intervals throughout each test cycle.

The GC/FPD was multilevel calibrated using certified calibration gases purchased from Scott Specialty Gases, Inc., and a Monitor Labs dilution calibrator. The GC/FPD was equipped with a Supelco, Inc., Teflon packed column (BHT 100). The calibration gases contained the following compounds:

hydrogen sulfide	dimethyl sulfide
carbonyl sulfide	carbon disulfide
methyl mercaptan	dimethyl disulfide

#### 4.2.5 GPU Outlet Reduced Sulfur Compounds (Off-site GC/FPD Method)

The same GPU outlet bag samples collected for VOC were also analyzed by GC/FPD for seven target compounds. Samples were analyzed by gas injection on a Hewlett-Packard 5890 GC/FPD with a 60 m by 0.53 mm ID capillary column (crossbonded 100% dimethyl



polysiloxane). These analyses were conducted off-site by Performance Analytical, Inc. A multilevel calibration was performed for each compound.

#### 4.2.6 GPU Outlet Volumetric Flowrate

The volumetric flowrate was continuously measured with a calibrated in-line electronic flowmeter. The flowmeter was a permanently installed device used as a GPU operational parameter.

#### 4.2.7 GPU Outlet Total Nonmethane Hydrocarbons

Total nonmethane hydrocarbons and methane concentrations were measured with a single Tedlar bag sample, collected during the second test cycle, according to CARB Method 25.2. Analysis was conducted by ATMAA, Inc of Chatsworth, California, using TCA/FID analysis.

### 4.3 Flare Emission Tests

#### 4.3.1 Flare Inlet and Outlet VOC Emission Concentration

Off-site GC/MS analyses were conducted on the same day as sampling by Performance Analytical, Inc., of Canoga Park, California. Triplicate one-hour samples were collected simultaneously at the inlet and outlet in Tedlar bags using the evacuated canister technique according to EPA Method 18. The samples were analyzed by gas injections on a GC/MS according to EPA Method TO-14. The samples were concentrated with a cryogenic trap prior to analysis. The target compound list is presented in the protocol in **Appendix A** (Table 4.3-1). These compounds were quantitated by external calibration curves prepared from gas standards.

#### 4.3.2 Flare Inlet and Outlet Reduced Sulfur Compounds Concentration

The same flare inlet and outlet bag samples collected for VOCs were also analyzed by GC/FPD for seven target compounds. Samples were analyzed by gas injection on a Hewlett-Packard 5890 GC/FPD with a 60 m by 0.53 mm ID capillary column (crossbonded 100% dimethyl polysiloxane). These analyses were conducted off-site by Performance Analytical, Inc. A multilevel calibration was performed for each compound.

#### 4.3.3 Flare Outlet Particulate Emissions

Particulate emissions were measured according to EPA Methods 5 and 202 at the flare outlet. Triplicate one-hour tests were conducted using non-isokinetic sampling. Samples were collected non-isokinetically because the gas velocity in the stack was below the detection limit of the pitot tube/manometer and hot wire anemometer methods.

Total particulate matter was determined as “front half” which included material collected in the probe wash and filter, and “back half” which included both inorganic and organic material collected in the impingers.

#### 4.3.4 Flare Outlet NO<sub>x</sub>, CO, and O<sub>2</sub> Emission Concentrations

Triplicate one-hour tests were conducted according to EPA Methods 7E, 10, and 3A. The reference method analyzers were housed in a mobile CEM laboratory parked at the base of the stack. Sample gas was transported to the system through 50 feet of heated Teflon sample line to a VIA, Inc., sample gas conditioner in the laboratory.

NO<sub>x</sub> concentration was monitored with a Thermo Environmental Instruments, Inc., Model 10 analyzer. CO concentration was monitored with a Fugi, Inc., infrared-type analyzer, and O<sub>2</sub> was monitored with a Teledyne chemical cell-type analyzer. Data was recorded with a Campbell Scientific, Inc., data system. Calibrations were conducted with EPA Protocol I gases.

#### 4.3.5 Flare Outlet Volumetric Flowrate

Flowrate was calculated as the sum of the stoichiometric air required to burn 11.2 scfm of methane and 13.8 scfm of carbon dioxide, with an excess air factor of 2.3 times the stoichiometric air. The flare outlet air flowrate calculation is presented in **Appendix H**.

#### 4.4 Ambient Monitoring for Particulate, NO<sub>x</sub>, and CO

An eight-hour sample was collected on a high-volume sampler within 20 feet of the base of the flare stack according to 40 CFR 50, Appendix B. The sampler was calibrated with a certified calibrator prior to the field test.

NO<sub>x</sub> and CO concentration were also monitored for approximately 10 minutes with the EPA Method 7E and 10 analyzers prior to conducting the emission tests.

## 5.0 QUALITY ASSURANCE

The TRC quality assurance (QA) program is designed to ensure that emission measurement work is performed by qualified people using proper equipment following written procedures in order to provide accurate, defensible data. This program is based upon the EPA *Quality Assurance Handbook for Air Pollution Measurement Systems*, Volume III (EPA-600/4-77-027b).

### 5.1 Emission Measurement Methods

Sampling and measurement equipment including continuous analyzers, recorders, pitot tubes, dry gas meters, orifice meters, thermocouples, nozzles, and any other pertinent apparatus are uniquely identified, undergo preventive maintenance, and were calibrated before and after the test program. Most calibrations were performed with standards traceable to the National Institute of Standards and Technology (NIST) or other appropriate references. These standards include wet test meters and NIST Standard Reference Materials. Records of all calibration data are maintained in TRC files.

During the field tests, sampling performance, and progress were continually evaluated, and deviations from sampling method criteria were reported to the Field Team Leader who then assessed the validity of the test run. All field data were recorded on prepared data sheets or laboratory notebooks. The Field Team Leader maintained a written log describing the events of each day. Field samples including field blanks were transported from the field in shock-proof, secure containers. Sample integrity was controlled through the use of prepared data sheets, positive sample identification, and chain-of-custody forms. All sampling trains were leak-checked before and after each test.

#### Methods 1, 2, 4, 5

All Method 5 related sampling runs were operated nonisokinetically. Probe and hotbox temperatures were maintained within 25°F of the temperatures specified.

Prior to the field test programs, full clean-up (background) evaluations of all sampling equipment are periodically performed at the TRC laboratories. This procedure ensured the accuracy of the chosen equipment and procedures.

### Continuous Emission Monitoring System

The CEM system was calibrated, leak, and bias checked at the beginning and end of each emission test. All calibration gases were Protocol I or equivalent ( $\pm 1\%$ ). Multipoint calibrations were performed on the analyzers prior to the field program to establish linearity.

#### 5.2 Analysis

All sample preparation and sample analyses were performed at or under the direction of the TRC Environmental Corporation. Standards of QA set forth in the *Quality Assurance Handbook for Air Pollution Measurement Systems*, Volume III (EPA-600/4-77-027b) and the *Handbook for Analytical Quality Control in Water and Wastewater Laboratories* (EPA-600/4-79-019, March 1979) were strictly followed.

In the analytical laboratories, all quality control samples including field blank samples, reagents, and filter blanks were analyzed with the actual test samples.

The TRC Laboratory maintains a continuous quality control (QC) program to monitor instrument response and analyst proficiency, and to ensure the precision and accuracy of all analytical results. This program has been developed in consultation with EPA, NIOSH, and State regulatory agencies.

TRC participates in the audit programs of the EPA Environmental Monitoring Systems Laboratory (source and ambient air) and the EPA Environmental Monitoring and Support Laboratory (water). TRC will provide a compressed gas cylinder audit to the subcontract laboratories conducting the toxic air analyzes. Audit results are reviewed by the Chemistry Laboratory Manager and the Emission Measurement Section Manager, and corrective action is initiated when acceptance criteria are not met.

During the data reduction process, all calculations were reviewed initially by a person intimately associated with the emission test program, and finally by a senior scientist or engineer not associated with the program. These QC checks provide a means to ensure that the calculations are performed correctly and that the data are reasonable.

### Laboratory Subcontractors

Subcontract laboratories were selected by TRC to provide analytical support using state-of-the-art laboratory equipment and professional staff.

### 5.3 Program-Specific Quality Control Discussion

In addition to standard emission measurements QC, this program used several redundant measurements to maximize the confidence level. The parameters of key importance were halides and sulfur compounds entering and exiting the GPU. Measurements were conducted with both on-site and off-site methods by independent parties for both key parameters.

Sulfur compounds at the GPU exhaust were determined with three independent test methods including on-line GC/FPD analysis, continuous on-line total reduced sulfur monitoring, and off-site GC/FPD analysis of Tedlar bag samples. The three methods were in agreement; all three methods demonstrated that the emission concentration of total reduced sulfur compounds was below 0.2 ppmv.

Halides were analyzed at the GPU inlet and outlet by both on-site GC/ECD and off-site GC/MS analysis. The on-site GC/ECD method also included analysis of dichlorodifluoromethane audit samples prepared in nitrogen. The high-level audit was analyzed at 12.5 ppmv versus an actual concentration of 10.0 ppmv. The outlet concentration measurements conducted by GC/ECD and GC/MS concurred; both methods showed that emission concentrations were below the detection limits. However, the inlet measurements showed some disparity between the two methods with respect to quantification of three compounds including dichlorodifluoromethane, trichloroethene, and tetrachloroethene. The GC/MS measurements were consistently lower than the on-site GC/ECD measurements. The cause of this disparity created uncertainty which required resolution, so an audit was conducted in April–May 1994 using cylinder gases.

The audit was designed to test three possible causes of bias including the effect of a landfill gas matrix, the Tedlar bag holding time effect, and the effect of moisture. The results are summarized in **Table 5-1**. The audit indicated that the GC/ECD error for dichlorodifluoromethane was 108% at the high level (50 ppmv) and 345% at the low level. The cause of error may be the effect of methane on the ECD which has a known “quenching” effect. The GC/MS audit results were within 2% for both levels. The complete audit results are contained in **Appendix L**.

**TABLE 5-1**

**Summary of Results – Audit to Resolve Discrepancy  
Between GC/ECD and GC/MS Analyses of Landfill Gas Samples**

Phase II Landfill Gas Program – GPU Demonstration Project  
International Fuel Cells, Inc.  
May 1994

CONCENTRATION (ppmv)					
<u>Cylinder No./ Compound</u>	<u>Vendor Certification</u>	<u>Independent Laboratory</u>	<u>TRC (GC/ECD)</u>	<u>Performance Analytical (GC/MS)</u>	
				<u>1st Analysis</u>	<u>8-hour Hold</u>
<b>Cylinder FF37098</b>					
dichlorodifluoro- methane	2.0	1.4	8.9	2.0	
trichloroethene	1.0	11*	9.4	12.0	
tetrachloroethene	1.0	11*	9.8	12.0	
<b>Cylinder FF37105</b>					
dichlorodifluoro- methane	50.0	49.7	104	51.0	54
trichloroethene	4.8	4.8*	4.3	5.4	
tetrachloroethene	4.8	4.8*	4.3	5.3	

**Notes:**

1. Methylene chloride was not included in the audit study because GC/ECD does not have the required sensitivity.
2. \* = estimated concentration based on internal standard.

The effect of humidity was also evaluated by comparing the detector response of a dry and a saturated sample. The saturated sample was 9.9% lower than the dry sample. Humidity results are summarized in Table 5-2.

**TABLE 5-2**

**Effect of Humidity on GC/MS Analyses – Audit to Resolve Discrepancy  
Between GC/ECD and GC/MS Analyses of Landfill Gas Samples**

Phase II Landfill Gas Program – GPU Demonstration Project  
International Fuel Cells, Inc.  
May 1994

<u>Compound</u>	<u>Response (area)</u>	<u>Response (area) Saturated With Water</u>	<u>% Diff</u>
dichlorodifluoromethane	70677	63950	9.9
methylene chloride	7768	7446	4.2
trichloroethene	11315	10808	4.6
tetrachloroethene	10294	9037	13.0

## **APPENDIX E**

### **PROPERTIES OF d-limonene REFRIGERANT**



3 of 4

# D-LIMONENE

## HEAT TRANSFER FLUID APPLICATIONS

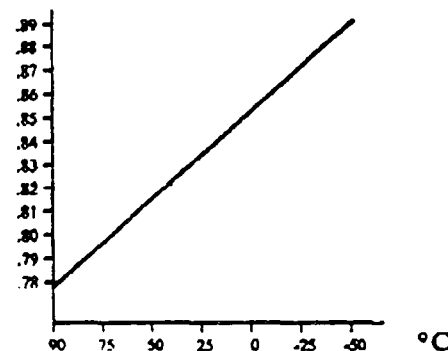
REVISION DATE 2/15/91

**APPLICATION AND DESCRIPTION:** D-Limonene is an effective and relatively inexpensive fluid for a variety of low temperature heat exchange applications — particularly applications involving closed systems with minimal exposure to air. D-Limonene is a naturally occurring product distilled from orange oil.

<b>CHARACTERISTICS:</b>	Freezing Point .....	-142° F
	Boiling Point .....	310° F
	Flash Point (TCC) .....	115° F
	Molecular Wt. ....	136.23
	Specific Heat .....	0.49 BTU's/lb. @ 80° F
		(59.62 calories per gram/mole @ 20.2° C)
	Dielectric Constant .....	2.3
	Thermal Conductivity .....	0.07 @ 70° F.
		0.08 @ -80° F
	Heat of Combustion .....	1,473.9 Kcal/mole @ 25° C
		19,470 BTU's/lb. @ 68° F
	Heat Trans. Coefficient .....	0.08 BTU's per hr. per ° F
	Heat Capacity .....	0.48 calories per CC
	Specific Gravity .....	0.84-0.85 @ 68° F
	Vapor Pressure .....	2 mm Hg @ 68° F
	Vapor Density .....	0.015 grams per liter @ 68° F
	Heat Content .....	1.834 kilojoules per kilogram ° K
		(0.438 calories per gram ° C)
	Thermal Conductivity .....	0.17482 - (1.873 <sup>K<sub>W</sub></sup> x temperature ° K)
		units in $\frac{\text{Joules}}{\text{Seconds} \cdot \text{Meters} \cdot \text{Kelvin}}$
	Liquid Density .....	0.85200 g/ml @ 20° C

TEMP .. VAPOR P	DENSITY, LB/CF
DEG F MM HG	LIQUID VAPOR
0 0.05	54.546 0.000029
50 0.60	53.219 0.000289
100 3.86	51.814 0.001696
150 16.98	50.375 0.006846
200 56.66	48.940 0.021144
250 153.93	47.539 0.056634
300 357.48	46.196 0.117443
350 734.36	44.929 0.230333
400 1368.20	43.754 0.416460

ENTHALPY BTU/LB	ENTROPY, BTU/LB-DEG F
LIQUID LATENT VAPOR	LIQUID LATENT VAPOR
0.000 170.957 170.957	0.00000 0.37197 0.37197
20.858 159.366 180.224	0.06579 0.31273 0.37852
42.913 150.683 193.596	0.12766 0.26927 0.39693
66.165 143.878 210.043	0.18628 0.23602 0.42230
90.615 138.249 228.864	0.24217 0.20960 0.45176
116.262 133.223 249.485	0.29572 0.18774 0.48347
143.106 128.255 271.362	0.34726 0.16885 0.51610
171.148 122.780 293.929	0.39703 0.15166 0.54869
200.387 116.206 316.594	0.44526 0.13519 0.58045



Densities at different temperatures/water @ 40° C

### ADDITIONAL INFORMATION:

**Drying Agent:** Anhydrous Sodium Sulphate  
(typical water content of d-limonene between 250-500 PPM @ 70° F)

**Solvents for removal of oxidized d-limonene:** Methyl Ethyl Ketone  
(ie. from chiller units) Tri-Chlor Ethylene  
Methanol  
N-Methyl - 2 Pyrrolidone  
(freezes 11° F)

**Gasket Material:** Man-holes use Viton  
Pump parts use teflon  
O-Rings use Fluoro-Silicon  
Rubber gaskets must be periodically replaced.  
Acetone  
Alcohol  
Pentonene — (ether ketone made by Shell)

**Anti-Oxidant:** BHT (use approximately 1 cup per 55 gallons d-limonene).

**Germicide:** Ortho Phenyl Phenol

Rust will occur in the presence of d-limonene. Stainless steel and some hard plastics (such as fluorocarbon barrier plastic containers by Air Products, Emmaus, PA.) are most compatible. D-Limonene is often placed in contact with copper piping with minimal negative effect (ie. d-limonene picks up elemental copper which turns fluid green).

PINT SAMPLES AVAILABLE ON REQUEST

# FLORIDA CHEMICAL COMPANY, INC.

475 Dakota Ave. N., P.O. Box 997, Lake Alfred, FL 33850  
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## **APPENDIX F**

### **Laboratory Tests Showing Reaction Of $\text{H}_2\text{S} + \text{CO}_2$ To $\text{COS} + \text{H}_2\text{O}$ Over Alumina**

## Alumina

Two tests were run with Alcoa F200 adsorbent. In the most recent test carbonyl sulfide was produced duplicating the field experience at Penrose in May 1993 during which carbonyl sulfide was formed in the pretreatment system. In the laboratory test an on line flame photometric chromatograph capable of detecting hydrogen sulfide and carbonyl sulfide was used. The tabulated data is shown in Table 5. As shown in the table, the disappearance of hydrogen sulfide corresponds to formation of carbonyl sulfide. It is somewhat surprising that this reaction can occur at ambient temperatures of 60°F.

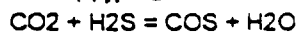
Since the presence of the water vapor in the reactant stream inhibits the formation of carbonyl sulfide based on chemical equilibrium, some discussion of the subject is in order. Some equilibrium compositions are shown in Figure 11. The data in the figure show that the gas must be dry or almost completely dry to attain quantitative conversion of the hydrogen sulfide to carbonyl sulfide. Even the water formed in the reaction is sufficient to limit conversions. As the first step in the laboratory test, the alumina was regenerated with nitrogen at 450°F to simulate the regeneration that alumina undergoes in the pretreatment system. When the reactants are subsequently passed over this very dry alumina, the water vapor is removed in inlet section of alumina bed and the dry gases are free to react in the downstream sections of the alumina bed. Furthermore, the very dry alumina apparently removes the water of reaction allowing almost complete conversions.

Previous tests with alumina had been run to check for elemental sulfur formation by the reaction of hydrogen sulfide with oxygen. Only rudimentary Kitagawa tubes capable of measuring only hydrogen sulfide were used. No flame photometric chromatograph was available at that time. No regeneration program to dry the alumina was run before the adsorption test. The data show hydrogen sulfide being removed for less than one hour at ambient temperatures. Reactor temperatures were increased and some hydrogen sulfide disappearance was recorded at 155°F. No means was available to determine the sulfur product. The fact that no ambient temperature reaction was found in this experiment is attributed to the fact that the alumina was not pre-dried with a regeneration cycle. Hence, the "wet" alumina did not dry the gas stream sufficiently to allow carbonyl sulfide formation.

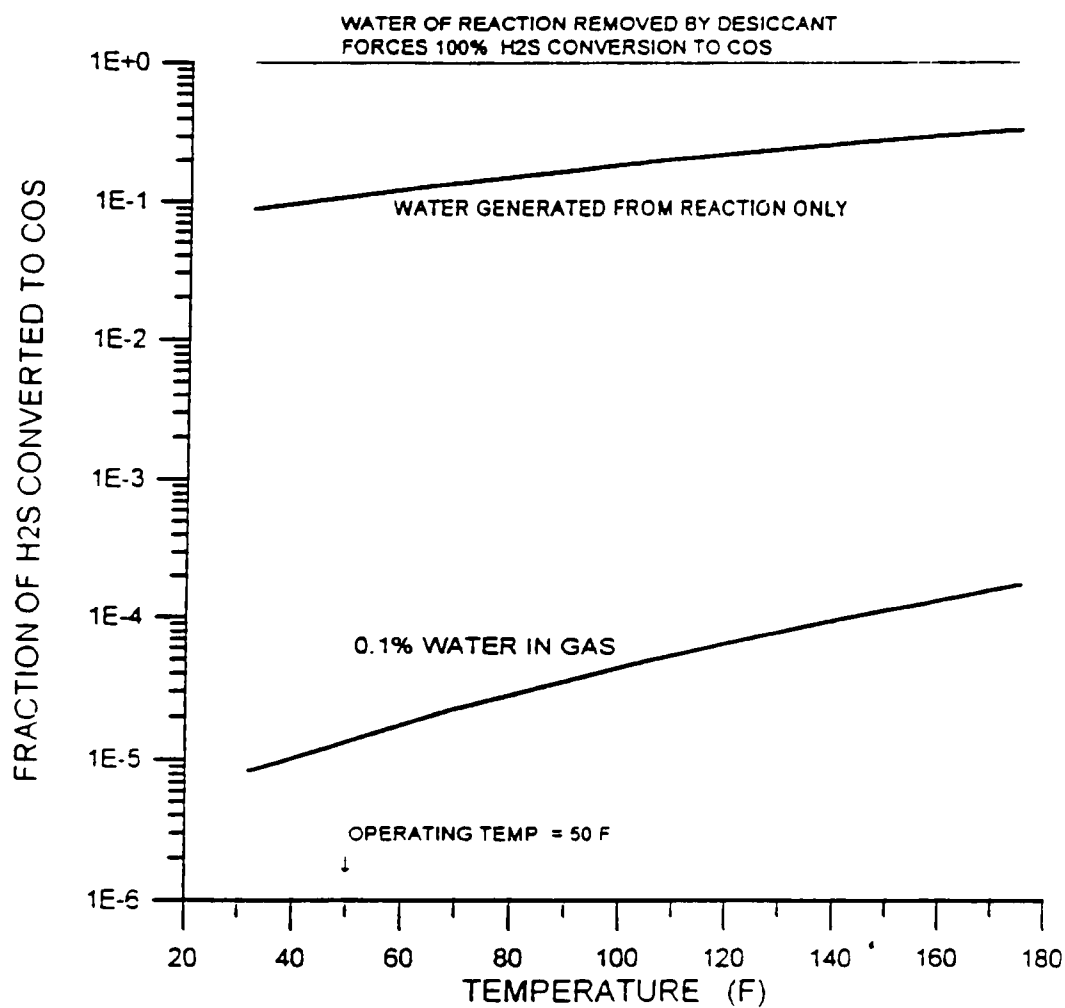
Figure 11

## EQUILIBRIUM CONVERSION OF H<sub>2</sub>S TO COS

OVER ACTIVATED ALUMINA



50% CO<sub>2</sub>  
100 ppm H<sub>2</sub>S



# IFC LABORATORY TEST DATA FOR THE REMOVAL OF H2S USING ACTIVATED ALUMINA

CONDITIONS: 50% CH4  
50% CO2  
20 PSIG  
DRY GAS

POINT	DATE	VHSV (hr-1)	TEMPERATURES (deg F)					OXYGEN		SULFUR CONC. (ppm)			COMMENTS	
			1	2	3	4	5	6	AVE (conc %)	H2S In	H2S out	COS out		
1	6/18/93	1920	53	57	57	54	54	56	55	0.0	100	6	83	Starting test dry and with no O2.
2	6/18/93	1920	56	58	58	55	56	56	57	0.0	100	<1	85	After one hour on stream.
3	6/18/93	1920	57	60	60	57	54	54	57	0.0	100	<1	100	Complete conversion of H2S to COS.
TURNED ON OXYGEN TO 1%.														
4	6/18/93	1920	58	60	59	57	55	53	57	1.0	100	1	98	After 26 minutes with O2 turned on.
5	6/18/93	1920	59	60	60	57	56	56	58	1.0	100	4	94	After one hour and 20 minutes on 1% oxygen.
6	6/18/93	1920	60	61	62	57	58	58	59	1.0	100	5	94	After two hours on 1% O2, the H2S seems to be climbing (as is the temp.).
TURNED ON THE SATURATOR (DEW POINT APPROX 36 F).														
7	6/18/93	1920	62	65	64	59	60	60	62	1.0	100	7	98	H2S continuing to climb.
8	6/18/93	1920	62	67	65	60	61	61	63	1.0	100	9	100	H2S continuing to climb.
9	6/18/93	1920	62	68	66	60	62	62	63	1.0	100	11	98	H2S continuing to climb.
10	6/18/93	1920	63	69	67	61	63	64	65	1.0	100	11	98	H2S continuing to climb.
11	6/18/93	1920	64	72	69	62	64	64	66	1.0	100	13	100	At low temps, very little reaction of O2 with H2S.
12	6/18/93	1920	69	80	77	67	67	68	71	1.0	100	19	98	Shut down after 6 hours of running.
Left over the weekend with N2 flowing. Condensate which had accumulated in the cooling coils was carried into and absorbed on the alumina.														
13	6/21/93	1920	51	54	52	50	48	48	51	1.0	100	97	<2	No COS formation.
14	6/21/93	1920	52	57	56	52	51	50	53	1.0	100	100	<2	Shut down after 2 hours. No COS observed since restarting the test.
Regenerated with dry N2 for six hours at 400 - 450F														
15	6/22/93	1920	52	56	53	51	48	46	51	1.0	100	<2	83	After running for 50 min. after regeneration, COS increasing.
16	6/22/93	1920	53	60	57	53	50	50	54	1.0	100	<2	88	Shut down after 1.5 hours demonstrating repeatability of 6/18/93 data.

Note that the VHSV = 1920 hr-1 is the design condition of the alumina in the clean up train.

## **APPENDIX G**

**Site Specific Test Plan and Quality Assurance Project Plan, Revision No. 2, December 1994**

Site-Specific Test Plan and  
Quality Assurance Project Plan

Phase III Landfill Gas Program  
Penrose Landfill

TRC Project No. 02030-0000-00006

APPROVAL:

IFC Program Manager \_\_\_\_\_

Date \_\_\_\_\_

TRC Project Manager \_\_\_\_\_

Date \_\_\_\_\_

TRC QA Officer \_\_\_\_\_

Date \_\_\_\_\_

IFC Project Manager J.L. Penrose

Date Dec. 1994

IFC QA Officer John Hecht

Date Dec. 21, 1994

EPA Project Officer \_\_\_\_\_

Date \_\_\_\_\_

EPA QA Officer \_\_\_\_\_

Date \_\_\_\_\_

## Table of Contents

<u>SECTION</u>	<u>PAGE</u>
1.0 PROGRAM DESCRIPTION . . . . .	1
1.1 Background . . . . .	1
1.2 Description of Phase III Activities . . . . .	2
1.3 Process Description . . . . .	4
1.3.1 GPU Description . . . . .	4
1.3.2 Fuel Cell Power Plant Description . . . . .	6
1.4 Scope of Work . . . . .	6
1.4.1 Performance Demonstration . . . . .	6
1.4.2 Emission Measurements . . . . .	8
1.4.3 Measurement Data Summary . . . . .	9
1.5 Schedule . . . . .	9
1.6 Operation of the Fuel Cell . . . . .	9
2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES . . . . .	13
2.1 Overall Organization . . . . .	13
2.2 IFC Organization and Responsibilities . . . . .	13
2.3 TRC Organization and Responsibilities . . . . .	13
2.4 Analytical Laboratory and Responsibilities . . . . .	15
3.0 CALCULATIONS AND DATA QUALITY INDICATOR GOALS . . . . .	16
3.1 General Description of Test Data and Calculations . . . . .	16
3.2 Expected Values . . . . .	17
3.3 Data Quality Indicators . . . . .	18
3.3.1 Power Plant and Flare Stack Continuous Emission Measurements . . . . .	18
3.3.2 GPU Outlet Measurements (EPA TO-14 and EPA Method 16) . . . . .	20
3.3.3 On-Line Raw Landfill Gas Heat Content Analyzer . . . . .	21
3.3.4 GPU Outlet Heat Content Measurement . . . . .	22
3.3.5 Power Plant Flowrate (Continuous Hot-Wire Anemometer) . . . . .	22
3.3.6 Electrical Output . . . . .	22



## Table of Contents (Continued)

<u>SECTION</u>	<u>PAGE</u>
4.0 SAMPLING PROCEDURES . . . . .	23
4.1 Sampling Locations . . . . .	23
4.1.1 Performance Demonstration Test . . . . .	23
4.1.2 Emissions Testing . . . . .	23
4.2 GPU Outlet and Raw Landfill Gas Sampling Methods . . . . .	23
4.3 Power Plant and Flare Stacks Continuous Monitoring Methods . . . . .	25
4.3.1 Sample Conditioning System . . . . .	25
4.3.2 NO <sub>x</sub> Analyzer . . . . .	25
4.3.3 SO <sub>2</sub> Analyzer . . . . .	25
4.3.4 CO Analyzer . . . . .	27
4.3.5 O <sub>2</sub> Analyzer . . . . .	27
4.3.6 CO <sub>2</sub> Analyzer . . . . .	27
4.4 Flowrate Monitoring . . . . .	27
4.5 Power Plant Electrical Measurements . . . . .	27
5.0 SAMPLE CUSTODY . . . . .	28
5.1 Sample Documentation . . . . .	28
5.1.1 Sampling Data Forms . . . . .	28
5.1.2 Sample Identification and Labeling . . . . .	28
5.2 Chain-of-Custody Forms . . . . .	30
5.3 Laboratory Custody . . . . .	30
6.0 CALIBRATION PROCEDURES . . . . .	32
6.1 Manual Sampling Equipment . . . . .	32
6.2 Power Plant and Flare Continuous Monitoring Methods . . . . .	32
6.3 In-Situ Flowrate Meters . . . . .	32
6.4 Electrical Power Measurements/Power Plant Efficiency . . . . .	32
6.5 On-Line Raw Landfill Gas Heat Content Analyzer . . . . .	32
7.0 ANALYTICAL PROCEDURES . . . . .	33
7.1 Continuous Emissions Monitoring . . . . .	33
7.2 Heat Content Analysis of GPU Outlet Samples . . . . .	33
7.3 GPU Outlet Constituent Analysis . . . . .	33
7.3.1 Sulfur Compound Analysis . . . . .	33
7.3.2 Volatile Organic Compound Analysis . . . . .	33

## Table of Contents (Continued)

<u>SECTION</u>	<u>PAGE</u>
8.0 DATA REDUCTION, VALIDATION, AND REPORTING . . . . .	35
8.1 Overall Calculations . . . . .	35
8.2 Data Validation . . . . .	35
8.3 Identification and Treatment of Outliers . . . . .	35
9.0 INTERNAL QUALITY CONTROL CHECKS . . . . .	37
9.1 Data Collection and Sampling QC Procedures . . . . .	37
9.2 Analytical Laboratory QC Checks . . . . .	37
10.0 PERFORMANCE AND SYSTEM AUDITS . . . . .	38
10.1 Performance Audits . . . . .	38
10.2 System Audit . . . . .	38
11.0 CALCULATION OF DATA QUALITY INDICATORS . . . . .	39
11.1 Precision . . . . .	39
11.1.1 Continuous Emission Monitoring . . . . .	39
11.1.2 Sulfur and Halide Compounds – GPU Outlet Samples . . . . .	39
11.1.3 GPU Outlet – Heat Content Analysis . . . . .	39
11.1.4 Flowrate . . . . .	39
11.2 Accuracy . . . . .	39
11.2.1 Continuous Emission Monitoring . . . . .	39
11.2.2 Sulfur and Halide Compounds . . . . .	40
11.2.3 GPU Outlet – BTU Analysis . . . . .	40
11.2.4 Flowrate . . . . .	40
11.3 Completeness . . . . .	40
12.0 CORRECTIVE ACTION . . . . .	41
12.1 Emission Measurements . . . . .	41
12.2 System Performance . . . . .	41

## List of Tables, Figures, and Attachments

<u>TABLE</u>	<u>PAGE</u>
1-1 Typical Concentrations and Detection Limits of Targeted Compounds in the Raw Landfill Gas at the Penrose Landfill . . . . .	7
1-2 Measurement Data Summary . . . . .	10
3-1 Data Quality Objectives . . . . .	19
4-1 GPU Outlet and Sampling Matrix . . . . .	24

<u>FIGURE</u>	<u>PAGE</u>
1-1 Demonstrator System Schematic . . . . .	3
1-2 Gas Pretreatment Unit Schematic . . . . .	5
1-3 Demonstrator System Interface Conditions . . . . .	11
2-1 Organization Chart . . . . .	14
4-1 Continuous Emission Monitoring System Schematic . . . . .	26
5-1 Data Reduction Form . . . . .	29
5-2 Chain-of-Custody Form . . . . .	31

### ATTACHMENT

A	Weekly Landfill Gas Methane Concentration Data from the Penrose Site .	G-A
B	Hourly Landfill Gas Heating Value Data from the Penrose Site .	G-B
C	Schedule .	G-C
D	Example Calibration Report of the On-Line Heat Content Analyzer .	G-D
E	May, September, and October 1993 Penrose Landfill Gas Analysis .	G-E
F	Electrical Output Meter Calibration Data .	G-F

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## 1.0 PROGRAM DESCRIPTION

This quality assurance project plan (QAPP) is for the final demonstration phase of the U.S. Environmental Protection Agency (EPA) landfill gas/fuel cell energy recovery program. The overall program objective is to demonstrate the feasibility of energy recovery from landfill gas using a commercial phosphoric acid fuel cell. The plan has been prepared for EPA's Air and Energy Engineering Research Laboratory (AEERL). This plan is designed to meet the requirements of an EPA Category II quality assurance plan and a site-specific test plan.

The Phase III program has three objectives:

- 1) Demonstrate the performance of a landfill gas pretreatment system for up to one year.
- 2) Demonstrate the performance of a 200-kilowatt (kW) fuel cell, including fuel cell efficiency, operated with treated landfill gas for up to one year.
- 3) Measure air pollutant emissions per quantity of energy produced. Emissions from the landfill gas cleanup system and the fuel cell power plant will be measured over a 30-day period.

### 1.1 Background

The EPA has proposed standards for the control of air emissions from municipal solid waste landfills. These actions have provided an opportunity for energy recovery from the waste methane. International Fuel Cells Corporation (IFC) was awarded a contract by the EPA to demonstrate energy recovery from landfill gas using a commercial phosphoric acid fuel cell. The IFC contract includes a three-phase program to show that fuel cell energy recovery is economically and environmentally feasible in commercial operation.

Phase I of the program was a conceptual design and cost analysis evaluation. Phase II included construction and testing of a landfill gas pretreatment unit (GPU). The objective of Phase II was to demonstrate the GPU effectiveness in removing fuel cell catalyst poisons such as sulfur and halide compounds. The Phase II demonstration test was conducted in October 1993 at the Penrose Station in Sun Valley, California, owned by Pacific Energy. The Penrose Station is an 8.9-megawatt (MW) internal combustion engine facility supplied with landfill gas from four landfills. The Phase II data indicated that the GPU performance was acceptable.

Phase III of the program will be a complete demonstration of the fuel cell energy recovery concept at the Penrose Station. The GPU and fuel cell generating system will be operated and tested to evaluate the economic and environmental features of the concept.

## 1.2 Description of Phase III Activities

The test plan defined in this document pertains to Work Plan Subtask 3.3. Prior to the onset of this task, per Subtask 3.2, a PC25™ power plant will be installed at the site and its performance will be checked using natural gas. This will verify normal power plant operation prior to preparing the power plant for the landfill gas demonstration. The system will then be modified to run on landfill gas. It will be connected to the GPU outlet and checked out on landfill gas to verify proper operation prior to the Phase III demonstration test.

The demonstration system at Penrose Station consists of the existing gas collection system, the GPU, plus a commercial fuel cell power plant. The GPU removes contaminants from raw landfill gas and destroys the contaminants in an enclosed flare. The treated gas is converted to electrical energy with the PC25 power plant, which is a 200 kW unit (140 kW on landfill gas). A schematic of the demonstration system is presented in Figure 1-1. The landfill gas at the Penrose facility has an average heat content of 430 BTU/scf. The variation in fuel heat content is expected to be low as shown by the weekly methane concentration data included in Attachment A and the hourly heat content included in Attachment B; this data was collected from the on-line raw landfill heat content analyzer at Penrose Landfill.

The system will be operated for up to one year. System performance measurements will be conducted periodically over the entire demonstration, and air pollutant emission measurements will be conducted during a 30-day period during the second month of the demonstration. The test parameters are outlined below.

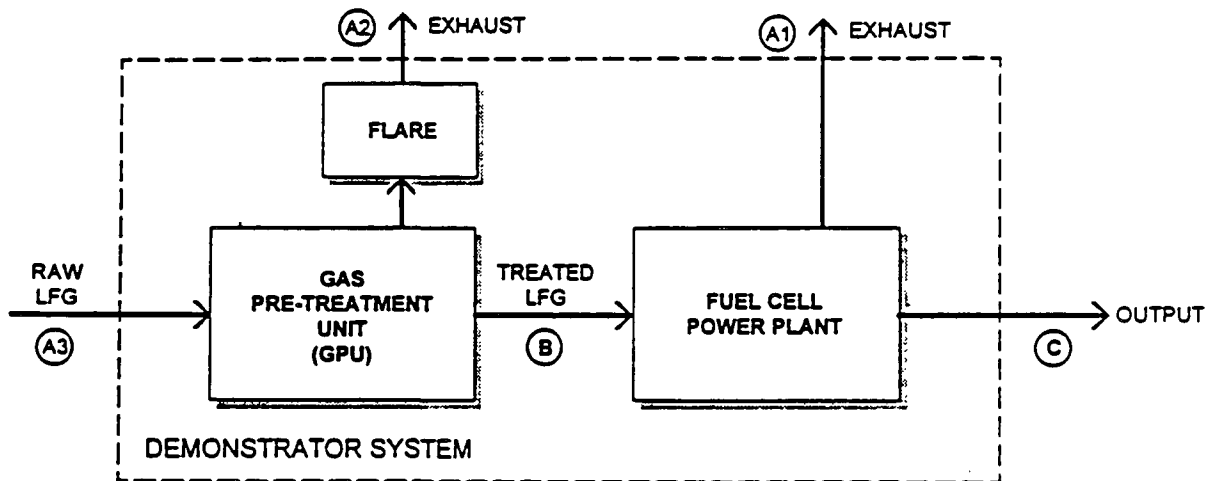
### **System Performance Measurements**

- GPU Output Gas Purity – analysis for sulfur and target-list volatile organic compounds (VOCs including halides)
- Fuel Cell Efficiency, determined from the following measurements:
  - GPU Output Gas Heat Content (on-line and manual methods)
  - GPU Output Gas Flowrate
  - Fuel Cell Electrical Output
- Availability, Maintenance, and Operator Requirements

### **Emission Measurements (Fuel Cell Exhaust and Flare Exhaust)**

- Sulfur Dioxide (SO<sub>2</sub>)
- Nitric Oxides (NO<sub>x</sub>)
- Carbon Monoxide (CO)
- Carbon Dioxide (CO<sub>2</sub>)
- Oxygen (O<sub>2</sub>)
- Flowrate
- Moisture

Figure 1-1  
Demonstrator System Schematic



PERFORMANCE DEMONSTRATION INTERFACES: (B), (C)

EMISSION TEST INTERFACES: (A1), (A2), (A3)

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	INTERNATIONAL FUEL CELLS INC. EPA/AEERL PHASE III FUEL CELL/LANDFILL GAS ENERGY RECOVERY PROGRAM
<b>FIGURE 1-1.</b> <b>DEMONSTRATOR SYSTEM SCHEMATIC</b>	
Date: 6/94	Drawing No. 02030-05

### 1.3 Process Description

The demonstrator consists of the landfill gas wells and collection system, a modular gas pretreatment system, and a PC25 natural gas fuel cell power plant modified for landfill gas operation. Landfill gas collected at the site is processed to remove contaminants in the pretreatment system. This clean, medium-BTU landfill gas fuels the fuel cell power plant to produce AC power for sale to the electric utility and cogeneration heat which, for the demonstration, will be rejected by an air cooling module. All pretreatment and fuel cell process functions are described in this section.

#### 1.3.1 GPU Description

The demonstration site has a landfill gas collection system in place. The Penrose site will provide compressed 85 psig gas to the gas pretreatment system. Since collection and compression result in some condensed water, hydrocarbon, and other contaminants, the existing site also has a condensate collection and treatment system.

A slipstream of landfill gas from the site will be supplied to the GPU at a pressure of 85 psig and regulated down to 20 psig. (A schematic of the GPU is presented in Figure 1-2.) The first active bed of the GPU is a carbon adsorber designed to remove hydrogen sulfide. A first-stage refrigeration condenser ( $\sim 33^{\circ}\text{F}$ ) then removes most of the water contained in the saturated landfill gas and some of the heavier hydrocarbon and contaminant species in the gas. The first-stage refrigeration condenser acts as a bulk remover of water and nonmethane organic compound (NMOC) species. This increases the flexibility of the pretreatment system to handle very high levels of landfill gas contaminants without need for modification or increasing the size of the regenerable adsorption beds, thus making the system an all-purpose landfill gas contaminant removal system.

In the commercial application, the condensate from the first-stage condenser is vaporized and incinerated to avoid all site liquid effluents. However, to avoid the extra cost and complexity for the demonstration, this condensate is returned to the existing site condensate treatment system.

Landfill gas exiting the first-stage refrigeration condenser is then sent to a dryer bed where the water content of the landfill gas is reduced to a  $-50^{\circ}\text{F}$  dew point. This bed is periodically regenerated every eight hours with heated clean landfill gas (heated by an electric heater). During regeneration, a second fully regenerated bed takes over the function. The regeneration gas is subsequently incinerated in a low  $\text{NO}_x$  flare. Following the dryer step, the landfill gas proceeds to a second-stage low-temperature cooler ( $-20^{\circ}\text{F}$ ) to enhance the performance of the downstream activated carbon bed



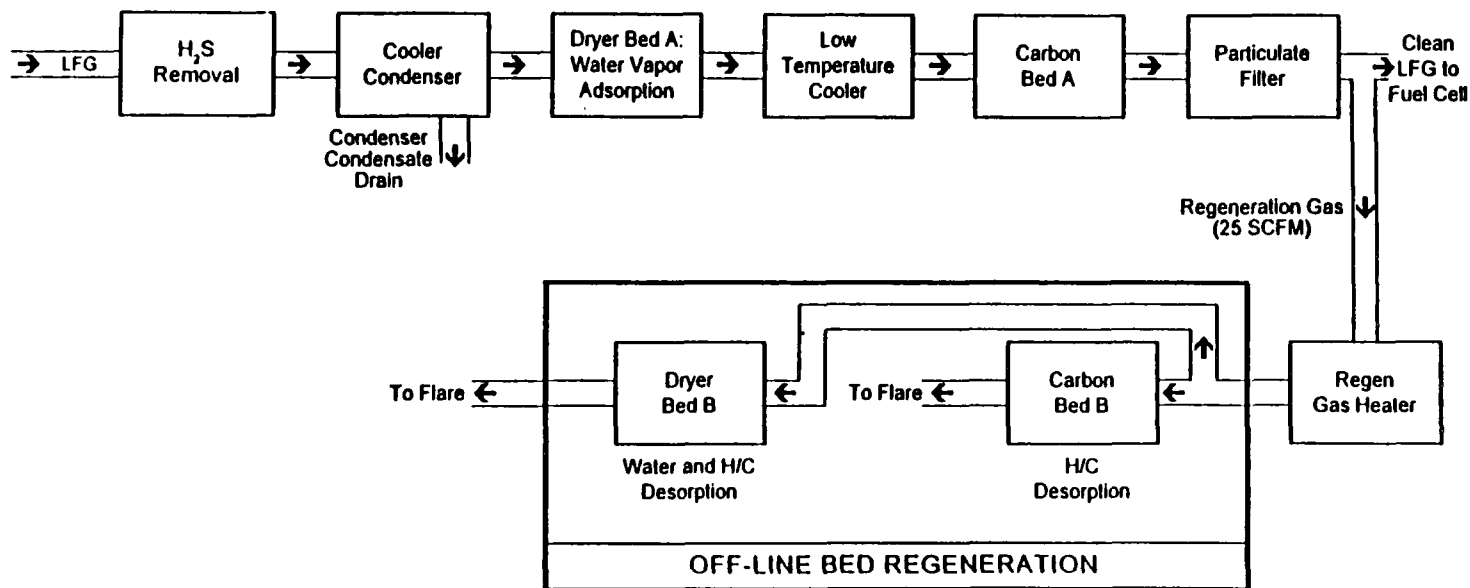


Figure 1-2  
Gas Pretreatment Unit Schematic

**Clean Gas Production Process** - This process incorporates H<sub>2</sub>S removal by the Claus reaction, refrigerated cooling and condensation, drying, cooling and hydrocarbon adsorption process units to remove contaminants from the landfill gas.

The H<sub>2</sub>S removal bed reacts H<sub>2</sub>S with O<sub>2</sub> found in the landfill gas to produce elemental sulfur. This bed is non-regenerable and is replaced periodically. The first and second stage refrigeration coolers operate at approximately +35°F and -20°F, respectively.

**TRC**

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**FIGURE 1-2.**  
**GAS PRETREATMENT UNIT SCHEMATIC**

Date: 6/94

Drawing No 02030-05

Next, the landfill gas proceeds to the activated carbon bed which adsorbs the remaining NMOCs including organic sulfur and halogen compounds. This bed is periodically regenerated every eight hours, with the regeneration gas being burned in a low NO<sub>x</sub> flare. The flare (an enclosed type) achieves greater than 98% destruction of all NMOCs by maintaining the combusted regeneration gas at a temperature of at least 1600°F for a residence time of at least one second.

In order to avoid the carryover of attrition products (dust) from the regenerable beds, the output gas is filtered through a submicron filter.

A clean, dry, particulate-free medium-BTU landfill gas exits the filter for consumption in the fuel cell. A portion of this gas is extracted to provide regeneration gas. A backup natural gas supply is used to initially qualify the fuel cell power plant before operation on landfill gas.

#### 1.3.2 Fuel Cell Power Plant Description

Clean landfill gas is converted in the fuel cell power plant to AC power and heat. The general fuel cell system consists of three major subsystems—fuel processing, DC power generation in the fuel cell stack, and DC-to-AC power conditioning by the inverter.

The fuel cell converts hydrogen and oxygen in air electrochemically to produce AC power and heat. The waste heat will be rejected by an air cooling module. The AC power will be delivered to the utility grid.

### 1.4 Scope of Work

#### 1.4.1 Performance Demonstration

The performance demonstration test of the landfill gas-to-energy demonstrator system will be conducted for up to one year. The demonstrator system includes the GPU and the fuel cell power plant. Measurement specifications and sampling frequency are outlined below.

- *GPU Performance*—GPU outlet gas constituent concentration measurements will be conducted twice per week for the first month of the demonstration and biweekly during the remainder of the demonstration. Integrated samples will be collected and analyzed off-site by gas chromatography/mass spectrometry (GC/MS) and gas chromatography/flame photometric detector (GC/FPD). The target compound list is contained in Table 1-1.

Table 1-1

Typical Concentrations and Detection Limits  
of Targeted Compounds in the  
Raw Landfill Gas at the Penrose Landfill

Sulfur Compounds (ppmv)	Typical Value in Untreated Landfill Gas	Detection Limit Objective
1. H <sub>2</sub> S	102.0	0.04
2. Methyl mercaptan	3.0	0.04
3. Ethyl mercaptan	0.5	0.04
4. Dimethyl sulfide	6.5	0.04
5. Dimethyl disulfide	< 0.07	0.02
6. Carbonyl sulfide	0.2	0.04
7. Carbon disulfide	< 0.07	0.02
8. Total sulfur as H <sub>2</sub> S (ppmv)	109.0	0.28
<b>Volatile Organic Compounds (ppmv)</b>		
1. Dichlorodifluoromethane	0.3-0.9	0.009
2. 1,1-dichloroethane	1.2-2.9	0.002
3. Benzene	1.1-1.7	0.002
4. Chlorobenzene	0.6-1.4	0.002
5. Ethylbenzene	4.5-12.0	0.002
6. Methylene chloride	4.0-11.0	0.003
7. Styrene	0.5-1.1	0.003
8. Trichloroethene	1.3-2.4	0.001
9. Trichlorofluoromethane	0-0.6	0.004
10. Toluene	28.0-47.0	0.002
11. Tetrachloroethene	2.4-4.8	0.002
12. Vinyl chloride	0.1-1.4	0.005
13. Xylene isomers	5.0-28.0	0.005
14. cis-1,2-dichloroethene	3.9-5.9	0.003
15. Total halides as Cl	47.0-67.0	0.086

Since the GPU is primarily a carbon bed system, breakthrough of organic compounds is most likely to occur at the end of an on-line cycle, so sampling must be conducted at the end of the cycle to assess performance. Samples will be collected during the last hour of an eight-hour GPU bed "make" cycle (after seven hours of on-line operation; before regeneration commences at eight hours).

The target list for GPU performance samples was developed from GC/MS and GC/FPD measurements conducted during the Phase II GPU performance test. Each target compound will be included in a multipoint calibration, and additional unknown compounds detected by GC/MS will be identified by ion matching and quantified by internal standard. The 10 next largest GC/MS peaks will be included in the nontarget compounds category. No significant concentrations of nontarget compounds are expected; however, the ion matching/internal standard method will prevent the potential of missing the quantification of other halide compounds if the landfill gas composition unexpectedly changes. If other halide compounds are identified, a separate qualitative total halide result will be reported.

- *Fuel Cell Power Plant Performance*—Power plant efficiency, availability, and maintenance and operator requirements will be demonstrated. The heating value and flowrate of the fuel and the power plant output (kilowatt-hours) will be measured to determine efficiency. The efficiency measurements are summarized below.
  - a) Power output will be measured continuously with a calibrated utility-grade digital electric meter.
  - b) Fuel flowrate will be measured continuously with a calibrated process monitor.
  - c) Heat content of the clean fuel (GPU output) will be determined with ASTM D3588-91 measurements conducted twice per week during the first month of the test and biweekly for the remainder of the program. In addition, Pacific Energy operates a continuous fuel heat content analyzer (gas chromatograph) on the raw landfill gas which analyzes a sample every four minutes. The project plan is to use the continuous analyzer weekly averages for efficiency calculations, after a correction factor is developed from the ratio of the clean fuel ASTM D3588-91 measurements to the raw gas on-line measurements. Development of a correction factor will allow the on-line measurements to be used for fuel cell efficiency calculation over the duration of the performance demonstration.

#### 1.4.2 Emission Measurements

During the second month of the performance demonstration test, a 30-day emissions test program will be conducted. Emissions will be measured from both the fuel cell power plant exhaust and the GPU flare, five days per week over the 30-day period. The emission parameters are outlined below.

- *Power Plant Emissions*—SO<sub>2</sub>, NO<sub>x</sub>, CO, CO<sub>2</sub>, O<sub>2</sub>, and exhaust flowrate will be continuously monitored for 10 hours per day for the 30-day period. Pollutant measurements will be conducted according to EPA Methods 6C, 7E, 10, and 3A. Moisture will also be measured daily according to EPA Methods.
- *GPU Flare Emissions*—SO<sub>2</sub>, NO<sub>x</sub>, CO, CO<sub>2</sub>, and O<sub>2</sub> will be continuously monitored for 10 hours per day for the 30-day period. Measurements will be conducted according to EPA Methods 6C, 7E, 10, and 3A. Exhaust gas flowrate will be determined with a process monitor flowmeter measurement on the flare inlet gas line and an excess air correction factor.

#### 1.4.3 Measurement Data Summary

A measurement data summary is provided in Table 1-2. Expected numbers of data points have been calculated for 5, 13, and 26 weeks. This table assumes that the emission program will begin during the second month of the performance demonstration. (The number of samples listed in the table does not include quality assurance samples.)

System performance measurements may be taken for up to 12 months. Nine GPU output system performance sampling events will have been conducted by the fifth week, 13 sampling events in the first three months, and 19 within the first six months. Continuous emission monitors will record levels of SO<sub>2</sub>, NO<sub>x</sub>, CO, CO<sub>2</sub>, and O<sub>2</sub>. These data will be presented as 60-minute average values in tabular format. Moisture and fuel cell flow rates will be measured once daily by manual methods. Weekly summaries of information on system availability, maintenance requirements, and operator requirements will be prepared by Pacific Energy.

#### 1.5 Schedule

The performance demonstration test is scheduled to begin on December 1, 1994. The emissions testing is scheduled to begin on January 2, 1995. A detailed schedule for performance and emissions testing is presented in Attachment C.

#### 1.6 Operation of the Fuel Cell

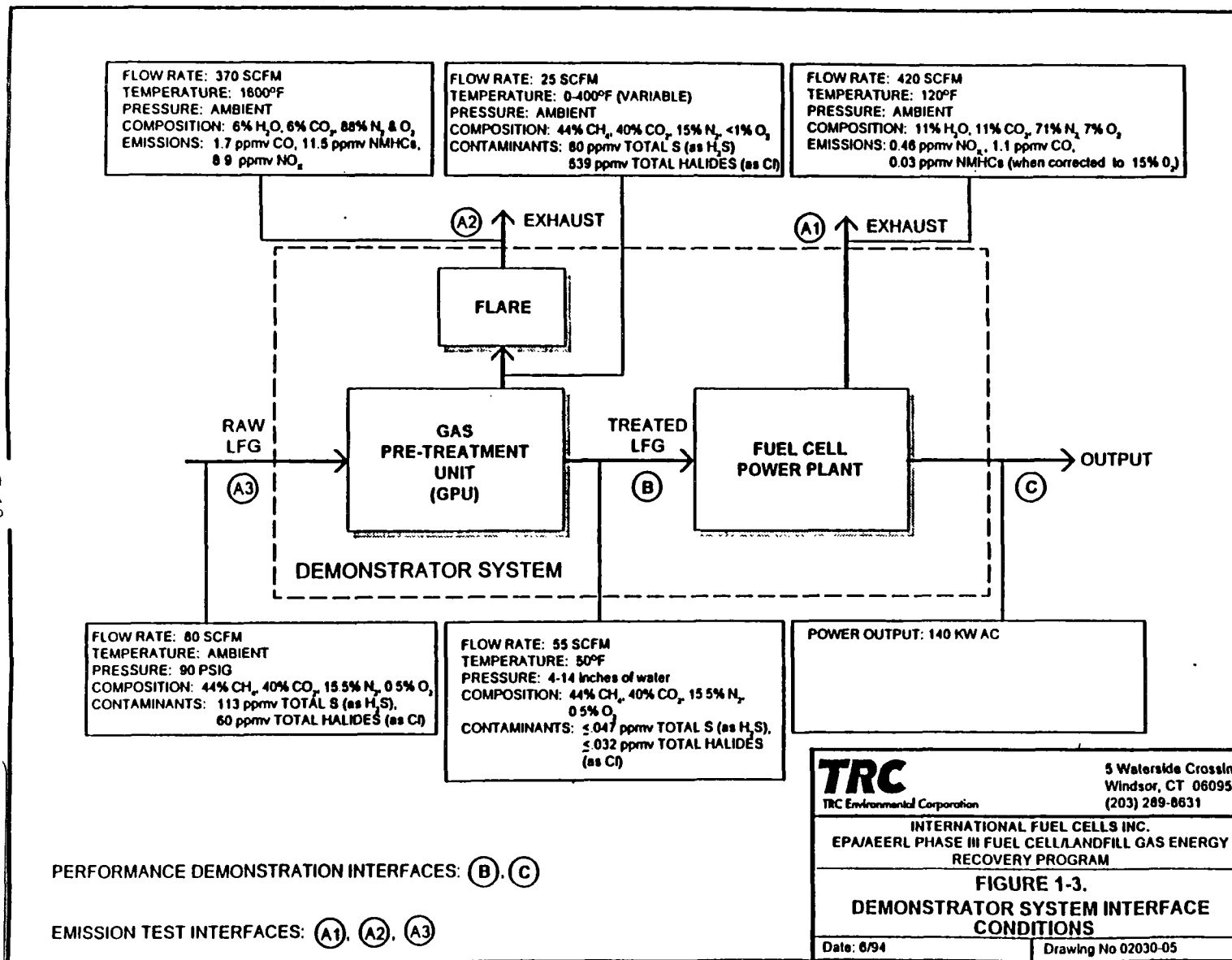
The fuel cell power plant will be started up using the normal automatic control sequencing. The power level will be set at the design power output associated with landfill gas (expected to be 140 kW AC net). The design power output is to be maintained for the duration of the test. Operating parameters are listed on the schematic presented in Figure 1-3.

Table 1-2  
Measurement Data Summary

Parameter	Frequency	Expected Data Points by the End of Week			Comments
		5	13	26	
SYSTEM PERFORMANCE					
Sulfur compounds and volatile organic compounds	Weekly for 4 weeks, then biweekly	9	13	19	2 samples per week for 4 weeks, then 1 sample every 2 weeks. Samples to be taken during the last hour of the make cycle.
GPU input gas heat content (on-line)	Weekly average	5	13	26	(Pacific Energy) *
GPU output gas heat content (manual)	Weekly for 4 weeks, then monthly	9	13	19	2 samples per week for 4 weeks, then 1 sample every 2 weeks.
GPU output gas flow	Weekly total	5	13	26	(Pacific Energy) *
Fuel cell electrical output	Weekly total	5	13	26	(Pacific Energy) *
Availability, maintenance requirements, and operator requirements	Weekly	5	13	26	(Pacific Energy) *
EMISSION MEASUREMENTS					
SO <sub>2</sub> , NO <sub>x</sub> , CO, CO <sub>2</sub> , O <sub>2</sub> , exhaust flowrate (fuel cell) each measured at the flare and fuel cell; a total of 10 measuring-point/parameter combinations	Continuous; presented as hourly averages		10 hours /day 22 days		22 days of data for each parameter over a 30-day test period; 10 hours per sampling point per day, 5 days per week. CEM monitors will be in use on 2 sampling points per day for a total of 20 hours plus setup, calibration, and maintenance.
Flare exhaust flowrate	Continuous		10 hours /day 22 days		Determined by flare inlet fuel gas flowrate plus excess air factor from flare exit percent O <sub>2</sub> (based upon complete combustion)
Fuel cell exhaust moisture	Once daily		22		Web bulb/dry bulb temperature measurement

\* Pacific Energy will provide data.

Figure 1-3  
Demonstrator System Interface Conditions



The plant will be operated in a grid connected configuration. All phases of the plant operation are controlled by a microprocessor control system (MCS). There are eight operating modes, which are described below.

- *De-energized/Off Mode*—The MCS is off and the power plant can be shipped or stored. If freezing weather exists, the plant water systems must be drained or auxiliary power must be supplied.
- *Energized/Off Mode*—The MCS is on and the thermal management and water treatment systems are active to prevent electrolyte and water freezing.
- *Start Mode*—The thermal management and fuel processing systems are heated, the fuel processing system starts generating hydrogen, the power section starts generating DC power, and the power conditioning system starts delivering AC power for auxiliary power loads. The continuous controls are automatically activated during this mode.
- *Idle Mode*—The power plant is running but the power output is zero. All systems and subsystems are operating and power for the power plant auxiliary loads is supplied by the fuel cell. During power plant start-up, this mode is automatically entered from the start mode when the start-up sequence has been completed.
- *Load Mode*—Customer loads are powered. Operation can be conducted in either of four configurations: (1) grid connected, (2) grid independent, (3) grid independent multi-unit load sharing, and (4) grid independent-synchronized with grid. If grid connect is selected, the output is connected to the utility grid and power is supplied at a dispatched level. The demonstrator power plant will operate only in the grid connected mode.
- *Hot-Hold Mode*—The plant is shut down without cooling the cell stack. This mode is entered following certain automatic shutdowns and it allows the power plant to be restarted quickly with a minimum of power and fuel consumption after the cause of the shutdown has been identified and corrected.
- *Cool-Down Mode*—The cell stack is actively cooled by the thermal management system as part of the normal shutdown procedure before the Energized/Off Mode is reentered.



## 2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

### 2.1 Overall Organization

IFC will provide project management of the demonstration team consisting of Pacific Energy, Southern California Gas, the Los Angeles Department of Water and Power (LADWP), and TRC Environmental Corporation (TRC).

IFC will be ultimately responsible for operating the plant and conducting the demonstration in accordance with the approved QAPP.

Pacific Energy will provide the landfill gas site, facilities, and landfill gas supply from their existing operation. Pacific Energy will operate the GPU, and monitor and document the gas quality and quantity from this system during the demonstration. They will also document the operating costs associated with the GPU and the utility connection from the fuel cell to the electric utility grid. Pacific Energy will also operate the fuel cell on landfill gas and monitor the fuel cell; they will document performance and cost, including kilowatt-hour (kWh) output, availability, efficiency, and O&M costs.

TRC will conduct emission tests, collect and analyze GPU gas samples to determine performance, and prepare the emission test report.

The project organization management team is outlined in Figure 2-1. The EPA Project Officer will be Dr. Ron Spiegel, and the Program Manager will be Mr. John Trocciola of IFC. Mr. Larry Preston of IFC will be the Project Manager, and the subcontractors including the TRC technical staff will report to him. The quality assurance officers of both TRC and IFC will report directly to the Program Manager, allowing them to bypass the technical staff for any quality-related issues.

### 2.2 IFC Organization and Responsibilities

IFC will be responsible for the overall program management as well as providing the GPU and power plant equipment. IFC will also provide a quality assurance officer who will be responsible for evaluating measurement data independent of the Project Manager and the technical staff.

### 2.3 TRC Organization and Responsibilities

TRC will provide all equipment and manpower to conduct emission testing on the power plant, flare stack, GPU outlet, and the raw landfill gas. TRC will provide an on-site laboratory trailer for the duration of the 30-day emission test. One technician will be assigned to the site for the emission test period. The technician will be responsible for daily calibration and maintenance of the emission monitoring equipment and sampling of the GPU outlet and raw landfill gas. TRC will also provide a Quality Assurance Officer who will evaluate the measurement data independent of the TRC Project Manager and technical staff.

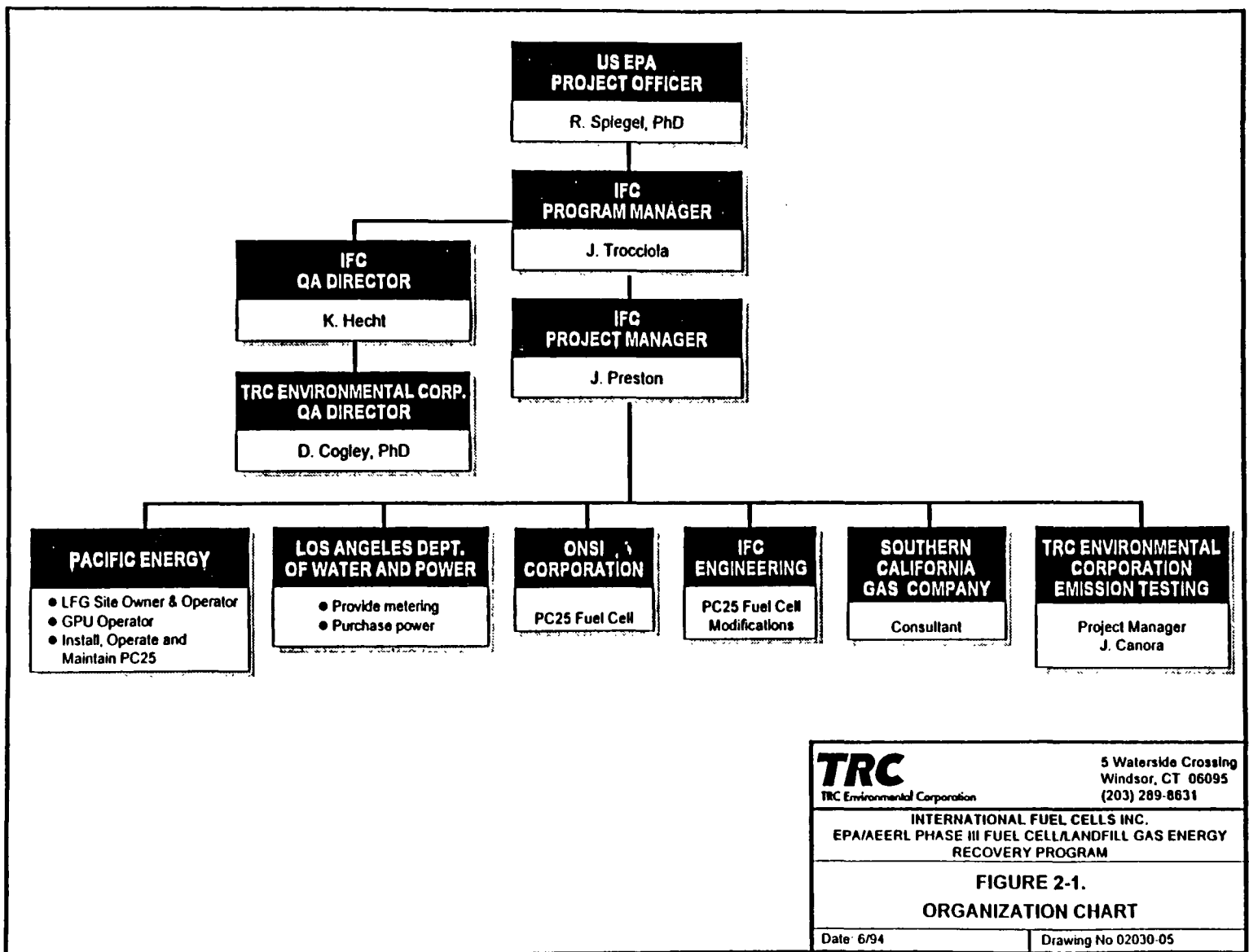


Figure 2-1  
Organization Chart

#### 2.4 Analytical Laboratory and Responsibilities

Laboratory analysis will be conducted by Performance Analytical, Inc. (PAI) of Canoga Park, California. PAI will conduct EPA Method TO-14 analysis for target VOCs (including organic halides), EPA Method 16 analysis for reduced sulfur compounds, and ASTM Method D3588-91 for heat content analysis of landfill gas samples. Analyses will be conducted under the supervision of the laboratory director, Mr. Michael Tuday.

### 3.0 CALCULATIONS AND DATA QUALITY INDICATOR GOALS

This section includes a general description of the data and calculations involved with the performance demonstration and the emission tests, followed by a discussion of the expected results, and then a discussion of data quality indicators (DQIs) and DQI goals.

#### 3.1 General Description of Test Data and Calculations

The performance test includes a fuel cell efficiency evaluation and a GPU performance evaluation. The calculations involved with these objectives are outlined below.

- Fuel cell efficiency will be calculated on a weekly basis using the following test data and calculation:

<u>Measurement</u>	<u>Unit</u>	<u>Measurement Type</u>
Fuel cell energy output	kWh	Utility-grade electric meter
Fuel heat content	BTU/scf	Raw landfill gas on-line gas chromatograph and empirical correction factor developed for cleaned gas
Fuel use	scf	In-line totalizing flowmeter

$$\text{Efficiency} = \frac{\text{Energy output (kWh)} \times 3413 \text{ BTU/kWh}}{\text{Fuel use (scf)} \times \text{heat content (BTU/scf)}} \quad (\text{Eq. 1})$$

- Fuel cell availability will be calculated weekly and tracked on a cumulative basis. The fuel cell availability will be adjusted to compensate for factors which are not caused by the power plant, as follows:

Raw availability (OPERATING TIME divided by elapsed clock time since first start) is adjusted to account for

- unforced outages not due to power plant
- shutdowns due to operator error
- waiting time for replacement parts where parts were recommended the customer have on hand
- periods of time when power plant could be worked but manpower not available (weekends, vacations)

$$\text{Adjusted availability} = \frac{\text{OPERATING HOURS}}{[(\text{elapsed clock time}) - \text{adjustment}]}$$

- GPU performance will be calculated on the basis of two measurements per week during the first four weeks of the program and a biweekly measurement thereafter. The performance limit is 3.0 ppmv of total sulfur and 3.0 ppmv of total halides. Total sulfur and total halides will be calculated as follows:
  - Total sulfur to be computed by summing the products of each sulfur species times number of sulfur atoms per mole. Results will be plotted vs. operating hours.
  - Total halides to be computed by summing the products of each halide species times the number of halide atoms per mole of species (e.g.,  $\text{CCl}_4 = 4$ ). Results will be plotted vs. operating hours.
- Flare and power plant emissions. Concentration and flowrate measurements will be used to calculate a mass emission rate of  $\text{NO}_x$ ,  $\text{SO}_2$ , CO, and  $\text{CO}_2$  from the flare stack and the power plant. Emissions from each source will be summed and converted to mass emissions per energy output as follows:

$$\text{Emissions (lb/kWh)} = \frac{\text{Mass Emission Rate (lb/hr)}}{140 \text{ kWh}} \quad (\text{Eq. 2})$$

### 3.2 Expected Values

The expected values are outlined below.

#### (1) Emissions

	Mass Emission Rate (lb/hr)					Emissions (lb/kWh)
	Flare		Fuel cell		Total	
$\text{NO}_x$	0.025	+	0.001	=	0.026	$1.86 \times 10^{-4}$
$\text{SO}_x$	0.007	+	0.000	=	0.007	$5.00 \times 10^{-5}$
CO	0.005	+	0.002	=	0.007	$5.00 \times 10^{-5}$
$\text{CO}_2$	201	+	333	=	534	3.81

- (2) Total kWh = (140 kW) (demonstration hours) (availability)
- (3) Availability = 80%
- (4) Efficiency (fuel cell) = 38% LHV

- (5) Operation and maintenance: IFC will document O&M costs, and then use to adjust the existing PC25A fuel cell O&M database for natural gas to project O&M costs for landfill gas.
- (6) Heating value GPU exit = 430 BTU/scf
- (7) Total GPU scf to fuel cell = (55 scfm) (demonstration hours) (availability)
- (8) GPU contaminants: total sulfur as  $H_2S$  < 3 ppmv  
total halides as  $HCl$  < 3 ppmv

### 3.3 Data Quality Indicators

The DQIs are defined in this section for continuous emission measurements, integrated sampling emission measurements, and process monitoring measurements. The DQIs established in the "AEERL Quality Assurance Procedures Manual"—precision, bias or accuracy, and completeness—are discussed below when applicable. In addition, DQI goals for precision, accuracy, and completeness are summarized in Table 3-1 for each type of measurement.

#### 3.3.1 Power Plant and Flare Stack Continuous Emission Measurements

Continuous emissions monitoring for  $NO_x$ ,  $SO_2$ , CO, and  $CO_2$  will be conducted 10 hours per day over a 30-day period on the flare stack and the fuel cell exhaust. Measurements will be conducted using 40 CFR 60, Appendix A, Methods 7E ( $NO_x$ ), 6C ( $SO_2$ ), 10 (CO), and 3A ( $CO_2$ ) and 40 CFR 60, Appendix B and Appendix F quality assurance specifications. DQIs for these measurements include precision and bias/accuracy. Definitions of these statistical terms and DQI goals are discussed below.

**Precision** will be quantified on a daily basis by conducting calibration drift tests (zero and span) according to 40 CFR 60 Appendix F – Quality Assurance Procedures. The amount of drift, calculated as a percentage of the analyzer range for the pollutant analyzers over each 24-hour period, will be used as the precision DQI. This method of quantifying precision is atypical of standard statistics, which generally use the standard deviation of repeated measurements to define precision; however, the use of calibration drift to define precision for continuous emission monitors is a long-established EPA convention. In effect, calibration drift is a repeat measurement of a reference material at the beginning and end of a monitoring period.

The program goals for the precision DQI were developed from 40 CFR 60, Appendix B and Appendix F specifications. For the flare stack measurements, the calibration drift goal for  $NO_x$  and  $SO_2$  shall be  $2\times$  the Appendix B specification, or 5%. On the power plant exhaust, the  $NO_x$  drift goal shall be increased to  $4\times$  the specification, or 10%. This higher drift goal is necessary because of the low-concentration  $NO_x$  emissions and the low analyzer range that will be used. For the CO measurements on both stacks, the DQI precision goal will be 10%, which is  $2\times$  the Appendix B specification. The  $CO_2$  measurement DQI goal shall be equal to the Appendix B specification, which is  $\pm 0.5\%$  of  $CO_2$ .

**Table 3-1**  
**Data Quality Indicator Goals**  
**EPA/AEERL Landfill Gas/**  
**Fuel Cell Energy Recovery Demonstration**

Parameter	Method	Operating Range	Precision Goal	Bias (Accuracy) Goal	Completeness Goal
<b>SYSTEM PERFORMANCE</b>					
Sulfur compounds	EPA 16 & 18	(a)	5%	15%	100%
Volatile organic compounds (including halides)	EPA TO-14	(a)	15%	15%	100%
GPU input gas heat content	on-line analyzer	N/A	2%	2%	100%
GPU output gas heat content	ASTM D3588-91	(a)	2%	2%	100%
GPU output gas flowrate	Process monitor	N/A	N/A	4%	100%
Fuel cell electrical output	kWh meter	N/A	N/A	2%	100%
<b>EMISSION MEASUREMENTS</b>					
SO <sub>2</sub>	EPA-6C	0-100 ppm	5%	15%	100%
NO <sub>x</sub> (flare)	EPA-7E	0-100 ppm	5%	15%	100%
NO <sub>x</sub> (fuel cell)	EPA-7E	0-2.5 ppm	10%	15%	100%
CO	EPA-10	0-100 ppm	10%	15%	100%
CO <sub>2</sub>	EPA-3A	0-25%	5%	15%	100%
O <sub>2</sub>	EPA-3A	0-25%	5%	15%	100%
Flowrate (flare)	process monitor	N/A	5%	N/A	100%
Flowrate (fuel cell)	continuous monitor	N/A	2%	15%	100%
Moisture	EPA-4	N/A	N/A	N/A	100%

(a) See Table 1-1 for detection limit objectives on sulfur compounds, volatile organic compounds, and heat content.

***Bias or Accuracy*** for continuous analyzers will be quantified with cylinder gas audits conducted according to 40 CFR 60, Appendix F. Each analyzer will be challenged with two levels of calibration gas on each operation range. The accuracy DQI goal for all continuous analyzers will be  $\pm 15\%$ , which is the accuracy specification in 40 CFR 60, Appendix F.

***Completeness*** will be 100%, which means that data will be collected within the specified quality assurance (QA) limits for at least 22 testing days of the 30-day emission test period (weekend measurements will not be conducted). Additional monitoring days will be added to the program if required to provide at least 22 days of data within QA specifications.

### 3.3.2 GPU Outlet Measurements (EPA TO-14 and EPA Method 16)

These measurements will consist of Tedlar bags filled from the pressurized GPU outlet sampling valve. The bag samples will be delivered immediately after sampling to a local laboratory and analyzed for VOCs and reduced sulfur compounds. DQIs will include blanks and audits and two series of triplicate samples to determine precision. The DQIs and DQI goals are discussed below.

***Precision*** will be determined by collecting and analyzing replicate samples at the beginning of the program. Since the concentration of volatile organics and sulfur compounds will likely be near or below the method detection limits, triplicate Tedlar bag samples of an audit gas will be also be submitted and analyzed. The following samples will be collected to quantify precision:

- Analyze three samples collected concurrently and calculate relative standard deviation of three compounds if three compounds are detected.
- Analyze three samples of Level 1 audit gas and calculate relative standard deviation of three compounds.
- Laboratory duplicates will be analyzed weekly and the relative percent difference will be calculated for three compounds on the Method TO-14 analysis and three compounds on the Method 16 analysis.

***Accuracy/Bias*** will be determined by analysis of two audit gases for both TO-14 and Method 16 measurements. The TO-14 audit samples will contain three halogenated VOCs and the Method 16 audits will contain three reduced sulfur compounds. Accuracy will be quantified as follows:

$$\text{Accuracy} = \frac{C_m - C_s}{C_s} \times 100$$

$C_m$  = measured concentration

$C_s$  = certified concentration

***Completeness*** will be 100% for the TO-14 and EPA Method 16 measurements.



### 3.3.3 On-Line Raw Landfill Gas Heat Content Analyzer

This analyzer is operated by Pacific Energy. A daily calibration is performed with a certified gas standard containing carbon dioxide, oxygen, nitrogen, and methane, and the drift from the certified concentrations of each compound is automatically recorded. An example of the calibration report is presented in Attachment D.

Special consideration for representativeness is also discussed below for the heat content measurements.

**Representativeness.** The project plan is to use the analyzer data for fuel cell efficiency calculation. Since the analyzer measures the heat content of raw landfill gas, and heat content of the treated gas is required to calculate efficiency, a correlation factor relating the treated gas heat content to the raw gas heat content will be developed from simultaneous measurements. These simultaneous correlation factor development measurements will be conducted twice per week during the first month of the performance demonstration and biweekly thereafter.

The representativeness of using the raw gas analyzer and the correlation factor to determine treated gas heat content is dependent on the variation of the raw gas heat content; if the variation is low, the measurement representativeness will be good.

Selection of this measurement method was based on existing NMOC concentration data, which shows minimal variation of heat content. This data was obtained in May, September, and October of 1993 and is included in Attachment E. In summary, the variation of the raw gas heat content is expected to be minimal, so that empirical factors correlating raw gas heat content to treated gas heat content will be representative.

**Precision** will be measured with the daily calibration, and the deviation from the certified gas concentration will be automatically recorded for each compound. The DQI precision goal will be 1% drift for each specific compound.

**Accuracy/Bias** will be determined by comparison of the raw landfill analyzer data to a heat content measurement conducted according to ASTM D3588-91. Four samples of raw landfill gas will be collected at 15-minute intervals over a one-hour period correlating to a one-hour averaging period on the continuous analyzer. The average heat content of the four samples will be compared to the continuous analyzer to determine accuracy. The accuracy goal for the measurement is  $\pm 1\%$ .

**Completeness** will be 100%, meaning that beyond time spent for normal maintenance and calibration, the continuous analyzer will be operational.

#### 3.3.4 GPU Outlet Heat Content Measurement

The heat content of the GPU outlet gas will be measured with integrated samples collected according to ASTM D3588-91. The DQI goals are as follows:

*Precision* will be determined by analysis of one series of triplicate samples collected simultaneously. Precision will be calculated as the relative standard deviation, and the goal is 2%.

*Accuracy/Bias* will be quantified by the analysis of a single certified heat content gas standard. The DQI goal for accuracy is also 2%.

*Completeness* will be 100% for these heat content measurements.

#### 3.3.5 Power Plant Flowrate (Continuous Hot-Wire Anemometer)

A calibrated hot-wire anemometer will be used to measure flowrate continuously. The expected precision is 1% based on the manufacturer's specifications. Accuracy will be quantified by comparison to triplicate EPA Methods 1 and 2 measurements. The accuracy determination will be conducted at the beginning of the 30-day emissions program.

#### 3.3.6 Electrical Output

Electrical output will be measured by a kWh billing meter, which will be calibrated according to the American National Standard Code for Electricity Metering (ANSI C12). The expected accuracy and precision is 2%. Completeness of the power output measurement will be 100%.

The billing meter will be calibrated by LADWP prior to installation. The results of the meter calibration for the existing meters at the Penrose Station are included in Attachment F.

## 4.0 SAMPLING PROCEDURES

### 4.1 Sampling Locations

The sampling locations for the power plant, the flare stack, the GPU outlet, and the raw landfill gas are indicated on the schematic presented in Figure 1-1. The GPU outlet and raw landfill gas sampling locations are in one-inch pipes. The flare stack is a 32-inch-diameter refractory lined stack with two sampling ports located 90° apart, one diameter upstream from the outlet and approximately three diameters downstream of the nearest flow disturbance. The power plant stack is a six-inch-diameter stack with two ports located 90° apart.

#### 4.1.1 Performance Demonstration Test

Samples will be collected from the GPU outlet (location B) to verify GPU performance. The sampling location is under 24 psig pressure. The sampling port consists of a gate valve with a 1/4-inch tube Swagelok-type connector.

Electrical output (location C) will be acquired from the LADWP kWh electric meter. Fuel flowrate will be measured with a process flowrate monitor located at the GPU outlet. A treated fuel heat content sample will also be collected from the clean fuel line at the GPU outlet using a valve connected to a Swagelok fitting.

#### 4.1.2 Emissions Testing

Data will be acquired from the fuel cell power plant exhaust (Emission Point A1) and the GPU flare exhaust (Emission Point A2) to establish the emissions characteristic of the demonstrator system.

### 4.2 GPU Outlet and Raw Landfill Gas Sampling Methods

The test matrix is presented in Table 4-1. Tedlar bag samples will be collected twice per week from the GPU outlet during the first month of the demonstration. The bags will be analyzed for volatile organic compounds (including halides) and sulfur compounds according to EPA Method TO-14 and Method 16. After the first month of operation, the volatile-organic/sulfur compound sampling at the GPU outlet will be reduced to biweekly for the remainder of the program. The Tedlar bags will be collected as grab samples over approximately five-minute periods using a stainless steel valve to regulate the flowrate (sampling location is under positive pressure so that no sampling pumps will be required). Heat content samples of treated landfill gas will be collected in steel canisters by purging the canisters with at least 12 volumes of sample gas.

**Table 4-1**  
**GPU Outlet Sampling Matrix**

Month	Week	Number of Samples Collected	
		GPU Outlet (TO-14/EPA 16)	GPU Outlet Heat Content (ASTM D3588-91)
1	1	2	2
	2	2	2
	3	2	2
	4	2	2
2	1	1	1
	2	—	—
	3	1	1
	4	—	—

Notes:

1. Month 2 sampling matrix will be continued for the duration of the demonstration.
2. GPU outlet heat content measurements will be conducted to correlate the on-line heat content analyzer data obtained by Pacific Energy on the raw landfill gas with the heat content of the clean GPU exit gas to the fuel cell. The corrected raw landfill gas analyzer data will then be used for fuel cell efficiency calculations.

#### 4.3 Power Plant and Flare Stacks Continuous Monitoring Methods

EPA Methods 7E, 6C, 10, and 3A will be used to measure flare exhaust and power plant exhaust emissions of  $\text{NO}_x$ ,  $\text{SO}_2$ , CO,  $\text{CO}_2$ , and  $\text{O}_2$ . Monitoring will be conducted 10 hours per day on each stack for the 30-day period. The monitors will be calibrated daily with EPA Protocol 1 gases and the drift performance specifications will be twice the 40 CFR 60, Appendix B specification. A schematic of the measurement system is presented in Figure 4-1.

All continuous emission monitoring (CEM) data will be recorded in five-minute intervals by a Yokogawa Model 2300 stripchart/data logger or equivalent. The CEM system will be housed in TRC's equipment trailer located within 100 feet of the sampling locations.

Calibration gas will enter the system at the probe outlet. This method of inputting calibration gas will challenge the entire system outside of the stack including heated sample line, out-of-stack filters, and moisture condenser.

##### 4.3.1 Sample Conditioning System

An in-stack Alundum thimble filter with a stainless steel nozzle facing away from the stack gas flow will serve to remove any particulate matter from the sample gas stream. The thimble filter will be mounted on the end of a stainless steel sampling probe. The sample will be drawn through 100 feet of heated ( $325^\circ\text{F} \pm 25^\circ\text{F}$ ) Teflon sample line through a condenser system to remove the moisture from the gas stream. The sample will be drawn through the tubing by a leak-free Teflon double-diaphragm pump to a stainless steel sample manifold with an atmospheric bypass rotameter. The analyzers will then draw their samples from the manifold.

##### 4.3.2 $\text{NO}_x$ Analyzer

A Thermo-Electron Corporation Model 10A chemiluminescent  $\text{NO}/\text{NO}_x$  analyzer will be used to determine  $\text{NO}_x$  concentrations. The chemiluminescent reaction of NO and  $\text{O}_3$  (ozone) provides the basis for the analytical method ( $\text{NO} + \text{O}_3 \rightarrow \text{NO}_2 + \text{O}_2 + \text{light}$ ). A photomultiplier-electrometer-amplifier produces a current proportional to the NO concentration. The output of the amplifier provides a signal for direct readout on a meter indicator, or for outputs to a recorder or computer.

##### 4.3.3 $\text{SO}_2$ Analyzer

A Western Research Model 721  $\text{SO}_2$  analyzer will be used to determine  $\text{SO}_2$  concentrations in the stack gas. This instrument utilizes the ultraviolet photometric principle, and was designed to meet the stringent California Air Resources Board (CARB) requirements to ensure maximum accuracy and reliability, without  $\text{NO}_x$  interference, in the 0-1000 ppm and 0-100 ppm ranges.

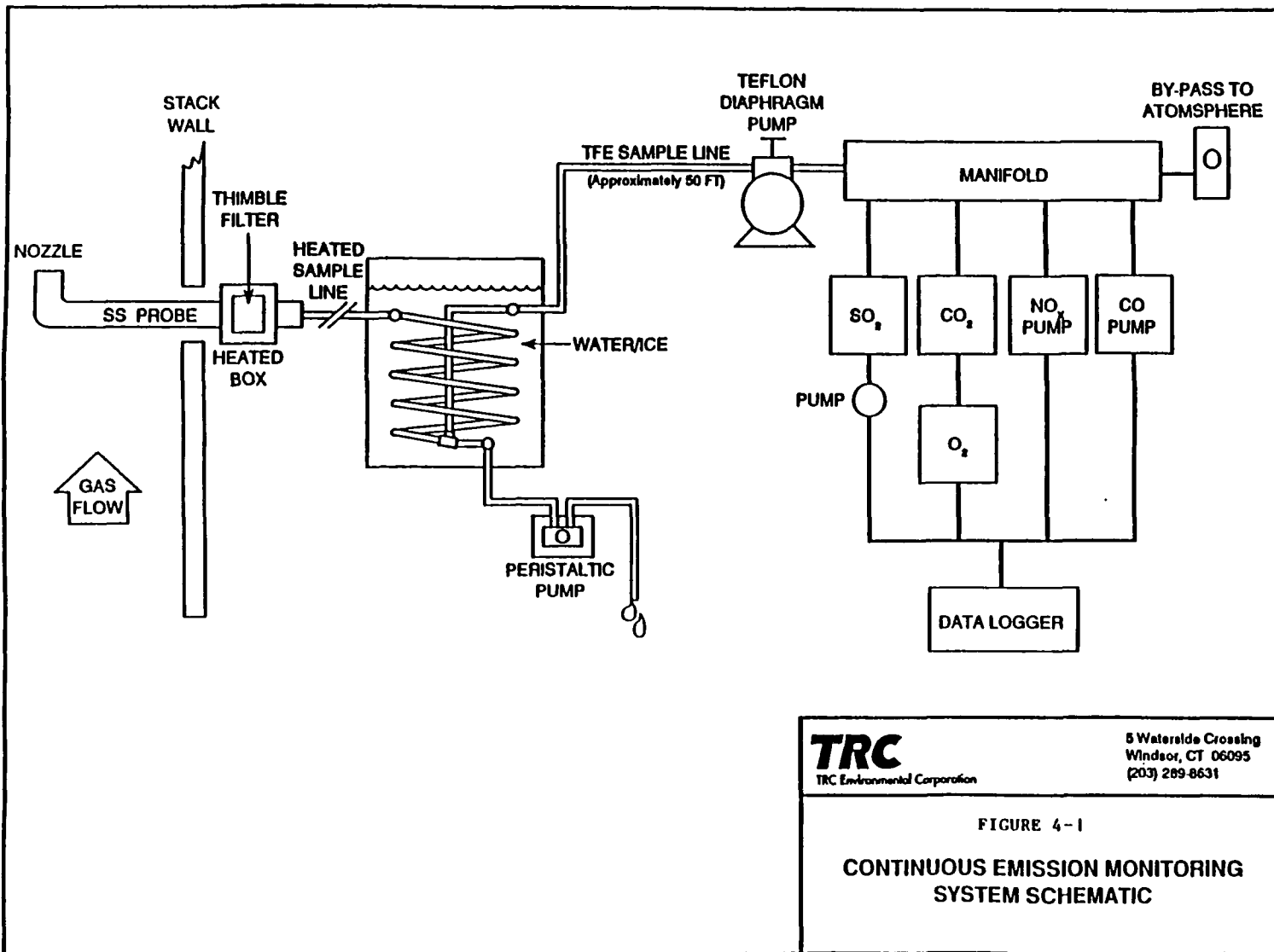


Figure 4-1  
Continuous Emission Monitoring Schematic

#### 4.3.4 CO Analyzer

A TECO Model 48 nondispersive infrared gas analyzer will measure CO concentrations. The analyzer contains an infrared detector that uses the signal nondispersive beam technique with alternate modulations of the sample and reference cells. Radiation absorbed by CO in the sample cell results in a capacitance change in the detector which is proportional to the CO concentration.

#### 4.3.5 O<sub>2</sub> Analyzer

A Horiba Model PMA-200 O<sub>2</sub> analyzer will be used to determine the concentration of O<sub>2</sub> in the stack gas. This instrument uses the paramagnetic principle, whereby the magnetic susceptibility of the gas volume is measured by the force acting on a nonmagnetic test body suspended in a magnetic field. The force is converted to an output current proportional to the O<sub>2</sub> concentration.

#### 4.3.6 CO<sub>2</sub> Analyzer

An Infra-Red Industries, Inc., infrared CO<sub>2</sub> analyzer will be used to monitor CO<sub>2</sub> emissions. This instrument operates on the principle of CO<sub>2</sub> having a known characteristic absorption spectra in the infrared range. Radiation absorbed by CO<sub>2</sub> in the sample cell produces a capacitance change in the detector which is proportional to the CO<sub>2</sub> concentration.

#### 4.4 Flowrate Monitoring

Flowrate will be continuously monitored in the power plant exhaust stack using a calibrated hot-wire anemometer according to EPA Method 2D. The accuracy of this measurement will be determined by comparison to the triplicate EPA Method 1 and 2 measurements. The flare exhaust flowrate will be calculated from measured inlet gas flowrate and an excess air factor developed from the diluent measurements. The flare inlet gas flow is measured with an in-line process monitor which sends a signal to the control room chart recorder. The GPU outlet flowrate is also monitored with an in-line process monitor.

#### 4.5 Power Plant Electrical Measurements

The power plant output is continuously monitored with a utility-grade kWh electric meter. The meter is a digital-display-type meter (Model PMG 30018-15) calibrated according to ANSI C12. Additional information is presented in Attachment F.

## 5.0 SAMPLE CUSTODY

The purpose of sample custody procedures is to document the identity of the sample and its handling from its first existence as a sample until analysis and data reduction are completed. Custody records trace a sample from its collection through all transfers of custody until it is transferred to the analytical laboratory. Internal laboratory records then document the custody of the sample through its final disposition.

In accordance with SW-846, a sample is considered to be under a person's custody if the sample is:

- In that person's possession.
- In view of that person after acquiring possession.
- Secured by that person so that no one can tamper with the sample.
- Secured by that person in an area which is restricted to authorized personnel.

These criteria will be used to define the meaning of "custody" and ensure the integrity of the samples from collection to data reporting.

### 5.1 Sample Documentation

Documentation of all samples and data collected during this program will be performed using TRC data forms (both hard copy as well as computer) and bound laboratory notebooks.

#### 5.1.1 Sampling Data Forms

Emission data from the power plant and flare exhaust will be recorded with a digital data logger which provides a stripchart-type trend as well as periodic averages. The data will be reduced on a daily basis according to EPA methods using a personal computer and Lotus 1-2-3. A data reduction form similar to one presented in Figure 5-1 will be prepared daily. All additional field data and observations will be recorded in bound laboratory notebooks.

#### 5.1.2 Sample Identification and Labeling

The samples will be identified with the following information:

- Sample location (GPU outlet or raw landfill gas)
- Date and time of collection
- Required analytical parameters
- Sampler name
- Project name and number

This information will be entered on to a TRC label and placed on the Tedlar bag sample. The information will also be recorded in a bound laboratory notebook.



Figure 5-1  
Data Reduction Form

TRC Environmental Corporation CEM Data Sheet				Calibration Gases			
		Mid Cal	High Cal	Tank ID			
				Mid	High		
Firm	Ambient Temp, deg. F =						
Location	MEL Temp, deg. F =						
Tester	Bar. Pressure, in Hg =						
Test No.	Vacuum Gauge =						
Sample Loc	Pressure Gauge =						
Date							
TIME							

	(Rack) Analyzer Cal. Response	Initial Values		Final Values		Drift % of Span	Analyzer Range & Units	Avg. Gas Conc.	Effluent Gas Conc.
		System Cal. Response	System Cal. Bias % of Span	System Cal. Response	System Cal. Bias % of Span				
CO	Zero		0		0	0	ppm	-	-
	Upscale		0		0	0	250	-	ERR
O2	Zero		0		0	0	PERCENT	-	-
	Upscale		0		0	0	25	-	ERR
CO2	Zero		0		0	0	PERCENT	-	-
	Upscale		0		0	0	20	-	ERR
NOx	Zero		0		0	0	ppm	-	-
	Upscale		0		0	0	250	-	ERR
SO2	Zero		0		0	0	ppm	-	-
	Upscale		0		0	0	250	-	ERR
THC	Zero		0		0	0	ppm	-	-
	Upscale		0		0	0	100	-	ERR
		LIMITS +/- 5%		+/- 5%		+/- 3%			

	Cal. Back Analyzer Response	Cal. Upstream Analyzer Response	Bias Check % of Span	ZERO Cal. Gas Analyzer Response	Analyzer Calib. Error	MID Cal. Gas Analyzer Response	Analyzer Calib. Error	HIGH Cal. Gas Analyzer Response	Analyzer Calib. Error
	Upscale		0		0.00		0.00		0.00
NOx	Zero		0		0.00		0.00		0.00
	Upscale		0		0.00		0.00		0.00
		LIMIT +/- 5%		+/- 2%		+/- 2%		+/- 2%	

40 CFR 60, Appendix A, Method 6C, subpart 4.1

## 5.2 Chain-of-Custody Forms

Custody of the samples will be documented using a chain-of-custody form (Figure 5-2). The chain-of-custody form will be completed providing sample identification, required analyses, sample container descriptions, project identification. Prior to sample shipment, the TRC sampler will relinquish custody of the samples by signing and dating the chain-of-custody form in the "Relinquished by" box. The TRC sampler will require the laboratory to complete the "Received by" box if the samples are to be hand delivered by TRC. If the samples are to be shipped by common carrier, TRC will relinquish the samples to the carrier airbill by entering the airbill in the "Received by" box. Following completion of the chain-of-custody form, TRC will retain the bottom copy and send the remaining copies along with the samples.

## 5.3 Laboratory Custody

Samples arriving at the laboratory will be compared against the chain of custody prior to the laboratory acknowledging sample receipt by signing the chain-of-custody forms. The laboratory will then continue the chain of custody by entering the samples into the laboratory information system (LIMS). This is done by assigning an internal project number and individual sample identifications. The samples will be stored in a controlled access area until analysis. Sample transfers between the storage area and the analytical area of the laboratory are documented through internal chain of custody generated by the LIMS.

## G-38

Nº 0862

**TRC**  
TRC Environmental Corporation

Phase III QAPP  
Revision No. 1  
October 1994  
Page 31 of 41

## 6.0 CALIBRATION PROCEDURES

### 6.1 Manual Sampling Equipment

The TRC quality assurance program for source testing is designed to ensure that emission measurement work is performed by qualified people using proper equipment and following written procedures in order to provide accurate, defensible data. The program is based upon the EPA *Quality Assurance Handbook for Air Pollution Measurement Systems*, Volume III (EPA-600/4-77-0276).

Sampling and measurement equipment, including continuous analyzers, recorders, pitot tubes, dry-gas meters, orifice meters, thermocouples, probes, nozzles, and any other pertinent apparatus, is uniquely identified, undergoes preventive maintenance, and is calibrated before and after each field effort, following written procedures and acceptance criteria. Most calibrations are performed with standards traceable to the National Institute for Science and Technology (NIST). These standards include wet test meters, standard pitot tubes, and NIST Standard Reference Materials. Records of all calibration data are maintained in TRC files.

### 6.2 Power Plant and Flare Continuous Monitoring Methods

The continuous measurements will be calibrated daily for zero and span drift according to EPA Methods 6C, 7E, 10, and 3A. EPA Protocol 1 gases will be used. Calibration gas will be introduced to the system at the probe outlet using a three-way tee. An excess flow of calibration gas will be metered to the tee with the excess flowing into the stack through the probe. On a weekly basis, a calibration bias test will be conducted by first conducting a zero and span calibration, followed by a complete system calibration (the system calibration is conducted with calibration gas delivered to the probe outlet as described above).

### 6.3 In-Situ Flowrate Meters

Calibration of the meters installed on the flare inlet and the GPU outlet were performed by the manufacturer. Documentation of the calibrations will be provided with the final test report.

### 6.4 Electrical Power Measurements/Power Plant Efficiency

Calibration documentation will be provided by LADWP for inclusion in the final report. See Attachment A for a sample calibration form.

### 6.5 On-Line Raw Landfill Gas Heat Content Analyzer

This analyzer is automatically calibrated daily using a certified gas. The calibration gas contains carbon dioxide, oxygen, nitrogen, and methane. The data system records the response factor of each compound, compares it to the certified reference, and reports a deviation. An example of a calibration report is included in Attachment D.

## 7.0 ANALYTICAL PROCEDURES

### 7.1 Continuous Emissions Monitoring

See Section 4.3.

### 7.2 Heat Content Analysis of GPU Outlet Samples

The heat content (BTU/scf) of the GPU outlet samples will be determined according to ASTM Method D3588-91. This method covers procedures for calculating heat content from compositional analyses of the samples. Compositional analysis of the samples will be conducted using a gas chromatograph equipped with a thermal conductivity detector to measure the concentrations of nitrogen, oxygen, methane, and carbon dioxide, and a gas chromatograph equipped with a flame ionization detector to measure the concentrations of C1 through C6 hydrocarbons. For each gas chromatograph method, an initial calibration curve with a minimum of three points is analyzed using calibration gas standards containing the analytes of concern. The calibration curve will span the expected concentration of the samples. The initial calibration is verified at least once at the beginning of each 24-hour period with the analysis of a mid-level Continuing Calibration standard. The percent difference of the continuing calibration response factors shall be within  $\pm 15\%$  from the initial calibration mean response factor. One field sample per analytical sequence will be analyzed in duplicate to demonstrate the precision of the analytical technique on the sample matrix. The heat content of the samples is then calculated using the equations presented in ASTM Method D3588-91 from the measured chemical composition.

### 7.3 GPU Outlet Constituent Analysis

#### 7.3.1 Sulfur Compound Analysis

Tedlar bag samples will be analyzed for seven sulfur compounds and total reduced sulfur as hydrogen sulfide utilizing a GC/FPD according to the procedures outlined in EPA Method 16. An initial calibration curve with a minimum of three points is analyzed using calibration gas standards containing the analytes of concern. The calibration curve will span the expected concentration of the samples. The initial calibration is verified at least once at the beginning of each 24-hour period with the analysis of a mid-level Continuing Calibration standard. The percent difference of the continuing calibration response factors shall be within  $\pm 15\%$  from the initial calibration mean response factor. One field sample per analytical sequence will be analyzed in duplicate to demonstrate the precision of the analytical technique on the sample matrix.

#### 7.3.2 Volatile Organic Compound Analysis

The Tedlar bag samples will also be analyzed by GC/MS for VOCs and specified tentatively identified compounds. The analyses will be performed according to the methodology outlined in EPA Method TO-14 from the *Compendium of Methods for the Determination of Toxic*

*Organic Compounds in Ambient Air* (EPA 600/4-84-041, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, April 1984 and May 1988). The method will be modified for using Tedlar bags. The analyses will be performed by GC/MS utilizing a direct cryogenic trapping technique.

Verification of the mass calibration of the GC/MS is checked at the beginning of every 24-hour analytical sequence by the direct injection of 50 nanograms (ng) of bromofluorobenzene. The calibration range of the target compounds is determined by the three-point curve. Linearity is established over the range of the three-point curve if the percent relative standard deviation of the response factors is less than 30% for each analyte. A continuing calibration is considered to establish the same conditions of linearity and range as the initial calibration if the response factor for each analyte is within 20% of the average response factor of the initial calibration. A continuing calibration is performed at the beginning of each 24-hour period. A blank is analyzed following calibration as a sample to demonstrate that the analytical system is free from contamination.

Internal standards and surrogates are introduced into the sample stream to monitor the method efficiency. If the internal standard area changes by a factor of two (-50% to +200%) and/or surrogate recoveries are less than 80% or greater than 120%, the internal standard/surrogate gas standard is reevaluated by analyzing a lab blank. If the internal standard areas in the blank are within a factor of two of the quantitation standard and surrogate recoveries are within 80%–120%, then the sample analyses may be continued. The earlier low recoveries may be attributed to a matrix effect. The sample must be reanalyzed to verify that a matrix effect was the cause and not some intermittent problem. If the areas and recoveries remain poor in the lab blank, then corrective action must be taken. This may include leak checking the system and/or the preparation of a fresh internal standard surrogate mix.

A minimum of one duplicate is analyzed per analytical sequence.

## 8.0 DATA REDUCTION, VALIDATION, AND REPORTING

### 8.1 Overall Calculations

- **POLLUTANT MASS EMISSION RATE** (SO<sub>2</sub>, NO<sub>x</sub>, and CO)

Concentration (ppmvd) × flowrate (dscfm) × 60 × k = pounds/hr

$$k (\text{SO}_2) = 1.660 \times 10^{-7}$$

$$k (\text{NO}_x) = 1.194 \times 10^{-7}$$

$$k (\text{CO}) = 7.263 \times 10^{-8}$$

- **FUEL CELL EFFICIENCY** (reference Figure 1-1 for measurement locations)

$$\text{Efficiency (\%)} = \frac{(\text{kwh at [C]}) (3413 \text{ BTU/kwh})}{(\text{scf at [B]}) (\text{BTU/scf})} \times 100$$

where: scf = measured GPU exit gas by totalizer at [B], based on flow, temperature, pressure.

BTU/scf = weekly average of 168 hourly readings at [A3] adjusted by periodic exit samples taken weekly for first 4 weeks, and monthly thereafter at [B], tested by ASTM D3588-91. Adjustment to be made by comparing ASTM D3588-91 samples to hourly inlet sample value taken at same time.

### 8.2 Data Validation

Each 24-hour period of continuous emission data will be reduced on a separate Lotus file. Transfer of all data logger averages and calibration data to the Lotus 1-2-3 spreadsheet will be performed manually each day. Copies of the raw data logger charts and the spreadsheet printout will be mailed on a weekly basis to TRC's Windsor, Connecticut, office where an independent QA check of the data will be conducted.

Laboratory data will be submitted to TRC for a QA evaluation. A QA specialist will examine the data, check the precision and accuracy of the results (duplicate analyses and audits), and report the findings to the TRC Project Manager.

### 8.3 Identification and Treatment of Outliers

Continuously monitored parameters are not expected to change significantly throughout the program. Responses for CEM monitors and Pacific Energy process monitors will be evaluated daily for the first week of the emissions testing. "Control limits" will be established for CEM monitors and Pacific Energy process monitors at the end of the first week of the

emissions testing. They will be updated weekly. Any deviations outside these limits will be assessed to determine if: trends are developing, process aberrations are occurring, and/or monitoring instruments are malfunctioning. These assessments will be performed by the designated Pacific Energy representative, and the TRC field team leader. Results will be summarized and reported to the IFC Program Manager each week.

Similarly, the analytical values for halide and sulfur compounds concentrations of the GPU outlet gas will be evaluated weekly for the first week and biweekly thereafter to determine the GPU effectiveness. Again, control limits will be established for halide and sulfur compounds upon receipt of analytical data. The control limits will be based on IFC's knowledge of concentrations significantly higher than expected for the GPU unit or concentrations that could produce significant catalyst poisoning. TRC will coordinate with the analytical laboratory to review quality control data and to generally assess validity of the analytical data. IFC and Pacific Energy will assess GPU performance. Due to the constraints on analytical laboratory data turnaround times, it is unlikely that even preliminary data from the first week's test will be available until the middle of the second week's test. TRC will work with IFC and Pacific Energy to ensure that the first VOC/sulfur samples are taken early in the first week. TRC will take pretest GPU exit samples prior to the initial fuel cell checkout on LFG (before start of the demonstration test). TRC will also work with the laboratory to expedite analysis of these first samples and to compare results to historical data from Phase II. TRC will communicate analytical results to IFC within 24 hours of receipt.

Corrective action options are discussed in Section 12.0.



## 9.0 INTERNAL QUALITY CONTROL CHECKS

### 9.1 Data Collection and Sampling QC Procedures

Continuous emission monitoring QC checks include daily zero and span drift tests, weekly audits, and weekly system bias checks. All continuous monitoring zero and span gases will be delivered to the probe outlet to challenge the entire sampling system. This QC data will be recorded on the data logger chart and will be identified with a felt pen. The data will then be transferred directly to a Lotus 1-2-3 spreadsheet as presented in Section 5.0.

In addition to the daily zero and span calibrations, the operator will conduct several daily equipment checks to verify proper operation of sampling equipment. These checks include:

- Sample vacuum (high vacuum indicates an overloaded filter)
- Chiller condenser (temperature will be set at 40°F)
- Data logger paper supply
- Condensation in sample line entering instrument rack (moisture indicates condenser problem)
- Pressures on zero and span gas cylinders (additional gases will be obtained if necessary)

### 9.2 Analytical Laboratory QC Checks

**Blanks** for both sulfur and VOC analyses will be conducted with each set of samples received by the laboratory. The blank concentration of target sulfur compounds will be less than 2 ppbv and the blank concentration of target VOCs will be less than 1 ppbv.

**Audit samples** for this program will be purchased by TRC for target volatile, sulfur compound, and heat content analysis. The results of the audit analyses will determine the accuracy of the analyses. Accuracy (recovery) objectives are presented in Table 3-1.

**Instrument calibration verifications** for GC and GC/MS will be performed for target volatile, sulfur compound, and heat content analysis. Acceptance criteria for the calibration verification samples is presented in Section 7.0.

**Laboratory duplicates** will be performed for each analytical parameter for each analytical sequence. The percent difference determined will be used to evaluate matrix effect on the precision of the analytical technique. The precision objective for laboratory duplicate is 10% relative percent difference (RPD).

**Surrogate spikes** will be added to each sample for target volatile organic analysis. The recovery objectives for the surrogate spikes are presented in Section 7.0.

## 10.0 PERFORMANCE AND SYSTEM AUDITS

### 10.1 Performance Audits

These audits will be conducted at EPA's discretion. EPA must provide the cylinder gases, which would preferably be analyzed prior to the initiation of the 30-day period. The audits should also be in the ranges of the expected concentrations, which are outlined below.

<u>Analysis</u>	<u>Critical Ranges</u>
Sulfur	20-200 ppbv
VOCs	50-200 ppbv
NO <sub>x</sub> (power plant)	0.5-2.0 ppmv
NO <sub>x</sub> (flare)	10-20 ppmv
SO <sub>2</sub>	50-100 ppmv
CO	5-10 ppmv
O <sub>2</sub>	5-15 %
CO <sub>2</sub>	10-20 %

### 10.2 System Audit

If requested by EPA and approved by IFC, the TRC Director of Quality Assurance will conduct a systems audit based on QAPP requirements. The audit would include assessments of: project responsibilities, intercompany communication, intracompany communication, monitoring instruments (measurements and quality control data), sampling, chemical analysis (methods, record keeping, scheduling, quality control data, and reporting), data reduction, and report preparation. The audit would be conducted with a formal checklist with provision for corrective action and reports to the IFC Program Manager.

## 11.0 CALCULATION OF DATA QUALITY INDICATORS

### 11.1 Precision

#### 11.1.1 Continuous Emission Monitoring

Precision will be determined on a daily basis between 9:00 and 10:00 A.M. using a zero and span calibration drift test. The drift will be calculated as a percentage of instrument range, as follows:

$$\% \text{ drift} = \frac{[\text{monitor value}] - [\text{certified concentration}]}{\text{span value}} \times 100$$

#### 11.1.2 Sulfur and Halide Compounds - GPU Outlet Samples

A series of three samples will be collected simultaneously. Samples will be collected and analyzed in duplicate. The precision will be calculated for each detectable compound by the relative standard deviation (RSD), as follows:

$$\text{RSD} = \frac{S}{X} \times 100$$

Since the expected halide concentrations are near or below the detection limit, a series of triplicate audit samples containing three compounds will also be analyzed and the RSD will also be calculated.

#### 11.1.3 GPU Outlet - Heat Content Analysis

The RSD from a series of three replicate samples will be calculated to determine precision. The RSD calculation is defined above.

#### 11.1.4 Flowrate

Flowrate monitoring precision by electronic flowmeters will be determined by the manufacturer's specifications.

### 11.2 Accuracy

#### 11.2.1 Continuous Emission Monitoring

Accuracy will be determined by analyzing two audit gases for each parameter. The audit cylinders will be EPA Protocol 1 ( $\pm 1\%$ ) or equivalent. Accuracy will be calculated as follows:

$$\text{accuracy} = \frac{C_m - C_a}{C_a} \times 100$$

$C_m$  = monitor response  
 $C_s$  = certified audit concentration

#### 11.2.2 Sulfur and Halide Compounds

Two audit samples will be prepared gravimetrically by a specialty gas manufacturer and certified for  $\pm 5\%$  accuracy. The audits will be analyzed with each set of samples submitted to the laboratory and accuracy will be calculated for each compound. The sulfur audit gases will contain three reduced sulfur compounds, and the halide audit gas will also contain three compounds. Accuracy will be determined as previously described for continuous monitoring.

$$\text{accuracy} = \frac{[\text{analyzed value}] - [\text{certified value}]}{\text{certified value}} \times 100$$

#### 11.2.3 GPU Outlet - BTU Analysis

One BTU audit cylinder gas will be purchased from a specialty gas manufacturer and analyzed with the heat content samples. The accuracy will be calculated as outlined previously.

#### 11.2.4 Flowrate

Single-point flow monitoring at the power plant stack will be certified for accuracy by EPA Methods 1 and 2. Continuous electronic flowmeter (GPU outlet and flare inlet) accuracy will be determined by the manufacturer's factory calibration.

### 11.3 Completeness

Completeness for continuous emission monitoring will be 100%, which requires at least 22 days of valid data captured. Completeness is specified at 100% for all measurements including power output.

## 12.0 CORRECTIVE ACTION

Opportunities for collection of valid data depend on the duration of each type of measurement, frequency of the measurements, turnaround time for receipt of data, data assessment procedures, and assignment of responsibility for corrective action. The measurement data summary (Table 1-2) provides a good overview. The program is structured with sufficient time for data assessment and corrective action.

### 12.1 Emission Measurements

The emission measurements occur over a 30-day period. Fortunately, data will be available on a daily basis, thus allowing sufficient time to collect valid data.

Corrective actions for on-site monitors may include actions by TRC or Pacific Energy. The TRC technician will perform a system calibration and audit as well as a visual check of the system. If the calibration and audit meet the specifications, Pacific Energy will be responsible for checking out the gas purification unit, fuel processor, or fuel cell.

Corrective actions for flowrate and moisture determinations will include system checks and repeat of measurements depending on results of EPA Method quality control checks.

### 12.2 System Performance

System performance measurements will occur over a period of up to 12 months. It is anticipated that, on at least 18 occasions over the first six months, samples will be taken for chemical analysis to determine sulfur/halide compound concentrations. The control limit for the program shall be 1.0 ppmv total sulfur and 1.0 ppmv total halide. These control limits were developed by dividing the GPU performance specifications by 3.

If chemical analysis data appears to be outside the current control limits, the first corrective action will be to review chemical analysis quality control data and assess data validity. Data validation would be performed by the TRC Laboratory Coordinator using analytical method criteria. If data is suspect, a determination will be made as to whether reanalysis can correct the problem. If this is not possible, a new round of sampling and analysis will be required.

If the analytical data is determined to be valid, it will be necessary to assess GPU performance. Corrective action options for GPU malfunction (high concentrations of sulfur or halide compounds) will be determined by the IFC Program Manager. One option would be to suspend further testing pending correction of the malfunction.

## Attachment A

### Weekly Landfill Gas Methane Concentration Data From the Penrose Site

22.141 50 SHEETS  
22.142 100 SHEETS  
22.144 200 SHEETS

1993	PERCENT METHANE	1993	PERCENT METHANE	1994	PERCENT METHANE
1/4	42.2	6/21	42.1	11/29	45.7
1/11	42.4	4/28	42.8	12/6	41.7
1/18	42.5	7/5	43.6	12/13	41.9
1/25	—	7/12	43.7	12/20	41.6
2/8	43.3	7/19	43.7	12/27	41.9
2/15	44.1	7/26	43.6	1/1/94	42.0
2/22	44.2	8/2	43.6	1/10/94	42.6
3/1	44.0	8/9	44.0	1/17	42.8
3/8	44.4	8/16	43.3		
3/15	44.6	8/23	43.1		
3/22	44.7	8/31	43.3		
3/29	44.8	9/6	43.5		
4/5	44.7	9/13	43.5		
4/12	44.1	9/20	43.2		
4/19	43.3	9/27	43.0		
4/26	43.3	10/4	43.0		
5/3	45.3	10/11	42.9		
5/10	43.3	10/18	43.3		
5/17	42.8	10/25	42.9		
5/24	42.7	11/1	43.0		
5/31	42.2	11/8	42.6		
6/7	41.9	11/15	42.3		
6/14	41.8	11/22	42.0		

AVG 43.2%

## Attachment B

### Hourly Landfill Gas Heating Value Data From the Penrose Site



	15.	15.	15.	15.	15.	15.	TO
15.	15.	15.	15.	15.	15.	15.	15.
13.	13.	14.	15.	15.	15.	15.	15.
12.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	15.	15.	15.	15.
BUFFER # 11, SOURCE 511 S/B SCFM 1830., TRIGGER 914							
1830.	1830.	1830.	1830.	1830.	1830.	1830.	1830.
1830.	1817.	1830.	1830.	1830.	1830.	1831.	1819.
1620.	1825.	1825.	1825.	1825.	1825.	1824.	1824.
1824.	1824.	1824.	1824.	1824.	1824.	1824.	1824.
BUFFER # 12, SOURCE 309 E2 SKW 1925., TRIGGER 914							
1925.	1915.	1920.	1926.	1918.	1926.	1951.	1948.
1934.	1890.	1759.	1875.	1940.	1952.	1958.	1939.
1938.	1949.	1960.	1959.	1956.	1955.	1949.	1930.
1935.	1938.	1923.	1938.	1952.	1947.	1957.	1940.
BUFFER # 13, SOURCE 511 E2SCFMFG 697., TRIGGER 914							
698.	696.	695.	696.	694.	695.	696.	697.
694.	696.	658.	677.	692.	697.	694.	691.
738.	697.	698.	699.	699.	699.	698.	697.
696.	696.	693.	692.	695.	697.	692.	689.
BUFFER # 14, SOURCE 315 E2SCFMFG 14., TRIGGER 914							
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	13.	14.	14.	14.	14.	14.
15.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
BUFFER # 15, SOURCE 504 A/O B IN 423., TRIGGER 914							
422.	423.	424.	425.	425.	424.	424.	423.
424.	425.	426.	425.	424.	423.	OPEN	OPEN
OPEN	OPEN	OPEN	OPEN	OPEN	OPEN	OPEN	OPEN
OPEN	OPEN	OPEN	OPEN	OPEN	OPEN	OPEN	OPEN
BUFFER # 16, SOURCE 625 OPEN VAC 56., TRIGGER 914							
-56.	-55.	-55.	-55.	-54.	-54.	-54.	-53.
-53.	-51.	-55.	-56.	-56.	-56.	-57.	-60.
-46.	-59.	-58.	-58.	-58.	-57.	-57.	-57.
-57.	-57.	-56.	-55.	-55.	-54.	-54.	-53.

PAGE 1 OF 7

NEXT READING  
IS 8-26 2300

MIN 422  
MAX 425  
AVG 424.1 (14 Readings)

00:00:00 ON 8/27

START ON 8/26  
11:00

Pen 1

8-27-94

TOTAL FOR PERIOD: 1100 8/26/94 → TO 9/2/94 00:00:00.  
158 READINGS. MIN 400  
MAX 432  
AVG 422.7

SEP-02-1994 16:10 FROM PACIFIC ENERGY

TO

126

~~15. 15. 15. 15. 15. 15. 15. 15.  
15. 16. 16. 16. 16. 16. 16. 16.  
17. 16. 16. 15. 15. 15. 15. 15.  
15. 15. 15. 15. 15. 15. 15. 15.~~

~~BUFFER # 11, SOURCE 511 S/B SCFM 1824., TRIGGER 914  
1824. 1824. 1824. 1824. 1824. 1824. 1825. 1824.  
1806. 1774. 1787. 1777. 1599. 1600. 1600. 1600.  
1600. 1599. 1600. 1803. 1830. 1830. 1830. 1830.  
1830. 1830. 1830. 1830. 1830. 1830. 1830. 1830.~~

~~BUFFER # 12, SOURCE 309 E2 GKM 1930. TRIGGER 914  
1925. 1923. 1922. 1933. 1936. 1933. 1936. 1925.  
1913. 1927. 1923. 1918. 1932. 1934. 1930. 1948.  
1941. 1944. 1948. 1948. 1951. 1947. 1924. 1925.  
1925. 1916. 1920. 1926. 1918. 1926. 1951. 1948.~~

~~BUFFER # 13, SOURCE 311 E2SCFMFG 698. TRIGGER 914  
698. 698. 697. 695. 695. 692. 689. 686.  
685. 739. 740. 731. 760. 763. 766. 769.  
769. 767. 768. 706. 700. 700. 698. 697.  
698. 696. 695. 696. 694. 695. 696. 697.~~

~~BUFFER # 14, SOURCE 315 E2SCFMNG 14., TRIGGER 914  
14. 14. 14. 14. 14. 14. 14. 14.  
14. 15. 15. 15. 15. 15. 15. 15.  
15. 15. 15. 14. 14. 14. 14. 14.  
14. 14. 14. 14. 14. 14. 14. 14.~~

~~BUFFER # 15, SOURCE 504 A/O B IN 420. TRIGGER 914  
419. 419. 421. 422. 424. 425. 425. 425.  
424. 425. 424. 423. 421. 420. 419. 419.  
420. 420. 420. 421. 422. 423. 422. 423.  
422. 423. 424. 425. 425. 424. 424. 423.~~

~~BUFFER # 16, SOURCE 515 PER HAS 58. TRIGGER 914  
-60. -60. -59. -59. -58. -57. -57. -56.  
-55. -54. -51. -55. -59. -58. -58. -58.  
-58. -58. -57. -57. -57. -56. -56. -56.  
-56. -56. -56. -56. -56. -56. -56. -56.~~

2 OF 7

MIN 419  
MAX 425  
AVG 421.9

Pen 1  
8-28-94

3 OF 7

16.	15.	10.	0.	9.	15.	15.	15.
15.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	15.	15.	15.	15.

BUFFER # 11, SOURCE 511 S/B SCFM 1608., TRIGGER 914

1608.	1653.	666.	0.	1667.	1825.	1824.	1825.
1825.	1825.	1824.	1824.	1824.	1824.	1825.	1825.
1825.	1825.	1825.	1825.	1825.	1825.	1825.	1824.
1824.	1824.	1824.	1824.	1824.	1824.	1825.	1824.

BUFFER # 12, SOURCE 309 E2 GKW 1898., TRIGGER 914

1893.	1832.	1305.	0.	1666.	1933.	1929.	1930.
1921.	1914.	1906.	1922.	1907.	1915.	1923.	1930.
1919.	1917.	1935.	1926.	1931.	1932.	1937.	1930.
1925.	1923.	1922.	1933.	1936.	1933.	1936.	1925.

BUFFER # 13, SOURCE 311 E2SCFMFG 738., TRIGGER 914

733.	715.	592.	18.	641.	692.	691.	690.
690.	690.	688.	692.	689.	691.	693.	698.
697.	697.	698.	697.	698.	698.	698.	698.
698.	698.	697.	695.	695.	692.	689.	686.

BUFFER # 14, SOURCE 315 E2SCFMFG 15., TRIGGER 914

15.	14.	12.	0.	13.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.

BUFFER # 15, SOURCE 504 A/O B IN 423., TRIGGER 914

422.	416.	424.	424.	420.	424.	424.	424.
423.	423.	422.	421.	420.	420.	419.	418.
418.	419.	420.	420.	420.	421.	420.	420.
419.	419.	421.	422.	424.	425.	425.	425.

BUFFER # 16, SOURCE 313 PER YAG 44., TRIGGER 914

-41.	-43.	-54.	-25.	-56.	-59.	-58.	-58.
-58.	-58.	-58.	-59.	-59.	-60.	-50.	-61.
-61.	-61.	-61.	-60.	-60.	-60.	-60.	-60.
-60.	-60.	-59.	-59.	-58.	-57.	-57.	-56.

MIN 416

MAX 424

AVG 420.9

Pen  
8/29/94

BUFFER # 10, SOURCE 307 E2SCFM 1830., TRIGGER 914

15.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	16.	15.	15.	15.
15.	15.	15.	16.	16.	16.	16.	16.
16.	15.	10.	0.	9.	15.	15.	15.

BUFFER # 11, SOURCE 511 S/E SCFM 1830., TRIGGER 914

1830.	1830.	1830.	1830.	1830.	1830.	1830.	1830.
1830.	1830.	1830.	1830.	1790.	1802.	1828.	1827.
1827.	1827.	1819.	1696.	1655.	1609.	1609.	1608.
1608.	1653.	666.	0.	1667.	1825.	1824.	1825.

BUFFER # 12, SOURCE 309 E2 GKW 1942., TRIGGER 914

1935.	1925.	1918.	1942.	1927.	1949.	1944.	1949.
1945.	1938.	1930.	1915.	1929.	1929.	1922.	1905.
1905.	1874.	1881.	1890.	1896.	1884.	1902.	1898.
1893.	1837.	1305.	0.	1666.	1933.	1929.	1930.

BUFFER # 13, SOURCE 311 E2SCFMFG 697., TRIGGER 914

696.	695.	693.	694.	692.	693.	691.	688.
687.	689.	691.	691.	716.	698.	691.	688.
689.	683.	683.	721.	759.	778.	756.	738.
733.	715.	592.	18.	641.	692.	691.	690.

BUFFER # 14, SOURCE 315 E2SCFMNG 14., TRIGGER 914

14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	15.	15.	16.	15.	15.
15.	14.	12.	0.	13.	14.	14.	14.

BUFFER # 15, SOURCE 504 A/O B IN 423., TRIGGER 914

423.	423.	424.	426.	427.	427.	427.	427.
427.	426.	423.	424.	423.	422.	422.	422.
432.	421.	422.	424.	423.	423.	423.	423.
422.	416.	424.	424.	420.	424.	424.	424.

BUFFER # 16, SOURCE 515 PEN VAC -59., TRIGGER 914

-58.	-58.	-58.	-57.	-56.	-56.	-55.	-54.
-54.	-54.	-54.	-55.	-54.	-55.	-56.	-57.
-58.	-58.	-57.	-54.	-58.	-57.	-53.	-46.
-41.	-43.	-54.	-25.	-56.	-59.	-58.	-58.

4 OF 7

MIN 421  
MAX 432  
AVG 424.3

New  
8-30-94

SEP-02-1994 16:11

FROM PACIFIC ENERGY

TO

15.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	15.	15.	15.	15.
BUFFER # 11, SOURCE 511 S/B SCFM 1831., TRIGGER 914							
1831.	1830.	1830.	1830.	1830.	1830.	1830.	1830.
1830.	1830.	1830.	1830.	1831.	1831.	1831.	1831.
1831.	1830.	1831.	1831.	1831.	1831.	1831.	1830.
1830.	1830.	1830.	1830.	1830.	1830.	1830.	1830.
BUFFER # 12, SOURCE 309 E2 GKW 1957., TRIGGER 914							
1957.	1953.	1939.	1946.	1941.	1939.	1955.	1966.
1952.	1956.	1960.	1966.	1971.	1972.	1943.	1943.
1966.	1953.	1955.	1949.	1950.	1950.	1946.	1942.
1935.	1925.	1918.	1942.	1927.	1949.	1944.	1949.
BUFFER # 13, SOURCE 311 E2SCFMFG 700., TRIGGER 914							
701.	701.	699.	698.	695.	694.	695.	694.
694.	695.	695.	695.	698.	702.	697.	702.
699.	699.	699.	698.	698.	699.	698.	697.
696.	695.	693.	694.	692.	693.	691.	688.
BUFFER # 14, SOURCE 315 E2SCFMFG 14., TRIGGER 914							
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
BUFFER # 15, SOURCE 504 A/O B IN 423., TRIGGER 914							
423.	423.	424.	425.	426.	427.	427.	427.
427.	426.	425.	424.	423.	423.	422.	417.
422.	422.	422.	422.	423.	423.	423.	423.
423.	423.	424.	426.	427.	427.	427.	427.
BUFFER # 16, SOURCE 515 PEN VAC -60., TRIGGER 914							
-60.	-60.	-59.	-59.	-58.	-57.	-57.	-56.
-56.	-56.	-56.	-56.	-57.	-57.	-58.	-59.
-61.	-60.	-60.	-59.	-59.	-59.	-59.	-59.
-58.	-58.	-58.	-57.	-56.	-55.	-55.	-54.

5 OF 7

MIN 417

MAX 427

AVG 423.7

*Review!*  
9/31/94

SEP-02-1994 16:12 FROM PACIFIC ENERGY

TO

SOURCE	10	11	12	13	14	15	16
15.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	15.	15.	15.	16.
15.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	15.	15.	15.	15.

BUFFER # 11, SOURCE 311 S/B SCFM 1831., TRIGGER 914

1831.	1831.	1831.	1830.	1830.	1830.	1830.	1831.
1830.	1831.	1831.	1831.	1831.	1831.	1809.	1725.
1831.	1831.	1831.	1831.	1831.	1831.	1831.	1831.
1831.	1830.	1830.	1830.	1830.	1830.	1830.	1830.

BUFFER # 12, SOURCE 309 E2 GKW 1966., TRIGGER 914

1961.	1968.	1975.	1968.	1963.	1975.	1980.	1974.
1967.	1975.	1982.	1985.	1984.	1975.	1952.	1954.
1969.	1948.	1963.	1957.	1958.	1951.	1953.	1957.
1957.	1953.	1939.	1946.	1941.	1939.	1955.	1966.

BUFFER # 13, SOURCE 311 E2SCFMFG 697., TRIGGER 914

698.	704.	703.	702.	701.	701.	700.	699.
696.	695.	696.	697.	699.	700.	708.	725.
701.	699.	701.	700.	701.	701.	701.	700.
701.	701.	699.	698.	695.	694.	695.	694.

BUFFER # 14, SOURCE 315 E2SCFMNG 14., TRIGGER 914

14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	15.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.

BUFFER # 15, SOURCE 504 A/O B IN 421., TRIGGER 914

421.	421.	422.	423.	425.	426.	426.	426.
425.	424.	423.	422.	420.	421.	421.	420.
422.	423.	423.	423.	423.	422.	422.	423.
423.	423.	424.	425.	426.	427.	427.	427.

BUFFER # 16, SOURCE 515 PEN VAC -62., TRIGGER 914

-62.	-62.	-61.	-61.	-60.	-59.	-58.	-58.
-58.	-58.	-58.	-59.	-59.	-59.	-57.	-53.
-62.	-61.	-61.	-61.	-61.	-60.	-60.	-60.
-60.	-60.	-59.	-59.	-58.	-57.	-57.	-56.

6 OF 7

MIN 420

MAX 427

AVE 422.8

*Process!*  
9-1-94

FFER # 10, SOURCE 307 E2SCFMNG 1831., TRIGGER 914

15.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	15.	13.	15.	15.
15.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	15.	15.	15.	15.

FFER # 11, SOURCE 311 S/B SCFM 1831., TRIGGER 914

1831.	1831.	1830.	1830.	1830.	1830.	1830.	1830.
1830.	1830.	1831.	1830.	1799.	1469.	1830.	1815.
1796.	1831.	1831.	1831.	1831.	1831.	1830.	1831.
1831.	1831.	1831.	1830.	1830.	1830.	1830.	1831.

FFER # 12, SOURCE 309 E2 SCFM 1961., TRIGGER 914

1952.	1952.	1956.	1970.	1971.	1968.	1975.	1974.
1986.	1950.	1933.	1945.	1457.	1080.	1965.	1937.
1968.	1964.	1974.	1976.	1971.	1961.	1970.	1966.
1961.	1968.	1975.	1968.	1965.	1975.	1980.	1974.

FFER # 13, SOURCE 311 E2SCFMFG 703., TRIGGER 914

702.	701.	701.	701.	700.	699.	699.	696.
699.	695.	694.	696.	558.	443.	698.	706.
702.	695.	695.	697.	698.	696.	697.	697.
698.	704.	703.	702.	701.	701.	700.	699.

FFER # 14, SOURCE 315 E2SCFMNG 14., TRIGGER 914

14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	11.	9.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.

FFER # 15, SOURCE 504 A/O B IN 421., TRIGGER 914

421.	422.	423.	424.	425.	425.	425.	426.
426.	425.	423.	422.	421.	400.	419.	419.
421.	421.	422.	422.	421.	421.	421.	421.
421.	421.	422.	423.	425.	426.	426.	426.

FFER # 16, SOURCE 515 PEN VAC -61., TRIGGER 914

-61.	-61.	-60.	-59.	-59.	-58.	-58.	-57.
-56.	-57.	-56.	-57.	-58.	-46.	-60.	-61.
-59.	-63.	-62.	-62.	-62.	-62.	-62.	-62.
-62.	-62.	-61.	-61.	-60.	-59.	-58.	-58.

7 OF 7

MIN 400

MAX 426

Avg 421.5

00:00:00 ON 9/2/94

*Review!*  
9-2-94

**Attachment C**

**Schedule**



# EPA LANDFILL GAS PHASE 3 SCHEDULE

MILESTONES FOR SUBTASK 3.3 CONDUCT PERFORMANCE TEST																									
	'93	1994												1995											
	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
<u>WORK ELEMENT</u>																									
1 FIELD TEST															▽					▽					
2 ASSESS																				▽					
FINAL REPORT																DRAFT	▽				▽				
END PERIOD OF PERFORMANCE																									

HS940011-2  
R942009

• EMISSION TEST SCHEDULED FOR JANUARY 1995

## Attachment D

### Example Calibration Report of the On-Line Heat Content Analyzer

# ATTACHMENT

## DAILY CALIBRATION

1 OF 3

CALIBRATION

PAGE 1 OF 1

DATE: 10/06/74  
TIME: 07:45  
ALDR: PENROSE

ANALYSIS TIME: 220  
CYCLE TIME: 240  
MODE: REMOTE

STREAM SEQUENCE: 11  
CAL GAS STREAM#: 3  
CYCLE START TIME: 07:46

COMP NAME	COMP CODE	CAL CONC	RAW DATA	OLD RF	NEW* RF	% DEV	OLD RT	NEW* RT	% DEV
C O 2	117	39.6010	1.41088+6	35580.2	35627.3	0.1	46.97	47.05	0.1
OXYGEN	116	0.39900	12668.0	31909.8	31749.4	0.5	94.23	94.37	0.1
NITROGEN	114	15.1000	508770	33626.2	33693.4	0.2	104.67	104.63	0.0
METHANE	100	44.9000	1.50822+6	29142.5	29136.2	0.0	121.77	121.57	0.1

CONTROL ALARMS

TIME

↑  
CERTIFIED  
CAL BOTTLE

↑  
RESPONSE  
FACTOR

↑  
DAILY  
DEVIATION  
IN RESPONSE  
(METHANE ~ 0%)

↑  
RETENTION  
TIME

# ATTACHMENT

2 OF 3

## ANALYSIS

ORIG CGL GAS - GAMMA ANALYSIS  
DONE ~~PERIOD~~ ON LFG EVERY  
240 SEC

DATE: 10/06/94 ANALYSIS TIME: 220 STREAM SEQUENCE: 10  
TIME: 07:46 CYCLE TIME: 240 STREAM#: 3  
WELL ID#: PENROSE MODE: REMOTE CYCLE START TIME: 07:46

COMP NAME	COMP CODE	MOLE %	GAL/MCF**	B.T.U.*	SP. GR.*
O 2	117	39.6253	0.0000	0.00	0.6021
OXYGEN	116	0.39671	0.0000	0.00	0.0044
NITROGEN	114	15.1195	0.0000	0.00	0.1462
METHANE	100	44.8585	0.0000	453.97	0.2485
TOTALS		100.0000	0.0000	453.97	1.0012

@ 14.730 PSIA DRY & UNCORRECTED FOR COMPRESSIBILITY

@ 14.730 & 60 DEG. F

COMPRESSIBILITY FACTOR (1/Z) = 1.0020  
BTU B.T.U. @ 14.730 PSIA & 60 DEG. F CORRECTED FOR (1/Z) = 455.2  
BTU B.T.U. @ 14.730 PSIA & 60 DEG. F CORRECTED FOR (1/Z) = 447.3  
GAL SPECIFIC GRAVITY = 1.0035  
GASE INDEX @ 14.730 PSIA = 0.45.5  
NORMALIZED TOTAL MOLE % = 100.00

ACTIVE ALARMS

ONE

# ATTACHMENT

3 OF 3

## CALIBRATION

P I N 4

DATE: 10/06/94  
TIME: 07:47  
GCID#: PENROSE

ANALYSIS TIME: 220  
CYCLE TIME: 240  
NODE: REMOTE

STREAM SEQUENCE:  
CAL GAS STREAM#: 3  
CYCLE START TIME: 07:46

COMP NAME	COMP CODE	CAL CONC	RAW DATA	OLD RF	NEW* RF	% DEV	OLD RT	NEW* RT	% DEV
O 2	117	39.6010	1.41088+6	35580.2	35627.3	* 0.1	46.97	47.93	* 0.1
OXYGEN	116	0.39900	12668.0	31909.0	31749.4	* 0.5	94.23	94.37	* 0.1
NITROGEN	114	15.1000	508770	33626.2	33693.4	* 0.2	104.67	104.63	* 0.1
METHANE	100	44.9000	1.30922+6	29142.5	29136.2	* 0.0	121.77	121.57	* 0.1

NO LEVEL ALARMS

END

## Attachment E

May, September, and October 1993  
Penrose Landfill Gas Analysis



# Performance Analytical Inc.

Environmental Testing and Consulting

PERFORMANCE ANALYTICAL INC.

## RESULTS OF ANALYSIS

Client: TRC Environmental Corporation

Client Sample ID: PTU-IN-2-1A (10/21/93)  
PAI Sample ID: 9304074

Test Code: GC/MS Mod. EPA TO-14  
Analyst: Kathleen Aguilera  
Instrument ID: Finnigan 4500B/Entech 2000  
Verified by: Michael Taday

Matrix: Tedlar Bag  
Date Received: 10/21/93  
Date Analyzed: 10/21/93  
Volume Analyzed: 3.5 ml

CAS #	COMPOUND	RESULT (MG/M <sup>3</sup> )	DETECTION LIMIT (MG/M <sup>3</sup> )	RESULT (PPM)	DETECTION LIMIT (PPM)
75-01-4	Vinyl Chloride	3.5	1.4	1.4	0.55
67-64-1	Acetone	37	2.9	15	1.2
75-69-4	Trichlorofluoromethane	ND	1.4	ND	0.25
75-35-4	1,1-Dichloroethene	ND	1.4	ND	0.36
75-09-2	Methylene Chloride	14	1.4	4.1	0.41
156-60-5	trans-1,2-Dichloroethene	ND	1.4	ND	0.36
156-59-2	cis-1,2-Dichloroethene	23	1.4	5.8	0.36
75-34-3	1,1-Dichloroethane	11	1.4	2.8	0.35
78-93-3	2-Butanone	11	2.9	3.7	0.99
67-66-3	Chloroform	ND	1.4	ND	0.29
107-06-2	1,2-Dichloroethane	ND	1.4	ND	0.35
71-55-6	1,1,1-Trichloroethane	ND	1.4	ND	0.26
71-43-2	Benzene	5.6	1.4	1.7	0.44
56-23-5	Carbon Tetrachloride	ND	1.4	ND	0.23
75-27-4	Bromodichloromethane	ND	1.4	ND	0.21
79-01-6	Trichloroethene	13	1.4	2.4	0.26
10061-01-5	cis-1,3-Dichloropropene	ND	1.4	ND	0.31
108-10-1	4-Methyl-2-Pentanone	15	2.9	3.6	0.71
108-88-3	Toluene	180	1.4	47	0.37
127-18-4	Tetrachloroethene	32	1.4	4.8	0.21
108-90-7	Chlorobenzene	6.6	1.4	1.4	0.31
100-41-4	Ethylbenzene	53	1.4	12	0.32
100-42-5	Styrene	4.6	1.4	1.1	0.33
1330-20-7	m- & p-Xylenes	90	1.4	21	0.32
95-47-6	o-Xylene	31	1.4	7.2	0.32
75-71-8	Dichlorodifluoromethane	1.3 TR	1.4	0.26 TR	0.28

ND = Not Detected TR = Trace Level - Below Indicated Detection Limit G-E2



**Performance Analytical Inc.**  
Environmental Testing and Consulting

**PERFORMANCE ANALYTICAL INC.**

**TENTATIVELY IDENTIFIED COMPOUNDS**

**Client:** TRC Environmental Corporation

**Client Sample ID:** PTU-IN-2-1A (10/21/93)

**PAI Sample ID:** 9304074

**Test Code:** GC/MS Mod. EPA TO-14  
**Analyst:** Kathleen Aguilera  
**Instrument ID:** Finnigan 4500B/Entech 2000  
**Verified by:** Michael Tuday

**Matrix:** Tedlar Bag  
**Date Received:** 10/21/93  
**Date Analyzed:** 10/21/93  
**Volume Analyzed:** 3.5 ml

GC/MS SCAN NO.	COMPOUND IDENTIFICATION	ESTIMATED CONCENTRATION	
		MG/M3	Ppm
	FREON 22	ND	
49	FREON 21	2	
156	ETHYL ACETATE	40	10.3
174	TETRAHYDROFURAN	6	2.0
	1-BUTANOL	ND	
595	ETHYL BUTYRATE	40	2.4
957	ALPHA-PINENE	100	13
1092	d-LIMONENE	100	12
	NAPHTHALENE	ND	
	NITROBENZENE	ND	





**Performance Analytical Inc.**  
Environmental Testing and Consulting

**PERFORMANCE ANALYTICAL INC.**

**RESULTS OF ANALYSIS**

Client: TRC Environmental Corporation

Client Sample ID: B1-WG (09/09/93) (13:45)

PAI Sample ID: 9303221

Test Code: GC/MS Mod. EPA TO-14  
Analyst: Kathleen Aguilera  
Instrument ID: Finnigan 4500B/Entech 2000  
Verified by: Michael Tuday

Matrix: Tedlar Bag  
Date Received: 09/09/93  
Date Analyzed: 09/09/93  
Volume Analyzed: 3.0 ml

CAS #	COMPOUND	RESULT (MG/M <sup>3</sup> )	DETECTION LIMIT (MG/M <sup>3</sup> )	RESULT (PPM)	DETECTION LIMIT (PPM)
75-01-4	VINYL CHLORIDE	3.1	1.7	1.2	0.67
67-64-1	ACETONE	26	3.3	11	1.4
75-69-4	TRICHLOROFLUOROMETHANE	ND	1.7	ND	0.31
75-35-4	1,1-DICHLOROETHENE	ND	1.7	ND	0.43
75-09-2	METHYLENE CHLORIDE	15	1.7	4.5	0.50
156-60-5	TRANS-1,2-DICHLOROETHENE	ND	1.7	ND	0.43
156-59-2	CIS-1,2-DICHLOROETHENE	16	1.7	4.2	0.43
75-34-3	1,1-DICHLOROETHANE	8.8	1.7	2.2	0.42
78-93-3	2-BUTANONE	27	3.3	9.0	1.1
67-66-3	CHLOROFORM	ND	1.7	ND	0.35
107-06-2	1,2-DICHLOROETHANE	ND	1.7	ND	0.42
71-55-6	1,1,1-TRICHLOROETHANE	ND	1.7	ND	0.32
71-43-2	BENZENE	4.4	1.7	1.4	0.53

ND = Not Detected TR = Trace Level - Below Indicated Detection Limit



**Performance Analytical Inc.**  
Environmental Testing and Consulting

**PERFORMANCE ANALYTICAL INC.**

**RESULTS OF ANALYSIS**  
(Continued)

**Client:** TRC Environmental Corporation

**Client Sample ID:** B1-WG (09/09/93) (13:45)

**PAI Sample ID:** 9303221

**Test Code:** GC/MS Mod. EPA TO-14  
**Analyst:** Kathleen Aguilera  
**Instrument ID:** Finnigan 4500B/Entech 2000  
**Verified by:** Michael Taday

**Matrix:** Tedlar Bag  
**Date Received:** 09/09/93  
**Date Analyzed:** 09/09/93  
**Volume Analyzed:** 3.0 ml

CAS #	COMPOUND	RESULT (MG/M <sup>3</sup> )	DETECTION LIMIT (MG/M <sup>3</sup> )	RESULT (PPM)	DETECTION LIMIT (PPM)
56-23-5	CARBON TETRACHLORIDE	ND	1.7	ND	0.27
75-27-4	BROMODICHLOROMETHANE	ND	1.7	ND	0.25
79-01-6	TRICHLOROETHENE	8.7	1.7	1.6	0.31
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	1.7	ND	0.37
108-10-1	4-METHYL-2-PENTANONE	8.6	3.3	2.1	0.82
108-88-3	TOLUENE	120	1.7	32	0.44
127-18-4	TETRACHLOROETHENE	20	1.7	3.0	0.25
108-90-7	CHLOROBENZENE	6.3	1.7	1.4	0.36
100-41-4	ETHYLBENZENE	39	1.7	9.1	0.39
100-42-5	STYRENE	3.1	1.7	0.73	0.39
1330-20-7	m- & p-XYLENES	67	1.7	15	0.39
95-47-6	o-XYLENE	22	1.7	5.1	0.39

ND = Not Detected TR = Trace Level - Below Indicated Detection Limit



**Performance Analytical Inc.**  
Environmental Testing and Consulting

PERFORMANCE ANALYTICAL INC.

TENTATIVELY IDENTIFIED COMPOUNDS

Client: TRC Environmental Corporation

Client Sample ID: B1-WG (09/09/93) (13:45)

PAI Sample ID: 9303221

Test Code: GC/MS Mod. EPA TO-14  
Analyst: Kathleen Aguilera  
Instrument ID: Finnigan 4500B/Entech 2000  
Verified by: Michael Today

Matrix: Tedlar Bag  
Date Received: 09/09/93  
Date Analyzed: 09/09/93  
Volume Analyzed: 3.0 ml

GC/MS SCAN NO.	COMPOUND IDENTIFICATION	ESTIMATED CONCENTRATION MG/M3
28	DICHLORODIFLUOROMETHANE	7
969	ALPHA-PINENE	60
1097	d-LIMONENE	50
162	ETHYL ACETATE	20
	n-BUTANOL	ND
	NAPHTHALENE	ND
49	DICHLOROFLUOROMETHANE	7
27	CHLORODIFLUOROMETHANE	5
	ETHYL BUTYRATE	ND
18	TETRAHYDROFURAN	2
	NITROBENZENE	ND



Performance Analytical Inc.  
Environmental Testing and Consulting

PERFORMANCE ANALYTICAL INC.

RESULTS OF ANALYSIS

Client: TRC Environmental Corporation

Client Sample ID: B2 (05/01/93)

PAI Sample ID: 9301501

Test Code: GC/MS Mod. EPA TO-14  
Analyst: Chris Parnell  
Instrument ID: Finnigan 4500C/Tekmar 5010  
Verified by: Michael Taday

Matrix: Tedlar Bag  
Date Received: 05/03/93  
Date Analyzed: 05/03/93  
Volume Analyzed: 5.0 ml

CAS #	COMPOUND	RESULT (MG/M <sup>3</sup> )	DETECTION LIMIT (MG/M <sup>3</sup> )	RESULT (PPM)	DETECTION LIMIT (PPM)
75-71-8	DICHLORODIFLUOROMETHANE *	ND	40	ND	8.2
75-01-4	VINYL CHLORIDE	3.5	1.0	1.4	0.39
67-64-1	ACETONE	40	2.0	17	0.84
75-69-4	TRICHLOROFLUOROMETHANE	1.3	1.0	0.24	0.18
75-35-4	1,1-DICHLOROETHENE	0.53 TR	1.0	0.14 TR	0.25
75-09-2	METHYLENE CHLORIDE	27	1.0	8.0	0.29
156-60-5	TRANS-1,2-DICHLOROETHENE	0.79 TR	1.0	0.20 TR	0.25
156-59-2	CIS-1,2-DICHLOROETHENE	19	1.0	5.0	0.25
75-34-3	1,1-DICHLOROETHANE	9.1	1.0	2.3	0.25
78-93-3	2-BUTANONE	27	2.0	9.3	0.68
67-66-3	CHLOROFORM	ND	1.0	ND	0.21
107-06-2	1,2-DICHLOROETHANE	ND	1.0	ND	0.25
71-55-6	1,1,1-TRICHLOROETHANE	ND	1.0	ND	0.19
71-43-2	BENZENE	4.9	1.0	1.5	0.31

ND = Not Detected TR = Trace Level - Below Indicated Detection Limit

\* = Result Is Qualitative Only



**Performance Analytical Inc.**  
Environmental Testing and Consulting

**PERFORMANCE ANALYTICAL INC.**

**RESULTS OF ANALYSIS**  
(Continued)

Client: TRC Environmental Corporation

Client Sample ID: B2 (05/01/93)

PAI Sample ID: 9301501

Test Code: GC/MS Mod. EPA TO-14  
Analyst: Chris Parnell  
Instrument ID: Finnigan 4500C/Tekmar 5010  
Verified by: Michael Taday

Matrix: Tedlar Bag  
Date Received: 05/03/93  
Date Analyzed: 05/03/93  
Volume Analyzed: 5.0 ml

CAS #	COMPOUND	RESULT (MG/M3)	DETECTION LIMIT (MG/M3)	RESULT (PPM)	DETECTION LIMIT (PPM)
56-23-5	CARBON TETRACHLORIDE	ND	1.0	ND	0.16
75-27-4	BROMODICHLOROMETHANE	ND	1.0	ND	0.15
79-01-6	TRICHLOROETHENE	8.4	1.0	1.6	0.19
10061-01-5	CIS-1,3-DICHLOROPROPENE	ND	1.0	ND	0.22
108-10-1	4-METHYL-2-PENTANONE	ND	2.0	ND	0.49
108-88-3	TOLUENE	150	1.0	41	0.27
127-18-4	TETRACHLOROETHENE	24	1.0	3.6	0.15
108-90-7	CHLOROBENZENE	7.6	1.0	1.7	0.22
100-41-4	ETHYLBENZENE	52	1.0	12	0.23
100-42-5	STYRENE	4.0	1.0	0.94	0.24
1330-20-7	m- & p-XYLENES	86	1.0	20	0.23
95-47-6	o-XYLENE	35	1.0	8.0	0.23
7785-70-8	ALPHA-PINENE	160	1.0	29	0.18
5989-27-5	d-LIMONENE	240	1.0	44	0.18

ND = Not Detected TR = Trace Level - Below Indicated Detection Limit

## Attachment F

### Electrical Output Meter Calibration Data

## APPENDIX (A)

### Pacific Energy Co-Generation Penrose Landfill Metering Summary

- The major components of the revenue billing meter system are a bi-directional, multifunction meter, two potential transformers, and two current transformers monitoring a 3Ø, 3 wire, delta service. (See Page 1 of the Attachment)
- The billing meter, PMG30018-15 is programmed to display the information shown on Page 2 of the Attachment.
- The billing meter is tested in the Meter Laboratory prior to installation. Test results are shown on Page 3 of the Attachment. These results are within the  $\pm 2\%$  of the accuracy called for in the American National Standard Code for Electricity Metering (ANSI C12). LADWP rules call for all meters to be within  $\pm 1\%$  accuracy before being installed. Test Lab policy is to calibrate each meter within  $\pm .5\%$  accuracy.
- Each potential transformer (ratio 300 to 1) was tested in the Standards Laboratory before installation. Each was tested at O, W, X, Y, and Z burden. As indicated on Pages 3 and 4 of the Attachment, each was within  $\pm 1\%$  accuracy.
- Each current transformer (ratio 150 to 5) was tested in the Standards Laboratory before installation. Each was tested at burdens from 0 to B2.0. As indicated on Pages 5 through 8 of the Attachment, each was within  $\pm 1\%$  accuracy.
- After the metering system was installed on the customers service, an install test was performed on the system. As shown on Page 9 of the Attachment, this test indicates the meter was 100% accurate.

Also attached is a brochure for the Transdata EMS 96 Meter installed at this location.

AMG:sls

Attachments

Post-It® brand fax transmittal memo 7571		# of pages > 11	
To	Larry Preston	From	Bob Briffett
Co	IEC	Co	
Dept		Phone	213 367 0395
Fax	(203) 727 2319	Fax	

Larry,

This is information for existing Pacific Energy meters at Penrose Landfill. The setup for Penrose fuel cell will be the same.

Call me if you have questions

Bob Briffett

6/24/94

JUL 1 '94 09:08 FROM INTL FUEL CELLS A  
LADWP RES PLAN&DEV TEL:213-367-0210

TO 92986399  
Jun 27, 94

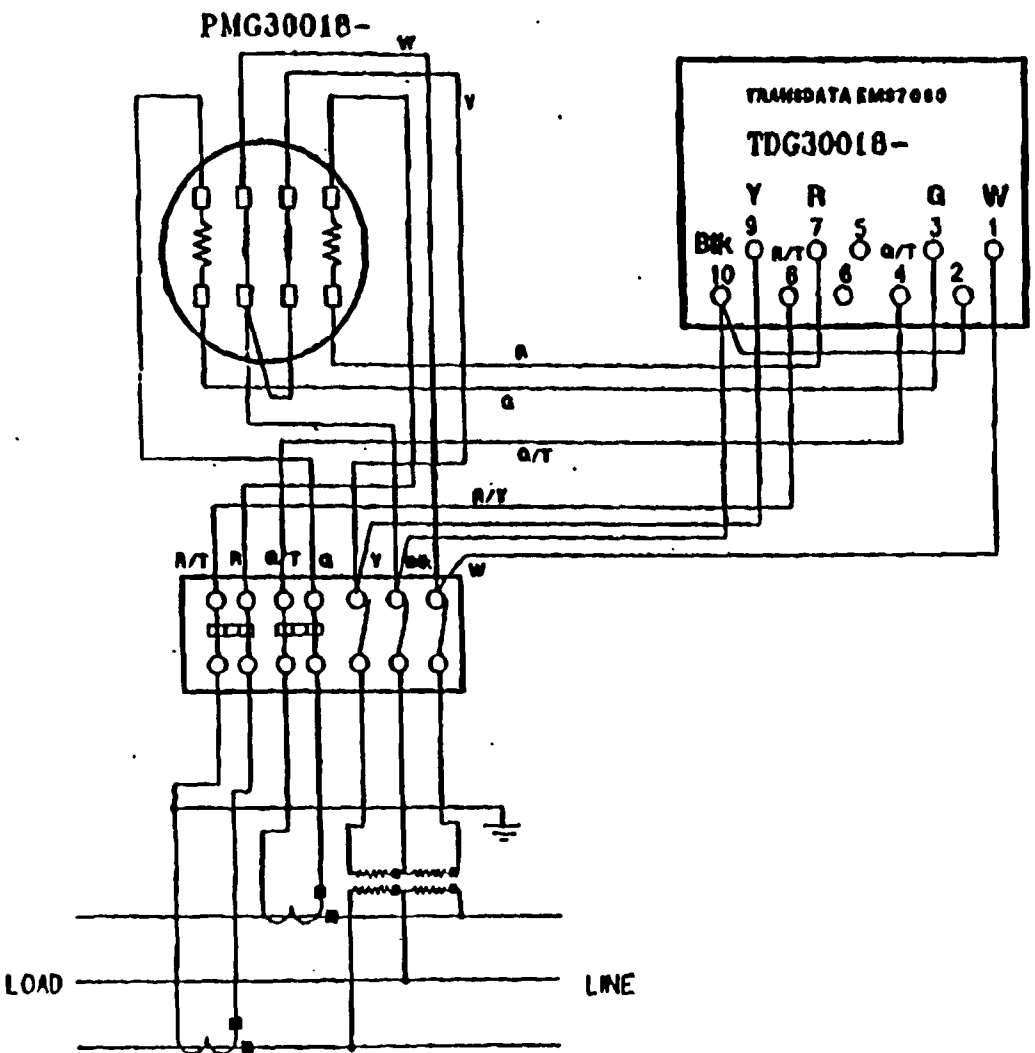
PAGE 003  
9:55 No.003 P.02

ENGINEERING DATA SHEET

Penrose Landfill - Pacific Energy Co-Gen.  
8301 Tujunga Ave. IS.2197

Sheet No.	2073	Date	
Prepared	Brion Haggard	12-17-94	
Checked			
Approved			

PAGE 1 of ATTACHMENT 10



REAR PANEL VIEW

JUN 27 '94 13:56

G-F3

213 367 0210

PAGE 003



PARALLEL GENERATION - LARGE (PG-3)

BI-DIRECTIONAL KWH/KVARH METER

	METER DISPLAY CHECK			
01	DATE			
02	TIME			
03	KW	MAXIMUM DEMAND	HIGH PEAK	DELIVERED
04	KWH	CONSUMPTION	HIGH PEAK	DELIVERED
05	KVARH	CONSUMPTION	HIGH PEAK	DELIVERED
09	KW	MAXIMUM DEMAND	LOW PEAK	DELIVERED
10	KWH	CONSUMPTION	LOW PEAK	DELIVERED
11	KVARH	CONSUMPTION	LOW PEAK	DELIVERED
15	KW	MAXIMUM DEMAND	BASE	DELIVERED
16	KWH	CONSUMPTION	BASE	DELIVERED
17	KVARH	CONSUMPTION	BASE	DELIVERED
21	KWH	CONSUMPTION	HIGH PEAK	RECEIVED
25	KWH	CONSUMPTION	LOW PEAK	RECEIVED
29	KWH	CONSUMPTION	BASE	RECEIVED
39	KWH	CONSUMPTION	TOTAL	DELIVERED
40	KVARH	CONSUMPTION	TOTAL	DELIVERED

JUL 1 '94 09:09  
LADWP RES PLAN&DEV

FROM INTL FUEL CELLS A  
TEL:213-367-0210

TO 92986399  
Jun 27,94

PAGE.005  
9:56 No.003 P.04

3/10

**Meter Laboratory Meter Rsprot**

Penrose Landfill  
8301 Tujunga Ave IS 2197  
PMG30018-15  
9-22-93

Meter Form: 5S Meter Register: EMS96 Rotation: ABC  
9-17-93 07:20:01 Dowty

Test Setting 1: Volts=120.0 Amps=5.00 Pf Offset=60  
P.F.=0.5

KWH Del  
Series Full Load: 99.99  
Series Power: 100.04  
Series Light Load: 99.99

KWh Rec  
Series Full Load: -100.05  
Series Power: -100.13  
Series Light Load: -100.03

Test Setting 2: Volts=120.0 Amps=5.00 Pf Offset=12  
P.F.=0.2

KVAR Del  
Series Full Load: 100.05  
Series Power: 100.03  
Series Light Load: 100.11

Test Setting 3: Volts=120.0 Amps=5.00 Pf Offset=0  
P.F.=1.0

KVAR Del  
Series Full Load: 100.06  
Series Power: 100.06  
Series Light Load: 100.10

JUN 27 '94 13:57

G-F5

213 367 0210

PAGE.004

## **APPENDIX H**

### **System Performance and Emission Test Report, by TRC Environmental Phase III Fuel Cell/Landfill Gas Energy Recovery Demonstration, Penrose Landfill**

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# ***System Performance and Emission Test Report***

## ***Phase III Fuel Cell/Landfill Gas Energy Recovery Demonstration Penrose Landfill***

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# Table of Contents

<u>SECTION</u>	<u>PAGE</u>
1.0 <u>PROGRAM DESCRIPTION</u> . . . . .	H-7
1.1 <u>Background</u> . . . . .	H-8
1.2 <u>Description of Phase III Activities</u> . . . . .	H-8
1.3 <u>Process Description</u> . . . . .	H-11
1.3.1 <u>GPU Description</u> . . . . .	H-11
1.3.2 <u>Fuel Cell Power Plant Description</u> . . . . .	H-14
1.4 <u>Scope of Work</u> . . . . .	H-14
1.4.1 <u>Performance Demonstration</u> . . . . .	H-14
1.4.2 <u>Emission Measurements</u> . . . . .	H-17
1.5 <u>Operation of the Fuel Cell</u> . . . . .	H-18
2.0 <u>PROJECT ORGANIZATION AND RESPONSIBILITIES</u> . . . . .	H-21
2.1 <u>Overall Organization</u> . . . . .	H-21
3.0 <u>SUMMARY AND DISCUSSION OF RESULTS</u> . . . . .	H-23
3.1 <u>Fuel Cell Energy Efficiency</u> . . . . .	H-23
3.2 <u>Power Plant Emissions</u> . . . . .	H-23
3.3 <u>Flare Emissions</u> . . . . .	H-26
3.4 <u>Gas Pretreatment Performance Test</u> . . . . .	H-26
3.5 <u>GPU Exit Gas Heat Content</u> . . . . .	H-28
4.0 <u>CALCULATIONS AND DATA QUALITY INDICATOR GOALS</u> . . . . .	H-30
4.1 <u>General Description of Test Data and Calculations</u> . . . . .	H-30
4.2 <u>Electrical Output</u> . . . . .	H-31
5.0 <u>SAMPLING PROCEDURES</u> . . . . .	H-32
5.1 <u>Sampling Locations</u> . . . . .	H-32
5.1.1 <u>Performance Demonstration Test</u> . . . . .	H-32
5.1.2 <u>Emissions Testing</u> . . . . .	H-32
5.2 <u>GPU Outlet and Raw Landfill Gas Sampling Methods</u> . . . . .	H-33
5.3 <u>Power Plant Emissions Monitoring Methods</u> . . . . .	H-33
5.3.1 <u>Sample Conditioning System</u> . . . . .	H-35
5.3.2 <u>NO<sub>x</sub> Analyzer</u> . . . . .	H-35
5.3.3 <u>SO<sub>2</sub> Analyzer</u> . . . . .	H-35
5.3.4 <u>CO Analyzer</u> . . . . .	H-36
5.3.5 <u>O<sub>2</sub> Analyzer</u> . . . . .	H-36
5.3.6 <u>CO<sub>2</sub> Analyzer</u> . . . . .	H-36
5.4 <u>Flowrate Monitoring</u> . . . . .	H-36
5.5 <u>Power Plant Electrical Measurements</u> . . . . .	H-37

## Table of Contents (continued)

6.0	<u>SAMPLE CUSTODY</u> . . . . .	H-38
6.1	<u>Sample Documentation</u> . . . . .	H-38
	6.1.1 <u>Sampling Data Forms</u> . . . . .	H-38
	6.1.2 <u>Sample Identification and Labeling</u> . . . . .	H-39
6.2	<u>Chain-of-Custody Forms</u> . . . . .	H-39
6.3	<u>Laboratory Custody</u> . . . . .	H-40
7.0	<u>CALIBRATION PROCEDURES</u> . . . . .	H-41
7.1	<u>Manual Sampling Equipment</u> . . . . .	H-41
7.2	<u>Power Plant Continuous Monitoring Methods</u> . . . . .	H-41
7.3	<u>GPU Exit Gas Flowrate Meter</u> . . . . .	H-42
7.4	<u>Electrical Power Measurements</u> . . . . .	H-42
7.5	<u>On-Line Raw Landfill Gas Heat Content Analyzer</u> . . . . .	H-42
8.0	<u>ANALYTICAL PROCEDURES</u> . . . . .	H-43
8.1	<u>Continuous Emissions Monitoring</u> . . . . .	H-43
8.2	<u>Heat Content Analysis of GPU Exit Samples</u> . . . . .	H-43
8.3	<u>GPU Exit Contaminant Analysis</u> . . . . .	H-43
	8.3.1 <u>Sulfur Compound Analysis</u> . . . . .	H-43
	8.3.2 <u>Volatile Organic Compound Analysis</u> . . . . .	H-44
9.0	<u>DATA REDUCTION, VALIDATION, AND REPORTING</u> . . . . .	H-46
9.1	<u>Overall Calculations</u> . . . . .	H-46
9.2	<u>Data Validation</u> . . . . .	H-47
9.3	<u>Identification and Treatment of Outliers</u> . . . . .	H-47
10.0	<u>QUALITY CONTROL CHECKS</u> . . . . .	H-48
10.1	<u>Data Collection and Sampling QC Procedures</u> . . . . .	H-48
10.2	<u>Analytical Laboratory QC Checks</u> . . . . .	H-48
11.0	<u>QUALITY CONTROL TEST RESULTS</u> . . . . .	H-49
11.1	<u>Fuel Heat Content Measurement</u> . . . . .	H-49
11.2	<u>GPU Exit Gas Contaminant Measurements</u> . . . . .	H-49
	11.2.1 <u>Sulfur Compounds</u> . . . . .	H-49
	11.2.2 <u>Volatile Organic Compounds</u> . . . . .	H-52
11.3	<u>Fuel Cell Emissions</u> . . . . .	H-52
12.0	<u>CALCULATION OF DATA QUALITY INDICATORS</u> . . . . .	H-55
12.1	<u>Precision</u> . . . . .	H-55
	12.1.1 <u>Continuous Emission Monitoring</u> . . . . .	H-55
	12.1.2 <u>Sulfur and Halide Compounds – GPU Outlet Samples</u> . . . . .	H-55
	12.1.3 <u>GPU Outlet – Heat Content Analysis</u> . . . . .	H-55

**Table of Contents** (continued)

12.2 Accuracy . . . . . H-56

12.2.1 Continuous Emission Monitoring . . . . . H-56

12.2.2 Sulfur and Halide Compounds . . . . . H-56

12.2.3 GPU Outlet Heat Content Analysis . . . . . H-56

# List of Tables, Figures, and Attachments

<u>TABLE</u>	<u>PAGE</u>
1-1 Typical Concentrations and Detection Limits of Targeted Compounds in the Raw Landfill Gas at the Penrose Landfill . . . . .	H-16
3-1 Fuel Cell Energy Efficiency Summary . . . . .	H-24
3-2 Fuel Cell Emissions Summary . . . . .	H-25
3-3 Gas Pretreatment System Performance Test: Summary of Contaminant Removal Measurements . . . . .	H-27
3-4 Comparison of ASTM Method Heat Content Measurements on Treated GPU Exit Gas to On-Line Raw Landfill Gas Heat Content Measurements . . . . .	H-29
11-1 Heat Content Measurement Quality Assurance Data Summary . . . . .	H-50
11-2 Gas Pretreatment System Outlet Halide and Sulfur Analysis QA Data . . . . .	H-51
11-3 Fuel Cell Emissions Testing QA Data Cylinder Gas Audit Summary . . . . .	H-53
11-4 Fuel Cell Emissions-EPA Methods 3A, 6C, 7E and 10 QA Summary Including Calibration Drift and Calibration Error . . . . .	H-54

<u>FIGURE</u>	<u>PAGE</u>
1-1 Demonstrator System Schematic . . . . .	H-10
1-2 Gas Pretreatment Unit Schematic . . . . .	H-13
1-3 Demonstrator System Interface Conditions . . . . .	H-19
2-1 Organization Chart . . . . .	H-22
5-1 Continuous Emission Monitoring Schematic . . . . .	H-34

<u>ATTACHMENT</u>	
A Process Data . . . . .	H-A1
B GPU Exit Heat Content/Analytical Data-ASTM Method . . . . .	H-B1
C Power Plant Emission Data . . . . .	H-C1
D Flare Emission Data From Phase II . . . . .	H-D1
E GPU Exit Contaminant Measurement Data . . . . .	H-E1
F Calibration Data and Certifications . . . . .	H-F1
G ASTM Method Heat Content Analysis QA Replicates . . . . .	H-G1
H Halides and Sulfur Compound Audit Data . . . . .	H-H1
I Fuel Cell Emissions QA Data . . . . .	H-I1
J Fuel Cell Emissions Calibration Error Data . . . . .	H-J1
K Fuel Cell Exhaust Gas Flowrate Data . . . . .	H-K1
L ASTM Heat Content Analysis Audit Data . . . . .	H-L1



## 1.0 PROGRAM DESCRIPTION

A demonstration of a 200 kilowatt fuel cell powered with purified landfill gas was conducted at the Penrose landfill in Sun Valley, California. The program was the final demonstration phase of the U.S. Environmental Protection Agency (EPA), Air and Energy Engineering Research Laboratory (AEERL) landfill gas/fuel cell energy recovery program. International Fuel Cells, Inc. (IFC) of South Windsor, Connecticut, installed and operated the fuel cell system and TRC Environmental Corporation (TRC) conducted the test program. The overall program objective was to demonstrate the feasibility of energy recovery from landfill gas using a commercial phosphoric acid fuel cell.

The program objectives were as follows:

- 1) Demonstrate the performance of a landfill gas pretreatment system.
- 2) Demonstrate the performance of a 200-kilowatt (kW) fuel cell, including fuel cell efficiency, operated with treated landfill gas.
- 3) Measure air pollutant emissions per quantity of energy produced.

Several alterations to the planned program were implemented for budgetary constraints. The demonstration was conducted over a thirty-three day period beginning on January 16 and ending on February 17 according to the technical specifications in the approved Quality Assurance Project Plan (QAPP); however, the demonstration was originally planned to be conducted over one year. The shortened program had minimal effect on the conclusions for air emissions and fuel cell efficiency because there was minimal variation of system performance or emissions. A second alteration of the program was the elimination of emission testing on the gas pretreatment unit flare stack (flare and fuel cell emissions data is required to calculate total emissions from the demonstration system). The consensus between EPA, IFC and TRC was that the flare stack emissions were sufficiently characterized during the Phase II program and that only fuel cell emissions data was needed to complete the required measurements. However, the shortened program provided less data to evaluate the reliability of the system over time.

## 1.1 Background

The EPA has proposed standards for the control of air emissions from municipal solid waste landfills. These actions have provided an opportunity for energy recovery from the waste methane. International Fuel Cells Corporation (IFC) was awarded a contract by the EPA to demonstrate energy recovery from landfill gas using a commercial phosphoric acid fuel cell. The IFC contract includes a three-phase program to show that fuel cell energy recovery is economically and environmentally feasible in commercial operation.

Phase I of the program was a conceptual design and cost analysis evaluation. Phase II included construction and testing of a landfill gas pretreatment unit (GPU). The objective of Phase II was to demonstrate the GPU effectiveness in removing fuel cell catalyst poisons such as sulfur and halide compounds. The Phase II demonstration test was conducted in October 1993 at the Penrose Station in Sun Valley, California, owned by Pacific Energy. The Penrose Station is an 8.9-megawatt (MW) internal combustion engine facility supplied with landfill gas from four landfills. The Phase II data indicated that the GPU performance was acceptable.

Phase III of the program was a complete demonstration of the fuel cell energy recovery concept at the Penrose Station. The GPU and fuel cell generating system was operated and tested to evaluate the economic and environmental features of the concept.

## 1.2 Description of Phase III Activities

A PC25™ power plant was installed at the site and its performance was checked using natural gas to verify normal power plant operation prior to preparing the power plant for the landfill gas demonstration. The system was then modified to run on landfill gas. It was connected to the GPU outlet and checked out on landfill gas to verify proper operation prior to the Phase III demonstration test.

The demonstration system at Penrose Station consisted of the existing gas collection system, the GPU, plus a commercial fuel cell power plant. The GPU removes contaminants from raw landfill gas and destroys the contaminants in an enclosed flare. The treated gas is converted to electrical energy with the PC25 power plant, which is a 200 kW unit (140 kW on landfill gas). A schematic of the demonstration system is presented in **Figure 1-1**. The landfill gas at the Penrose facility has an average heat content of 430 BTU/scf.

The system was operated for one month. System performance measurements were conducted weekly over the entire demonstration, and air pollutant emission measurements were conducted during a single day at the end of the one month demonstration. The test parameters are outlined below.

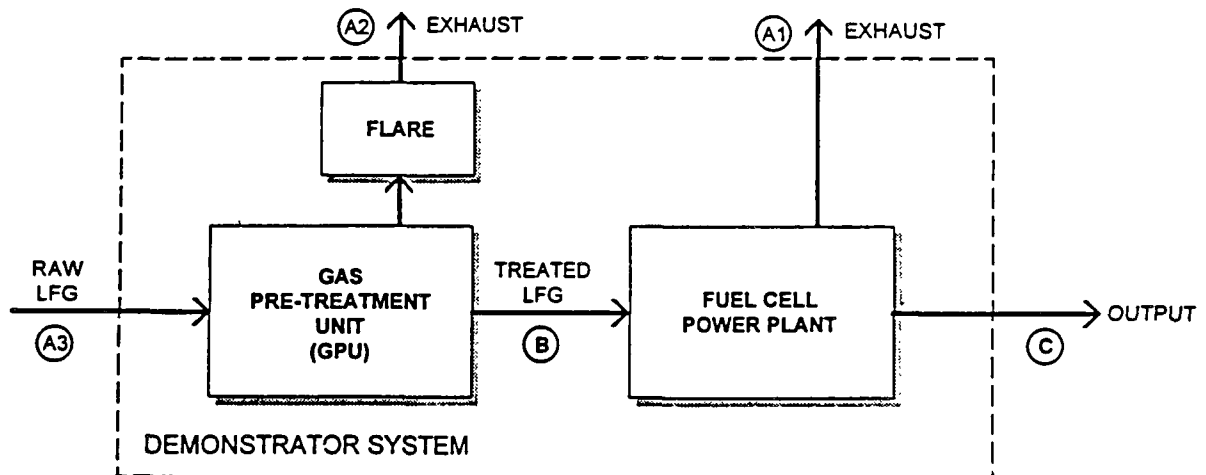
#### **System Performance Measurements**

- GPU Output Gas Purity – analysis for sulfur and target-list volatile organic compounds (VOCs including halides)
- Fuel Cell Efficiency, determined from the following measurements:
  - GPU Output Gas Heat Content (on-line and manual methods)
  - GPU Output Gas Flowrate
  - Fuel Cell Electrical Output
- Availability, Maintenance, and Operator Requirements

#### **Emission Measurements (Fuel Cell Exhaust and Flare Exhaust)**

- Sulfur Dioxide (SO<sub>2</sub>)
- Nitric Oxides (NO<sub>x</sub>)
- Carbon Monoxide (CO)
- Carbon Dioxide (CO<sub>2</sub>)
- Oxygen (O<sub>2</sub>)
- Flowrate
- Moisture

Figure 1-1  
Demonstrator System Schematic



PERFORMANCE DEMONSTRATION INTERFACES: (B), (C)

EMISSION TEST INTERFACES: (A1), (A2), (A3)

<b>TRC</b> TRC Environmental Corporation	5 Waterside Crossing Windsor, CT 06095 (203) 289-8631
	INTERNATIONAL FUEL CELLS INC. EPA/AEERL PHASE III FUEL CELL/LANDFILL GAS ENERGY RECOVERY PROGRAM
<b>FIGURE 1-1.</b> <b>DEMONSTRATOR SYSTEM SCHEMATIC</b>	
Date: 6/94	Drawing No. 02030-05

### 1.3 Process Description

The demonstrator consists of the landfill gas wells and collection system, a modular gas pretreatment system, and a PC25 natural gas fuel cell power plant modified for landfill gas operation. Landfill gas collected at the site is processed to remove contaminants in the pretreatment system. This clean, medium-BTU landfill gas fuels the fuel cell power plant to produce AC power for sale to the electric utility and cogeneration heat which, for the demonstration, will be rejected by an air cooling module. All pretreatment and fuel cell process functions are described in this section.

#### 1.3.1 GPU Description

The demonstration site has a landfill gas collection system in place. The Penrose site will provide compressed 85 psig gas to the gas pretreatment system. Since collection and compression result in some condensed water, hydrocarbon, and other contaminants, the existing site also has a condensate collection and treatment system.

A slipstream of landfill gas from the site will be supplied to the GPU at a pressure of 85 psig and regulated down to 20 psig. (A schematic of the GPU is presented in **Figure 1-2.**) The first active bed of the GPU is a carbon adsorber designed to remove hydrogen sulfide. A first-stage refrigeration condenser ( $\sim 33^{\circ}\text{F}$ ) then removes most of the water contained in the saturated landfill gas and some of the heavier hydrocarbon and contaminant species in the gas. The first-stage refrigeration condenser acts as a bulk remover of water and nonmethane organic compound (NMOC) species. This increases the flexibility of the pretreatment system to handle very high levels of landfill gas contaminants without need for modification or increasing the size of the regenerable adsorption beds, thus making the system an all-purpose landfill gas contaminant removal system.

In the commercial application, the condensate from the first-stage condenser is vaporized and incinerated to avoid all site liquid effluents. However, to avoid the extra cost and complexity for the demonstration, this condensate is returned to the existing site condensate treatment system.

Landfill gas exiting the first-stage refrigeration condenser is then sent to a dryer bed where the water content of the landfill gas is reduced to a -50°F dew point. This bed is periodically regenerated every eight hours with heated clean landfill gas (heated by an electric heater). During regeneration, a second fully regenerated bed takes over the function. The regeneration gas is subsequently incinerated in a low NO<sub>x</sub> flare. Following the dryer step, the landfill gas proceeds to a second-stage low-temperature cooler (-20°F) to enhance the performance of the downstream activated carbon bed.

Next, the landfill gas proceeds to the activated carbon bed which adsorbs the remaining NMOCs including organic sulfur and halogen compounds. This bed is periodically regenerated every eight hours, with the regeneration gas being burned in a low NO<sub>x</sub> flare. The flare (an enclosed type) achieves greater than 98% destruction of all NMOCs by maintaining the combusted regeneration gas at a temperature of at least 1400°F for a residence time of at least one second.

In order to avoid the carryover of attrition products (dust) from the regenerable beds, the output gas is filtered through a submicron filter.

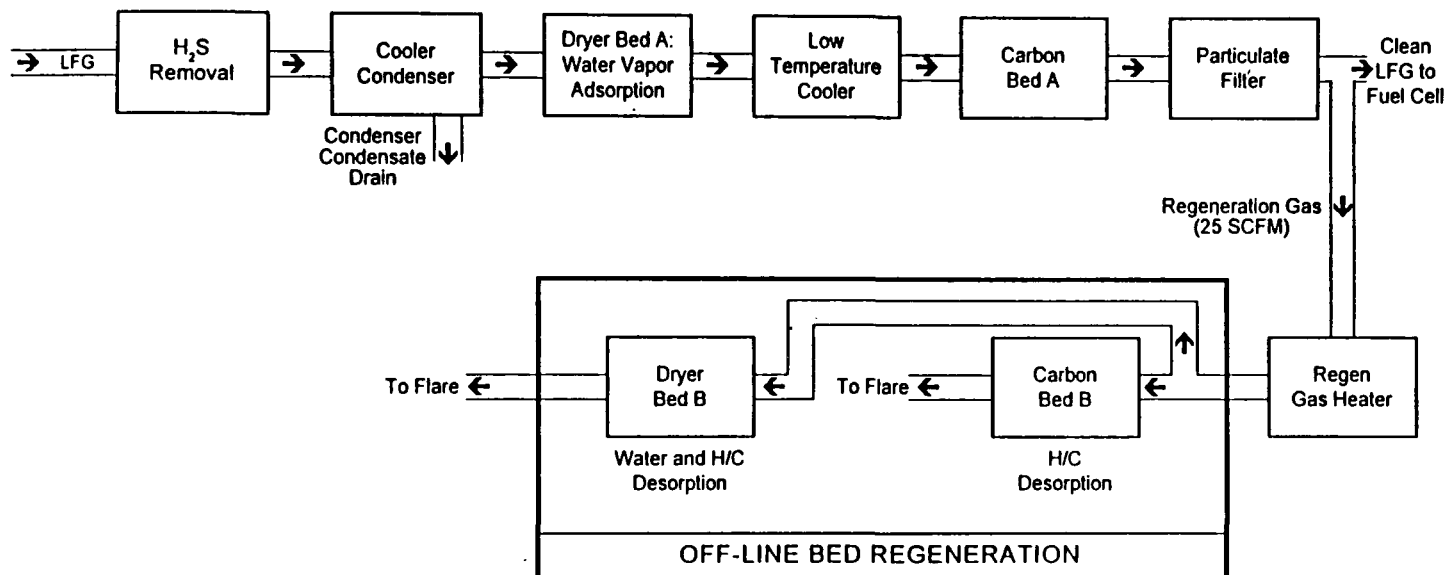


Figure 1-2  
Gas Pretreatment Unit Schematic

**Clean Gas Production Process** - This process incorporates H<sub>2</sub>S removal by the Claus reaction, refrigerated cooling and condensation, drying, cooling and hydrocarbon adsorption process units to remove contaminants from the landfill gas.

The H<sub>2</sub>S removal bed reacts H<sub>2</sub>S with O<sub>2</sub> found in the landfill gas to produce elemental sulfur. This bed is non-regenerable and is replaced periodically. The first and second stage refrigeration coolers operate at approximately +35°F and -20°F, respectively.

**TRC**

TRC Environmental Corporation

5 Waterside Crossing  
Windsor, CT 06095  
(203) 289-8631

INTERNATIONAL FUEL CELLS INC.  
EPA/AEERL PHASE III FUEL CELL/LANDFILL GAS ENERGY  
RECOVERY PROGRAM

**FIGURE 1-2.**  
**GAS PRETREATMENT UNIT SCHEMATIC**

Date: 6/94

Drawing No. 02030-05

A clean, dry, particulate-free medium-BTU landfill gas exits the filter for consumption in the fuel cell. A portion of this gas is extracted to provide regeneration gas. A backup natural gas supply is used to initially qualify the fuel cell power plant before operation on landfill gas.

### 1.3.2 Fuel Cell Power Plant Description

Clean landfill gas is converted in the fuel cell power plant to AC power and heat. The general fuel cell system consists of three major subsystems—fuel processing, DC power generation in the fuel cell stack, and DC-to-AC power conditioning by the inverter.

The fuel cell converts fuel hydrogen with oxygen in the air electrochemically to produce AC power and heat. The waste heat will be rejected by an air cooling module. The AC power will be delivered to the utility grid.

## 1.4 Scope of Work

### 1.4.1 Performance Demonstration

The performance demonstration test of the landfill gas-to-energy demonstrator system was conducted for one month. Measurement specifications and sampling frequency are outlined below.

- *GPU Performance*—GPU outlet gas constituent concentration measurements were conducted twice per week. Integrated samples were collected and analyzed off-site by gas chromatography/mass spectrometry (GC/MS) and gas chromatography/flame photometric detector (GC/FPD). The target compound list is contained in Table 1-1.



Since the GPU is primarily a carbon bed system, breakthrough of organic compounds is most likely to occur at the end of an on-line cycle, so sampling was conducted at the end of the cycle to assess performance. Samples were collected during the last hour of an eight-

hour GPU bed “make” cycle (after seven hours of on-line operation; before regeneration commences at eight hours).

The target list for GPU performance samples was developed from GC/MS and GC/FPD measurements conducted during the Phase II GPU performance test. Each target compound was included in a multipoint calibration.

- *Fuel Cell Power Plant Performance*—Power plant efficiency, availability, and maintenance and operator requirements were demonstrated. The heating value and flowrate of the fuel and the power plant output (kilowatt-hours) was measured to determine efficiency. The efficiency measurements are summarized below.

**Table 1-1**

**Typical Concentrations and Detection Limits  
of Targeted Compounds in the  
Raw Landfill Gas at the Penrose Landfill**

<b>Sulfur Compounds (ppmv)</b>	<b>Typical Value in Untreated Landfill Gas</b>	<b>Detection Limit Objective</b>
1. H <sub>2</sub> S	102.0	0.04
2. Methyl mercaptan	3.0	0.04
3. Ethyl mercaptan	0.5	0.04
4. Dimethyl sulfide	6.5	0.04
5. Dimethyl disulfide	< 0.07	0.02
6. Carbonyl sulfide	0.2	0.04
7. Carbon disulfide	< 0.07	0.02
8. Total sulfur as H <sub>2</sub> S (ppmv)	109.0	0.28
<b>Volatile Organic Compounds (ppmv)</b>		
1. Dichlorodifluoromethane	0.3-0.9	0.009
2. 1,1-dichloroethane	1.2-2.9	0.002
3. Benzene	1.1-1.7	0.002
4. Chlorobenzene	0.6-1.4	0.002
5. Ethylbenzene	4.5-12.0	0.002
6. Methylene chloride	4.0-11.0	0.003
7. Styrene	0.5-1.1	0.003
8. Trichloroethene	1.3-2.4	0.001
9. Trichlorofluoromethane	0-0.6	0.004
10. Toluene	28.0-47.0	0.002
11. Tetrachloroethene	2.4-4.8	0.002
12. Vinyl chloride	0.1-1.4	0.005
13. Xylene isomers	5.0-28.0	0.005
14. cis-1,2-dichloroethene	3.9-5.9	0.003
15. Total halides as Cl	47.0-67.0	0.086

- a) Power output was measured continuously with a calibrated utility-grade digital electric meter.
- b) Fuel flowrate was measured continuously with a temperature and pressure calibrated process monitor.
- c) Heat content of the clean fuel (GPU Exit) was measured with an on-line heat content analyzer on the GPU Inlet. The on-line system analyzes a sample every four minutes. Data from the GPU Inlet on-line analyzer was corrected to GPU Exit heat content using a factor developed from a comparison of periodic measurements on the GPU Exit gas conducted by TRC. Seven GPU Exit samples were collected during the performance test and analyzed by ASTM methods for heat content and compared to the GPU Inlet on-line analyzer to develop a correction factor. The corrected averages of the GPU Inlet on-line analyzer were then used for efficiency calculations.

#### 1.4.2 Emission Measurements

Emissions were measured from the fuel cell power plant exhaust over one day. Flare emissions were not measured during the Phase III field program; however, flare emission data from Phase II is included in the Appendices. The emission parameters are outlined below.

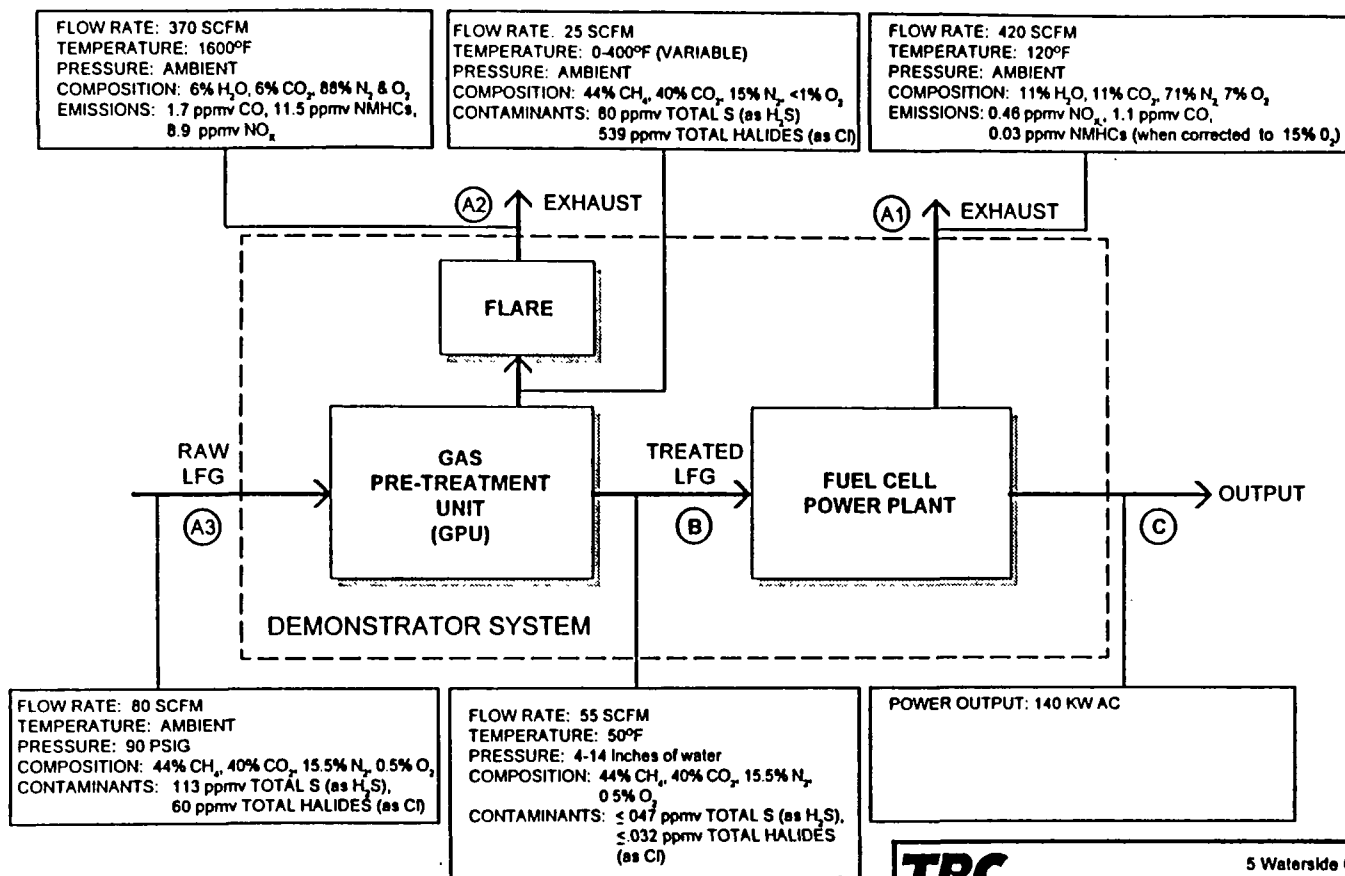
- *Power Plant Emissions*—SO<sub>2</sub>, NO<sub>x</sub>, CO, CO<sub>2</sub>, O<sub>2</sub>, and exhaust flowrate were monitored for six 1-hour periods on February 17, 1995. Pollutant measurements were conducted according to EPA Methods 6C, 7E, 10, and 3A. Exhaust gas flowrate was also measured according to EPA Methods 1 and 2.

## 1.5 Operation of the Fuel Cell

The fuel cell power plant was started up using the normal automatic control sequencing. The power level was originally set at the design power output associated with landfill gas (140 kW AC net). This power output level was difficult to maintain due to upsets in gas quality; as a result, the power plant was operated at 120 kW during the performance test. Operating parameters are listed on the schematic presented in Figure 1-3.

The plant was operated in a grid connected configuration. All phases of the plant operation are controlled by a microprocessor control system (MCS). There are eight operating modes, which are described below.

- *De-energized/Off Mode*—The MCS is off and the power plant can be shipped or stored. If freezing weather exists, the plant water systems must be drained or auxiliary power must be supplied.
- *Energized/Off Mode*—The MCS is on and the thermal management and water treatment systems are active to prevent electrolyte and water freezing.
- *Start Mode*—The thermal management and fuel processing systems are heated, the fuel processing system starts generating hydrogen, the power section starts generating DC power, and the power conditioning system starts delivering AC power for auxiliary power loads. The continuous controls are automatically activated during this mode.
- *Idle Mode*—The power plant is running but the power output is zero. All systems and subsystems are operating and power for the power plant auxiliary loads is supplied by the fuel cell. During power plant start-up, this mode is automatically entered from the start mode when the start-up sequence has been completed.



PERFORMANCE DEMONSTRATION INTERFACES: (B), (C)

EMISSION TEST INTERFACES: (A1), (A2), (A3)

**TRC**

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INTERNATIONAL FUEL CELLS INC.  
 EPA/AEERL PHASE III FUEL CELL/LANDFILL GAS ENERGY  
 RECOVERY PROGRAM

FIGURE 1-3.  
 DEMONSTRATOR SYSTEM INTERFACE  
 CONDITIONS

Date: 6/94

Drawing No. 02030-05

Figure 1-3  
 Demonstrator System Interface Conditions

- *Load Mode*—Customer loads are powered. Operation can be conducted in either of four configurations: (1) grid connected, (2) grid independent, (3) grid independent multi-unit load sharing, and (4) grid independent-synchronized with grid. If grid connect is selected, the output is connected to the utility grid and power is supplied at a dispatched level. The demonstrator power plant will operate only in the grid connected mode.
- *Hot-Hold Mode*—The plant is shut down without cooling the cell stack. This mode is entered following certain automatic shutdowns and it allows the power plant to be restarted quickly with a minimum of power and fuel consumption after the cause of the shutdown has been identified and corrected.
- *Cool-Down Mode*—The cell stack is actively cooled by the thermal management system as part of the normal shutdown procedure before the Energized/Off Mode is reentered.

## 2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

### 2.1 Overall Organization

IFC provided project management of the demonstration team consisting of Pacific Energy, Southern California Gas, the Los Angeles Department of Water and Power (LADWP), and TRC Environmental Corporation (TRC). IFC was ultimately responsible for operating the plant and conducting the demonstration in accordance with the approved QAPP. IFC also operated the fuel cell on landfill gas and monitored the fuel cell; they documented performance and cost, including kilowatt-hour (kWh) output, availability, efficiency, and O&M costs.

Pacific Energy provided the landfill gas site, facilities, and landfill gas supply from their existing operation. Pacific Energy operated the GPU, and monitored and documented the gas quality and quantity from this system during the demonstration. TRC conducted emission tests, collected and analyzed GPU gas samples to determine performance, and prepared the emission test report.

Laboratory analysis were conducted by Performance Analytical, Inc. (PAI) of Canoga Park, California. PAI conducted EPA Method TO-14 analysis for target VOCs (including organic halides), EPA Method 16 analysis for reduced sulfur compounds. Texas Oiltech Laboratories, Inc conducted ASTM Method D3588-91 for heat content analysis of landfill gas samples.

The project organization management team is outlined in Figure 2-1. The EPA Project Officer was Dr. Ron Spiegel, and the Program Manager was Mr. John Trocciola of IFC. Mr. Larry Preston of IFC was the Project Manager, and the subcontractors including the TRC technical staff reported to him. The quality assurance officers of both TRC and IFC reported directly to the Program Manager, allowing them to bypass the technical staff for quality-related issues.

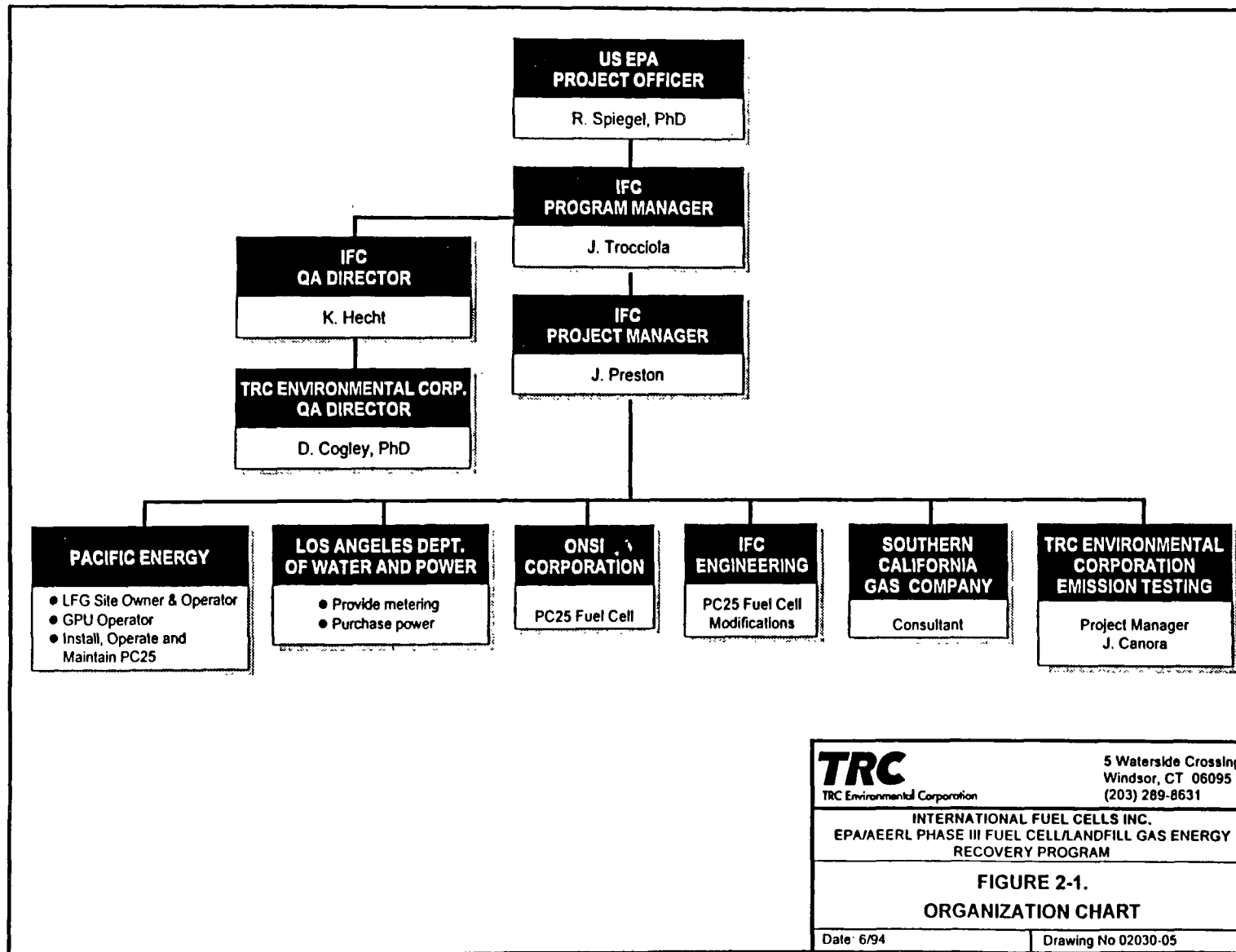


Figure 2-1  
Organization Chart



### 3.0 SUMMARY AND DISCUSSION OF RESULTS

#### 3.1 Fuel Cell Energy Efficiency

Fuel cell efficiency was calculated from data collected during a six-day period from January 24 to 30 and an eight-day period from February 9-17 and the results are presented in Table 3-1. Efficiency was 37.1% and 36.5% for the respective periods.

Efficiency was calculated as the ratio of energy output to energy input. The energy output was measured with the Los Angeles Department of Water and Power (LADWP) electric meter and the raw data from the meter is included in Appendix A. Energy input was calculated from fuel flowrate (measured with a Yokagawa calibrated gas flowmeter) and the lower heating value of the treated landfill gas (measured by an on-line analyzer sampling the GPU Inlet gas and an empirical correction factor). The flowmeter data and the on-line heat content analyzer data is also included in Appendix A. Data used to develop the correction factor for the on-line heat content analyzer is contained in Appendix B.

#### 3.2 Power Plant Emissions

The power plant emissions are summarized in Table 3-2 and the field data is presented in Appendix C. Emissions of NO<sub>x</sub>, SO<sub>2</sub>, and CO are reported as actual dry concentration in parts per million:volume (ppmv), concentration corrected to 15% oxygen, mass emission rate in grams per hour, and as a mass emission rate in grams per kilowatt-hour. The power plant SO<sub>2</sub> emissions were below the method detection limit. Emissions of NO<sub>x</sub> averaged 0.0024 grams/kilowatt-hour. CO emissions were marginally above the detection limit averaging 0.0096 grams/kilowatt-hour.

**Table 3-1**  
**Fuel Cell Energy Efficiency Summary**

**Penrose Landfill - Phase III Fuel Cell Energy Recovery Demonstration**  
**January 24 - February 17, 1995**

Period	Time	Energy Output (LADWP Meter)		Gas Consumption (Yokagawa Meter)		Lower Heating Value		Energy Input (Kcal)	Efficiency
		(kWh)	(Kcal)	(scf)	(SL)	(Btu/scf)	(Kcal/SL)		
Jan 24- Jan 30	0707 1023	16800	1.45E+07	392514	1.11E+07	394	3.50	3.894E+07	37.1%
Feb 9- Feb 17	1102 0733	18400	1.58E+07	444025	1.26E+07	387	3.45	4.334E+07	36.5%

**NOTES:**

1. Heating value data is from Pacific Energy's on-line raw gas analyzer HHV hourly averages corrected to GPU exit LHV. A correction factor (1.01) was developed from a comparison of six GPU Exit ASTM measurements to six GPU Inlet HHV on-line averages. The HHV was then converted to the LHV using the correction factor 0.900. The following equation was used for the complete conversion:

$$\text{Exit LHV} = \text{GPU Inlet HHV} \times 1.01 \times 0.900$$

2. Efficiency =  $\frac{\text{Energy Output (kWh)} \times 860.5 \text{ Kcal/kWh} \times 100}{\text{Gas Consumed (SL)} \times \text{LHV (Kcal/L)}}$

SL = standard liters at 15.5 oC

**Table 3-2**  
**Fuel Cell Emissions Summary**

**Penrose Landfill Phase III Fuel Cell Energy Recovery Demonstration**  
**February 17, 1995**

<b>SAMPLING TIME</b>	<b>0800- 0900</b>	<b>0950- 1050</b>	<b>1155- 1255</b>	<b>1332- 1442</b>	<b>1457- 1557</b>	<b>1622- 1722</b>	<b>AVERAGE</b>
<b>EMISSION CONCENTRATION</b> <b>(actual dry measurements)</b>							
nitrogen oxides (ppmv)	0.3	0.17	0.31	0.17	0.41	0.18	0.26
sulfur dioxide (ppmv)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.50
carbon monoxide (ppmv)	1.5	1.8	2.1	2.3	0.6	1.9	1.70
oxygen (%)	7.96	8.01	7.88	7.8	8.03	7.91	7.93
carbon dioxide (%)	12.5	12.6	12.7	12.3	12.4	12.5	12.50
<b>EMISSION CONCENTRATION</b> <b>(dry measurements corrected to 15% oxygen)</b>							
nitrogen oxides (ppmv)	0.14	0.08	0.14	0.08	0.19	0.08	0.12
sulfur dioxide (ppmv)	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23
carbon monoxide (ppmv)	0.68	0.82	0.95	1.04	0.28	0.86	0.77
<b>VOLUMETRIC FLOWRATE (dscm/m)</b>	10.1	10.1	9.4	9.4	9.7	9.7	9.7
<b>STACK TEMPERATURE (oC)</b>	56.7	56.7	43.3	43.3	42.8	42.8	48
<b>MASS EMISSION RATE (grams/hour)</b>							
nitrogen oxides	0.35	0.20	0.33	0.18	0.46	0.20	0.29
sulfur dioxide	< 0.80	< 0.80	< 0.75	< 0.75	< 0.78	< 0.78	< 0.78
carbon monoxide	1.06	1.27	1.37	1.51	0.41	1.29	1.15
<b>MASS EMISSION RATE (grams/kilowatt-Hr)</b>							
nitrogen oxides	0.0029	0.0016	0.0028	0.0015	0.0038	0.0017	0.0024
sulfur dioxide	< 0.0067	< 0.0067	< 0.0062	< 0.0062	< 0.0065	< 0.0065	< 0.0065
carbon monoxide	0.0088	0.0106	0.0115	0.0125	0.0034	0.0107	0.0096

**NOTES:**

1. dscm/m = dry standard cubic meters per minute at 20 oC
2. grams/hour = actual ppm x Mol. Wt. x flowrate (dscm/m) x 0.0025
3. grams/kilowatt-Hr = grams/hour/120 kilowatts

### 3.3 Flare Emissions

Flare emissions, measured on October 21, 1993 on the GPU installed at Penrose, were 0.087 grams/kWh of NO<sub>x</sub>, 0.015 grams/kWh of CO, and an estimated 0.009 grams/kWh of SO<sub>2</sub> (estimate based on total sulfur measured at the flare inlet). The flare emissions data summary table and calculations are contained in **Appendix D**.

### 3.4 Gas Pretreatment Performance Test

Seven GPU Exit gas samples were collected in Tedlar bags during the final hour of a bed absorption cycle, and analyzed for sulfur and volatile organic target compounds. The data is summarized in **Table 3-3** and sampling and analytical data is in **Appendix E**.

Carbonyl sulfide was detected in five of seven samples; the highest concentration was 0.385 ppmv detected on February 10. The only halogenated VOC detected was methylene chloride at 0.005 ppmv in the sample collected on January 19. The six remaining samples contained no detectable levels of the halogenated target compounds. The detection limits for halogenated compounds was 0.002 ppmv or lower for each halogenated compound, with the exception of dichlorodifluoromethane, which had a detection limit of 0.020 ppmv in five samples. In summary, the measurements demonstrated that the GPU removed contaminants to levels far below the 3.0 ppmv performance limit.

**Table 3-3**  
**Gas Pretreatment System Performance Test:**  
**Summary of Contaminant Removal Measurements**

**Penrose Landfill - Phase III Fuel Cell Energy Recovery Demonstration**  
**January 19 - February 17, 1995**

<b>SAMPLING DATE</b>	<b>Jan 19</b>	<b>Jan 20</b>	<b>Jan 25</b>	<b>Jan 26</b>	<b>Feb 9</b>	<b>Feb 10</b>	<b>Feb 17</b>
<b>Total GPU Operating Time (hours)</b>	1685	1701	1710	1826	2046	2069	2235
<b>Sampling Time</b>	17:00	09:22	16:14	08:26	10:41	09:29	12:55
<b>GPU Process Counter</b>	24969	24900	53080	52362	no data	23146	23217
<b>SULFUR COMPOUNDS (ppm)</b>							
hydrogen Sulfide	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
methyl mercaptan	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
ethyl mercaptan	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
dimethyl sulfide	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
dimethyl disulfide	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
carbonyl sulfide	< 0.004	< 0.004	0.071	0.077	0.173	0.385	0.061
carbon disulfide	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
<b>Total Sulfur</b>	<b>nd</b>	<b>nd</b>	<b>0.071</b>	<b>0.077</b>	<b>0.173</b>	<b>0.385</b>	<b>0.061</b>
<b>VOLATILE ORGANIC COMPOUNDS (ppm)</b>							
dichlorodifluoromethane	< 0.02	< 0.02	< 0.001	< 0.001	< 0.02	< 0.02	< 0.02
1,1-dichloroethane	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.0012	< 0.001
benzene	0.001	< 0.002	< 0.002	< 0.002	< 0.002	< 0.0016	< 0.002
chlorobenzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.0011	< 0.001
ethyl benzene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.0012	< 0.001
methylene chloride	0.005	< 0.002	< 0.002	< 0.002	< 0.002	< 0.0015	< 0.002
styrene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.0012	< 0.001
trichloroethene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.0009	< 0.001
toluene	0.002	0.003	0.002	0.001	0.004	0.0041	0.002
tetrachloroethene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.0007	< 0.001
vinyl chloride	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
xylene isomers	0.001	0.003	0.001	< 0.002	< 0.002	0.0042	0.004
cis-1,2-dichloroethene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.0013	< 0.001
<b>Total Halides as Cl</b>	<b>0.009</b>	<b>nd</b>	<b>nd</b>	<b>nd</b>	<b>nd</b>	<b>nd</b>	<b>nd</b>

NOTES:

1. nd=non-detected
2. All GPU Exit samples were collected during the last hour before regeneration.

### 3.5 GPU Exit Gas Heat Content

The GPU Exit gas heat content was determined from the on-line GPU Inlet gas heat content analyzer and a correction factor to determine the fuel cell efficiency. The correction factor was developed from a comparison of six GPU Exit gas ASTM method heat content measurements to hourly averages from the on-line analyzer. The GPU Exit gas heat content averaged 1.0% higher than the Inlet and a factor of 1.01 was used to correct the GPU Inlet gas on-line data to GPU Exit heat content. A summary of the correction factor development is presented in **Table 3-4** and the data is in **Appendix B**.

**Table 3-4**  
**Comparison of ASTM Method Heat Content Measurements on Treated GPU Exit Gas**  
**to On-Line Raw Landfill Gas Heat Content Measurements**

**Penrose Landfill - Phase III Fuel Cell Energy Recovery Demonstration**  
**January 19 - February 17, 1995**

Sampling Date	Jan 19	Jan 20	Jan 25	Jan 26	Feb 9	Feb 10	Feb 17
Sampling Time	16:44	09:27	16:09	08:31	10:37	09:26	13:33
<b>Treated Landfill Gas Composition Measured</b>							
<b>By ASTM Method at GPU Exit (%)</b>							
nitrogen	16.266	17.251	16.244	16.34	23.888	17.656	20.096
carbon dioxide	35.542	38.896	39.555	39.531	36.042	38.863	34.908
methane	44.165	43.807	44.142	44.092	40.07	43.481	44.996
ethane	0.024	0.029	0.049	0.037	nd	nd	nd
propane	nd	nd	nd	nd	nd	nd	nd
iso-butane	nd	nd	nd	nd	nd	nd	nd
n-butane	nd	nd	nd	nd	nd	nd	nd
iso-pentane	nd	nd	nd	nd	nd	nd	nd
n-pentane	nd	nd	nd	nd	nd	nd	nd
hexanes	nd	nd	nd	nd	nd	nd	nd
heptanes	nd	nd	nd	nd	nd	nd	nd
<b>GPU Exit HHV by ASTM Method</b>							
Btu/standard cubic foot	446	443	447	446	405	439	454
Kcal/standard liter	3.97	3.94	3.98	3.97	3.60	3.91	4.04
<b>GPU Exit LHV by ASTM Method</b>							
Btu/standard cubic foot	402	399	402	401	364	395	409
Kcal/standard liter	3.58	3.55	3.58	3.57	3.24	3.52	3.64
<b>GPU Inlet HHV by Pacific Energy</b>							
<b>On-Line Analyzer</b>							
HHV (Btu/standard cubic foot)	437	435	445	445	436	429	no data
HHV (Kcal/standard liter)	3.89	3.87	3.96	3.96	3.88	3.82	no data
<b>Heat Content Correction Factor</b>							
[GPU Exit HHV/GPU Inlet HHV]	1.02	1.02	1.00	1.00	0.93	1.02	no data

NOTE 1: nd=non-detected

NOTE 2: Standard Conditions at 20 oC

NOTE 3: Average correction factor is 1.01 (Exclude Feb 9 data from average-suspected sampling error.)

## 4.0 CALCULATIONS AND DATA QUALITY INDICATOR GOALS

This section includes a general description of the data and calculations involved with the performance demonstration and the emission tests, followed by a discussion of the expected results, and then a discussion of data quality indicators (DQIs) and DQI goals.

### 4.1 General Description of Test Data and Calculations

The performance test includes a fuel cell efficiency evaluation and a GPU performance evaluation. The calculations involved with these objectives are outlined below.

- Fuel cell efficiency was calculated over a six-day operating period from January 24-30 and an eight-day period from February 9-17.

<u>Measurement</u>	<u>Unit</u>	<u>Measurement Type</u>
Fuel cell energy output	kWh	Utility-grade electric meter
Fuel heat content	BTU/scf	Raw landfill gas on-line gas chromatograph and empirical correction factor developed for cleaned gas
Fuel use	scf	In-line totalizing flowmeter

$$\text{Efficiency} = \frac{\text{Energy output (kWh)} \times 3413 \text{ BTU/kWh}}{\text{Fuel use (scf)} \times \text{heat content (BTU/scf)}} \quad (\text{Eq. 1})$$



- Fuel cell availability is not included in this report.
- GPU performance was measured on the basis of seven measurements conducted over the four week program. The performance limit is 3.0 ppmv of total sulfur and 3.0 ppmv of total halides. Total sulfur and total halides were calculated as follows:
  - Total sulfur was computed by summing the products of each sulfur species times number of sulfur atoms per mole.
  - Total halides was computed by summing the products of each halide species times the number of halide atoms per mole of species (e.g.,  $\text{CCl}_4 = 4$ ).
- Power plant emission concentration and flowrate measurements were used to calculate a mass emission rate of  $\text{NO}_x$ ,  $\text{SO}_2$ ,  $\text{CO}$ , and  $\text{CO}_2$  from the power plant. Emissions from power plant and the flare (flare emissions were measured during Phase II) were summed and converted to mass emissions per energy output as follows:

$$\text{Emissions (grams/kWh)} = \frac{\text{Mass Emission Rate (grams/hr)}}{120 \text{ kWh}} \quad (\text{Eq. 2})$$

## 4.2 Electrical Output

Electrical output was measured by a kWh billing meter, which was calibrated according to the American National Standard Code for Electricity Metering (ANSI C12). The accuracy and precision is 2%. Completeness of the power output measurement was 100%. The billing meter was calibrated by LADWP prior to installation. The results of the meter calibration for the existing meters at the Penrose Station are included in Appendix F.

## 5.0 SAMPLING PROCEDURES

### 5.1 Sampling Locations

The sampling locations for the power plant, the flare stack, the GPU outlet, and the raw landfill gas are indicated on the schematic presented in Figure 1-1. The GPU outlet and raw landfill gas sampling locations are in 1½" pipes. The flare stack is a 32-inch-diameter refractory lined stack with two sampling ports located 90° apart, one diameter upstream from the outlet and approximately three diameters downstream of the nearest flow disturbance. The power plant stack is a six-inch-diameter stack with two ports located 90° apart.

#### 5.1.1 Performance Demonstration Test

Samples were collected from the GPU outlet (location B) to verify GPU performance. The sampling location is under 24 psig pressure. The sampling port consists of a gate valve with a ¼-inch tube Swagelok-type connector.

Electrical output (location C) was acquired from the LADWP kWh electric meter. Fuel flowrate was measured with a Yokagawa process flowrate monitor located at the GPU outlet (location B). Treated fuel heat content samples were collected from the clean fuel line at the GPU Exit (location B) using a valve connected to a Swagelok fitting.

#### 5.1.2 Emissions Testing

Data was acquired from the fuel cell power plant exhaust (Emission Point A1) and the GPU flare exhaust (Emission Point A2) to establish the emissions characteristic of the demonstrator system.

## 5.2 GPU Outlet and Raw Landfill Gas Sampling Methods

Tedlar bag samples were collected twice per week from the GPU outlet during the one-month demonstration. The bags were analyzed for volatile organic compounds (including halides) and sulfur compounds according to EPA Method TO-14 and Method 16. The Tedlar bags were collected as grab samples over approximately five-minute periods using a stainless steel valve to regulate the flowrate (the sampling location is under positive pressure so that no sampling pumps were required). Heat content samples of treated landfill gas were collected in steel canisters by purging the canisters with at least 12 volumes of sample gas.

## 5.3 Power Plant Emissions Monitoring Methods

EPA Methods 7E, 6C, 10, and 3A were used to measure flare exhaust and power plant exhaust emissions of  $\text{NO}_x$ ,  $\text{SO}_2$ , CO,  $\text{CO}_2$ , and  $\text{O}_2$ . Monitoring was conducted for six, 1-hour periods on February 17, 1995. The monitors were calibrated before and after each 1-hour test with EPA Protocol 1 gases and the drift performance specifications were within the method specifications for each parameter except for  $\text{NO}_x$  (the  $\text{NO}_x$  analyzer was operated at the 0-2.5 ppm range which was too low to meet the method drift specification). A schematic of the measurement system is presented in Figure 5-1.

All continuous emission monitoring (CEM) data was recorded in five-minute intervals by a Yokogawa Model 2300 stripchart/data logger. The CEM system was housed in TRC's equipment trailer located within 100 feet of the sampling locations.

Calibration gas entered the system at the probe outlet. This method of inputting calibration gas challenged the entire system outside of the stack including heated sample line, out-of-stack filters, and moisture condenser.

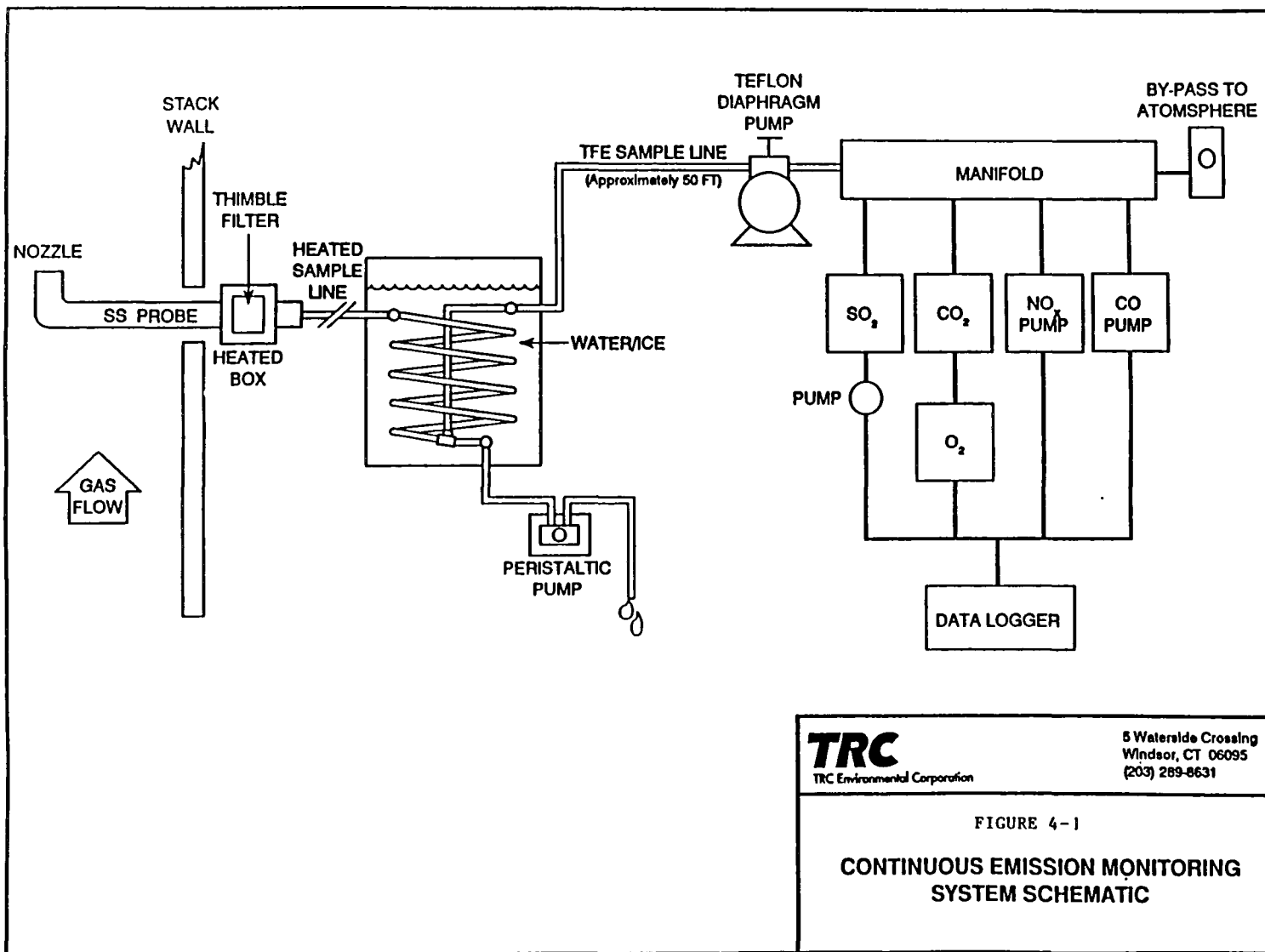


Figure 5-1  
Continuous Emission Monitoring Schematic

### 5.3.1 Sample Conditioning System

An in-stack Alundum thimble filter with a stainless steel nozzle facing away from the stack gas flow served to remove any particulate matter from the sample gas stream. The thimble filter was mounted on the end of a stainless steel sampling probe. The sample was drawn through 100 feet of heated ( $325^{\circ}\text{F} \pm 25^{\circ}\text{F}$ ) Teflon sample line through a condenser system to remove the moisture from the gas stream by a leak-free Teflon double-diaphragm pump. The pump outlet was connected to a stainless steel sample manifold with an atmospheric bypass rotameter.

### 5.3.2 NO<sub>x</sub> Analyzer

A Thermo-Electron Corporation Model 10A chemiluminescent NO/NO<sub>x</sub> analyzer was used to determine NO<sub>x</sub> concentrations. The chemiluminescent reaction of NO and O<sub>3</sub> (ozone) provides the basis for the analytical method ( $\text{NO} + \text{O}_3 \rightarrow \text{NO}_2 + \text{O}_2 + \text{light}$ ). A photomultiplier-electrometer-amplifier produces a current proportional to the NO concentration. The output of the amplifier provides a signal for direct readout on a meter indicator, or for outputs to a recorder or computer.

### 5.3.3 SO<sub>2</sub> Analyzer

A Western Research Model 721 SO<sub>2</sub> analyzer was used to determine SO<sub>2</sub> concentrations in the stack gas. This instrument utilizes the ultraviolet photometric principle, and was designed to meet the stringent California Air Resources Board (CARB) requirements to ensure maximum accuracy and reliability, without NO<sub>x</sub> interference, in the 0–1000 ppm and 0–100 ppm ranges.

#### 5.3.4 CO Analyzer

A California Instruments, Inc. nondispersive infrared gas analyzer was used to measure CO concentrations. The analyzer contains an infrared detector that uses the signal nondispersive beam technique with alternate modulations of the sample and reference cells. Radiation absorbed by CO in the sample cell results in a capacitance change in the detector which is proportional to the CO concentration.

#### 5.3.5 O<sub>2</sub> Analyzer

A Horiba Model PMA-200 O<sub>2</sub> analyzer was used to determine the concentration of O<sub>2</sub> in the stack gas. This instrument uses the paramagnetic principle, whereby the magnetic susceptibility of the gas volume is measured by the force acting on a nonmagnetic test body suspended in a magnetic field. The force is converted to an output current proportional to the O<sub>2</sub> concentration.

#### 5.3.6 CO<sub>2</sub> Analyzer

An Infra-Red Industries, Inc., infrared CO<sub>2</sub> analyzer was used to monitor CO<sub>2</sub> emissions. This instrument operates on the principle of CO<sub>2</sub> having a known characteristic absorption spectra in the infrared range. Radiation absorbed by CO<sub>2</sub> in the sample cell produces a capacitance change in the detector which is proportional to the CO<sub>2</sub> concentration.

### 5.4 Flowrate Monitoring

Flowrate was measured with triplicate tests according to EPA Methods 1 and 2. The flare exhaust flowrate was calculated from measured inlet gas flowrate and an excess air factor developed from the diluent measurements. The flare inlet gas flow was measured with an in-line process monitor which sends a signal to the control room chart recorder.

## 5.5 Power Plant Electrical Measurements

The power plant output was continuously monitored with a utility-grade kWh electric meter. The meter is a digital-display-type meter (Model PMG 30018-15) calibrated according to ANSI C12. Calibration data is included in **Appendix F-2**.

## 6.0 SAMPLE CUSTODY

The purpose of sample custody procedures is to document the identity of the sample and its handling from its first existence as a sample until analysis and data reduction are completed. Custody records trace a sample from its collection through all transfers of custody until it is transferred to the analytical laboratory. Internal laboratory records then document the custody of the sample through its final disposition.

In accordance with SW-846, a sample is considered to be under a person's custody if the sample is:

- In that person's possession.
- In view of that person after acquiring possession.
- Secured by that person so that no one can tamper with the sample.
- Secured by that person in an area which is restricted to authorized personnel.

These criteria were used to define the meaning of "custody" and ensure the integrity of the samples from collection to data reporting.

### 6.1 Sample Documentation

Documentation of all samples and data collected during this program was performed using TRC data forms (both hard copy as well as computer) and bound laboratory notebooks.

#### 6.1.1 Sampling Data Forms

Emission data from the power plant and flare exhaust was recorded with a digital data logger which provides a stripchart-type trend as well as periodic averages. The data was reduced according to EPA methods using a personal computer and Lotus 1-2-3. All additional field data and observations were recorded in bound laboratory notebooks.



### 6.1.2 Sample Identification and Labeling

The samples were identified with the following information:

- Sample location (GPU outlet or raw landfill gas)
- Date and time of collection
- Required analytical parameters
- Sampler name
- Project name and number

This information was entered on to a TRC label and placed on the Tedlar bag sample. The information was also recorded in a bound laboratory notebook.

## 6.2 Chain-of-Custody Forms

Custody of the samples was documented using a chain-of-custody form. The chain-of-custody form was completed providing sample identification, required analyses, sample container descriptions, project identification. Prior to sample shipment, the TRC sampler relinquished custody of the samples by signing and dating the chain-of-custody form in the “Relinquished by” box. The TRC sampler required the laboratory to complete the “Received by” box when the samples were hand delivered by TRC. Following completion of the chain-of-custody form, TRC retained the bottom copy.

### 6.3 Laboratory Custody

Samples arriving at the laboratory were compared against the chain of custody prior to the laboratory acknowledging sample receipt by signing the chain-of-custody forms. The laboratory then continued the chain of custody by entering the samples into the laboratory information system (LIMS). This is done by assigning an internal project number and individual sample identifications. The samples were stored in a controlled access area until analysis. Sample transfers between the storage area and the analytical area of the laboratory are documented through internal chain of custody generated by the LIMS.

## 7.0 CALIBRATION PROCEDURES

### 7.1 Manual Sampling Equipment

The TRC quality assurance program for source testing is designed to ensure that emission measurement work is performed by qualified people using proper equipment and following written procedures in order to provide accurate, defensible data. The program is based upon the EPA *Quality Assurance Handbook for Air Pollution Measurement Systems*, Volume III (EPA-600/4-77-0276).

Sampling and measurement equipment, including continuous analyzers, recorders, pitot tubes, dry-gas meters, orifice meters, thermocouples, probes, nozzles, and any other pertinent apparatus, is uniquely identified, undergoes preventive maintenance, and is calibrated before and after each field effort, following written procedures and acceptance criteria. Most calibrations are performed with standards traceable to the National Institute for Science and Technology (NIST). These standards include wet test meters, standard pitot tubes, and NIST Standard Reference Materials. Records of all calibration data are maintained in TRC files.

### 7.2 Power Plant Continuous Monitoring Methods

The continuous measurement analyzers were calibrated before and after each test for zero and span drift according to EPA Methods 6C, 7E, 10, and 3A. EPA Protocol 1 gases were used. Calibration gas was introduced to the system at the probe outlet using a three-way tee. An excess flow of calibration gas will be metered to the tee with the excess flowing into the stack through the probe. A calibration error test was also conducted once by first conducting a zero and span calibration, followed by introducing a zero, high and mid point calibration gas to the system.

### 7.3 GPU Exit Gas Flowrate Meter

Calibration of the gas meter installed on the GPU Exit was performed by the manufacturer. Calibration documentation is provided in **Appendix F-3**.

### 7.4 Electrical Power Measurements

Calibration documentation provided by LADWP is included in **Appendix F-2**.

### 7.5 On-Line Raw Landfill Gas Heat Content Analyzer

This analyzer is automatically calibrated daily using a certified gas. The calibration gas contains carbon dioxide, oxygen, nitrogen, and methane. The data system records the response factor of each compound, compares it to the certified reference, and reports a deviation. An example of a calibration report is included in **Appendix F-1**.

## 8.0 ANALYTICAL PROCEDURES

### 8.1 Continuous Emissions Monitoring

See Section 5.3.

### 8.2 Heat Content Analysis of GPU Exit Samples

The heat content (BTU/scf) of the GPU Exit samples was determined according to ASTM Method D3588-91. This method covers procedures for calculating heat content from compositional analyses of the samples. Compositional analysis of the samples was conducted using a gas chromatograph equipped with a thermal conductivity detector to measure the concentrations of nitrogen, oxygen, methane, and carbon dioxide, and a gas chromatograph equipped with a flame ionization detector to measure the concentrations of C1 through C6 hydrocarbons. For each gas chromatograph method, an initial calibration curve with a minimum of three points is analyzed using calibration gas standards containing the analytes of concern. The calibration curve spanned the expected concentration of the samples. The initial calibration is verified at least once at the beginning of each 24-hour period with the analysis of a mid-level Continuing Calibration standard. The percent difference of the continuing calibration response factors shall be within  $\pm 15\%$  from the initial calibration mean response factor. The heat content of the samples was then calculated using the equations presented in ASTM Method D3588-91 from the measured chemical composition.

### 8.3 GPU Exit Contaminant Analysis

#### 8.3.1 Sulfur Compound Analysis

Tedlar bag samples were analyzed for seven sulfur compounds and total reduced sulfur as hydrogen sulfide utilizing a GC/FPD according to the procedures outlined in EPA Method 16. An initial calibration curve with a minimum of three points was analyzed using

calibration gas standards containing the analytes of concern. The calibration curve spanned the expected concentration of the samples. The initial calibration is verified at least once at the beginning of each 24-hour period with the analysis of a mid-level Continuing Calibration standard. The percent difference of the continuing calibration response factors was within  $\pm 15\%$  from the initial calibration mean response factor. One field sample per analytical sequence was analyzed in duplicate to demonstrate the precision of the analytical technique on the sample matrix.

### 8.3.2 Volatile Organic Compound Analysis

The Tedlar bag samples were also analyzed by GC/MS for VOCs and specified tentatively identified compounds. The analyses were performed according to the methodology outlined in EPA Method TO-14 from the *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air* (EPA 600/4-84-041, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, April 1984 and May 1988). The method was modified for using Tedlar bags. The analyses were performed by GC/MS utilizing a direct cryogenic trapping technique.

Verification of the mass calibration of the GC/MS is checked at the beginning of every 24-hour analytical sequence by the direct injection of 50 nanograms (ng) of bromofluorobenzene. The calibration range of the target compounds is determined by the three-point curve. Linearity is established over the range of the three-point curve if the percent relative standard deviation of the response factors is less than 30% for each analyte. A continuing calibration is considered to establish the same conditions of linearity and range as the initial calibration if the response factor for each analyte is within 20% of the average response factor of the initial calibration. A continuing calibration is performed at the beginning of each 24-hour period. A blank is analyzed following calibration as a sample to demonstrate that the analytical system is free from contamination.

Internal standards and surrogates are introduced into the sample stream to monitor the method efficiency. If the internal standard area changes by a factor of two (-50% to +200%) and/or surrogate recoveries are less than 80% or greater than 120%, the internal standard/surrogate gas standard is reevaluated by analyzing a lab blank. If the internal standard areas in the blank are within a factor of two of the quantification standard and surrogate recoveries are within 80%–120%, then the sample analyses may be continued. The earlier low recoveries may be attributed to a matrix effect. The sample must be reanalyzed to verify that a matrix effect was the cause and not some intermittent problem. If the areas and recoveries remain poor in the lab blank, then corrective action must be taken. This may include leak checking the system and/or the preparation of a fresh internal standard surrogate mix. A minimum of one duplicate was analyzed per analytical sequence.

## 9.0 DATA REDUCTION, VALIDATION, AND REPORTING

### 9.1 Overall Calculations

- **POLLUTANT MASS EMISSION RATE (SO<sub>2</sub>, NO<sub>x</sub>, and CO)**

$$\text{grams/hour} = \text{concentration (ppmvd)} \times \text{flowrate (dscm/m)} \times \text{M.W.} \times 0.0025$$

$$\text{M.W. (SO}_2\text{)} = 64$$

$$\text{M.W. (NO}_x\text{)} = 46$$

$$\text{M.W. (CO)} = 28$$

- **FUEL CELL EFFICIENCY (reference Figure 1-1 for measurement locations)**

$$\text{Efficiency (\%)} = \frac{(\text{kwh at [C]}) (3413 \text{ BTU/kwh})}{(\text{scf at [B]}) (\text{BTU/scf})} \times 100$$

where: scf = measured GPU exit gas by totalizer at [B], based on flow, temperature, pressure.

BTU/scf = hourly average heat content measured with Pacific Energy's on-line analyzer and a correction factor (correction factor = 1.01) developed from a comparison of six GPU Exit ASTM measurements to six hourly averages from the Pacific Energy analyzer.



## 9.2 Data Validation

Each 1-hour period of continuous emission data was reduced on a separate Lotus file. Copies of the raw data logger charts and the spreadsheet printout are included in Appendix C. Laboratory data was submitted to TRC for a QA evaluation. A QA specialist examined the data, checked the precision and accuracy of the results (duplicate analyses and audits), and reported the findings to the TRC Project Manager.

## 9.3 Identification and Treatment of Outliers

Continuously monitored parameters did not change significantly throughout the program. Responses for CEM monitors and Pacific Energy process monitors were evaluated during the emissions testing and nothing unusual was observed. Similarly, the analytical values for halide and sulfur compounds concentrations of the GPU outlet gas were constant over the course of the program.

The GPU Exit heat content sample collected on February 9, was unusually low and was considered to be caused by sampling error. It was likely that the sampling bulb was not completely purged with sample gas.

## 10.0 QUALITY CONTROL CHECKS

### 10.1 Data Collection and Sampling QC Procedures

Continuous emission monitoring QC checks included zero and span drift tests, calibration error tests, system bias checks, and audits. All continuous monitoring zero and span gases were delivered to the probe outlet to challenge the entire sampling system. The QC data was recorded on the data logger chart and is summarized in the following section.

### 10.2 Analytical Laboratory QC Checks

*Blanks* for both sulfur and VOC analyses were conducted with each set of samples received by the laboratory. The blank concentration of target sulfur compounds was less than 2 ppbv and the blank concentration of target VOCs was less than 1 ppbv.

*Audit samples* for this program were purchased by TRC for target volatile compounds, sulfur compounds, and heat content analysis. The audits were used to determine the accuracy and results are summarized in Section 11.

*Instrument calibration verifications* for GC and GC/MS were performed for target volatile compounds, sulfur compounds, and heat content analysis.

*Laboratory duplicates* were performed for each analytical parameter for each analytical sequence. The percent difference determined was used to evaluate matrix effect on the precision of the analytical technique. The precision objective for laboratory duplicates is 10% relative percent difference (RPD). The results of laboratory duplicates are included with the laboratory results in **Appendix E**.

## 11.0 QUALITY CONTROL TEST RESULTS

### 11.1 Fuel Heat Content Measurements

Precision of the ASTM Method was measured by sampling and analysis of three replicate samples collected of the GPU Exit gas collected on January 19, 1995. In addition, four replicate samples of the GPU Inlet gas were collected and analyzed on the same day. The results of these replicate measurements are summarized in **Table 11-1** and the analytical data is in **Appendix G**. The precision was within expected variation with a relative standard deviation (RSD) of 0.11% for the GPU Exit samples and 0.6% for the GPU Inlet samples.

Accuracy of the GPU Inlet on-line analyzer was also evaluated by comparison to the four replicate samples collected on January 19. The results of this audit demonstrated an accuracy of 1.1% based on the relative standard deviation

### 11.2 GPU Exit Gas Contaminant Measurements

Precision and accuracy measurements were conducted to assess sulfur compound and VOC compound concentration measurements conducted on the clean gas at the GPU Exit. The results are summarized in **Table 11-2** and the raw data is in **Appendix H**.

#### 11.2.1 Sulfur Compounds

Sulfur compound precision was determined by three replicate measurements of a 10.1 ppmv hydrogen sulfide audit gas. The RSD was within QAPP limits at 0.6%. Accuracy, based on the hydrogen sulfide audit was 30.7% which was outside of the QAPP expectation of 15%.

**Table 11-1**  
**Heat Content Measurement Quality Assurance Data Summary**

**Penrose Landfill - Phase III Fuel Cell Energy Recovery Demonstration**  
**January 19 - February 10, 1995**

**ASTM Method Precision Determined with Triplicate Samples of GPU Exit Gas**

Sampling Date Sampling Time	Jan 19 1	Jan 19 2	Jan 19 3	Standard Deviation	Average	Relative Standard Deviation
GPU Heat Content HHV (Btu/scf) Measured Offsite by ASTM Method	446	445	446	0.47	446	0.11%

**ASTM Method Precision Determined with Quadruplicate Samples of Raw Landfill Gas**

Sampling Date Sampling Time	Jan 19 1	Jan 19 2	Jan 19 3	Jan 19 4	Standard Deviation	Average	Relative Standard Deviation
Raw Landfill Gas HHV (Btu/scf) Measured Offsite by ASTM Method	446	452	447	445	2.69	448	0.60%

**Comparison of Four ASTM GPU Inlet Measurements to Pacific  
Energy's On-Line Analyzer**

ASTM Method HHV (Btu/scf) (Average of four samples collected from 15:28 to 16:00)	448
Pacific Energy On-Line Analyzer HHV (Btu/scf)	438
Mean	443
Standard Deviation	5
Relative Standard Deviation	0.01

**Table 11-2**  
**Gas Pretreatment System Outlet**  
**Halide and Sulfur Analysis QA Data**

**Penrose Landfill - Phase III Fuel Cell Energy Recovery Demonstration**  
**January 19, 1995**

***Sulfur Compound Precision (Determined from triplicate audit samples)***

Compound	Concentration (ppm)				Standard Deviation	Relative Standard Deviation
	Sample 1	Sample 2	Sample 3	Average		
hydrogen sulfide	13.2	13.1	13.3	13.2	0.082	0.6%

***Halide Compound Precision (Determined from triplicate audit samples)***

Compound	Concentration (ppb)				Standard Deviation	Relative Standard Deviation
	Sample 1	Sample 2	Sample 2	Average		
vinyl chloride	15	15	22	17	3.300	19.0%
cis-1,2-dichloroethene	14	13	15	14	0.816	5.8%
1,1-dichloroethane	13	13	15	14	0.943	6.9%
tetrachloroethene	14	14	16	15	0.943	6.4%

***Sulfur Compound Accuracy (Determined from analysis of one hydrogen sulfide audit)***

Compound	Measured Concentration (ppm)	Certified Concentration (ppm)	Difference	Accuracy
hydrogen sulfide	13.2	10.1	3.1	30.7%

***Halide Compound Accuracy (Analysis of two certified audits-Cylinder No. 01046673 and 01046663)***

Compound	Measured Concentration (ppb)	Certified Concentration (ppb)	Difference	Accuracy
<b>Cylinder No. 01046673</b>				
vinyl chloride	17.3	11.2	6.1	54.5%
cis-1,2-dichloroethene	14	11.9	2.1	17.6%
1,1-dichloroethane	13.7	12.1	1.6	13.2%
tetrachloroethane	14.7	11.2	3.5	31.3%
<b>Cylinder No. 01046663</b>				
trichlorofluoromethane	70	99.2	-29	-29.4%
methylene chloride	91	120	-29	-24.2%

### 11.2.2 Volatile Organic Compounds

VOC precision was evaluated by three replicate measurements of an audit gas containing four target compounds. The RSD ranged from 5.8% to 19% and averaged 9.5% for the four compounds. VOC accuracy was determined by analysis of two audit cylinders; one cylinder contained four target compounds and the second cylinder contained two target compounds. On the first audit, accuracy ranged from 13.2% to 54.5% and averaged 29.2%. Accuracy based on the second audit ranged from -24.2% to -29.4 %. Accuracy based on these audits was above the expected range of 15%.

### 11.3 Fuel Cell Emissions

A series of cylinder gas audits were conducted on the emission monitoring system to evaluate accuracy and the results are summarized in **Table 11-3** with the raw data contained in **Appendix I**. Audits on the CO<sub>2</sub>, O<sub>2</sub>, SO<sub>2</sub>, and CO analyzers were with the expected range of 15% accuracy. Two NO<sub>x</sub> analyzer audits demonstrated the accuracy ranged from 20.7 to 22.4%. This was not unexpected at the low operating range of 0-2.5 ppmv.

In addition to audits, normal EPA reference method QC procedures were conducted and the data is summarized in **Table 11-4**. Calibration error was within 2% for each parameter with the exception of NO<sub>x</sub> because of the low range. Calibration drift was also acceptable (below 2% for each parameter except NO<sub>x</sub>). The raw data for the calibration error is contained in **Appendix J**.

**Table 11-3**  
**Fuel Cell Emissions Testing QA Data**  
**Cylinder Gas Audit Summary**

**Penrose Landfill - Phase III Fuel Cell Energy Recovery Demonstration**  
**February 16-19, 1995**

Parameter	Cylinder No.	Certified Concentration	Units	Average Response	Accuracy
Carbon dioxide	CC88851	6.12	%	6.2	1.3%
Oxygen	CC97847	12	%	12.1	0.8%
Sulfur dioxide	AAL7595	24.8	ppm	23.8	-4.0%
Carbon monoxide	AAL7595	25.8	ppm	24.4	-5.4%
Nitric oxide (Note 1)	ALM048981	1.4	ppm	1.46	4.3%
Nitric oxide (Note 1)	ALM048981	0.7	ppm	0.76	8.6%
Nitric oxide (Note 2)	ALM025536	2.37	ppm	1.84	-22.4%
Nitric oxide (Note 3)	AAL7595	2.37	ppm	1.88	-20.7%

Notes:

1. This audit was prepared from a 2.37 ppm NO certified cylinder with an Environics calibrator. The 2.37 ppm cylinder was also used as a span gas, so this data point was actually a calibration error test rather than an audit.
2. This audit was prepared from a 50.8 ppm NO certified cylinder using the Environics calibrator. Accuracy was outside the 15% objective. This accuracy was not unusual for the low range (0-2.5 ppm) used for the program.
3. This audit was prepared from a 26.7 ppm NO certified cylinder using the Environics calibrator. Accuracy was also outside the 15% objective because of the low operating range.

**Table 11-4**  
**Fuel Cell Emissions-EPA Methods 3A, 6C, 7E and 10**  
**QA Summary Including Calibration Drift and Calibration Error**

**Penrose Landfill- Phase III Fuel Cell Energy Recovery Demonstration**  
**February 17, 1995**

***Calibration Error Summary***

Parameter	Percent Error		
	zero	mid-point	high-point
nitric oxides	3.2	6.8	-0.4
sulfur dioxide	0	-0.2	0.4
carbon monoxide	1.2	1.8	0
oxygen	0	-1.2	0.4
carbon dioxide	0.4	0	-0.4

***Calibration Drift Summary***

Test No.	Time	nitric oxides		sulfur dioxide		carbon monoxide	
		Zero Drift	Span Drift	Zero Drift	Span Drift	Zero Drift	Span Drift
1	0800-0900	16.8%	10.8%	-0.1%	0.9%	-1.4%	-30.0%
2	0950-1050	35.2%	21.5%	-2.1%	-1.2%	-1.5%	0.2%
3	1155-1255	17.2%	16.4%	-0.6%	0.1%	-1.3%	-0.3%
4	1332-1432	6.0%	3.2%	-0.4%	0.2%	-0.8%	-1.6%
5	1457-1557	-28.0%	-32.0%	0.5%	0.0%	-2.8%	0.9%
6	1622-1722	-14.4%	-11.6%	0.9%	1.3%	1.9%	2.1%



## 12.0 CALCULATION OF DATA QUALITY INDICATORS

### 12.1 Precision

#### 12.1.1 Continuous Emission Monitoring

Precision was determined before and after each test period using a zero and span calibration drift test. The drift was calculated as a percentage of instrument range, as follows:

$$\% \text{ drift} = \frac{[\text{monitor value}] - [\text{certified concentration}]}{\text{span value}} \times 100$$

#### 12.1.2 Sulfur and Halide Compounds – GPU Outlet Samples

A series of three samples was collected simultaneously. The precision was calculated for each detectable compound by the relative standard deviation (RSD), as follows:

$$\text{RSD} = \frac{s}{\bar{x}} \quad \begin{array}{l} s = \text{standard deviation} \\ \bar{x} = \text{mean value} \end{array}$$

#### 12.1.3 GPU Outlet – Heat Content Analysis

The RSD from a series of three replicate samples will be calculated to determine precision. The RSD calculation is defined above.

## 12.2 Accuracy

### 12.2.1 Continuous Emission Monitoring

Accuracy was determined by analyzing audit gases for each parameter. The audit cylinders were EPA Protocol 1 ( $\pm 1\%$ ) or equivalent. Accuracy will be calculated as follows:

$$\text{accuracy} = \frac{C_m - C_a}{C_a} \times 100$$

$C_m$  = monitor response

$C_a$  = certified audit concentration

### 12.2.2 Sulfur and Halide Compounds

Audit samples were prepared gravimetrically by a specialty gas manufacturer and certified for  $\pm 5\%$  accuracy. The audits were analyzed with the first set of samples submitted to the laboratory. The sulfur audit gases contained hydrogen sulfide and the halide audit gases contained six target compounds. Accuracy was determined as previously described for continuous monitoring.

### 12.2.3 GPU Outlet Heat Content Analysis

One BTU audit cylinder gas audit was purchased from a specialty gas manufacturer and analyzed with the heat content samples by the ASTM method. The analysis indicated that the methane concentration was 3.5% lower than the certified value. Nitrogen, carbon dioxide, and propane measured concentrations were within 2% of the certified values. The remaining compounds (propane, butanes, and pentanes) had a variation greater than 10%. The results of this audit indicated that performance was less than QAPP specifications,

however, the net effect on heat content analyses is not significant. The comparison study between the on-line Pacific Energy analyzer and ASTM method measurements showed that the two methods were consistently within 2 % (see Table 3-4).

**SUB-APPENDIX A**

**PROCESS DATA**

# EFFICIENCY READING

Sheet

REVISED 3-30-95  
JLP

original  
Level

is same  
RANA  
RANA 1/2  
RANA 3/4  
RANA 5/8  
RANA 6/8  
RANA 7/8

Period 1  
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Period 2  
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Period 7  
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Period 8  
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12

## WEEKLY DATA FOR EFFICIENCY CALCULATIONS

PENROSE FUEL CELL

READ  
21 + 25 + 29  
x 160

H<sub>2</sub>S BED  
ON LINE

channel 606

SCR09 DATE	SCR09 TIME	SCR09 F/C OP HOURS	YOKOGAWA SCF	SCR00 TOTAL FUEL CON	METER CABINE LADWP (KW)	SCR09 CUM POWER	DIGI (BTU/SCF)
1 1-14-95	0900	239.2	106,015	420,056	000095	22,649	2AB-131
2 1-16-95	0755	284.6	107,039	525,077	000096	27,115	
3 1-16-95	0823	285.1	107,568	526,159	000096	27,159	
4 1-16-95	1303	283.2	166,422	526,423	000097	27,160	
5 1-18-95	1509	309.1	209,510	565,192	000100	29,570	
6 1-19-95	0720	325.3	214,802	628,286	000100	31,519	
7 1-23-95	0700	325.3	269,000	628,286	000102	31,465	
8 1-24-95	0707	345.9	333,700	682,200	000102	33,856	
9 1-25-95	0730	370.3	394,267	746,267	000102	36,778	
10 1-26-95	0705	393.9	1,005,975	808,097	000102	39,563	2AB-14
11 1-30-95	1023	423.1	1,279,000	1,074,094	000102	51,463	2AB-14
12 1-31-95	1102	597.7	1,323,450	1,346,225	000102	63,309	2AB-14
13 2-1-95	1327	696.7	1,390,680	1,617,361	000102	75,321	2AB-14
14 2-13-95	1511	697.8	1,420,823	1,666,354	000102	77,291	2AB-14
15 2-14-95	0736	714.2	1,450,000	1,727,684	000102	80,235	2AB-14
16 2-15-95	0813	738.8	1,450,000	1,757,437	000102	81,520	2AB-14
17 2-16-95	0752	749.8	1,450,000	1,786,659	000102	82,653	2AB-14
18 2-17-95	0733	762.5	1,101,000	1,104,459	000102	48,797	2AB-14
19 2-18-95		416.6	(112KW AVG)	(93.5%)	46,720	48,797	(104.4%)
20 2-25 DMS							
21							
22							
23 6 DAYS		147.2 Hrs	392,514 SCF	391,894 SCF	16,800 KW	17,607 KW	(104.8%)
24		(108% AVAIL)		(99.8%)			
25		(114 KW AVG)					
26 8 DAYS		164.8	444,025 SCF	440,430 SCF	18,400 KW	19,344 KW	(105.1%)
27		(86% AVAIL)		(99.2%)			
28		(112 KW AVG)					
29							
30							

NOTES: ① KWHR SENT OUT BY FUEL CELL IS SUM OF REGISTERS  
21 [KWHR HI PEAK REC] + 25 [KWHR LOW PEAK REC] + 29 [KWHR BASE]

TIMES 160

② CHANGE OVER TO H<sub>2</sub>S BED 2AB-140 ON MONDAY 1-30-95

MAR 30 '95 10:51

FROM INTL FUEL CELLS B

TO 92986399

PAGE 002

14.	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	15.	15.	15.	15.
OFFER # 11.	SOURCE 511	S/B SCFM	1956..	TRIGGER	914		
1956.	1955.	1956.	1956.	1957.	1956.	1957.	1957.
1956.	1956.	1957.	1914.	1955.	1956.	1860.	587.
1956.	2004.	2003.	2002.	2000.	1999.	1998.	1996.
1995.	1993.	1990.	1989.	1984.	1980.	1973.	1990.
OFFER # 12.	SOURCE 309	E2 GKW	1911..	TRIGGER	914		
1917.	1904.	1917.	1924.	1911.	1911.	1921.	1923.
1915.	1917.	1918.	1922.	1930.	1889.	1772.	736.
1841.	1916.	1922.	1923.	1919.	1922.	1926.	1924.
1909.	1911.	1910.	1914.	1918.	1914.	1933.	1926.
OFFER # 13.	SOURCE 311	E2SCFMFG	688..	TRIGGER	914		
688.	687.	689.	690.	688.	685.	684.	683.
688.	685.	689.	705.	694.	685.	675.	331.
667.	695.	694.	694.	694.	695.	693.	694.
693.	693.	692.	692.	699.	697.	695..	697.
OFFER # 14.	SOURCE 315	E2SCFMNG	14..	TRIGGER	914		
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	13.	7.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
OFFER # 15.	SOURCE 504	A/O B IN	435..	TRIGGER	914		
435.	23 435.	22 435.	21 435.	20 435.	19 436.	18 437.	17 437.
435.	15 436.	14 434.	13 435.	12 435.	11 435.	10 435.	9 423.
419.	7 433.	6 434.	5 434.	4 434.	3 433.	0200 434.	0100 433.
434.	434.	434.	434.	435.	436.	437.	437.
OFFER # 16.	SOURCE 515	PEN VAC	-62..	TRIGGER	914		
-61.	-61.	-61.	-61.	-61.	-61.	-61.	-60.
-60.	-60.	-60.	-57.	-61.	-61.	-56.	-45.
-66.	-64.	-64.	-64.	-64.	-64.	-64.	-64.
-64.	-64.	-64.	-64.	-64.	-64.	-64.	-63.

1-19-95

→ UPPER LEFT REGISTER IS MIDNITE (2400) 1-19-95

→ THIRD ROW, 8<sup>TH</sup> COLUMN IS 0100 ON 1-19-95

*Pen*  
1-19-95

\* GPU Sample

14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
OFFER # 11, SOURCE 511 S/B SCFM	1956.	1956.	1956.	1956.	1956.	1957.	1956.
1956.	1956.	1956.	1956.	1956.	1956.	1957.	1956.
1955.	1957.	1937.	1953.	1953.	1781.	1013.	25.
1889.	1956.	1956.	1955.	1955.	1955.	1956.	1956.
1956.	1955.	1956.	1956.	1957.	1956.	1957.	1957.
OFFER # 12, SOURCE 309 E2 GKW	1919.	1919.	1919.	1919.	1919.	1919.	1919.
1902.	1909.	1916.	1923.	1912.	1910.	1924.	1922.
1924.	1928.	1926.	1919.	1911.	1896.	1559.	89.
1863.	1912.	1909.	1905.	1910.	1930.	1930.	1911.
1917.	1904.	1917.	1924.	1911.	1911.	1921.	1923.
OFFER # 13, SOURCE 311 E2SCFMFG	691.	691.	691.	691.	691.	691.	691.
689.	689.	693.	699.	699.	695.	691.	694.
704.	694.	696.	695.	699.	723.	677.	81.
686.	687.	688.	687.	687.	690.	690.	688.
688.	687.	689.	690.	688.	685.	684.	683.
OFFER # 14, SOURCE 315 E2SCFMNG	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
OFFER # 15, SOURCE 504 A/O 5 IN	440.	440.	440.	440.	441.	441.	442.
439.	439.	439.	440.	440.	441.	441.	442.
438.	442.	442.	439.	437.	437.	430.	424.
437.	437.	437.	436.	435.	435.	435.	435.
435.	435.	435.	435.	435.	436.	437.	437.
OFFER # 16, SOURCE 515 PEN VAC	-62.	-62.	-62.	-62.	-61.	-59.	-61.
-62.	-62.	-62.	-62.	-62.	-61.	-59.	-61.
-60.	-59.	-57.	-58.	-57.	-47.	-44.	-4.
-59.	-61.	-61.	-61.	-61.	-61.	-61.	-62.
-61.	-61.	-61.	-61.	-61.	-61.	-61.	-60.

1-20-95

\* GPU Sample Time

1-20-95

MAR 30 '95 10:52

FROM INTL FUEL CELLS B

TO 92986399

PAGE.003

14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
DIFFER # 11, SOURCE 511 S/B SCFM	1953.,	TRIGGER	914				
1953.	1953.	1953.	1953.	1953.	1953.	1953.	1953.
1953.	1953.	1954.	1952.	1952.	1953.	1953.	1953.
1953.	1952.	1953.	1953.	1953.	1953.	1952.	1953.
1953.	1953.	1953.	1953.	1953.	1953.	1953.	1954.
DIFFER # 12, SOURCE 309 E2 GKW	1926.,	TRIGGER	914				
1917.	1927.	1928.	1935.	1921.	1919.	1931.	1944.
1946.	1934.	1940.	1937.	1930.	1933.	1931.	1936.
1935.	1928.	1926.	1928.	1921.	1919.	1927.	1938.
1928.	1918.	1917.	1918.	1910.	1912.	1930.	1938.
DIFFER # 13, SOURCE 311 E2SCFMFG	695.,	TRIGGER	914				
694.	696.	694.	695.	694.	694.	695.	695.
697.	696.	695.	693.	699.	702.	697.	700.
701.	702.	703.	704.	704.	704.	707.	710.
707.	705.	705.	706.	705.	704.	704.	702.
DIFFER # 14, SOURCE 315 E2SCFMNG	14.,	TRIGGER	914				
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
DIFFER # 15, SOURCE S04 A/O 8 IN	443.,	TRIGGER	914				
442.	441.	442.	442.	441.	441.	441.	442.
442.	442.	442.	441.	440.	440.	440.	441.
441.	441.	441.	441.	440.	440.	440.	439.
439.	439.	438.	438.	439.	439.	440.	440.
DIFFER # 16, SOURCE 515 PEN VAC	-66.,	TRIGGER	914				
-65.	-65.	-65.	-65.	-65.	-65.	-65.	-65.
-65.	-64.	-64.	-64.	-65.	-65.	-64.	-64.
-64.	-64.	-64.	-64.	-64.	-64.	-64.	-64.
-64.	-64.	-64.	-64.	-64.	-64.	-64.	-63.

1.24.95

Cwe=441

lower HV. 433

H-A5



MAR 30 '95 10:52

FROM INTL FUEL CELLS B

TO 92986399

PAGE.004

14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	13.
13.	13.	13.	14.	14.	15.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
JFFER # 11, SOURCE 511 S/B SCFM 1982., TRIGGER 914							
1982.	1983.	1982.	1982.	1982.	1982.	1982.	1983.
1982.	1983.	1978.	1981.	1981.	1979.	1928.	1953.
1953.	1952.	1952.	1953.	1953.	1953.	1952.	1953.
1953.	1953.	1953.	1953.	1953.	1953.	1953.	1953.
JFFER # 12, SOURCE 309 E2 GKW 1910., TRIGGER 914							
1909.	1915.	1915.	1914.	1907.	1901.	1912.	1913.
1917.	1927.	1933.	1945.	1952.	1951.	1942.	1929.
1927.	1930.	1931.	1925.	1923.	1923.	1927.	1926.
1917.	1927.	1928.	1935.	1921.	1919.	1931.	1944.
JFFER # 13, SOURCE 311 E2SCFMFG 691., TRIGGER 914							
692.	694.	695.	694.	694.	694.	695.	694.
691.	690.	693.	692.	694.	696.	703.	692.
691.	692.	693.	717.	738.	769.	711.	695.
694.	696.	694.	695.	694.	694.	695.	695.
JFFER # 14, SOURCE 315 E2SCFMNG 14., TRIGGER 914							
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	15.	15.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
JFFER # 15, SOURCE 504 A/O B IN 445., TRIGGER 914							
445.	445.	445.	445.	444.	444.	444.	445.
445.	445.	445.	442.	442.	443.	443.	443.
444.	444.	443.	443.	443.	444.	444.	443.
442.	441.	442.	442.	441.	441.	441.	442.
JFFER # 16, SOURCE 515 PEN VAC -66., TRIGGER 914							
-66.	-66.	-67.	-66.	-67.	-66.	-66.	-66.
-66.	-65.	-65.	-65.	-65.	-65.	-64.	-66.
-66.	-66.	-66.	-65.	-59.	-53.	-62.	-66.
-65.	-65.	-65.	-65.	-65.	-65.	-65.	-65.

\*  
445

1.25.95

higher H.V. are 444  
low H.V are 436

\* GPU Sample

1-25-95

MAR 27 '95 08:16

FROM INTL FUEL CELLS B

TO 92986399

PAGE.005

14.	12.	13.	13.	13.	3.	0.	5.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
OFFER # 11, SOURCE 511 S/B SCFM	1883.	1883.	1883.	1883.	1883.	1855.	1813.
1883.	1883.	1883.	1883.	1883.	1883.	1855.	1813.
1845.	1199.	1974.	1982.	1981.	1783.	1700.	1800.
1982.	1982.	1982.	1982.	1982.	1982.	1983.	1982.
1982.	1983.	1982.	1982.	1982.	1982.	1982.	1983.
OFFER # 12, SOURCE 309 E2 GKW	1930.	1930.	1930.	1930.	1930.	1930.	1930.
1920.	1911.	1916.	1915.	1905.	1903.	1908.	1912.
1915.	1594.	1890.	1914.	1911.	1912.	1902.	1898.
1898.	1906.	1904.	1905.	1908.	1907.	1924.	1910.
1909.	1915.	1915.	1914.	1907.	1901.	1912.	1913.
OFFER # 13, SOURCE 311 E2SCFMFG	687.	687.	687.	687.	687.	687.	687.
686.	685.	685.	684.	682.	678.	689.	696.
701.	611.	684.	686.	689.	715.	715.	708.
690.	689.	687.	687.	689.	689.	692.	691.
692.	694.	695.	694.	694.	694.	695.	694.
OFFER # 14, SOURCE 315 E2SCFMNG	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	12.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
OFFER # 15, SOURCE 504 A/O B IN	439.	439.	439.	439.	439.	439.	439.
440.	440.	439.	439.	442.	444.	445.	445.
447.	444.	444.	445.	445.	445.	445.	445.
446.	446.	446.	446.	446.	446.	446.	446.
445.	445.	445.	445.	444.	444.	444.	445.
OFFER # 16, SOURCE 515 PEN VAC	-65.	-65.	-65.	-65.	-65.	-65.	-65.
-65.	-65.	-65.	-65.	-65.	-65.	-62.	-56.
-58.	-61.	-65.	-66.	-67.	-52.	-46.	-56.
-67.	-66.	-66.	-66.	-66.	-66.	-66.	-66.
-66.	-66.	-67.	-66.	-67.	-66.	-66.	-66.

1.26.95

\* GPU sample

H-A7

MAR 30 '95 10:53

FROM INTL FUEL CELLS B

TO 92986399

PAGE.005

13.	13.	13.	13.	13.	13.	13.	14.
14.	12.	13.	13.	13.	3.	0.	5.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
OFFER # 11, SOURCE 511 S/B SCFM 1883., TRIGGER 914							
1883.	1883.	1883.	1883.	1883.	1883.	1855.	1813.
1845.	1199.	1974.	1982.	1981.	1783.	1700.	1800.
1982.	1982.	1982.	1982.	1982.	1982.	1983.	1982.
1982.	1983.	1982.	1982.	1982.	1982.	1982.	1983.
OFFER # 12, SOURCE 309 E2 GKW 1930., TRIGGER 914							
1920.	1911.	1916.	1915.	1905.	1903.	1908.	1912.
1915.	1594.	1890.	1914.	1911.	1912.	1902.	1898.
1898.	1906.	1904.	1905.	1908.	1907.	1924.	1910.
1909.	1915.	1915.	1914.	1907.	1901.	1912.	1913.
OFFER # 13, SOURCE 311 E2SCFMFG 687., TRIGGER 914							
686.	685.	685.	684.	682.	678.	689.	696.
701.	611.	684.	686.	689.	715.	715.	708.
690.	689.	687.	687.	689.	689.	692.	691.
692.	694.	695.	694.	694.	694.	695.	694.
OFFER # 14, SOURCE 315 E2SCFMNG 14., TRIGGER 914							
14.	14.	14.	14.	14.	14.	14.	14.
14.	12.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
OFFER # 15, SOURCE 504 A/O B IN 439., TRIGGER 914							
440.	440.	439.	439.	442.	444.	445.	445.
447.	444.	444.	445.	445.	445.	445.	445.
446.	446.	446.	446.	446.	446.	446.	445.
445.	445.	445.	445.	444.	444.	444.	445.
OFFER # 16, SOURCE 515 PEN VAC -65., TRIGGER 914							
-65.	-65.	-65.	-65.	-65.	-65.	-62.	-56.
-58.	-61.	-65.	-66.	-67.	-52.	-46.	-56.
-67.	-66.	-66.	-66.	-66.	-66.	-66.	-66.
-66.	-66.	-67.	-66.	-67.	-66.	-66.	-66.

1.26.95

H.H.V. 444

L.H.V. 436

*Pen*  
1.26.95

MAR 30 '95 10:53

FROM INTL FUEL CELLS B

TO 92986399

PAGE.006

10.	13.	13.	13.	11.	12.	13.	13.
13.	13.	13.	13.	13.	13.	13.	13.
13.	13.	13.	13.	13.	13.	13.	13.
13.	13.	13.	13.	13.	13.	13.	14.
FFER # 11, SOURCE 511 S/B SCFM 1802., TRIGGER 914							
1802.	1802.	1802.	1803.	1802.	1802.	1803.	1803.
1803.	1803.	1758.	1685.	610.	1207.	1884.	1883.
1883.	1883.	1883.	1883.	1884.	1883.	1883.	1883.
1883.	1883.	1883.	1883.	1883.	1883.	1855.	1813.
FFER # 12, SOURCE 309 E2 GKW 1894., TRIGGER 914							
1898.	1896.	1899.	1910.	1909.	1898.	1913.	1903.
1910.	1916.	1913.	1382.	0.	710.	1925.	1921.
1924.	1928.	1936.	1926.	1926.	1918.	1923.	1930.
1920.	1911.	1916.	1915.	1905.	1903.	1908.	1912.
FFER # 13, SOURCE 311 E2SCFMFG 676., TRIGGER 914							
677.	677.	677.	678.	678.	675.	673.	671.
670.	673.	666.	524.	0.	265.	688.	689.
689.	689.	687.	687.	687.	686.	686.	687.
686.	685.	685.	684.	682.	678.	689.	696.
FFER # 14, SOURCE 315 E2SCFMNG 14., TRIGGER 914							
14.	14.	14.	14.	14.	13.	13.	13.
13.	13.	13.	10.	0.	5.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
FFER # 15, SOURCE 504 A/O B IN 436., TRIGGER 914							
436.	436.	436.	437.	438.	438.	439.	440.
441.	439.	437.	438.	431.	428.	435.	435.
436.	436.	437.	437.	437.	438.	439.	439.
440.	440.	439.	439.	442.	444.	445.	445.
FFER # 16, SOURCE 515 PEN VAC -67., TRIGGER 914							
-67.	-67.	-67.	-67.	-67.	-66.	-66.	-66.
-65.	-65.	-65.	-64.	-68.	-64.	-64.	-64.
-64.	-64.	-64.	-64.	-64.	-64.	-64.	-65.
-65.	-65.	-65.	-65.	-65.	-65.	-62.	-56.

1.27.95

HHV 437

LHV 429

MAR 30 '95 10:53

FROM INTL FUEL CELLS B

TO 92986399

PAGE.005

13.	13.	13.	13.	13.	13.	13.	14.
14.	12.	13.	13.	13.	3.	0.	5.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
OFFER # 11, SOURCE 511 S/B SCFM 1883., TRIGGER 914							
1883.	1883.	1883.	1883.	1883.	1883.	1855.	1813.
1845.	1199.	1974.	1982.	1981.	1783.	1700.	1800.
1982.	1982.	1982.	1982.	1982.	1982.	1983.	1982.
1982.	1983.	1982.	1982.	1982.	1982.	1982.	1983.
OFFER # 12, SOURCE 309 E2 GKW 1930., TRIGGER 914							
1920.	1911.	1916.	1915.	1905.	1903.	1908.	1912.
1915.	1594.	1890.	1914.	1911.	1912.	1902.	1898.
1898.	1906.	1904.	1905.	1908.	1907.	1924.	1910.
1909.	1915.	1915.	1914.	1907.	1901.	1912.	1913.
OFFER # 13, SOURCE 311 E2SCFMFG 687., TRIGGER 914							
686.	685.	685.	684.	682.	678.	689.	696.
701.	611.	684.	686.	689.	715.	715.	708.
690.	689.	687.	687.	689.	689.	692.	691.
692.	694.	695.	694.	694.	694.	695.	694.
OFFER # 14, SOURCE 315 E2SCFMNG 14., TRIGGER 914							
14.	14.	14.	14.	14.	14.	14.	14.
14.	12.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
OFFER # 15, SOURCE 504 A/O B IN 439., TRIGGER 914							
440.	440.	439.	439.	442.	444.	445.	445.
447.	444.	444.	445.	445.	445.	445.	445.
446.	446.	446.	446.	446.	446.	446.	445.
445.	445.	445.	445.	444.	444.	444.	445.
OFFER # 16, SOURCE 515 PEN VAC -65., TRIGGER 914							
-65.	-65.	-65.	-65.	-65.	-65.	-62.	-56.
-58.	-61.	-65.	-66.	-67.	-52.	-46.	-56.
-67.	-66.	-66.	-66.	-66.	-66.	-66.	-66.
-66.	-66.	-67.	-66.	-67.	-66.	-66.	-66.

1.26.95

H.H.V. 444

L.H.V. 436

MAR 30 '95 10:54

FROM INTL FUEL CELLS B

TO 92986399

PAGE.008

14.	14.	14.	14.	14.	13.	13.	13.
13.	13.	13.	13.	13.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
FFER # 11, SOURCE 511 S/B SCFM	1926.	1926.	1926.	1926.	1924.	1925.	1926.
926.	1926.	1926.	1926.	1926.	1924.	1925.	1926.
926.	1926.	1926.	1928.	1924.	1928.	1926.	1925.
926.	1926.	1926.	1926.	1923.	1926.	1926.	1926.
926.	1926.	1926.	1926.	1926.	1926.	1926.	1926.
FFER # 12, SOURCE 309 E2 GKW	1932.	1932.	1932.	1932.	1932.	1932.	1932.
920.	1919.	1909.	1922.	1917.	1914.	1924.	1917.
919.	1919.	1924.	1914.	1907.	1918.	1913.	1906.
934.	1917.	1934.	1934.	1924.	1927.	1923.	1918.
917.	1929.	1926.	1925.	1933.	1934.	1932.	1934.
FFER # 13, SOURCE 311 E2SCFMFG	732.	732.	732.	732.	732.	732.	732.
731.	729.	729.	731.	730.	729.	727.	723.
723.	723.	723.	725.	722.	725.	724.	717.
699.	696.	699.	699.	698.	698.	696.	695.
696.	697.	696.	697.	697.	698.	694.	693.
FFER # 14, SOURCE 315 E2SCFMNG	15.	15.	15.	15.	15.	15.	15.
15.	15.	15.	15.	15.	15.	15.	14.
14.	14.	14.	15.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
FFER # 15, SOURCE 504 A/O 8 IN	436.	436.	436.	436.	436.	436.	436.
436.	436.	436.	437.	437.	438.	439.	439.
439.	439.	438.	437.	436.	436.	437.	436.
437.	437.	437.	437.	437.	437.	437.	437.
438.	438.	438.	438.	439.	439.	440.	440.
FFER # 16, SOURCE 515 PEN VAC	-66.	-66.	-66.	-66.	-66.	-66.	-66.
-66.	-66.	-66.	-66.	-66.	-65.	-65.	-64.
-64.	-64.	-64.	-65.	-65.	-65.	-66.	-66.
-66.	-65.	-65.	-66.	-66.	-66.	-65.	-66.
-66.	-66.	-65.	-66.	-65.	-66.	-65.	-65.

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MAR 30 '95 10:53

FROM INTL FUEL CELLS B

TO 92986399

PAGE.007

14.	14.	14.	14.	14.	14.	14.	14.
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14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
OFFER # 11, SOURCE 511 S/B SCFM	1926.	1926.	1926.	1926.	1926.	1926.	1926.
1926.	1926.	1926.	1926.	1926.	1926.	1926.	1926.
1926.	1926.	1926.	1927.	1926.	1925.	1926.	1926.
1925.	1926.	1925.	1925.	1926.	1925.	1925.	1926.
1925.	1926.	1925.	1926.	1926.	1926.	1926.	1926.
OFFER # 12, SOURCE 309 E2 GKW	1918.	1918.	1918.	1918.	1918.	1918.	1918.
1917.	1929.	1926.	1925.	1933.	1934.	1932.	1934.
1929.	1934.	1923.	1917.	1915.	1919.	1932.	1919.
1931.	1917.	1933.	1931.	1935.	1930.	1916.	1915.
1903.	1917.	1926.	1930.	1919.	1917.	1939.	1941.
OFFER # 13, SOURCE 311 E2SCFMFG	695.	695.	695.	695.	695.	695.	695.
696.	697.	696.	697.	697.	698.	694.	693.
691.	691.	690.	690.	690.	690.	692.	693.
695.	693.	697.	698.	697.	700.	697.	697.
695.	698.	699.	699.	699.	698.	699.	698.
OFFER # 14, SOURCE 315 E2SCFMNG	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
OFFER # 15, SOURCE 504 A/O B IN	437.	437.	437.	437.	437.	437.	437.
438.	438.	438.	438.	439.	439.	440.	440.
440.	440.	439.	438.	437.	437.	437.	437.
437.	438.	438.	437.	438.	438.	438.	438.
438.	438.	438.	439.	439.	438.	439.	439.
OFFER # 16, SOURCE 515 PEN VAC	-66.	-66.	-66.	-66.	-66.	-66.	-66.
-66.	-66.	-65.	-66.	-65.	-66.	-65.	-65.
-64.	-64.	-64.	-65.	-65.	-65.	-66.	-66.
-66.	-65.	-66.	-65.	-66.	-66.	-66.	-66.
-66.	-66.	-66.	-66.	-66.	-66.	-65.	-65.

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HHV 438  
LHV 430

MAR 30 '95 10:54

FROM INTL FUEL CELLS B

TO 92986399

PAGE.010

14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
FFER # 11, SOURCE 511 S/B SCFM	2001.,	TRIGGER	914				
000.	2001.	2001.	2000.	2001.	2001.	2001.	2001.
000.	2001.	2002.	2001.	2000.	2001.	2000.	2001.
000.	2000.	2001.	2000.	2000.	2001.	2001.	2001.
001.	2000.	2000.	2000.	2001.	2001.	2001.	2001.
FFER # 12, SOURCE 309 E2 GKW	1936.,	TRIGGER	914				
936.	1926.	1929.	1927.	1925.	1937.	1952.	1947.
930.	1925.	1931.	1929.	1937.	1935.	1949.	1926.
927.	1926.	1928.	1937.	1935.	1946.	1947.	1935.
931.	1926.	1933.	1937.	1932.	1927.	1932.	1951.
FFER # 13, SOURCE 311 E2SCFMFG	709.,	TRIGGER	914				
709.	708.	708.	706.	707.	708.	708.	703.
702.	700.	698.	699.	701.	706.	709.	709.
706.	706.	705.	705.	705.	706.	706.	706.
704.	703.	706.	706.	704.	702.	699.	701.
FFER # 14, SOURCE 315 E2SCFMNG	14.,	TRIGGER	914				
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
FFER # 15, SOURCE 606 LFGBTUAV	427.,	TRIGGER	914				
427.	426.	427.	428.	429.	430.	431.	431.
431.	431.	430.	429.	429.	430.	429.	430.
431.	432.	432.	432.	432.	432.	432.	432.
432.	432.	432.	433.	434.	434.	435.	435.
FFER # 16, SOURCE 515 PEN VAC	-58.,	TRIGGER	914				
-58.	-58.	-58.	-58.	-58.	-58.	-58.	-57.
-57.	-57.	-57.	-57.	-58.	-58.	-58.	-58.
-58.	-58.	-58.	-58.	-58.	-58.	-58.	-58.
-58.	-58.	-58.	-58.	-58.	-58.	-57.	-57.

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MAR 30 '95 10:55

FROM INTL FUEL CELLS B

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PAGE.011

14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
BUFFER # 11, SOURCE S11 S/B SCFM 2004., TRIGGER 914							
2004.	2004.	2003.	2003.	2004.	2004.	2003.	2006.
2002.	2004.	2004.	2005.	2003.	2003.	2003.	1815.
1796.	2001.	2000.	2000.	2001.	2000.	2000.	2001.
2000.	2001.	2001.	2000.	2001.	2001.	2001.	2001.
BUFFER # 12, SOURCE 309 E2 GKW 1915., TRIGGER 914							
1916.	1930.	1932.	1949.	1936.	1935.	1940.	1940.
1931.	1923.	1933.	1946.	1940.	1939.	1935.	1334.
1937.	1943.	1946.	1949.	1947.	1950.	1944.	1936.
1936.	1926.	1929.	1927.	1925.	1937.	1952.	1947.
BUFFER # 13, SOURCE 311 E2SCFMFG 710., TRIGGER 914							
708.	711.	711.	711.	705.	705.	706.	703.
698.	698.	698.	702.	704.	703.	706.	543.
730.	709.	710.	710.	710.	711.	710.	709.
709.	708.	708.	706.	707.	708.	708.	703.
BUFFER # 14, SOURCE 315 E2SCFMNG 14., TRIGGER 914							
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	11.
15.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
BUFFER # 15, SOURCE 606 LFGBTUAV 433., TRIGGER 914							
433.	433.	432.	433.	433.	434.	434.	434.
433.	433.	432.	431.	428.	426.	426.	424.
426.	427.	428.	428.	427.	427.	427.	427.
427.	426.	427.	428.	429.	430.	431.	431.
BUFFER # 16, SOURCE S15 PEN VAC -58., TRIGGER 914							
-57.	-58.	-58.	-58.	-58.	-58.	-58.	-57.
-57.	-57.	-56.	-57.	-57.	-57.	-58.	-52.
-50.	-58.	-58.	-58.	-58.	-58.	-58.	-58.
-58.	-58.	-58.	-58.	-58.	-58.	-58.	-57.

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MAR 30 '95 10:55

FROM INTL FUEL CELLS B

TO 92986399

PAGE.012

14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
OFFER # 11, SOURCE 511 S/B SCFM 2004., TRIGGER 914							
2003.	2004.	2004.	2003.	2004.	2003.	2004.	2004.
2004.	2004.	2004.	2004.	2004.	2004.	2003.	2004.
2004.	2003.	2004.	2004.	2004.	2003.	2004.	2004.
2004.	2004.	2003.	2003.	2004.	2004.	2003.	2006.
OFFER # 12, SOURCE 309 E2 GKW 1936., TRIGGER 914							
1940.	1947.	1939.	1941.	1926.	1927.	1932.	1935.
1940.	1948.	1931.	1928.	1926.	1928.	1930.	1937.
1935.	1947.	1936.	1941.	1947.	1933.	1938.	1915.
1916.	1930.	1932.	1949.	1936.	1935.	1940.	1940.
OFFER # 13, SOURCE 311 E2SCFMFG 707., TRIGGER 914							
708.	709.	708.	704.	703.	704.	704.	704.
703.	698.	700.	699.	700.	701.	705.	706.
704.	706.	705.	708.	708.	711.	711.	710.
708.	711.	711.	711.	705.	705.	706.	703.
OFFER # 14, SOURCE 315 E2SCFMNG 14., TRIGGER 914							
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
OFFER # 15, SOURCE 606 LFGBTUAV 432., TRIGGER 914							
433.	433.	433.	433.	434.	434.	434.	435.
434.	434.	433.	432.	431.	431.	431.	432.
432.	433.	433.	433.	432.	433.	433.	433.
433.	433.	432.	433.	433.	434.	434.	434.
OFFER # 16, SOURCE 515 PEN VAC -58., TRIGGER 914							
-58.	-58.	-58.	-58.	-58.	-58.	-58.	-57.
-57.	-57.	-57.	-57.	-58.	-58.	-58.	-58.
-58.	-58.	-58.	-57.	-58.	-58.	-58.	-58.
-57.	-58.	-58.	-58.	-58.	-58.	-58.	-57.

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MAR 30 '95 10:55			FROM INTL FUEL CELLS B			TO 92986399	
...	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
OFFER # 11, SOURCE 511 S/B SCFM 2003., TRIGGER 914							
2003.	2004.	2003.	2004.	2003.	2004.	2004.	2005.
2005.	2004.	2006.	2003.	2003.	2004.	2004.	2004.
2003.	2003.	2004.	2004.	2003.	2003.	2004.	2004.
2003.	2004.	2004.	2003.	2004.	2003.	2004.	2004.
OFFER # 12, SOURCE 309 E2 GKW 1939., TRIGGER 914							
1935.	1912.	1918.	1914.	1917.	1927.	1938.	1933.
1934.	1922.	1920.	1923.	1920.	1922.	1927.	1926.
1938.	1934.	1930.	1931.	1943.	1945.	1925.	1936.
1940.	1947.	1939.	1941.	1926.	1927.	1932.	1935.
OFFER # 13, SOURCE 311 E2SCFMFG 709., TRIGGER 914							
709.	709.	709.	704.	701.	702.	702.	699.
696.	696.	693.	696.	698.	701.	702.	702.
703.	703.	705.	709.	708.	706.	706.	707.
708.	709.	708.	704.	703.	704.	704.	704.
OFFER # 14, SOURCE 315 E2SCFMNG 14., TRIGGER 914							
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
OFFER # 15, SOURCE 606 LFGBTUAV 433., TRIGGER 914							
432.	431.	430.	432.	434.	434.	434.	435.
435.	435.	434.	433.	432.	432.	432.	433.
433.	433.	433.	433.	433.	433.	432.	432.
433.	433.	433.	433.	434.	434.	434.	435.
OFFER # 16, SOURCE 515 PEN VAC -58., TRIGGER 914							
-58.	-58.	-59.	-59.	-58.	-58.	-58.	-58.
-57.	-57.	-57.	-57.	-58.	-58.	-58.	-58.
-58.	-58.	-58.	-58.	-58.	-58.	-58.	-58.
-58.	-58.	-58.	-58.	-58.	-58.	-58.	-57.

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HHV 433  
LHV 425

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FROM INTL FUEL CELLS B

TO 92986399

PAGE.014

...	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
FFER # 11, SOURCE 511 S/B SCFM	2003.	2003.	2003.	2003.	2003.	2003.	2003.
2004.	2003.	2004.	2004.	2004.	2003.	2003.	2003.
2003.	2004.	2003.	2004.	2003.	2004.	2003.	2003.
2004.	2003.	2004.	2003.	2004.	2003.	2003.	2003.
2003.	2004.	2003.	2004.	2003.	2004.	2004.	2005.
FFER # 12, SOURCE 309 E2 GKW	1933.	1933.	1933.	1933.	1933.	1933.	1933.
1927.	1923.	1930.	1935.	1929.	1930.	1934.	1938.
1945.	1938.	1947.	1936.	1944.	1944.	1948.	1941.
1927.	1928.	1929.	1924.	1941.	1940.	1933.	1939.
1935.	1912.	1918.	1914.	1917.	1927.	1938.	1933.
FFER # 13, SOURCE 311 E2SCFMFG	697.	697.	697.	697.	697.	697.	697.
696.	695.	698.	699.	697.	697.	699.	702.
707.	705.	703.	699.	699.	698.	702.	702.
702.	707.	706.	708.	709.	707.	709.	709.
709.	709.	709.	704.	701.	702.	702.	699.
FFER # 14, SOURCE 315 E2SCFMNG	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
FFER # 15, SOURCE 606 LFGBTUAV	435.	435.	435.	435.	434.	434.	434.
435.	435.	435.	435.	435.	434.	434.	434.
429.	432.	433.	432.	432.	430.	432.	433.
432.	432.	428.	432.	432.	431.	433.	433.
432.	431.	430.	432.	434.	434.	434.	435.
FFER # 16, SOURCE 515 PEN VAC	-58.	-58.	-58.	-58.	-58.	-58.	-58.
-58.	-58.	-58.	-58.	-58.	-58.	-58.	-58.
-58.	-58.	-58.	-57.	-58.	-58.	-58.	-58.
-58.	-58.	-58.	-58.	-58.	-58.	-58.	-58.
-58.	-58.	-59.	-59.	-58.	-58.	-58.	-58.

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HNV 433

LNU 425

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MAR 30 '95 10:56

FROM INTL FUEL CELLS B

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PAGE.015

14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
DIFFER # 11, SOURCE 511 S/B SCFM	2003.	2004.	2004.	2003.	2004.	2004.	2005.
2003.	2004.	2004.	2004.	2003.	2004.	2004.	2005.
2004.	2004.	2003.	2004.	2004.	2004.	2003.	2003.
2004.	2004.	2004.	2003.	2003.	2003.	2004.	2003.
2004.	2003.	2004.	2004.	2004.	2003.	2003.	2003.
DIFFER # 12, SOURCE 309 E2 GKW	1921.	1929.	1932.	1939.	1931.	1925.	1925.
1921.	1929.	1932.	1939.	1931.	1925.	1925.	1941.
1937.	1925.	1931.	1968.	1972.	1960.	1938.	1939.
1930.	1935.	1926.	1934.	1935.	1937.	1940.	1933.
1927.	1923.	1930.	1935.	1929.	1930.	1934.	1938.
DIFFER # 13, SOURCE 311 E2SCFMFG	703.	705.	704.	704.	704.	703.	699.
703.	705.	704.	704.	704.	703.	699.	698.
697.	697.	696.	700.	700.	698.	696.	693.
693.	696.	694.	694.	697.	700.	699.	697.
696.	695.	698.	699.	697.	697.	699.	702.
DIFFER # 14, SOURCE 315 E2SCFMNG	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
14.	14.	14.	14.	14.	14.	14.	14.
DIFFER # 15, SOURCE 606 LFG8TUAV	433.	433.	434.	435.	435.	436.	436.
433.	433.	434.	435.	435.	436.	436.	437.
438.	438.	438.	438.	439.	439.	438.	439.
439.	439.	439.	438.	438.	437.	436.	435.
435.	435.	435.	435.	435.	434.	434.	434.
DIFFER # 16, SOURCE 515 PEN VAC	-59.	-59.	-59.	-59.	-59.	-58.	-58.
-59.	-59.	-59.	-59.	-59.	-59.	-58.	-58.
-58.	-58.	-58.	-58.	-59.	-59.	-59.	-59.
-59.	-58.	-58.	-58.	-58.	-58.	-58.	-58.
-58.	-58.	-58.	-58.	-58.	-58.	-58.	-58.

2.15.95  
HHV 437  
LHV 429

Row 15-91

## **SUB-APPENDIX B**

### **GPU EXIT HEAT CONTENT ANALYTICAL DATA – ASTM METHOD**

10669 RICHMOND AVENUE, SUITE 100, HOUSTON, TEXAS 77042  
P.O. BOX 741905, HOUSTON, TEXAS 77274

TEL: (713) 789-5591  
FAX: (713) 789-5593

<b>CLIENT:</b>	Environmental Solutions	<b>REQUESTED BY:</b>	Mr. Ken Pierce
<b>SAMPLE:</b>	GPU Out 11995 Btu-1 (1-19-95) 16:44	<b>REPORT DATE:</b>	February 6, 1995
<b>LABORATORY NO:</b>	4690 A	<b>PROJECT NAME:</b>	IFC, 2030-6
		<b>PURCHASE ORDER NO:</b>	P9-41038

<b>TEST</b>	<b>RESULTS</b>
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Natural Gas Analysis by Gas Chromatography, ASTM D 1945:

	<u><b>MOI %</b></u>	<u><b>GPM @ 14.650 psia</b></u>
Nitrogen	16.266	
Carbon Dioxide	39.542	
Methane	44.165	
Ethane	0.024	0.006
Propane	NIL	NIL
Iso-butane	NIL	NIL
N-butane	NIL	NIL
Iso-pentane	NIL	NIL
N-pentane	NIL	NIL
Hexanes	NIL	NIL
Heptanes plus	<u>0.003</u>	<u>0.001</u>
	100.000	0.007

Specific Gravity @ 60°F (air = 1)	1.0050
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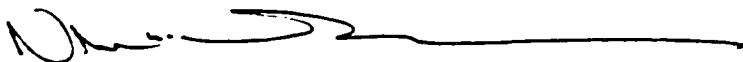
Calculated Btu/cu. ft. @ 14.650 psia and 60°F:

Dry basis	446
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Wet basis	438
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Z Factor	0.9978
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Respectfully Submitted,



Nader M. Sorurbakhsh, P.E.  
Laboratory Director

10669 RICHMOND AVENUE, SUITE 100, HOUSTON, TEXAS 77042  
P.O. BOX 741905, HOUSTON, TEXAS 77274

TEL: (713) 789-5591  
FAX: (713) 789-5593

<b>CLIENT:</b>	Environmental Solutions	<b>REQUESTED BY:</b>	Mr. Ken Pierce
<b>SAMPLE:</b>	GPU Out 12095 Btu-1 (1-20-95) 09:27	<b>REPORT DATE:</b>	February 6, 1995
<b>LABORATORY NO:</b>	4690 H	<b>PROJECT NAME:</b>	IFC, 2030-6
		<b>PURCHASE ORDER NO:</b>	P9-41038

<b>TEST</b>	<b>RESULTS</b>
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Natural Gas Analysis by Gas Chromatography, ASTM D 1945:

	<u>MOL %</u>	<u>GPM @ 14.650 psia</u>
Nitrogen	17.251	
Carbon Dioxide	38.896	
Methane	43.807	
Ethane	0.029	0.008
Propane	NIL	NIL
Iso-butane	NIL	NIL
N-butane	NIL	NIL
Iso-pentane	0.001	NIL
N-pentane	0.001	NIL
Hexanes	0.015	0.006
Heptanes plus	<u>NIL</u>	<u>NIL</u>
	100.000	0.014

Specific Gravity @ 60°F (air = 1)	1.0032
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Calculated Btu/cu. ft. @ 14.650 psia and 60°F:

Dry basis	443
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Wet basis	435
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Z Factor	0.9978
----------	--------

Respectfully Submitted,



Nader M. Sorurbakhsh, P.E.  
Laboratory Director



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<b>CLIENT:</b>	Environmental Solutions	<b>REQUESTED BY:</b>	Mr. Ken Pierce
<b>SAMPLE:</b>	GPU Out 12595 Btu-1 (1-25-95) 16:09	<b>REPORT DATE:</b>	February 6, 1995
<b>LABORATORY NO:</b>	4699 A	<b>PROJECT NAME:</b>	IFC, 2030-6
		<b>PURCHASE ORDER NO:</b>	P9-41038

**TEST**

**RESULTS**

Natural Gas Analysis by Gas Chromatography, ASTM D 1945:

	<u>MOL %</u>	<u>GPM @ 14.650 psia</u>
Nitrogen	16.244	
Carbon Dioxide	39.555	
Methane	44.142	
Ethane	0.049	0.012
Propane	NIL	NIL
Iso-butane	NIL	NIL
N-butane	NIL	NIL
Iso-pentane	NIL	NIL
N-pentane	NIL	NIL
Hexanes	NIL	NIL
Heptanes plus	<u>NIL</u>	<u>NIL</u>
	100.000	0.012

Specific Gravity @ 60°F (air = 1) 1.0052


Calculated Btu/cu. ft. @ 14.650 psia and 60°F:

Dry basis 445

Wet basis 437

Z Factor 0.9978

Respectfully Submitted,



Nader M. Sorurbakhsh, P.E.  
Laboratory Director

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FAX: (713) 789-5593

<b>CLIENT:</b>	Environmental Solutions	<b>REQUESTED BY:</b>	Mr. Ken Pierce
<b>SAMPLE:</b>	GPU Out 12695 Btu-1 (1-26-95) 08:31	<b>REPORT DATE:</b>	February 6, 1995
<b>LABORATORY NO:</b>	4699 B	<b>PROJECT NAME:</b>	IFC, 2030-6
		<b>PURCHASE ORDER NO:</b>	P9-41038

<b>TEST</b>	<b>RESULTS</b>
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Natural Gas Analysis by Gas Chromatography, ASTM D 1945:

	<u>MOL %</u>	<u>GPM @ 14.650 psia</u>
Nitrogen	16.340	
Carbon Dioxide	39.531	
Methane	44.092	
Ethane	0.037	0.010
Propane	NIL	NIL
Iso-butane	NIL	NIL
N-butane	NIL	NIL
Iso-pentane	NIL	NIL
N-pentane	NIL	NIL
Hexanes	NIL	NIL
Heptanes plus	<u>NIL</u>	<u>NIL</u>
	100.000	0.010

Specific Gravity @ 60°F (air = 1)	1.0053
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Calculated Btu/cu. ft. @ 14.650 psia and 60°F:

Dry basis	444
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Wet basis	436
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Z Factor	0.9978
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Respectfully Submitted,



Nader M. Sorurbakhsh, P.E.  
Laboratory Director

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FAX: (713) 789-5593

<b>CLIENT:</b>	Environmental Solutions	<b>REQUESTED BY:</b>	Mr. Ken Pierce
<b>SAMPLE:</b>	GPU Out 20995 Btu-1 (2-9-95) 10:37	<b>REPORT DATE:</b>	February 15, 1995
<b>LABORATORY NO:</b>	4775 A	<b>PROJECT NAME:</b>	IFC, 2030-6
		<b>PURCHASE ORDER NO:</b>	P9-41038

**TEST****RESULTS**

Natural Gas Analysis by Gas Chromatography, ASTM D 1945:

	<u>MOL %</u>	<u>GPM @ 14.650 psia</u>
Nitrogen	23.888	
Carbon Dioxide	36.042	
Methane	40.070	
Ethane	NIL	NIL
Propane	NIL	NIL
Iso-butane	NIL	NIL
N-butane	NIL	NIL
Iso-pentane	NIL	NIL
N-pentane	NIL	NIL
Hexanes	NIL	NIL
Heptanes plus	<u>NIL</u>	<u>NIL</u>
	100.000	0.000

Specific Gravity @ 60°F (air = 1) 1.0023

Calculated Btu/cu. ft. @ 14.650 psia and 60°F:

Dry basis 404

Wet basis 397

Z Factor 0.9980

Respectfully Submitted,

Nader M. Sorurbakhsh, P.E.  
Laboratory Director

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P.O. BOX 741905, HOUSTON, TEXAS 77274

TEL: (713) 789-5591  
FAX: (713) 789-5593

<b>CLIENT:</b>	Environmental Solutions	<b>REQUESTED BY:</b>	Mr. Ken Pierce
<b>SAMPLE:</b>	GPU Out 21095 Btu-1 (2-10-95) 09:26	<b>REPORT DATE:</b>	February 15, 1995
<b>LABORATORY NO:</b>	4775 B	<b>PROJECT NAME:</b>	IFC, 2030-6
		<b>PURCHASE ORDER NO:</b>	P9-41038

<b>TEST</b>	<b>RESULTS</b>
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Natural Gas Analysis by Gas Chromatography, ASTM D 1945:

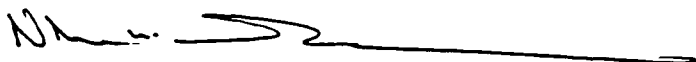
	<u>MOL %</u>	<u>GPM @ 14.650 psia</u>
Nitrogen	17.656	
Carbon Dioxide	38.863	
Methane	43.481	
Ethane	NIL	NIL
Propane	NIL	NIL
Iso-butane	NIL	NIL
N-butane	NIL	NIL
Iso-pentane	NIL	NIL
N-pentane	NIL	NIL
Hexanes	NIL	NIL
Heptanes plus	<u>NIL</u>	<u>NIL</u>
	100.000	0.000

Specific Gravity @ 60°F (air = 1)	1.0040
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Calculated Btu/cu. ft. @ 14.650 psia and 60°F:

Dry basis	439
Wet basis	431
Z Factor	0.9978

Respectfully Submitted,



Nader M. Sorurbakhsh, P.E.  
Laboratory Director

**CLIENT:** Environmental Solutions  
**SAMPLE:** GPU Out 21795 Btu-1  
(2-17-95) 13:33 Gas (Air)  
**LABORATORY NO:** 4835

**REQUESTED BY:** Mr. Ken Pierce  
**REPORT DATE:** February 24, 1995  
**PROJECT NAME:**  
**PURCHASE ORDER NO:** P9-41038

**TEST**

**RESULTS**

Natural Gas Analysis by Gas Chromatography, ASTM D 1945:

	<u>MOL %</u>	<u>GPM @ 14.650 psia</u>
Nitrogen	20.096	
Carbon Dioxide	34.908	
Methane	44.996	
Ethane	NIL	NIL
Propane	NIL	NIL
Iso-butane	NIL	NIL
N-butane	NIL	NIL
Iso-pentane	NIL	NIL
N-pentane	NIL	NIL
Hexanes	NIL	NIL
Heptanes plus	<u>NIL</u>	<u>NIL</u>
	100.000	0.000

Specific Gravity @ 60 °F (air = 1) ..... 0.9757  
Calculated Btu/cu. ft. @ 14.650 psia and 60 °F:  
Dry basis .....454  
Wet basis .....446  
Z Factor ..... 0.9979

Respectfully Submitted,



Nader M. Sorurbakhsh, P.E.  
Laboratory Director

## **SUB-APPENDIX C**

### **POWER PLANT EMISSIONS DATA**

TRC Environmental Corporation  
CEM Data Sheet

Firm IFC Ambient Temp, deg. F = 75  
 Location Penrose MEL Temp, deg. F = 75  
 Tester C. Scott Bar. Pressure, in Hg = 29.24  
 Test No. 1-120 KW Vacuum Gauge = NA  
 Location Fuel Cell Flowrate (lpm) 6  
 Date 2-17-95  
 TIME 0800-0900

Calibration Gases			
Mid Cal	High Cal	TankID	
		Mid	High
CO	50	90.4	ALM38592
O2	10	20.1	ALM022962
CO2	10	20.2	ALM022962
NOx	1.25	2.37	ALM43127
SO2	50	90.7	ALM36593
THC			

	(Rack) Analyzer Cal.	Initial Values			Final Values			Analyzer Range & Units	Avg. Gas Conc.	Corrected Gas Conc.
		System Cal. Response	System Cal. Bias % of Span		System Cal. Response	System Cal. Bias % of Span	Drift % of Span			
CO	Zero	-0.8	-0.6	0.2	-2	-1.2	-1.4	ppm	-	-
	Upscale	87.9	88	0.1	87.7	-0.2	-0.3	100	0.2	1.5
O2	Zero	0.2	0.1	-0.4	0.1	-0.4	0	PERCENT	-	-
	Upscale	20.1	20.1	0	20	-0.4	-0.4	25	8.00	7.96
CO2	Zero	0.1	0.1	0	0.2	0.4	0.4	PERCENT	-	-
	Upscale	20.1	20.2	0.4	20.2	0.4	0	25	12.6	12.5
NOx	Zero	-0.04	0.09	5.2	0.51	22	16.8	ppm	-	-
	Upscale	2.41	2.41	0	2.68	10.8	10.8	2.5	0.61	0.3
SO2	Zero	0.7	-0.1	-0.8	-0.2	-0.9	-0.1	ppm	-	-
	Upscale	89.8	88.5	-1.3	89.4	-0.4	0.9	100	0	0.2
THC	Zero			0		0	0	ppm	-	-
	Upscale			0		0	0	100		ERR
		LIMITS	+/- 5%			+/- 5%	+/- 3%			

	Cal.		
	Cal. Back Analyzer Response	Upstream Analyzer Response	Bias Check % of Span
CO	Zero		0
	Upscale		0
NOx	Zero		0
	Upscale		0
		LIMIT	+/- 5%

	ZERO Cal. Gas Analyzer Response	Analyzer Calib. Error	MID Cal. Gas Analyzer Response	Analyzer Calib. Error	HIGH Cal. Gas Analyzer Response	Analyzer Calib. Error
CO	1.2	1.20	51.8	1.80	90.4	0.00
O2	0	0.00	9.7	-1.20	20.2	0.40
CO2	0.1	0.40	10	0.00	20.1	-0.40
NOx	0.08	3.20	1.42	6.80	2.36	-0.40
SO2	0	0.00	49.8	-0.20	91.1	0.40
THC		0.00		0.00		0.00
		LIMIT	+/- 2%	+/- 2%		+/- 2%

**TRC Environmental Corporation**  
**CEM Data Sheet**

Firm IFC Ambient Temp, deg. F = 75  
 Location Penrose MEL Temp, deg. F = 75  
 Tester C. Scott Bar. Pressure, in Hg = 29.24  
 Test No. 2-120 KW Vacuum Gauge = NA  
 Location Fuel Cell Flowrate (lpm) 6  
 Date 2-17-95  
 TIME 0950-1050

Calibration Gases			
Mid Cal	High Cal	TankID	
		Mid	High
CO	50.7	90.4	ALM25536 ALM38592
O2	12	20.1	CC97847 ALM022962
CO2	6.12	20.2	CC88851 ALM022962
NOx		2.37	ALM43127
SO2	49.6	90.7	ALM25536 ALM36593
THC			

		(Rack) Analyzer Cal.	Initial Values		Final Values		Drift  % of Span	Analyzer Range & Units	Avg. Gas Conc.	Corrected Gas Conc.
			System Cal. Response	System Cal. Bias % of Span	System Cal. Response	System Cal. Bias % of Span				
CO	Zero	-0.8	1.1	1.9	-0.4	0.4	-1.5	ppm	-	-
	Upscale	87.9	87.7	-0.2	87.9	0	0.2	100	2.1	1.8
O2	Zero	0.2	0	-0.8	0.1	-0.4	0.4	PERCENT	-	-
	Upscale	20.1	20	-0.4	20	-0.4	0	25	8.00	8.01
CO2	Zero	0.1	0.1	0	0.2	0.4	0.4	PERCENT	-	-
	Upscale	20.1	20.2	0.4	20.2	0.4	0	25	12.7	12.6
NOx	Zero	-0.04	0.06	4	0.94	39.2	35.2	ppm	-	-
	Upscale	2.41	2.68	10.8	3.21	32	21.2	2.5	0.68	0.17
SO2	Zero	0.7	1.6	0.9	-0.5	-1.2	-2.1	ppm	-	-
	Upscale	89.8	89.4	-0.4	88.2	-1.6	-1.2	100	-0.1	-0.7
THC	Zero			0		0	0	ppm	-	-
	Upscale			0		0	0	100		ERR
LIMITS			+/- 5%		+/- 5%	+/- 3%				

	Cal.		
	Cal. Back Analyzer Response	Upstream Analyzer Response	Bias Check % of Span
CO	Zero		0
	Upscale		0
NOx	Zero		0
	Upscale		0
		LIMIT	+/- 5%

	ZERO Cal. Gas Analyzer Response	Analyzer Calib. Error	MID Cal. Gas Analyzer Response	Analyzer Calib. Error	HIGH Cal. Gas Analyzer Response	Analyzer Calib. Error
CO		0.00		-50.70		-90.40
O2		0.00		-48.00		-80.40
CO2		0.00		-24.48		-80.80
NOx		0.00		0.00		-94.80
SO2		0.00		-49.60		-90.70
THC		0.00		0.00		0.00
		LIMIT	+/- 2%	+/- 2%		+/- 2%

40 CFR 60, Appendix A, Method 6C, subpart 4.1



**TRC Environmental Corporation**  
**CEM Data Sheet**

Firm IFC Ambient Temp, deg. F = 75  
 Location Penrose MEL Temp, deg. F = 75  
 Tester C. Scott Bar. Pressure, In Hg = 29.24  
 Test No. 3-120 KW Vacuum Gauge = NA  
 Location Fuel Cell Flowrate (lpm) 6  
 Date 2-17-95  
 TIME 1155-1255

Calibration Gases			
Mid Cal	High Cal	TankID	
		Mid	High
CO	50.7	90.4	ALM25536 ALM38592
O2	12	20.1	CC97847 ALM022962
CO2	6.12	20.2	CC88851 ALM022962
NOx		2.37	ALM43127
SO2	49.6	90.7	ALM25536 ALM36593
THC			

	(Rack) Analyzer Cal.	Initial Values		Final Values		Drift % of Span	Analyzer Range & Units	Avg. Gas Conc.	Corrected Gas Conc.
		System Cal. Response	System Cal. Bias % of Span	System Cal. Response	System Cal. Bias % of Span				
CO	Zero	-0.8	-0.6	-1.9	-1.1	-1.3	ppm	-	-
	Upscale	87.9	87.9	87.6	-0.3	-0.3	100	0.8	2.1
O2	Zero	0.2	0	0.2	0	0.8	PERCENT	-	-
	Upscale	20.1	20	20	-0.4	0	25	7.90	7.88
CO2	Zero	0.1	0.1	0.1	0	0	PERCENT	-	-
	Upscale	20.1	20.2	20.1	0	-0.5	20	12.7	12.7
NOx	Zero	-0.04	0	0.43	18.8	17.2	ppm	-	-
	Upscale	2.41	2.3	2.71	12	16.4	2.5	0.51	0.31
SO2	Zero	0.7	-0.1	-0.7	-1.4	-0.6	ppm	-	-
	Upscale	89.8	88.2	88.3	-1.5	0.1	100	-0.6	-0.2
THC	Zero		0		0	0	ppm	-	-
	Upscale		0		0	0	100		ERR
		LIMITS	+/- 5%	+/- 5%	+/- 3%				

	Cal.		Bias Check % of Span
	Cal. Back Analyzer Response	Upstream Analyzer Response	
CO	Zero		0
	Upscale		0
NOx	Zero		0
	Upscale		0
		LIMIT	+/- 5%

	ZERO Cal. Gas Analyzer Response	Analyzer Calib. Error	MID Cal. Gas Analyzer Response	Analyzer Calib. Error	HIGH Cal. Gas Analyzer Response	Analyzer Calib. Error
CO		0.00		-50.70		-90.40
O2		0.00		-48.00		-80.40
CO2		0.00		-30.60		-101.00
NOx		0.00		0.00		-94.80
SO2		0.00		-49.60		-90.70
THC		0.00		0.00		0.00
		LIMIT	+/- 2%	+/- 2%		+/- 2%

**TRC Environmental Corporation**  
**CEM Data Sheet**

Firm IFC Ambient Temp, deg. F = 75  
 Location Penrose MEL Temp, deg. F = 75  
 Tester C. Scott Bar. Pressure, In Hg = 29.24  
 Test No. 4-120 KW Vacuum Gauge = NA  
 Location Fuel Cell Flowrate (lpm) 6  
 Date 2-17-95  
 TIME 1332-1432

Calibration Gases			
Mid Cal	High Cal	TankID	
		Mid	High
CO	50.7	90.4	ALM25536 ALM38592
O2	12	20.1	CC97847 ALM022962
CO2	6.12	20.2	CC88851 ALM022962
NOx		2.37	ALM43127
SO2	49.6	90.7	ALM25536 ALM36593
THC			

		(Rack) Analyzer Cal.	Initial Values		Final Values		Drift  % of Span	Analyzer Range & Units	Avg. Gas Conc.	Corrected Gas Conc.
			System Cal. Response	System Cal. Bias % of Span	System Cal. Response	System Cal. Bias % of Span				
CO	Zero	-0.8	-1.9	-1.1	-2.7	-1.9	-0.8	ppm	-	-
	Upscale	87.9	87.6	-0.3	86	-1.9	-1.6	100	0	2.3
O2	Zero	0.2	0.2	0	0.2	0	0	PERCENT	-	-
	Upscale	20.1	20	-0.4	20.1	0	0.4	25	7.90	7.80
CO2	Zero	0.1	0.1	0	0.1	0	0	PERCENT	-	-
	Upscale	20.1	20.1	0	20.1	0	0	25	12.3	12.3
NOx	Zero	-0.04	0.05	3.6	0.2	9.6	6	ppm	-	-
	Upscale	2.41	2.34	-2.8	2.42	0.4	3.2	2.5	0.29	0.17
SO2	Zero	0.7	-0.7	-1.4	-1.1	-1.8	-0.4	ppm	-	-
	Upscale	89.8	88.3	-1.5	88.5	-1.3	0.2	100	-0.8	0.1
THC	Zero			0		0	0	ppm	-	-
	Upscale			0		0	0	100		ERR
			LIMITS	+/- 5%		+/- 5%	+/- 3%			

	Cal.		
	Cal. Back Analyzer Response	Upstream Analyzer Response	Bias Check % of Span
CO	Zero		0
	Upscale		0
NOx	Zero		0
	Upscale		0
LIMIT		+/- 5%	

	ZERO Cal. Gas Analyzer Response	Analyzer Calib. Error	MID Cal. Gas Analyzer Response	Analyzer Calib. Error	HIGH Cal. Gas Analyzer Response	Analyzer Calib. Error
CO		0.00		-50.70		-90.40
O2		0.00		-48.00		-80.40
CO2		0.00		-24.48		-80.80
NOx		0.00		0.00		-94.80
SO2		0.00		-49.60		-90.70
THC		0.00		0.00		0.00
LIMIT		+/- 2%		+/- 2%		+/- 2%

TRC Environmental Corporation  
CEM Data Sheet

Firm IFC Ambient Temp, deg. F = 75  
 Location Penrose MEL Temp, deg. F = 75  
 Tester C. Scott Bar. Pressure, in Hg = 29.24  
 Test No. 5-120 KW Vacuum Gauge = NA  
 Location Fuel Cell Flowrate (lpm) 6  
 Date 2-17-95  
 TIME 1457-1557

Calibration Gases			
Mid Cal	High Cal	TankID	
		Mid	High
CO	50.7	90.4	ALM25536 ALM38592
O2	12	20.1	CC97847 ALM022962
CO2	6.12	20.2	CC88851 ALM022962
NOx		2.37	ALM43127
SO2	49.6	90.7	ALM25536 ALM36593
THC			

	(Rack) Analyzer Cal.	Initial Values		Final Values		Drift % of Span	Analyzer Range & Units	Avg. Gas Conc.	Corrected Gas Conc.
		System Cal. Response	System Cal. Bias % of Span	System Cal. Response	System Cal. Bias % of Span				
CO	Zero	-0.8	0.9	-1.9	-1.1	-2.8	ppm	-	-
	Upscale	87.9	86	-1.9	86.9	-1	100	0.1	0.6
O2	Zero	0.2	0	-0.8	0.1	-0.4	PERCENT	-	-
	Upscale	20.1	20.1	0	20.3	0.8	25	8.10	8.03
CO2	Zero	0.1	0	-0.4	0.1	0	PERCENT	-	-
	Upscale	20.1	20.1	0	20.1	0	25	12.4	12.4
NOx	Zero	-0.04	0.03	2.8	-0.67	-25.2	ppm	-	-
	Upscale	2.41	2.34	-2.8	1.54	-34.8	2.5	0.07	0.41
SO2	Zero	0.7	-1.3	-2	-0.8	-1.5	ppm	-	-
	Upscale	89.8	88.5	-1.3	88.5	-1.3	100	-0.8	0.3
THC	Zero		0		0	0	ppm	-	-
	Upscale		0		0	0	100		ERR
LIMITS		+/- 5%		+/- 5%		+/- 3%			

	Cal. Back Analyzer Response	Cal. Upstream		Bias Check % of Span
		Analyzer Response	Analyzer Response	
CO	Zero			0
	Upscale			0
NOx	Zero			0
	Upscale			0
LIMIT		+/- 5%		

	ZERO Cal. Gas Analyzer Response	Analyzer Calib. Error	MID Cal. Gas Analyzer Response	Analyzer Calib. Error	HIGH Cal. Gas Analyzer Response	Analyzer Calib. Error
CO		0.00		-50.70		-90.40
O2		0.00		-48.00		-80.40
CO2		0.00		-24.48		-80.80
NOx		0.00		0.00		-94.80
SO2		0.00		-49.60		-90.70
THC		0.00		0.00		0.00
LIMIT		+/- 2%		+/- 2%		+/- 2%

**TRC Environmental Corporation**  
**CEM Data Sheet**

Firm IFC Ambient Temp, deg. F = 75  
 Location Penrose MEL Temp, deg. F = 75  
 Tester C. Scott Bar. Pressure, in Hg = 29.24  
 Test No. 6-120 KW Vacuum Gauge = NA  
 Location Fuel Cell Flowrate (lpm) 6  
 Date 2-17-95  
 TIME 1622-1722

Calibration Gases			
Mid Cal	High Cal	TankID	
		Mid	High
CO	50.7	90.4	ALM25536 ALM38592
O2	12	20.1	CC97847 ALM022962
CO2	6.12	20.2	CC88851 ALM022962
NOx		2.37	ALM43127
SO2	49.6	90.7	ALM25536 ALM36593
THC			

		(Rack) Analyzer Cal.	Initial Values		Final Values		Drift  % of Span	Analyzer Range & Units	Avg. Gas Conc.	Corrected Gas Conc.
			System Cal. Response	System Cal. Bias % of Span	System Cal. Response	System Cal. Bias % of Span				
CO	Zero	-0.8	-1.9	-1.1	0	0.8	1.9	ppm	-	-
	Upscale	87.9	86.9	-1	89	1.1	2.1	100	0.9	1.9
O2	Zero	0.2	0.1	-0.4	0	-0.8	-0.4	PERCENT	-	-
	Upscale	20.1	20.3	0.8	20.2	0.4	-0.4	25	8.00	7.91
CO2	Zero	0.1	0.1	0	0.1	0	0	PERCENT	-	-
	Upscale	20.1	20.1	0	20.1	0	0	25	12.5	12.5
NOx	Zero	-0.04	-0.05	-0.4	-0.4	-14.4	-14	ppm	-	-
	Upscale	2.41	2.4	-0.4	2.11	-12	-11.6	2.5	-0.04	0.18
SO2	Zero	0.7	-0.8	-1.5	0.1	-0.6	0.9	ppm	-	-
	Upscale	89.8	88	-1.8	89.3	-0.5	1.3	100	-0.01	0.3
THC	Zero			0		0	0	ppm	-	-
	Upscale			0		0	0	100		ERR
LIMITS			+/- 5%		+/- 5%		+/- 3%			

	Cal.		
	Cal. Back Analyzer Response	Upstream Analyzer Response	Bias Check % of Span
CO	Zero		0
	Upscale		0
NOx	Zero		0
	Upscale		0
LIMIT		+/- 5%	

	ZERO Cal. Gas Analyzer Response	Analyzer Calib. Error	MID Cal. Gas Analyzer Response	Analyzer Calib. Error	HIGH Cal. Gas Analyzer Response	Analyzer Calib. Error
CO		0.00		-50.70		-90.40
O2		0.00		-48.00		-80.40
CO2		0.00		-24.48		-80.80
NOx		0.00		0.00		-94.80
SO2		0.00		-49.60		-90.70
THC		0.00		0.00		0.00
LIMIT		+/- 2%		+/- 2%		+/- 2%

40 CFR 60, Appendix A, Method 6C, subpart 4.1

H-07

Plant: <b>IFC</b>	Date: <b>FEB 17, 95</b>											
Unit Number: <b>FUELCCELL</b>	Stack Diameter (in.): <b>10" = .545 ft<sup>2</sup></b>											
Load Condition: <b>120 KW</b>	Stack Gauge Pressure ("H <sub>2</sub> O):											
Run No.: <b>RUN 02</b>	Operators: <b>CRAIG SCOTT</b>											
Project No.: <b>02030</b>	<b>JIM CANDRA</b>											
Barometric Pressure at Ground Level ("Hg): <b>29.30</b>												
Pitot Tube ID: <b>1/4"</b>	Time: <b>1015</b>											
Pitot Tube Coefficient: <b>.99</b>	Port Change Pitot Leak Check	<table border="1"> <thead> <tr> <th>Pass</th> <th>Fail</th> </tr> </thead> <tbody> <tr> <td>✓</td> <td>—</td> </tr> <tr> <td>✓</td> <td>—</td> </tr> <tr> <td>—</td> <td>—</td> </tr> <tr> <td>—</td> <td>—</td> </tr> </tbody> </table>	Pass	Fail	✓	—	✓	—	—	—	—	—
Pass	Fail											
✓	—											
✓	—											
—	—											
—	—											
Estimated Stack CO <sub>2</sub> %: <b>12.0%: 11.0%: 9</b>												
Platform Elevation (feet):												
Schematic of Stack Cross Section:	<p><math>V_{\text{Pave}} = .193</math></p> <p>13.72 fpm      449 acfm</p> <p>823 fpm      390 acfm</p> <p>356 acfm</p> <p>900 FPM by KURTZ</p>											

Traverse Point Number	Velocity Head (In H <sub>2</sub> O)	Stack Temp. (F)
A 1	.04	134
2	.04	134
3	.035	134
4	.04	134
5	.04	134
6	.04	134
7	.04	134
8	.04	134
Average:		

Traverse Point Number	Velocity Head (In H <sub>2</sub> O)	Stack Temp. (F)
B 1	.03	134
2	.035	134
3	.04	134
4	.04	134
5	.04	134
6	.04	134
7	.03	134
8	.03	134
Average:	V <sub>ap</sub> = .193	

Plant: <i>IFC Penrose Landfill</i>	Date: <i>2/17/95</i>
Unit Number: <i>Fuel Cell</i>	Stack Diameter (in.): <i>10.0"</i>
Load Condition: <i>115 kW</i>	Stack Gauge Pressure ("H <sub>2</sub> O): <i>- 0.030"</i>
Run No.: <i>3</i>	Operators: <i>K. Prince</i>
Project No.: <i>95-112 / 02030</i>	
Barometric Pressure at Ground Level ("Hg): <i>29.42</i>	
Pitot Tube ID: <i>2 FT Stagnation</i>	
Pitot Tube Coefficient: <i>0.99</i>	Port Change Pitot Leak Check
Estimated Stack CO <sub>2</sub> %: <i>25.0% 7.911, 0% 9.0%</i>	Pass Fail
Platform Elevation (feet): <i>10'</i>	Port #1
Schematic of Stack Cross Section:	Port #2
	Port #3
	Port #4
	$Vel (ft/s) = 11.48$ $Acfm = 375.68$ $Scfm = 342.9$ $K_{ve} = 444 = 900 ft/min$

Traverse Point Number	Velocity Head (In H <sub>2</sub> O)	Stack Temp. (F)
A1	0.020	108
2	0.025	108
3	0.030	108
4	0.030	108
5	0.030	108
6	0.030	109
7	0.035	109
8	0.035	109
Average:		

Traverse Point Number	Velocity Head (in H <sub>2</sub> O)	Stack Temp. (F)
81	0.025	110
2	0.020	110
3	0.025	110
4	0.025	109
5	0.030	109
6	0.030	109
7	0.030	108
8	0.030	108
Average:	$\sqrt{0.167}$	1080

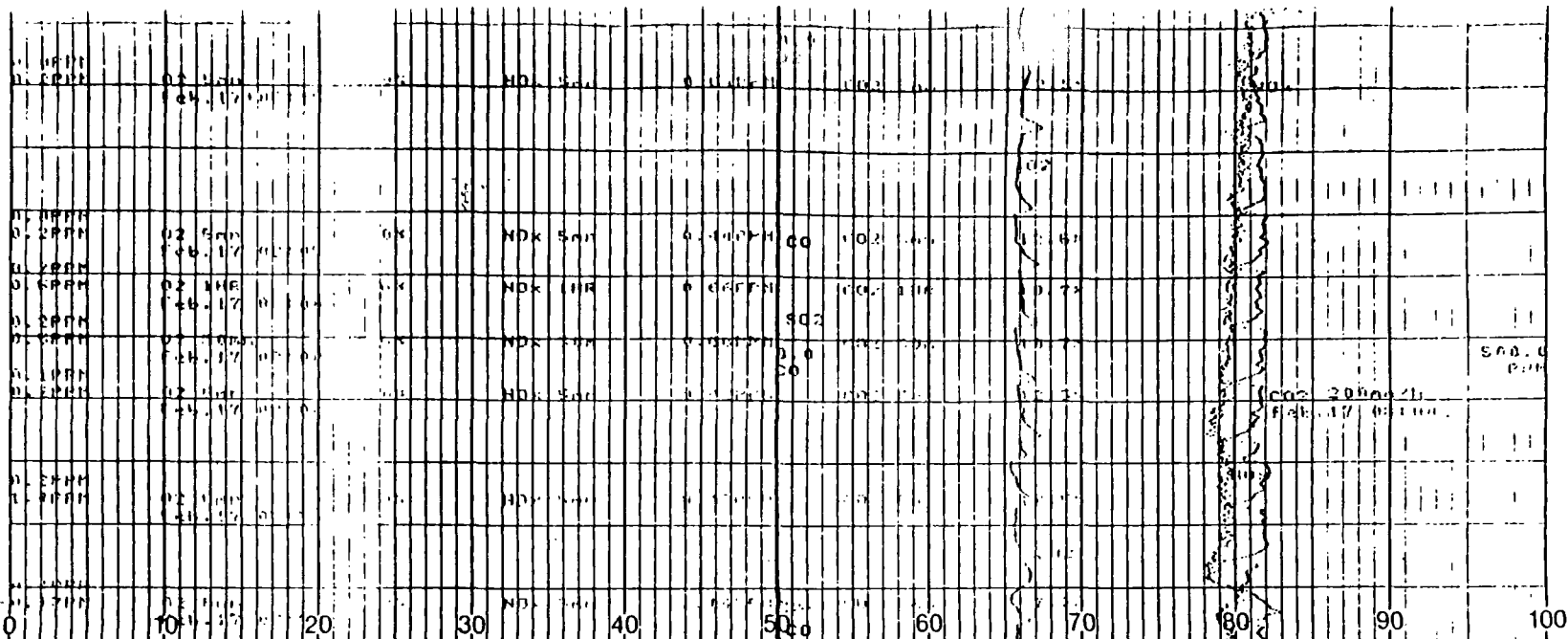
Traverse Point Number	Velocity Head (In H <sub>2</sub> O)	Stack Temp. (F)
81	0.025	111
2	0.030	110
3	0.030	110
4	0.030	110
5	0.030	110
6	0.030	110
7	0.030	111
8	0.030	111
Average:	$\sqrt{0.178}$	110.3

[illegible]

SYSTEM  
C&L  
ZERO



H-C12



MANUAL Feb. 17, 95 07:45  
 CO -1.5PPM  
 SO2 -0.5PPM  
 NOx 5an 2.41PPM  
 O2 5an 0.1%  
 O2 30an 0.1%  
 CO 1HR -1.4PPM  
 SO2 1HR -0.5PPM

NOx 2.41PPM  
 CO 5an -1.4PPM  
 SO2 5an 0.5PPM  
 CO2 30an 0.1%  
 NOx 1HR 2.41PPM

CO2 0.1%  
 O2 5an 0.1%  
 CO 30an -1.4PPM  
 SO2 30an 0.5PPM  
 CO2 1HR 0.1%

on-line @ 90 kw

NOx  
 VOLTAGE CH  
 -2.5+2.5

MANUAL Feb. 17, 95 07:43  
 CO -1.4PPM  
 SO2 -0.6PPM  
 NOx 5an 1.35PPM  
 O2 5an 0.1%  
 O2 30an 0.1%  
 CO 1HR 8.1PPM  
 SO2 1HR 8.1PPM

NOx 0.03PPM  
 CO 5an -1.2PPM  
 SO2 5an 0.9PPM  
 CO2 30an 5.5%  
 NOx 1HR 0.12PPM

CO2 0.1%  
 O2 5an 0.1%  
 CO 30an 3.6PPM  
 SO2 30an 18.2PPM  
 CO2 1HR 3.5%

NOx  
 ZERO

MANUAL Feb. 17, 95 07:41  
 CO -1.1PPM  
 SO2 -0.9PPM  
 NOx 5an 2.32PPM  
 O2 5an 0.1%  
 O2 30an 0.1%  
 CO 1HR 6.3PPM  
 SO2 1HR 8.4PPM

NOx 2.30PPM  
 CO 5an -1.0PPM  
 SO2 5an 1.1PPM  
 CO2 30an 4.0%  
 NOx 1HR 0.11PPM

CO2 0.1%  
 O2 5an 0.2%  
 CO 30an 9.4PPM  
 SO2 30an 13.3PPM  
 CO2 1HR 8.9%

NOx 2.37

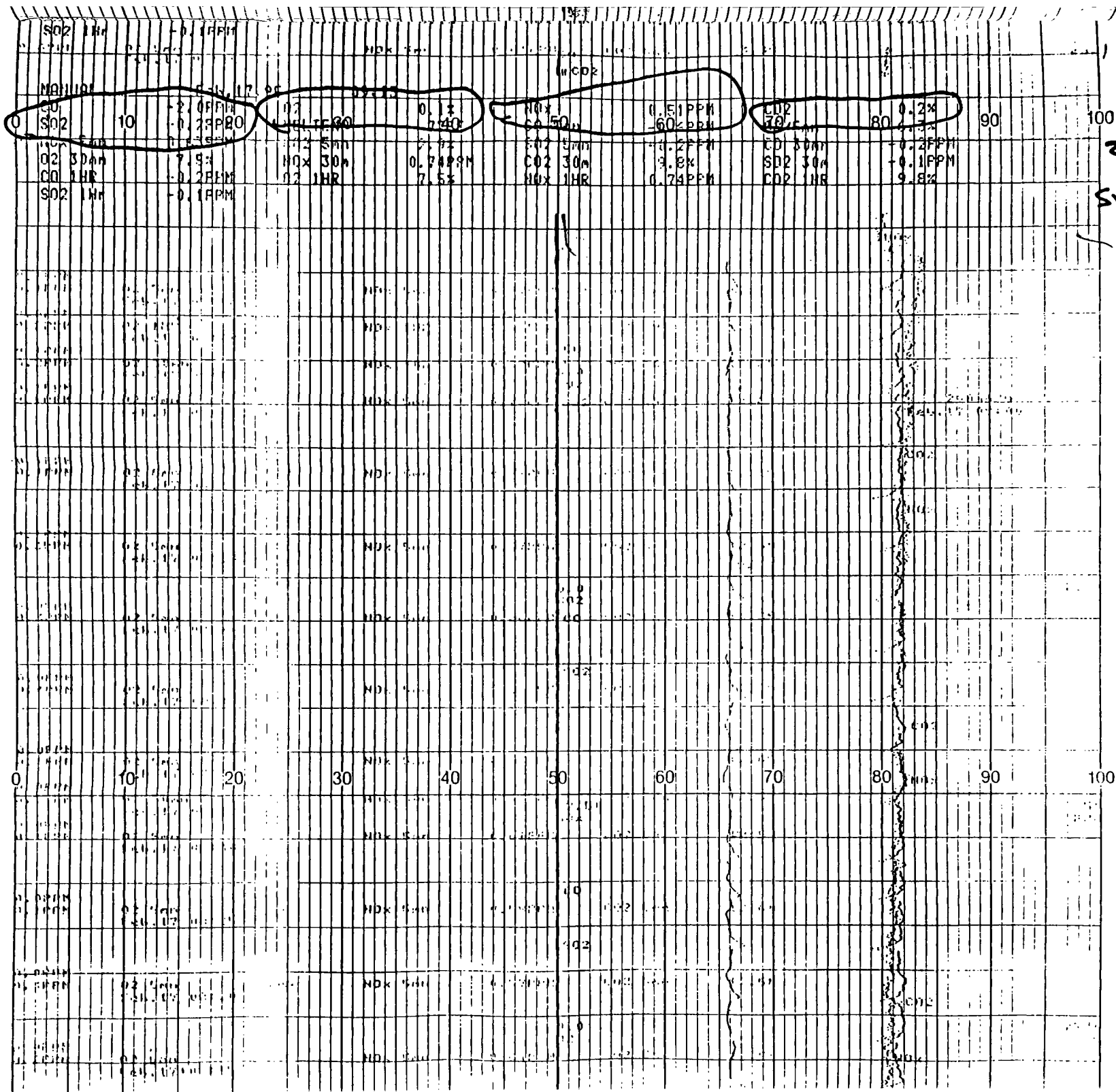
MANUAL Feb. 17, 95 07:37  
 CO -8.0PPM  
 SO2 -0.5PPM  
 NOx 5an 0.1%  
 O2 5an 0.1%  
 O2 30an 0.1%  
 CO 1HR 8.0PPM  
 SO2 1HR 8.0PPM

NOx 0.02PPM  
 CO 5an -1.3PPM  
 SO2 5an 0.7PPM  
 CO2 30an 0.1%  
 NOx 1HR 0.11PPM

CO2 0.2%  
 O2 5an 0.1%  
 CO 30an 1.6PPM  
 SO2 30an 1.6PPM  
 CO2 1HR 0.2%

CO 90.4

H-C13

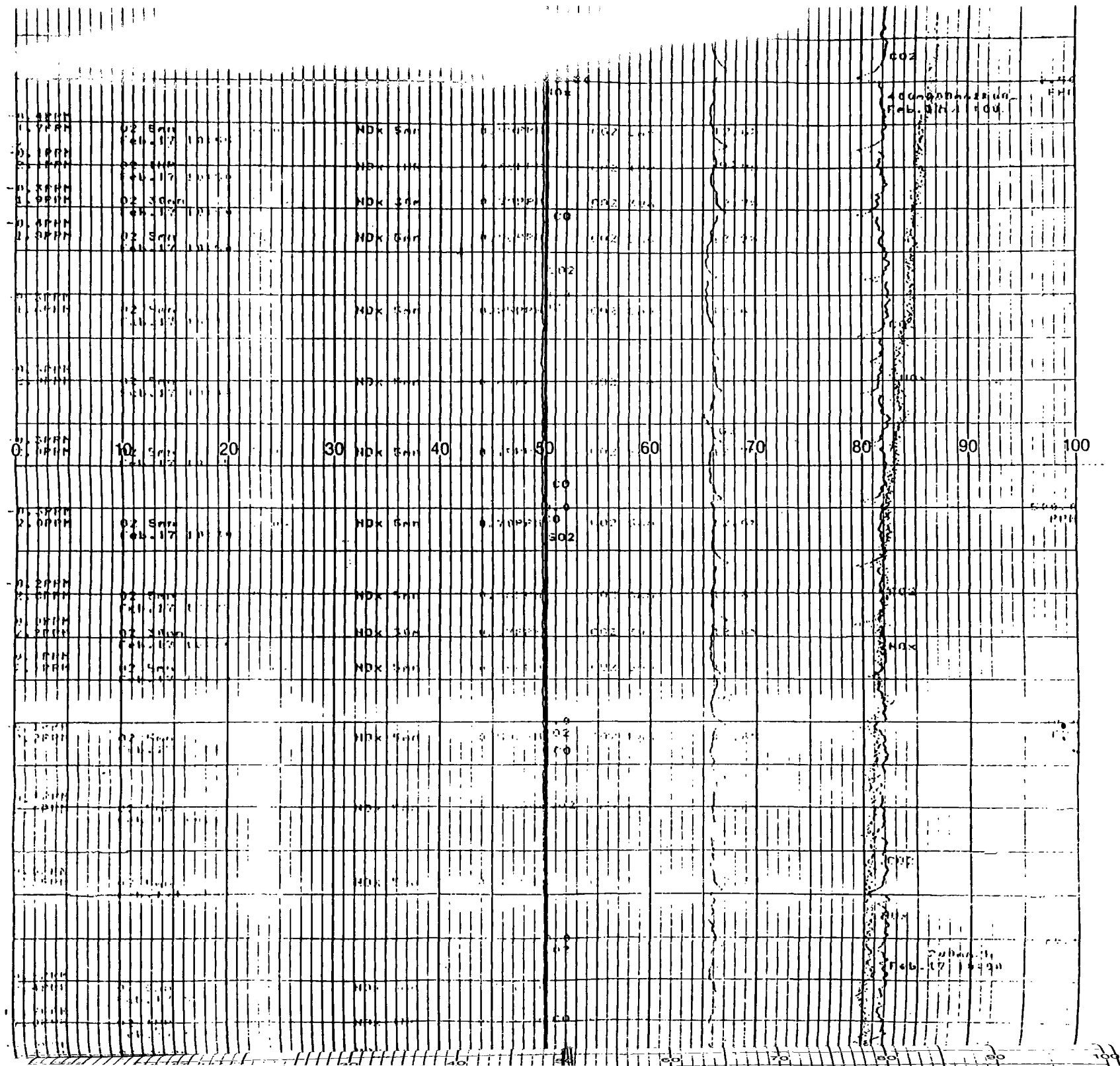


ZERO  
SYSTEM  
CAL  
END  
T-1

MANUAL		09:17		09:18		09:19		09:20	
CO	1.1PPM	CO	0.1%	CO	0.06PPM	CO	0.1%	CO	0.1%
SO2	0.4PPM	SO2	0.1%	SO2	0.06PPM	SO2	0.1%	SO2	0.1%
NOx 5min	0.3PPM	NOx 5min	0.1%	NOx 5min	0.06PPM	NOx 5min	0.1%	NOx 5min	0.1%
CO2 30min	0.1%	CO2 30min	0.1%	CO2 30min	0.1%	CO2 30min	0.1%	CO2 30min	0.1%
CO 1HR	5.7PPM	CO 1HR	4.4%	CO 1HR	0.72PPM	CO 1HR	5.4%	CO 1HR	5.4%
SO2 1HR	14.7PPM	SO2 1HR	4.4%	SO2 1HR	0.72PPM	SO2 1HR	5.4%	SO2 1HR	5.4%
MANUAL		09:21		09:22		09:23		09:24	
CO	0.1%	CO	0.1%	CO	0.1%	CO	0.1%	CO	0.1%
SO2	0.1%	SO2	0.1%	SO2	0.1%	SO2	0.1%	SO2	0.1%
NOx 5min	0.1%	NOx 5min	0.1%	NOx 5min	0.1%	NOx 5min	0.1%	NOx 5min	0.1%
CO2 30min	0.1%	CO2 30min	0.1%	CO2 30min	0.1%	CO2 30min	0.1%	CO2 30min	0.1%
CO 1HR	6.9PPM	CO 1HR	5.3%	CO 1HR	0.84PPM	CO 1HR	6.4%	CO 1HR	6.4%
SO2 1HR	13.2PPM	SO2 1HR	5.3%	SO2 1HR	0.84PPM	SO2 1HR	6.4%	SO2 1HR	6.4%
MANUAL		09:25		09:26		09:27		09:28	
CO	0.1%	CO	0.1%	CO	0.1%	CO	0.1%	CO	0.1%
SO2	0.1%	SO2	0.1%	SO2	0.1%	SO2	0.1%	SO2	0.1%
NOx 5min	0.1%	NOx 5min	0.1%	NOx 5min	0.1%	NOx 5min	0.1%	NOx 5min	0.1%
CO2 30min	0.1%	CO2 30min	0.1%	CO2 30min	0.1%	CO2 30min	0.1%	CO2 30min	0.1%
CO 1HR	6.3PPM	CO 1HR	5.6%	CO 1HR	0.89PPM	CO 1HR	9.0%	CO 1HR	9.0%
SO2 1HR	0.1PPM	SO2 1HR	5.6%	SO2 1HR	0.89PPM	SO2 1HR	9.0%	SO2 1HR	9.0%
MANUAL		09:29		09:30		09:31		09:32	
CO	0.1%	CO	0.1%	CO	0.1%	CO	0.1%	CO	0.1%
SO2	0.1%	SO2	0.1%	SO2	0.1%	SO2	0.1%	SO2	0.1%
NOx 5min	0.1%	NOx 5min	0.1%	NOx 5min	0.1%	NOx 5min	0.1%	NOx 5min	0.1%
CO2 30min	0.1%	CO2 30min	0.1%	CO2 30min	0.1%	CO2 30min	0.1%	CO2 30min	0.1%
CO 1HR	0.1PPM	CO 1HR	7.6%	CO 1HR	0.75PPM	CO 1HR	9.3%	CO 1HR	9.3%
SO2 1HR	0.1PPM	SO2 1HR	7.6%	SO2 1HR	0.75PPM	SO2 1HR	9.3%	SO2 1HR	9.3%
MANUAL		09:33		09:34		09:35		09:36	
CO	0.1%	CO	0.1%	CO	0.1%	CO	0.1%	CO	0.1%
SO2	0.1%	SO2	0.1%	SO2	0.1%	SO2	0.1%	SO2	0.1%
NOx 5min	0.1%	NOx 5min	0.1%	NOx 5min	0.1%	NOx 5min	0.1%	NOx 5min	0.1%
CO2 30min	0.1%	CO2 30min	0.1%	CO2 30min	0.1%	CO2 30min	0.1%	CO2 30min	0.1%
CO 1HR	0.1PPM	CO 1HR	8.1%	CO 1HR	0.72PPM	CO 1HR	10.3%	CO 1HR	10.3%
SO2 1HR	0.1PPM	SO2 1HR	8.1%	SO2 1HR	0.72PPM	SO2 1HR	10.3%	SO2 1HR	10.3%

0		10		20		30		40		50		60		70		80		90		100	
SO2 1HR 18.3PPM																					
MANUAL Rel. 12-45 09:43																					
CO		0.52PPM		0.23		NOx		2.17PPM		CO		0.3%									
SO2		7.2PPM		ALTENP		76°F		CO 5hr		12.1%		CO 30hr		10.3PPM							
NOx 5hr		0.96PPM		CO 5hr		11.6%		SO2 5hr		3.4PPM		CO 30hr		25.2PPM							
CO 30hr		3.5%		NOx 30hr		0.82PPM		CO 30hr		3.7%		CO 30hr		5.4%							
CO 1HR		7.7PPM		CO 1HR		1.6%		NOx 1HR		0.70PPM		CO 1HR									
SO2 1HR		8.8PPM																			
MANUAL Rel. 12-45 09:44																					
CO		2.8PPM		20.1%		NOx		0.06PPM		CO		20.3%									
SO2		6.8PPM		ALTENP		77°F		CO 5hr		12.1%		CO 30hr		12.2PPM							
NOx 5hr		0.10PPM		CO 5hr		20.2%		SO2 5hr		0.2PPM		CO 30hr		29.5PPM							
CO 30hr		2.7%		NOx 30hr		0.20PPM		CO 30hr		3.2%		CO 30hr		5.3%							
CO 1HR		8.1PPM		CO 1HR		1.6%		NOx 1HR		0.65PPM		CO 1HR									
SO2 1HR		19.6PPM																			
MANUAL Rel. 12-45 09:49																					
CO		8.92PPM		ALTENP		77°F		NOx		0.10PPM		CO		0.1%							
SO2		0.18PPM		CO 5hr		0.1%		CO 5hr		0.1PPM		CO 30hr		14.5PPM							
NOx 5hr		0.0%		CO 30hr		0.21PPM		SO2 5hr		0.1%		CO 30hr		26.1PPM							
CO 30hr		0.0%		NOx 30hr		0.40		CO 30hr		0.1%		CO 30hr		4.7%							
CO 1HR		8.49PPM		CO 1HR		1.40		NOx 1HR		0.60PPM		CO 1HR									
SO2 1HR		18.3PPM																			
MANUAL Rel. 12-45 09:55																					
CO		0.17PPM		ALTENP		77°F		NOx		0.10PPM		CO		0.1%							
SO2		0.03PPM		CO 5hr		0.1%		CO 5hr		0.1PPM		CO 30hr		2.7PPM							
NOx 5hr		0.03PPM		CO 30hr		0.24PPM		SO2 5hr		0.1%		CO 30hr		5.2PPM							
CO 30hr		0.0%		NOx 30hr		1.2%		CO 30hr		0.1%		CO 30hr		5.2PPM							
CO 1HR		7.50PPM		CO 1HR		1.2%		NOx 1HR		0.73PPM		CO 1HR		5.2%							
SO2 1HR		14.0PPM																			
MANUAL Rel. 12-45 09:54																					
CO		0.0%		ALTENP		77°F		NOx		0.10PPM		CO		0.1%							
SO2		0.0%		CO 5hr		0.1%		CO 5hr		0.1PPM		CO 30hr		2.7PPM							
NOx 5hr		0.03PPM		CO 30hr		0.24PPM		SO2 5hr		0.1%		CO 30hr		5.2PPM							
CO 30hr		0.0%		NOx 30hr		1.2%		CO 30hr		0.1%		CO 30hr		5.2PPM							
CO 1HR		7.50PPM		CO 1HR		1.2%		NOx 1HR													

H-C16





← NOx  
9/24

O<sub>2</sub>/CO<sub>2</sub> span

system zero

END  
T-2

H-C17

NOX  
VOLTAGE CH  
-2 / +2  
-5ppm / +5ppm

**H-C18**

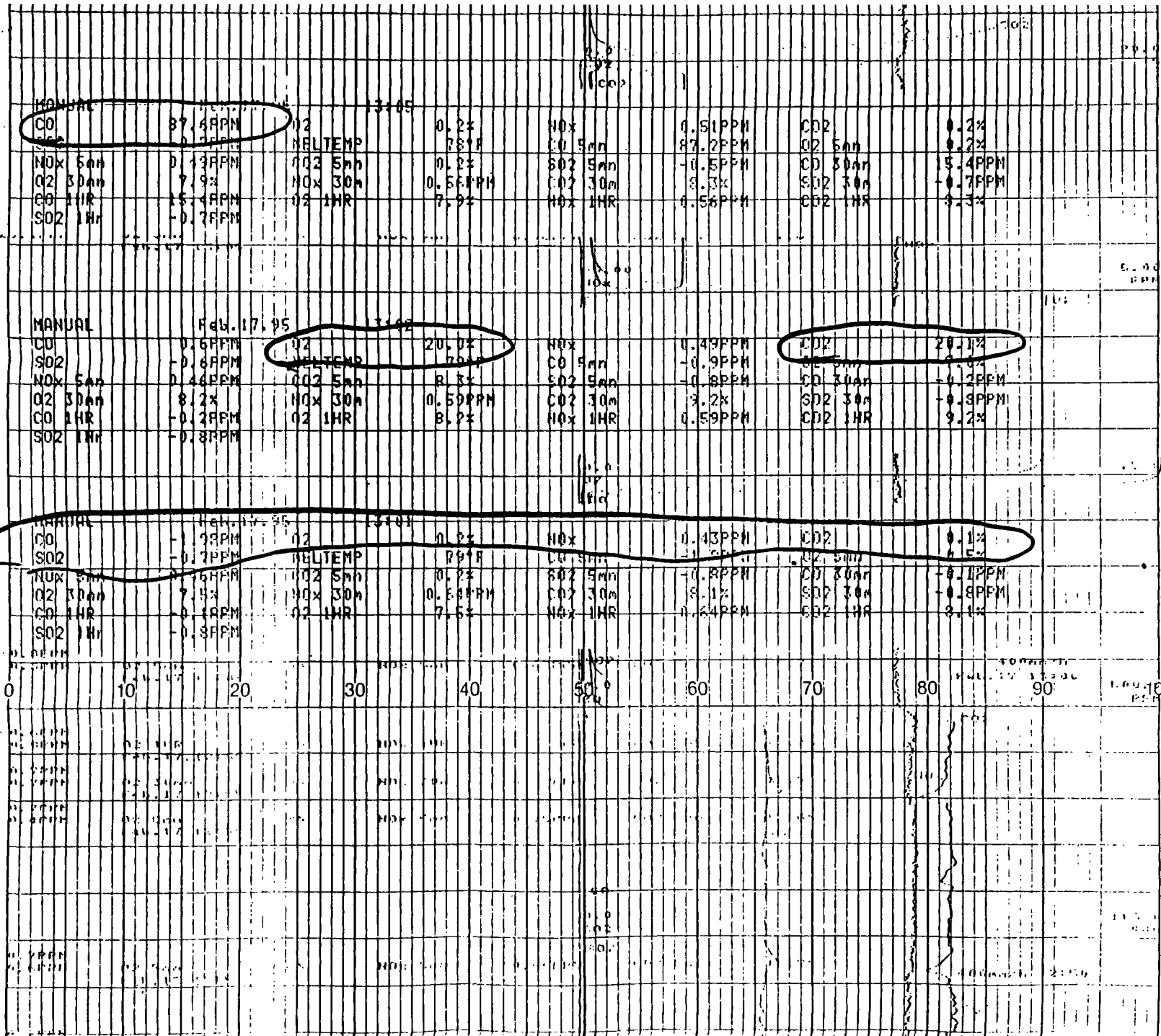
[illegible]

H-C19

0	MANUAL	10	Feb. 20, 95	30	40	50	60	70	80	90	100
CO	-0.7PPM	02	11:47	0.0%	NOx	2.30PPM	CO2	0.1%			
SO2	-0.3PPM	RELTEMP	78°F	CO 5m	-0.8PPM	CO2 5m	0.0%				
NOx 5m	1.63PPM	CO2 5m	0.1%	SO2 5m	-0.3PPM	CO2 30m	-0.3PPM				
O2 30m	0.0%	NOx 30m	1.53PPM	CO2 30m	0.1%	SO2 30m	-0.3PPM				
CO 1HR	-0.8PPM	O2 1HR	0.1%	NOx 1HR	1.63PPM	CO2 1HR	0.1%				
SO2 1HR	-0.3PPM										
1.1PPM	02 30m			NOx 30m		CO2 30m					
0.1PPM	02 5m			NOx 5m		CO2 5m					
0.7PPM	02 1HR			NOx 1HR		CO2 1HR					
MANUAL	Feb. 17, 95	11:49									
CO	-0.6PPM	O2	0.0%	NOx	0.00PPM	CO2	0.1%				
SO2	-0.1PPM	RELTEMP	77°F	CO 5m	-0.7PPM	CO2 5m	0.0%			zero	
NOx 5m	0.99PPM	CO2 5m	0.1%	SO2 5m	-0.1PPM	CO2 30m	3.2PPM				
O2 30m	1.9%	NOx 30m	1.12PPM	CO2 30m	1.5%	SO2 30m	14.5PPM				
CO 1HR	4.8PPM	O2 1HR	4.7%	NOx 1HR	1.13PPM	CO2 1HR	6.4%				
SO2 1HR	7.0PPM										
MANUAL	Feb. 17, 95	11:47									
CO	-0.4PPM	O2	0.0%	NOx	2.35PPM	CO2	0.1%				
SO2	-0.2PPM	RELTEMP	77°F	CO 5m	-0.7PPM	CO2 5m	0.0%				
NOx 5m	0.83PPM	CO2 5m	0.1%	SO2 5m	0.0PPM	CO2 30m	3.3PPM			Max span	
O2 30m	1.9%	NOx 30m	1.11PPM	CO2 30m	1.5%	SO2 30m	15.4PPM				
CO 1HR	5.0PPM	O2 1HR	4.9%	NOx 1HR	1.12PPM	CO2 1HR	6.6%				
SO2 1HR	7.2PPM										
MANUAL	Feb. 17, 95	11:46									
CO	-0.5PPM	O2	0.0%	NOx	-0.01PPM	CO2	0.1%				
SO2	0.1PPM	RELTEMP	78°F	CO 5m	-0.7PPM	CO2 5m	0.0%			zero	
NOx 5m	0.46PPM	CO2 5m	0.1%	SO2 5m	0.0PPM	CO2 30m	9.4PPM				
O2 30m	1.0%	NOx 30m	1.11PPM	CO2 30m	1.5%	SO2 30m	14.4PPM				
CO 1HR	5.1PPM	O2 1HR	5.0%	NOx 1HR	1.60PPM	CO2 1HR	6.8%				
SO2 1HR	7.1PPM										
MANUAL	Feb. 17, 95	11:44									
CO	-0.7PPM	O2	0.0%	NOx	2.34PPM	CO2	0.1%				
SO2	0.3PPM	RELTEMP	78°F	CO 5m	-0.7PPM	CO2 5m	0.0%				
NOx 5m	0.56PPM	CO2 5m	0.1%	SO2 5m	0.5PPM	CO2 30m	10.2PPM				
O2 30m	2.2%	NOx 30m	1.11PPM	CO2 30m	1.5%	SO2 30m	7.8PPM				
CO 1HR	5.4PPM	O2 1HR	5.2%	NOx 1HR	1.12PPM	CO2 1HR	7.0%				
SO2 1HR	7.6PPM										
MANUAL	Feb. 17, 95	11:41									
CO	-0.7PPM	O2	0.0%	NOx	0.04PPM	CO2	0.1%				
SO2	0.1PPM	RELTEMP	78°F	CO 5m	0.0PPM	CO2 5m	0.0%				



H-21



ZERO  
SYSTEM  
CAL

-END  
T-3

H-C22

02 30m	3.4%	NOx 30m	0.15PPM	CO 1HR	1.1PPM	SO2 1HR	0.4PPM
NOx 5m	0.1%	CO 5m	1.7PPM	SO2 5m	0.2PPM	NOx 30m	0.15PPM
CO 1HR	1.1PPM	SO2 1HR	0.4PPM	NOx 5m	0.1%	CO 5m	1.7PPM
SO2 1HR	0.4PPM	NOx 30m	0.15PPM	CO 1HR	1.1PPM	SO2 1HR	0.4PPM
MANUAL	Feb. 17. 95	13:19					
CO	1.7PPM	NOx 5m	0.1%	CO 5m	1.7PPM	SO2 5m	0.2PPM
SO2	0.2PPM	NOx 30m	0.15PPM	CO 1HR	1.1PPM	SO2 1HR	0.4PPM
NOx 5m	0.1%	CO 5m	1.7PPM	SO2 5m	0.2PPM	NOx 30m	0.15PPM
CO 30m	1.1%	CO 1HR	1.1PPM	SO2 1HR	0.4PPM	NOx 5m	0.1%
CO 1HR	1.1PPM	SO2 1HR	0.4PPM	NOx 30m	0.15PPM	CO 30m	1.1%
SO2 1HR	0.4PPM	NOx 5m	0.1%	CO 5m	1.7PPM	SO2 5m	0.2PPM
MANUAL	Feb. 17. 95	13:12					
CO	1.8PPM	NOx 5m	0.1%	CO 5m	1.8PPM	SO2 5m	0.2PPM
SO2	0.2PPM	NOx 30m	0.15PPM	CO 1HR	1.8PPM	SO2 1HR	0.2PPM
NOx 5m	0.1%	CO 5m	1.8PPM	SO2 5m	0.2PPM	NOx 30m	0.15PPM
CO 30m	1.8%	CO 1HR	1.8PPM	SO2 1HR	0.2PPM	NOx 5m	0.1%
CO 1HR	1.8PPM	SO2 1HR	0.2PPM	NOx 30m	0.15PPM	CO 30m	1.8%
SO2 1HR	0.2PPM	NOx 5m	0.1%	CO 5m	1.8PPM	SO2 5m	0.2PPM
MANUAL	Feb. 17. 95	13:15					
CO	1.8PPM	NOx 5m	0.1%	CO 5m	1.8PPM	SO2 5m	0.2PPM
SO2	0.2PPM	NOx 30m	0.15PPM	CO 1HR	1.8PPM	SO2 1HR	0.2PPM
NOx 5m	0.1%	CO 5m	1.8PPM	SO2 5m	0.2PPM	NOx 30m	0.15PPM
CO 30m	1.8%	CO 1HR	1.8PPM	SO2 1HR	0.2PPM	NOx 5m	0.1%
CO 1HR	1.8PPM	SO2 1HR	0.2PPM	NOx 30m	0.15PPM	CO 30m	1.8%
SO2 1HR	0.2PPM	NOx 5m	0.1%	CO 5m	1.8PPM	SO2 5m	0.2PPM
MANUAL	Feb. 17. 95	13:13					
CO	1.6PPM	NOx 5m	0.1%	CO 5m	1.6PPM	SO2 5m	0.2PPM
SO2	0.2PPM	NOx 30m	0.15PPM	CO 1HR	1.6PPM	SO2 1HR	0.2PPM
NOx 5m	0.1%	CO 5m	1.6PPM	SO2 5m	0.2PPM	NOx 30m	0.15PPM
CO 30m	1.6%	CO 1HR	1.6PPM	SO2 1HR	0.2PPM	NOx 5m	0.1%
CO 1HR	1.6PPM	SO2 1HR	0.2PPM	NOx 30m	0.15PPM	CO 30m	1.6%
SO2 1HR	0.2PPM	NOx 5m	0.1%	CO 5m	1.6PPM	SO2 5m	0.2PPM
MANUAL	Feb. 17. 95	13:11					
CO	1.3PPM	NOx 5m	0.1%	CO 5m	1.3PPM	SO2 5m	0.2PPM
SO2	0.2PPM	NOx 30m	0.15PPM	CO 1HR	1.3PPM	SO2 1HR	0.2PPM
NOx 5m	0.1%	CO 5m	1.3PPM	SO2 5m	0.2PPM	NOx 30m	0.15PPM
CO 30m	1.3%	CO 1HR	1.3PPM	SO2 1HR	0.2PPM	NOx 5m	0.1%
CO 1HR	1.3PPM	SO2 1HR	0.2PPM	NOx 30m	0.15PPM	CO 30m	1.3%
SO2 1HR	0.2PPM	NOx 5m	0.1%	CO 5m	1.3PPM	SO2 5m	0.2PPM

SO<sub>2</sub> span

H-C23

0	10	20	30	40	50	60	70	80	90	100
MANUAL FAN 17.95 13:28										
CO	0.4PPM	03	0.0%	NOx	2.34PPM	CO2	0.0%	No span		
SO2	0.0PPM	HETEMP	79°F	CO 5min	-0.7PPM	CO2 5min	0.0%			
NOx 5min	1.23PPM	CO2 5min	0.0%	SO2 5min	0.0%	CO 30min	-0.7PPM			
CO2 30min	0.0%	NOx 30min	1.23PPM	CO2 30min	0.0%	SO2 30min	-0.3PPM			
CO 1HR	6.2PPM	CO2 1HR	2.7%	NOx 1HR	0.98PPM	CO2 1HR	2.6%			
SO2 1HR	13.9PPM									
MANUAL FAN 17.95 13:27										
CO	0.4PPM	03	0.0%	NOx	0.02PPM	CO2	0.0%	zero		
SO2	0.0PPM	HETEMP	79°F	CO 5min	-0.7PPM	CO2 5min	0.0%			
NOx 5min	1.23PPM	CO2 5min	0.0%	SO2 5min	-0.7PPM	CO 30min	-1.0PPM			
CO2 30min	0.0%	NOx 30min	1.23PPM	CO2 30min	0.0%	SO2 30min	-0.7PPM			
CO 1HR	6.4PPM	CO2 1HR	2.7%	NOx 1HR	0.98PPM	CO2 1HR	2.7%			
SO2 1HR	13.3PPM									
MANUAL FAN 17.95 13:26										
CO	0.4PPM	03	0.0%	NOx	1.46PPM	CO2	0.0%	No span		
SO2	0.0PPM	HETEMP	79°F	CO 5min	-1.6PPM	CO2 5min	0.0%			
NOx 5min	1.33PPM	CO2 5min	0.0%	SO2 5min	-0.5PPM	CO 30min	-1.6PPM			
CO2 30min	0.0%	NOx 30min	1.53PPM	CO2 30min	0.0%	SO2 30min	-0.9PPM			
CO 1HR	6.8PPM	CO2 1HR	2.8%	NOx 1HR	0.98PPM	CO2 1HR	2.8%			
SO2 1HR	14.7PPM									
MANUAL FAN 17.95 13:24										
CO	0.3PPM	02	0.0%	NOx	0.07PPM	CO2	0.0%	7.1PPM		
SO2	0.5PPM	HETEMP	80°F	CO 5min	-1.9PPM	CO2 5min	0.0%			
NOx 5min	1.33PPM	CO2 5min	0.0%	SO2 5min	-0.1PPM	CO 30min	7.1PPM			
CO2 30min	0.0%	NOx 30min	0.98PPM	CO2 30min	0.0%	SO2 30min	15.8PPM			
CO 1HR	7.1PPM	CO2 1HR	3.1%	NOx 1HR	0.98PPM	CO2 1HR	2.9%			
SO2 1HR	15.3PPM									
MANUAL FAN 17.95 13:21										
CO	0.4PPM	02	0.0%	NOx	0.05PPM	CO2	0.0%	3.3%		
SO2	0.0PPM	HETEMP	79°F	CO 5min	-1.3PPM	CO2 5min	0.0%			
NOx 5min	0.42PPM	CO2 5min	0.0%	SO2 5min	0.0PPM	CO 30min	8.4PPM			
CO2 30min	0.0%	NOx 30min	0.98PPM	CO2 30min	0.0%	SO2 30min	3.0PPM			
CO 1HR	8.1PPM	CO2 1HR	2.6%	NOx 1HR	0.98PPM	CO2 1HR	3.3%			
SO2 1HR	14.0PPM									

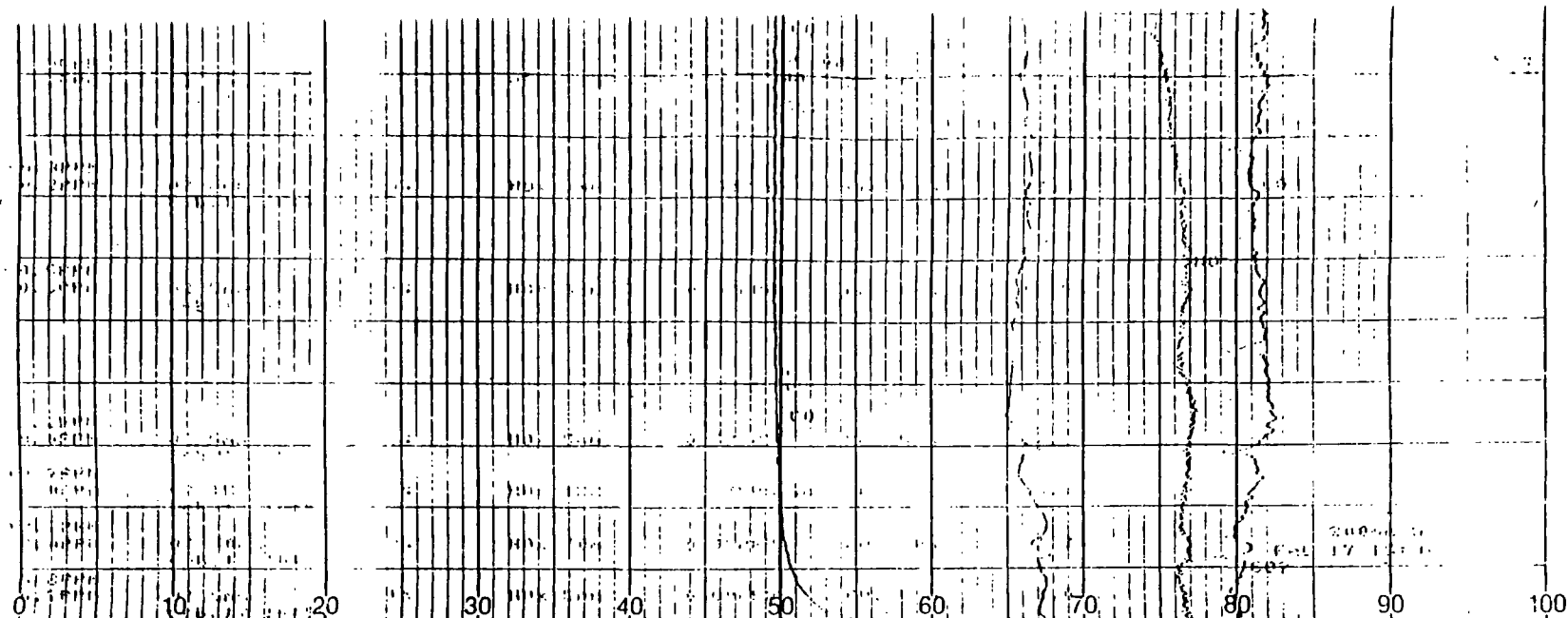
[illegible]
$$E \sim \frac{1}{4}$$

H-C25

MANUAL		14:49	0.0%		NOx	0.34PPM	CO2	0.0%
CO	88.5PPM	HALTEMP	79°F	CO 5min	-1.1PPM	CO2 5min	80	0.0%
SO2	1.1PPM	CO2 5min	0.0%	SO2 5min	960.1PPM	CO2 30min	80	9.5PPM
NOx 5min	3.2%	NOx 30min	0.48PPM	CO2 30min	4.7%	SO2 30min	90	23.3PPM
CO 1HR	9.5PPM	CO2 1HR	3.9%	NOx 1HR	0.13PPM	CO2 1HR		4.7%
SO2 1HR	23.3PPM							
MANUAL		14:43	0.2%		NOx	0.20PPM	CO2	0.2%
CO	86.0PPM	HALTEMP	79°F	CO 5min	80.5PPM	CO2 5min		3.2%
SO2	-0.48PPM	CO2 5min	1.1%	SO2 5min	-0.3PPM	CO2 30min		0.9PPM
NOx 5min	0.29PPM	NOx 30min	0.56PPM	CO2 30min	7.0%	SO2 30min		8.6PPM
CO 1HR	10.9PPM	CO2 1HR	5.8%	NOx 1HR	0.56PPM	CO2 1HR		7.0%
SO2 1HR	-0.8PPM							
MANUAL		14:41	20.1%		NOx	0.17PPM	CO2	20.1%
CO	-0.3PPM	HALTEMP	79°F	CO 5min	-2.2PPM	CO2 5min		6.6%
SO2	-0.18PPM	CO2 5min	5.7%	SO2 5min	-0.2PPM	CO2 30min		1.8PPM
NOx 5min	0.33PPM	NOx 30min	0.54PPM	CO2 30min	4.5%	SO2 30min		0.7PPM
CO 1HR	-0.3PPM	CO2 1HR	5.7%	NOx 1HR	0.54PPM	CO2 1HR		7.6%
SO2 1HR	-0.78PPM							
MANUAL		14:39	0.0%		NOx	0.51PPM	CO2	0.0%
CO	0.32PPM	HALTEMP	80°F	CO 5min	-1.2PPM	CO2 5min		1.9PPM
SO2	0.88PPM	CO2 5min	0.1%	SO2 5min	-0.2PPM	CO2 30min		0.1PPM
NOx 5min	0.3%	NOx 30min	0.51PPM	CO2 30min	5.6%	SO2 30min		5.6%
CO 1HR	-1.9PPM	CO2 1HR	5.6%	NOx 1HR	0.51PPM	CO2 1HR		5.6%
SO2 1HR	-0.32PPM							
MANUAL		14:37	0.1%		NOx	0.20PPM	CO2	0.1%
CO	0.32PPM	HALTEMP	80°F	CO 5min	-1.9PPM	CO2 5min		1.5PPM
SO2	-1.12PPM	CO2 5min	0.1%	SO2 5min	-1.1PPM	CO2 30min		1.1PPM
NOx 5min	0.2%	NOx 30min	0.32PPM	CO2 30min	7.7%	SO2 30min		7.7%
CO 1HR	-1.5PPM	CO2 1HR	5.2%	NOx 1HR	0.32PPM	CO2 1HR		7.7%
SO2 1HR	-1.1PPM							

END

H-026



MANUAL Feb. 17, 95 14:53

CO	0.9PPM	O2	0.0%	NOx	0.03PPM	CO2	0.0%
SO2	1.3PPM	RELTEMP	80°F	CO 5min	0.0PPM	O2 5min	0.0%
NOx 5min	1.6PPM	CO2 5min	0.0%	SO2 5min	-1.1PPM	CO 30min	8.0PPM
O2 30min	3.2%	NOx 30min	0.55PPM	CO2 30min	3.2%	SO2 30min	21.4PPM
CO 1HR	8.0PPM	O2 1HR	3.2%	NOx 1HR	0.53PPM	CO2 1HR	3.6%
SO2 1HR	21.4PPM						

zero

MANUAL Feb. 17, 95 14:52

CO	0.7PPM	O2	0.0%	NOx	0.34PPM	CO2	0.0%
SO2	1.1PPM	RELTEMP	80°F	CO 5min	0.7PPM	O2 5min	0.0%
NOx 5min	1.80PPM	CO2 5min	0.0%	SO2 5min	-1.0PPM	CO 30min	8.2PPM
O2 30min	3.3%	NOx 30min	0.50PPM	CO2 30min	4.0%	SO2 30min	22.2PPM
CO 1HR	8.2PPM	O2 1HR	3.3%	NOx 1HR	0.50PPM	CO2 1HR	4.0%
SO2 1HR	22.2PPM						

Not span

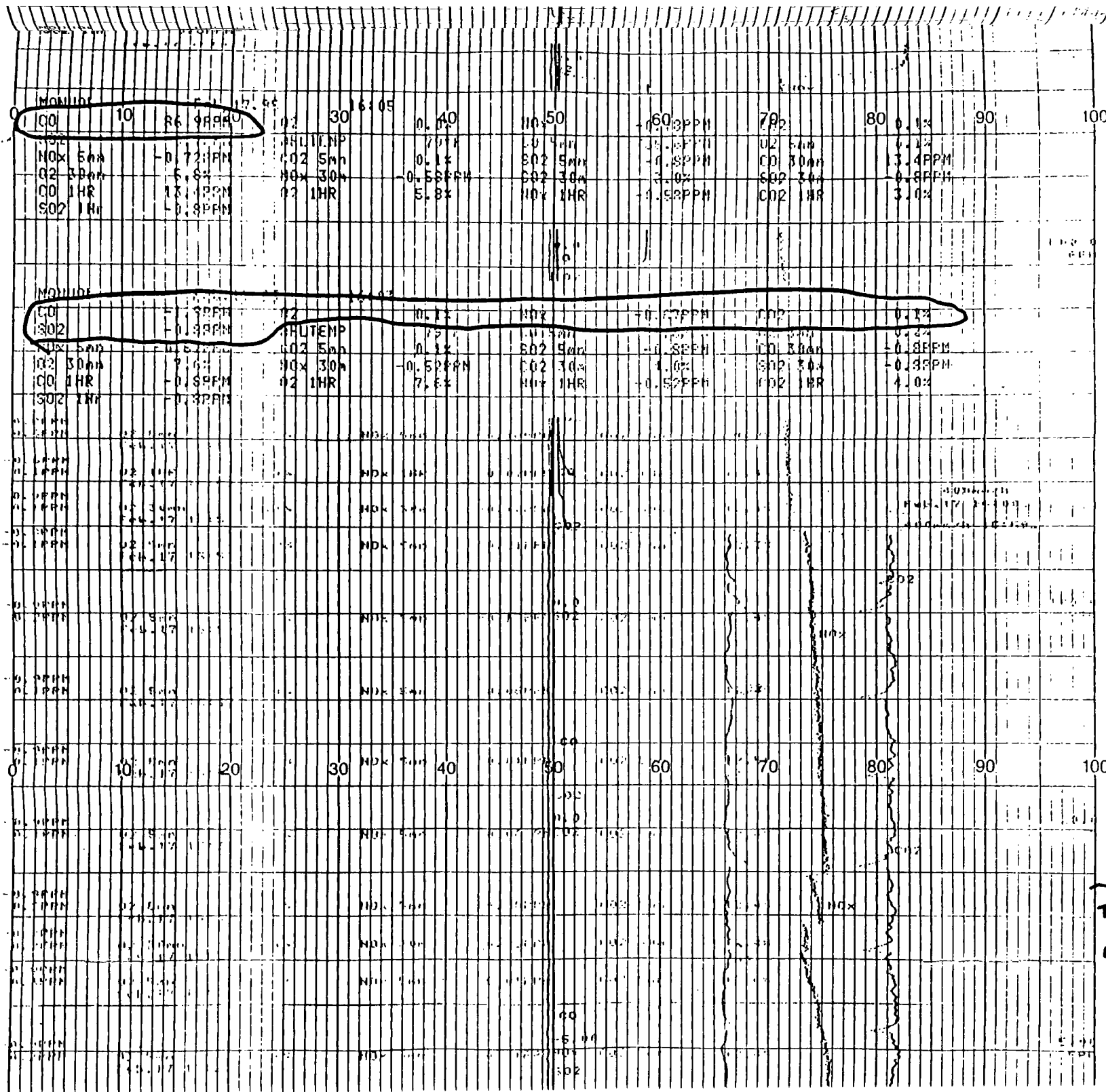
MANUAL Feb. 17, 95 14:51

CO	0.7PPM	O2	0.0%	NOx	0.00PPM	CO2	0.0%
SO2	0.5PPM	RELTEMP	79°F	CO 5min	-0.1PPM	O2 5min	0.0%
NOx 5min	0.24PPM	CO2 5min	0.0%	SO2 5min	59.0PPM	CO 30min	9.5PPM
O2 30min	3.5%	NOx 30min	0.44PPM	CO2 30min	4.7%	SO2 30min	23.2PPM
CO 1HR	2.5PPM	O2 1HR	3.5%	NOx 1HR	0.44PPM	CO2 1HR	4.7%
SO2 1HR	23.2PPM						

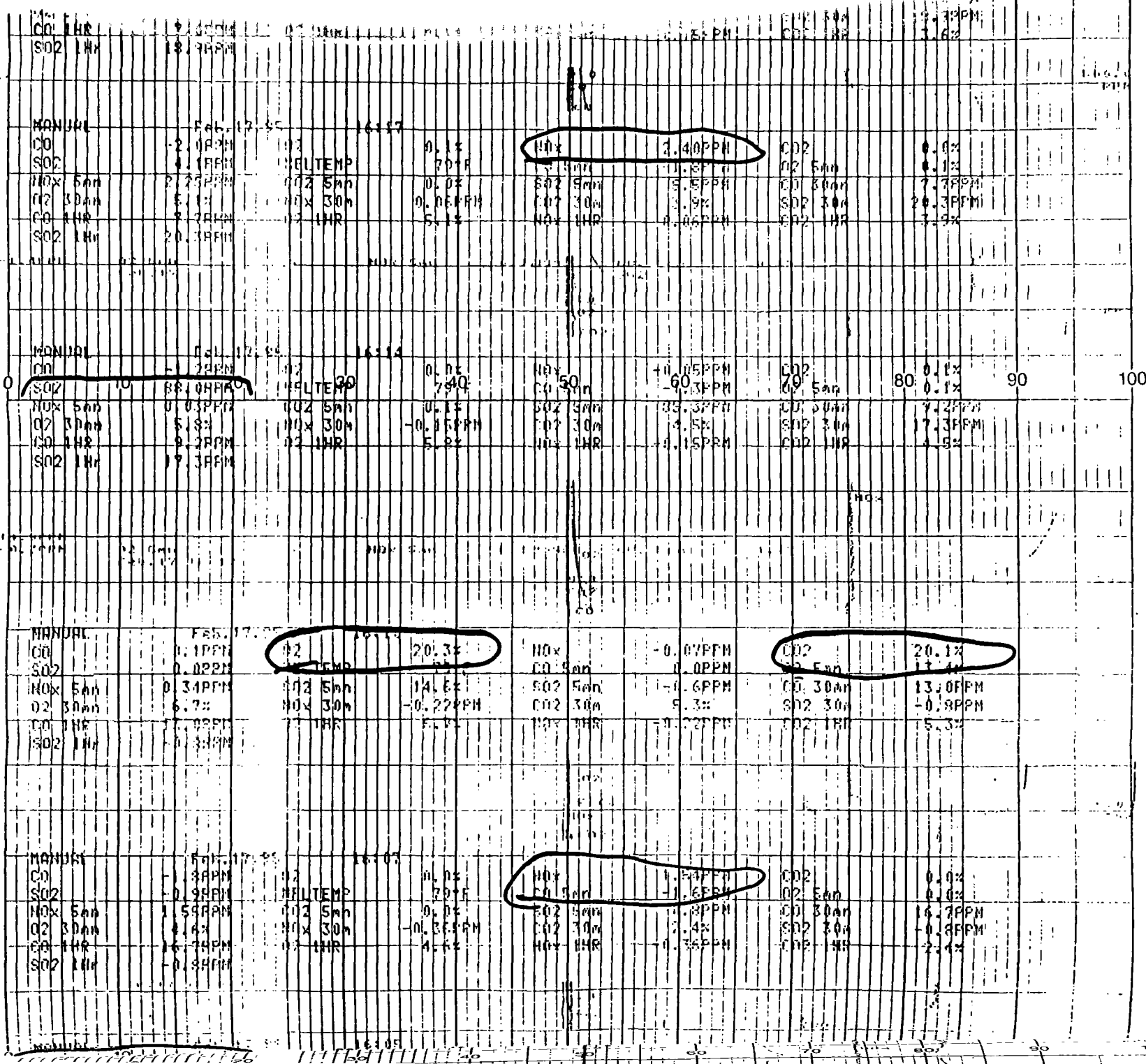
MANUAL Feb. 17, 95 14:49

CO	0.7PPM	O2	0.0%	NOx	0.34PPM	CO2	0.0%
SO2	0.5PPM	RELTEMP	79°F	CO 5min	0.1PPM	O2 5min	0.0%

H-07

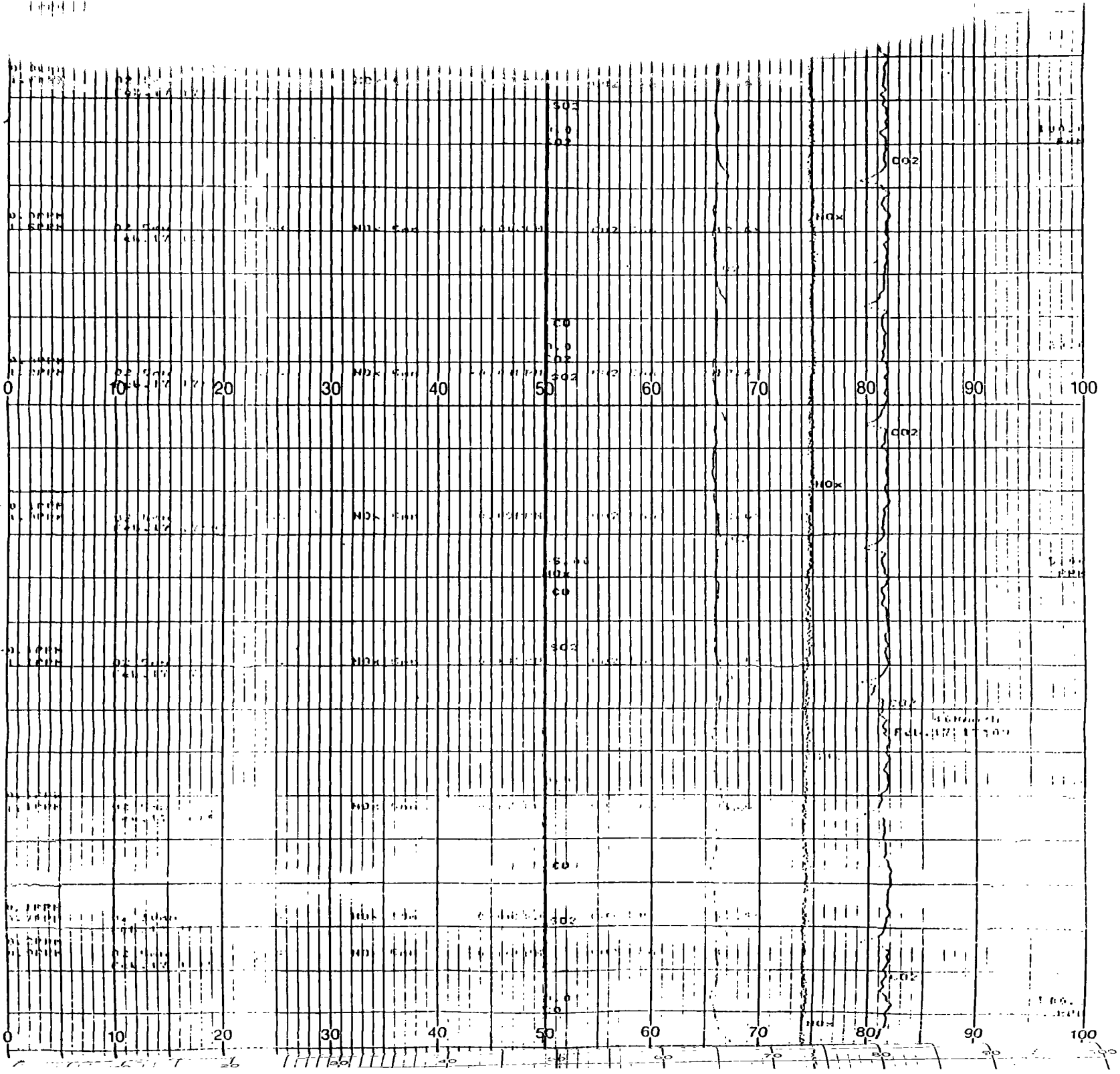


DUE TO TEMPERATURE CHANGE INTRAILOR





[illegible]



H-30

[illegible]

-END  
T-6

IFC 02030

MANUAL		FAN 17 95		17:39					
CO	0.1%	CO	0.1%	NOx	-0.21PPM	CO2	0.1%		
SO2	89.3PPM	SO2	89.3PPM	NOx	-0.21PPM	CO2	0.1%		
NOx 5m	0.1%	NOx 5m	0.1%	CO 5m	0.1%	CO 5m	0.1%		
NOx 30m	0.1%	NOx 30m	0.1%	CO 30m	0.1%	CO 30m	0.1%		
CO 1HR	0.1%	CO 1HR	0.1%	NOx 1HR	0.1%	CO2 1HR	0.1%		
SO2 1HR	15.2PPM	SO2 1HR	15.2PPM	NOx 1HR	0.1%	CO2 1HR	0.1%		
0 10 20 30 40 50 60 70 80 90 100									
MANUAL		FAN 17 95		17:39					
CO	0.1%	CO	0.1%	NOx	-0.36PPM	CO2	0.1%		
SO2	0.2PPM	SO2	0.2PPM	NOx	-0.36PPM	CO2	0.1%		
NOx 5m	0.1%	NOx 5m	0.1%	CO 5m	0.1%	CO 5m	0.1%		
NOx 30m	0.1%	NOx 30m	0.1%	CO 30m	0.1%	CO 30m	0.1%		
CO 1HR	0.1%	CO 1HR	0.1%	NOx 1HR	0.1%	CO2 1HR	0.1%		
SO2 1HR	0.1PPM	SO2 1HR	0.1PPM	NOx 1HR	0.1%	CO2 1HR	0.1%		
0 10 20 30 40 50 60 70 80 90 100									
MANUAL		FAN 17 95		17:39					
CO	0.1%	CO	0.1%	NOx	-0.24PPM	CO2	0.2%		
SO2	0.1PPM	SO2	0.1PPM	NOx	-0.24PPM	CO2	0.2%		
NOx 5m	0.1%	NOx 5m	0.1%	CO 5m	0.1%	CO 5m	0.1%		
NOx 30m	0.1%	NOx 30m	0.1%	CO 30m	0.1%	CO 30m	0.1%		
CO 1HR	0.1%	CO 1HR	0.1%	NOx 1HR	0.1%	CO2 1HR	0.1%		
SO2 1HR	0.1PPM	SO2 1HR	0.1PPM	NOx 1HR	0.1%	CO2 1HR	0.1%		
0 10 20 30 40 50 60 70 80 90 100									
MANUAL		FAN 17 95		17:39					
CO	0.1%	CO	0.1%	NOx	-0.37PPM	CO2	0.1%		
SO2	0.1PPM	SO2	0.1PPM	NOx	-0.37PPM	CO2	0.1%		
NOx 5m	0.1%	NOx 5m	0.1%	CO 5m	0.1%	CO 5m	0.1%		
NOx 30m	0.1%	NOx 30m	0.1%	CO 30m	0.1%	CO 30m	0.1%		
CO 1HR	0.1%	CO 1HR	0.1%	NOx 1HR	0.1%	CO2 1HR	0.1%		
SO2 1HR	0.1PPM	SO2 1HR	0.1PPM	NOx 1HR	0.1%	CO2 1HR	0.1%		

## **SUB-APPENDIX D**

### **FLARE EMISSION DATA FROM PHASE II**

SUBJECT Flare Emissions - Phase II Oct 6, 1993

I NO<sub>x</sub>

$$\text{average ppmv} = 10.4$$

$$\text{volumetric flowrate} = 367 \text{ scfm} = 22,020 \text{ scfh}$$

$$\text{pounds/scf as NO}_2 = 10.4 \text{ ppm} \times 1.194 \times 10^{-7} = 1.24 \times 10^{-6}$$

$$\text{pounds/hour} = 1.24 \times 10^{-6} \frac{\text{lbs}}{\text{scf}} \times 22,020 \frac{\text{scf}}{\text{hour}} = .027$$

$$\text{grams/hour} = 12.2$$

$$\text{grams/kwh} = 0.187$$

(based on 140 kW GPU gas output rate)

II CO

$$\text{average ppmv} = 3.0$$

$$\text{volumetric flowrate} = 22,020 \text{ scfh}$$

$$\text{pounds/scf} = 3.0 \times 7.268 \times 10^{-3} = 2.180 \times 10^{-2}$$

$$\text{pounds/hr} = 0.005$$

$$\text{grams/hr} = 2.177$$

$$\text{grams/kwh} = 0.015 \text{ (based on 140 kW GPU gas output rate)}$$

III SO<sub>2</sub> (based on 30.4 ppmv flame inlet concentration of total sulfur measured during 1 hour organized regeneration)

$$\text{average ppmv} = \frac{30.4}{8 \text{ hour}} = 10.5 \text{ ppmv average during 3-hour cycle}$$

$$\text{flowrate} = 25 \text{ scfm} = 1500 \text{ scfh}$$

$$\text{lbs/scf} = 10.5 \times 1.660 \times 10^{-7} = 1.743 \times 10^{-6}$$

$$\text{lbs/hr} = 0.003$$

$$\text{grams/hr} = 1.186$$

**TABLE 3-5  
FLARE INLET/OUTLET EMISSION TEST SUMMARY**

International Fuel Cells, Inc.  
Penrose Landfill  
October 21, 1993

GPU Inlet Flowrate: 81 scfm  
Regeneration Flowrate: 25 scfm  
GPU Output Flowrate: 56 scfm  
Flare Temperature: 1600 oF

Time Process Activity	1030-1130 Carbon Bed Regeneration		1230-1330 Dryer Bed Regeneration		1730-1830 Dryer Bed Cold Regeneration	
Flare Sampling Location	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET
Methane (ppm v/v)	440000	<1	448000	<1	463000	<1
Total Non-Methane Organics (ppm v/v as carbo)	1860	11.7	21100	11.5	250	6.8
Oxides of Nitrogen (ppm v/v)		7.5		8.9		14.9
Carbon Monoxide (ppm v/v)		5.8		1.7		1.6
Total Particulates (gr/dscf)		0.0182		0.0178		0.0088
Front half		0.0069		0.0135		0.0072
Back half (organic)		0.0005		0.001		0.0011
Back half (inorganic)		0.0108		0.0033		0.0005
Oxygen (%)		14.9		15.03		13.5
Moisture (%)	<0.1	9.2	<0.1	9.1	<0.1	8.6
Temperature (oF)	80	1186	80	929	79	990
Flowrate (scfm)	25		25		25	
Reduced Sulfur Compounds (ppm v/v)						
Sample Type	bag	bag	bag	bag	bag	bag
hydrogen sulfide	<0.004	<0.004	<0.016	0.327	<0.004	<0.004
carbonyl sulfide	0.061	<0.004	<0.016	<0.04	0.014	0.06
methyl mercaptan	<0.004	<0.004	0.087	<0.04	<0.004	<0.004
ethyl mercaptan	<0.004	<0.004	0.016	<0.04	<0.004	<0.004
dimethyl sulfide	0.042	<0.004	73.9	<0.04	0.031	<0.004
carbon disulfide	0.146	<0.002	<0.008	<0.02	<0.002	<0.002
dimethyl disulfide	<0.002	<0.002	0.908	<0.02	0.005	<0.002
Total Reduced Sulfur - see note	0.254	<0.004	80.4	0.327	0.05	0.06
Volatile Organic Compounds- GC/MS Analysis (ppm v/v)						
Sample Type	bag	bag	bag	bag	bag	bag
Compound						
dichlorodifluoromethane	3.6	<0.002	<2.0	<0.002	<0.03	<0.002
vinyl chloride	1.5	<0.002	<3.9	<0.002	<0.05	<0.002
methylene chloride	0.28	<0.002	110	<0.002	0.07	<0.002
cis-1,2-dichloroethene	<0.02	<0.002	62	<0.002	<0.04	<0.002
1,1-dichloroethane	<0.02	<0.002	32	<0.002	<0.04	<0.002
trichloroethene	0.02	<0.002	17	<0.002	<0.03	<0.002
tetrachloroethene	0.17	<0.002	19	<0.002	0.1	<0.002
chlorobenzene	<0.02	<0.002	3.8	<0.002	0.07	<0.002
benzene	0.03	<0.002	16	<0.002	<0.04	<0.002
toluene	1.2	0.007	230	0.004	0.83	0.0025
xylene	0.04	<0.002	43.8	<0.002	1.8	<0.002
ethyl benzene	0.04	<0.002	25	<0.002	0.76	<0.002
styrene	<0.02	<0.002	<2.4	<0.002	<0.03	<0.002
acetone	<0.07	<0.005	150	0.065	<0.12	0.02
2-butanone	<0.06	<0.004	28	<0.004	<0.99	<0.004
ethyl acetate	<0.04	<0.002	5.4	<0.002	<0.04	<0.002
ethyl butyrate	<0.04	<0.002	2.1	<0.002	<0.04	<0.002
alpha-pinene	0.05	<0.002	3.6	<0.002	1.8	<0.002
d-limonene	0.07	<0.002	1.4	<0.002	3.6	<0.002
tetrahydrofuran	<0.04	<0.002	0.99	<0.002	<0.04	<0.002

**NOTES:**

1. Total reduced sulfur is calculated as the sum of target compound concentrations as sulfur, plus the sum of any unknown sulfur compounds quantified as hydrogen sulfide.

## **SUB-APPENDIX E**

### **GPU EXIT CONTAMINANT MEASUREMENT DATA**



PROPORTIONAL SAMPLING DATA SHEET

DATE 1-19-95

BAROMETRIC PRESSURE (IN HG) \_\_\_\_\_

FACILITY IFC

TEMPERATURE (DEG F) \_\_\_\_\_

LOCATION Prairie Landfill / GPO Outlet

Technician A. Pierce

PROJECT NO. 2030-6

SAMPLE ID	SORBENT TYPE	PUMP ID	ORIFICE ID	DIFFERENTIAL PRESSURE (IN HG)	START TIME	STOP TIME	ELAPSED TIME (MIN)	SAMPLE FLOW RATE (L/MIN)	SAMPLE VOLUME (L)
6PUOUT 11995 BTU1	Steel Bulb	—	—	—	<u>23949</u> 16:43	<u>24009</u> 16:44	1	12	500cc
6PUOUT 11995 BTU2	Steel Bulb	—	—	—	<u>24249</u> 16:48	<u>24309</u> 16:49	1	12	500cc
6PUOUT 11995 BTU3	Steel Bulb	—	—	—	<u>24549</u> 16:53	<u>24609</u> 16:54	1	12	500cc

H-E2

PROPORTIONAL SAMPLING DATA SHEET

DATE 1-19-95

BAROMETRIC PRESSURE (IN HG) \_\_\_\_\_

FACILITY IFC

TEMPERATURE (DEG F) \_\_\_\_\_

LOCATION Panrose Landfill / Row Landfill Gas

Technician A. Pierce

PROJECT NO. 2030-6

SAMPLE ID	SORBENT TYPE	PUMP ID	ORIFICE ID	DIFFERENTIAL PRESSURE (IN HG)	START TIME	STOP TIME	ELAPSED TIME (MIN)	SAMPLE FLOW RATE (L/MIN)	SAMPLE VOLUME (L)
RLG 11995 BTU 1	Steel Bulb	—	—	—	<u>19449</u> 15:28	<u>19509</u> 15:29	1	12	500cc
RLG 11995 BTU 2	Steel Bulb	—	—	—	<u>19929</u> 15:36	<u>19989</u> 15:37	1	12	500cc
RLG 11995 BTU 3	Steel Bulb	—	—	—	<u>20649</u> 15:48	<u>20709</u> 15:49	1	12	500cc
RLG 11995 BTU 4	Steel Bulb	—	—	—	<u>21309</u> 15:59	<u>21369</u> 16:00	1	12	500cc

H-E3

# PROPORTIONAL SAMPLING DATA SHEET

DATE 1-19-95

BAROMETRIC PRESSURE (IN HG) \_\_\_\_\_

FACILITY IFC

TEMPERATURE (DEG F) \_\_\_\_\_

LOCATION Penrose Landfill / GPU Outlet

Technician K. Pirke

PROJECT NO. 2030-6

SAMPLE ID	SORBENT TYPE	PUMP ID	ORIFICE ID	DIFFERENTIAL PRESSURE (IN HG)	START TIME	STOP TIME	ELAPSED TIME (MIN)	SAMPLE FLOW RATE (L/MIN)	SAMPLE VOLUME (L)
GPU OUT 11995 TB1	Tedlar Bag	—	—	—	<u>24969</u> 17:00	<u>24999</u> 17:00:30	30 sec.	24	12
GPU OUT 11995 TB2	Tedlar Bag	—	—	—	<u>25149</u> 17:03	<u>25179</u> 17:03:30	30 sec.	24	12
GPU OUT 11995 TB3	Tedlar Bag	—	—	—	<u>25269</u> 17:05	<u>25299</u> 17:05:30	30 sec.	24	12

H-E4

PROPORTIONAL SAMPLING DATA SHEET

DATE 1-20-95

BAROMETRIC PRESSURE (IN HG) 29.25

FACILITY IEC

TEMPERATURE (DEG F) \_\_\_\_\_

LOCATION Pearse Landfill / 6PU Outlot

PROJECT NO. 2030-G

SAMPLE ID	SORBENT TYPE	PUMP ID	ORIFICE ID	DIFFERENTIAL PRESSURE (IN HG)	START TIME	STOP TIME	ELAPSED TIME (MIN)	SAMPLE FLOW RATE (L/MIN)	SAMPLE VOLUME (L)
6PU OUT 13095 8TV1	Steel Bulb	—	—	—	9:26:00	9:27:00	1	12	500 cc
6PU OUT 13095 T81	Tedlar Bag	—	—	—	2119:55 9:22:00	9:27:30	30 Sec.	24	12 L

H-ES

PROPORTIONAL SAMPLING DATA SHEET

DATE 1-25-95

BAROMETRIC PRESSURE (IN HG) \_\_\_\_\_

FACILITY IFC

TEMPERATURE (DEG F) \_\_\_\_\_

LOCATION GPU OUTLET

PROJECT NO. 2030-6

SAMPLE ID	SORBENT TYPE	PUMP ID	ORIFICE ID	DIFFERENTIAL PRESSURE (IN HG)	START TIME	STOP TIME	ELAPSED TIME (MIN)	SAMPLE FLOW RATE (L/MIN)	SAMPLE VOLUME (L)
GPUOUT 12595 BTU1	Steel Bulb	—	—	—	<u>52810</u> 16:08:30	<u>52840</u> 16:09:00	30 sec	12 L	500cc
GPUOUT 12595 T81	Tedlar Bag	—	—	—	<u>53080</u> 16:14:00	<u>53140</u> 16:15:00	60 sec	12 L	12 L

PROPORTIONAL SAMPLING DATA SHEET

DATE 1-26-95

BAROMETRIC PRESSURE (IN HG) 29.42

FACILITY IFC

TEMPERATURE (DEG F) \_\_\_\_\_

LOCATION Pearse Landfill / GPO-outlet

PROJECT NO. 2030-6

SAMPLE ID	SORBENT TYPE	PUMP ID	ORIFICE ID	DIFFERENTIAL PRESSURE (IN HG)	START TIME	STOP TIME	ELAPSED TIME (MIN)	SAMPLE FLOW RATE (L/MIN)	SAMPLE VOLUME (L)
GPOUT 12695 7B1	Tedlar Bag	—	—	—	8:26:30 52362	8:27:00 52394	30 sec	24L	12L
GPOUT 12695 8TV1	3Teal Bulb	—	—	—	8:32:00 52783	8:34:00 52848	1	12L	500 cc

H-E7

PROPORTIONAL SAMPLING DATA SHEET

DATE 2/9/95

BAROMETRIC PRESSURE (IN HG) 29.39

FACILITY IFC Penrose LMSF/1

TEMPERATURE (DEG F) 55

LOCATION GPU OUTLET

PROJECT NO. 2030-G

SAMPLE ID	SORBENT TYPE	PUMP ID	ORIFICE ID	DIFFERENTIAL PRESSURE (IN HG)	START TIME	STOP TIME	ELAPSED TIME (MIN)	SAMPLE FLOW RATE (L/MIN)	SAMPLE VOLUME (L)
GPUOUT BTU-1 20995	Steel Bulb	—	—	—	10:35 10:36	10:36 10:37	1 min.		500cc
GPUOUT 20995 TB1	Filter Bag	—	—	—	10:37 10:41	10:37:30 10:41:30	30 Sec		1.2

PROPORTIONAL SAMPLING DATA SHEET

DATE 2/10/95

BAROMETRIC PRESSURE (IN HG) 29.40

FACILITY IFE PINEBROOK LANDFILL

TEMPERATURE (DEG F) 53

LOCATION GPU OUTLET

PROJECT NO. 2030-6

SAMPLE ID	SORBENT TYPE	PUMP ID	ORIFICE ID	DIFFERENTIAL PRESSURE (IN HG)	START TIME	STOP TIME	ELAPSED TIME (MIN)	SAMPLE FLOW RATE (L/MIN)	SAMPLE VOLUME (L)
GPU OUT 21095 TB1	Teller Bag	—	—	—	09:29:00	09:29:30	30 sec	24 L	12 L
GPU OUT 21095 BTU1	Steel Bulb	—	—	—	09:25	09:26	1 min.		500 cc
GPU OUT -21795	Teller Bag				1255	1257		24	12 L
↓	steel bulb				1258	1300		24	500 cc

H-E9

2-17-95

→ Counter @ 23217





**Performance Analytical Inc.**

Air Quality Laboratory

**LABORATORY REPORT**

Client:	TRC ENVIRONMENTAL CORPORATION	Date of Report:	01/30/95
Address:	5 Waterside Crossing	Date Received:	01/19/95
	Windsor, CT 06095	PAI Project No:	P95-7639
Contact:	Mr. Jim Canora	Purchase Order:	026197
Client Project ID:	IFC #2030-6		

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Three (3) Tedlar Bag Samples labeled:

"GPU OUT 11995TB1"

"GPU OUT 11995TB2"

"GPU OUT 11995TB3"

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The samples were received at the laboratory under chain of custody on January 19, 1995. The samples were received intact. The dates of analyses are indicated on the attached data sheets.

Sulfur Compound Analysis

The samples were analyzed for twenty Sulfur Compounds by gas chromatography/flame photometric detection (FPD). The analytical system used was comprised of a Hewlett Packard Model 5890 equipped with a flame photometric detector (FPD). A thick film (5 micron) crossbonded 100% Dimethyl polysiloxane megabore column (60 meter x 0.53mm RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

Volatile Organic Compound Analysis

The samples were also analyzed by combined gas chromatography/mass spectrometry (GC/MS) for selected Volatile Organic Compounds. The analyses were performed according to the methodology outlined in EPA Method TO-14 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, EPA 600/4-84-041, U.S. Environmental Protection Agency, Research Triangle Park, NC, April, 1984 and May, 1988. The method was modified for using Tedlar bags. The analyses were performed by gas chromatography/mass spectrometry, utilizing a direct cryogenic trapping technique. The analytical system used was comprised of a Finnigan Model 4500 GC/MS/DS interfaced to a Tekmar 5010 Automatic Desorber. A 100% Dimethyl polysiloxane capillary column (RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

The results of analyses are given on the attached data summary sheets.

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Data Release Authorization:

Chris Parnell  
Senior Chemist

Reviewed and Approved:

Michael Tuday  
Laboratory Director

H-E10



Performance Analytical Inc.  
Environmental Testing and Consulting

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : N/A

PAI Sample ID : PAI Method Blank

Test Code : GC/FPD Reduced Sulfur Analysis

Analyst : Ku-Jih Chen

Instrument : HP5890A/FPD #4

Matrix : Tedlar Bag

Date Sampled : N/A

Date Received : N/A

Date Analyzed : 1/20/95

Volume(s) Analyzed : 10.000 (ml)

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	ND	9.80	ND	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
75-33-2	Isopropyl Mercaptan	ND	12.0	ND	4.00
75-66-1	tert-Butyl Mercaptan	ND	15.0	ND	4.00
107-03-9	n-Propyl Mercaptan	ND	12.0	ND	4.00
624-89-5	Ethyl Methyl Sulfide	ND	12.0	ND	4.00
110-02-1	Thiophene	ND	14.0	ND	4.00
513-44-0	Isobutyl Mercaptan	ND	15.0	ND	4.00
352-93-2	Diethyl Sulfide	ND	15.0	ND	4.00
109-79-5	n-Butyl Mercaptan	ND	15.0	ND	4.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
616-44-4	3-Methylthiophene	ND	16.0	ND	4.00
110-01-0	Tetrahydrothiophene	ND	14.0	ND	4.00
638-02-8	2,5-Dimethylthiophene	ND	18.0	ND	4.00
872-55-9	2-Ethylthiophene	ND	18.0	ND	4.00
110-81-6	Diethyl Disulfide	ND	10.0	ND	2.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SGP

Date : 1/25/95

H-E11



Performance Analytical Inc.  
Environmental Testing and Consulting

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : GPU Out 11995TB1

PAI Sample ID : 9500229

Test Code : GC/FPD Reduced Sulfur Analysis

Analyst : Ku-Jih Chen

Instrument : HP5890A/FPD #4

Matrix : Tedlar Bag

Date Sampled : 1/19/95

Date Received : 1/19/95

Date Analyzed : 1/20/95

Volume(s) Analyzed : 10.000 (ml)

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	ND	9.80	ND	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
75-33-2	Isopropyl Mercaptan	ND	12.0	ND	4.00
75-66-1	tert-Butyl Mercaptan	ND	15.0	ND	4.00
107-03-9	n-Propyl Mercaptan	ND	12.0	ND	4.00
624-89-5	Ethyl Methyl Sulfide	ND	12.0	ND	4.00
110-02-1	Thiophene	ND	14.0	ND	4.00
513-44-0	Isobutyl Mercaptan	ND	15.0	ND	4.00
352-93-2	Diethyl Sulfide	ND	15.0	ND	4.00
109-79-5	n-Butyl Mercaptan	ND	15.0	ND	4.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
616-44-4	3-Methylthiophene	ND	16.0	ND	4.00
110-01-0	Tetrahydrothiophene	ND	14.0	ND	4.00
638-02-8	2,5-Dimethylthiophene	ND	18.0	ND	4.00
872-55-9	2-Ethylthiophene	ND	18.0	ND	4.00
110-81-6	Diethyl Disulfide	ND	10.0	ND	2.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by :

SLC

Date :

1/25/95

H-E12



Performance Analytical Inc.  
Environmental Testing and Consulting

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : GPU Out 11995TB2

PAI Sample ID : 9500230

Test Code : GC/FPD Reduced Sulfur Analysis

Analyst : Ku-Jih Chen

Instrument : HP5890A/FPD #4

Matrix : Tedlar Bag

Date Sampled : 1/19/95

Date Received : 1/19/95

Date Analyzed : 1/20/95

Volume(s) Analyzed : 10.000 (ml)

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	ND	9.80	ND	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
75-33-2	Isopropyl Mercaptan	ND	12.0	ND	4.00
75-66-1	tert-Butyl Mercaptan	ND	15.0	ND	4.00
107-03-9	n-Propyl Mercaptan	ND	12.0	ND	4.00
624-89-5	Ethyl Methyl Sulfide	ND	12.0	ND	4.00
110-02-1	Thiophene	ND	14.0	ND	4.00
513-44-0	Isobutyl Mercaptan	ND	15.0	ND	4.00
352-93-2	Diethyl Sulfide	ND	15.0	ND	4.00
109-79-5	n-Butyl Mercaptan	ND	15.0	ND	4.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
616-44-4	3-Methylthiophene	ND	16.0	ND	4.00
110-01-0	Tetrahydrothiophene	ND	14.0	ND	4.00
638-02-8	2,5-Dimethylthiophene	ND	18.0	ND	4.00
872-55-9	2-Ethylthiophene	ND	18.0	ND	4.00
110-81-6	Diethyl Disulfide	ND	10.0	ND	2.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by :

SG

Date :

1/25/95

H-E13



**Performance Analytical Inc.**  
Environmental Testing and Consulting

**RESULTS OF ANALYSIS**

PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : GPU Out 11995TB3**

**PAI Sample ID : 9500231**

**Test Code : GC/FPD Reduced Sulfur Analysis**

**Analyst : Ku-Jih Chen**

**Instrument : HP5890A/FPD #4**

**Matrix : Tedlar Bag**

**Date Sampled : 1/19/95**

**Date Received : 1/19/95**

**Date Analyzed : 1/20/95**

**Volume(s) Analyzed : 10.000 (ml)**

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	ND	9.80	ND	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
75-33-2	Isopropyl Mercaptan	ND	12.0	ND	4.00
75-66-1	tert-Butyl Mercaptan	ND	15.0	ND	4.00
107-03-9	n-Propyl Mercaptan	ND	12.0	ND	4.00
624-89-5	Ethyl Methyl Sulfide	ND	12.0	ND	4.00
110-02-1	Thiophene	ND	14.0	ND	4.00
513-44-0	Isobutyl Mercaptan	ND	15.0	ND	4.00
352-93-2	Diethyl Sulfide	ND	15.0	ND	4.00
109-79-5	n-Butyl Mercaptan	ND	15.0	ND	4.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
616-44-4	3-Methylthiophene	ND	16.0	ND	4.00
110-01-0	Tetrahydrothiophene	ND	14.0	ND	4.00
638-02-8	2,5-Dimethylthiophene	ND	18.0	ND	4.00
872-55-9	2-Ethylthiophene	ND	18.0	ND	4.00
110-81-6	Diethyl Disulfide	ND	10.0	ND	2.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SG

Date : 1/25/95

H-E14



Performance Analytical Inc.  
Environmental Testing and Consulting

## RESULTS OF ANALYSIS

PAGE 1 OF 2

Client : TRC Environmental Corporation

Client Sample ID : N/A

PAI Sample ID : PAI Method Blank

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Kathleen Aguilera  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : N/A  
Date Received : N/A  
Date Analyzed : 1/19/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
74-87-3	Chloromethane	ND	5.0	ND	2.4
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-00-3	Chloroethane	ND	5.0	ND	1.9
74-83-9	Bromomethane	ND	5.0	ND	1.3
67-64-1	Acetone	ND	20	ND	8.4
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-35-4	1,1-Dichloroethene	ND	5.0	ND	1.3
75-09-2	Methylene chloride	ND	5.0	ND	1.5
75-15-0	Carbon Disulfide	ND	5.0	ND	1.6
76-13-1	Trichlorotrifluoroethane	ND	5.0	ND	0.66
156-60-5	trans-1,2-Dichloroethene	ND	5.0	ND	1.3
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
1634-04-4	Methyl tert-Butyl Ether	ND	5.0	ND	1.4
108-05-4	Vinyl Acetate	ND	10	ND	2.8
78-93-3	2-Butanone	ND	10	ND	3.4
67-66-3	Chloroform	ND	5.0	ND	1.0
107-06-2	1,2-Dichloroethane	ND	5.0	ND	1.2
71-55-6	1,1,1-Trichloroethane	ND	5.0	ND	0.93
71-43-2	Benzene	ND	5.0	ND	1.6
56-23-5	Carbon Tetrachloride	ND	5.0	ND	0.80
78-87-5	1,2-Dichloropropane	ND	5.0	ND	1.1

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : RT

Date : 1/20/95

H-E15



Performance Analytical Inc.  
Environmental Testing and Consulting

## RESULTS OF ANALYSIS

PAGE 2 OF 2

Client : TRC Environmental Corporation

Client Sample ID : N/A

PAI Sample ID : PAI Method Blank

Test Code : GC/MS Mod. EPA TO-14

Analyst : Kathleen Aguilera

Instrument : Finnigan 4500C/Tekmar 5010

Matrix : Tedlar Bag

Date Sampled : N/A

Date Received : N/A

Date Analyzed : 1/19/95

Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
75-27-4	Bromodichloromethane	ND	5.0	ND	0.75
79-01-6	Trichloroethene	ND	5.0	ND	0.94
10061-01-5	cis-1,3-Dichloropropene	ND	5.0	ND	1.1
108-10-1	4-Methyl-2-pentanone	ND	10	ND	2.4
10061-02-6	trans-1,3-Dichloropropene	ND	5.0	ND	1.1
79-00-5	1,1,2-Trichloroethane	ND	5.0	ND	0.93
108-88-3	Toluene	ND	5.0	ND	1.3
124-48-1	Dibromochloromethane	ND	5.0	ND	0.59
591-78-6	2-Hexanone	ND	10	ND	2.4
106-93-4	1,2-Dibromoethane	ND	5.0	ND	0.66
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
75-25-2	Bromoform	ND	5.0	ND	0.49
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	ND	5.0	ND	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2
79-34-5	1,1,2,2-Tetrachloroethane	ND	5.0	ND	0.74
541-73-1	1,3-Dichlorobenzene	ND	5.0	ND	0.84
106-46-7	1,4-Dichlorobenzene	ND	5.0	ND	0.84
95-50-1	1,2-Dichlorobenzene	ND	5.0	ND	0.84

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : RT

Date : 1/20/95

H-E16



Performance Analytical Inc.  
Environmental Testing and Consulting

## RESULTS OF ANALYSIS

PAGE 1 OF 2

Client : TRC Environmental Corporation

Client Sample ID : GPU OUT 11995TB1

PAI Sample ID : 9500229

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Chris Parnell  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : 1/19/95  
Date Received : 1/19/95  
Date Analyzed : 1/19/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
74-87-3	Chloromethane	ND	5.0	ND	2.4
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-00-3	Chloroethane	ND	5.0	ND	1.9
74-83-9	Bromomethane	ND	5.0	ND	1.3
67-64-1	Acetone	22	20	9.2	8.4
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-35-4	1,1-Dichloroethene	ND	5.0	ND	1.3
75-09-2	Methylene chloride	16	5.0	4.6	1.5
75-15-0	Carbon Disulfide	ND	5.0	ND	1.6
76-13-1	Trichlorotrifluoroethane	ND	5.0	ND	0.66
156-60-5	trans-1,2-Dichloroethene	ND	5.0	ND	1.3
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
1634-04-4	Methyl tert-Butyl Ether	ND	5.0	ND	1.4
108-05-4	Vinyl Acetate	ND	10	ND	2.8
78-93-3	2-Butanone	ND	10	ND	3.4
67-66-3	Chloroform	ND	5.0	ND	1.0
107-06-2	1,2-Dichloroethane	ND	5.0	ND	1.2
71-55-6	1,1,1-Trichloroethane	ND	5.0	ND	0.93
71-43-2	Benzene	4.1 TR	5.0	1.3 TR	1.6
56-23-5	Carbon Tetrachloride	ND	5.0	ND	0.80
78-87-5	1,2-Dichloropropane	ND	5.0	ND	1.1

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : RT

Date : 1/20/95

H-E17





Performance Analytical Inc.  
Environmental Testing and Consulting

## RESULTS OF ANALYSIS

PAGE 2 OF 2

Client : TRC Environmental Corporation

Client Sample ID : GPU OUT 11995TB1

PAI Sample ID : 9500229

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Chris Parnell  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : 1/19/95  
Date Received : 1/19/95  
Date Analyzed : 1/19/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
75-27-4	Bromodichloromethane	ND	5.0	ND	0.75
79-01-6	Trichloroethene	ND	5.0	ND	0.94
10061-01-5	cis-1,3-Dichloropropene	ND	5.0	ND	1.1
108-10-1	4-Methyl-2-pentanone	ND	10	ND	2.4
10061-02-6	trans-1,3-Dichloropropene	ND	5.0	ND	1.1
79-00-5	1,1,2-Trichloroethane	ND	5.0	ND	0.93
108-88-3	Toluene	8.2	5.0	2.2	1.3
124-48-1	Dibromochloromethane	ND	5.0	ND	0.59
591-78-6	2-Hexanone	ND	10	ND	2.4
106-93-4	1,2-Dibromoethane	ND	5.0	ND	0.66
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
75-25-2	Bromoform	ND	5.0	ND	0.49
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	5.4	5.0	1.2	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2
79-34-5	1,1,2,2-Tetrachloroethane	ND	5.0	ND	0.74
541-73-1	1,3-Dichlorobenzene	ND	5.0	ND	0.84
106-46-7	1,4-Dichlorobenzene	ND	5.0	ND	0.84
95-50-1	1,2-Dichlorobenzene	ND	5.0	ND	0.84

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : RT

Date : 1/20/95

H-E18



Performance Analytical Inc.  
Environmental Testing and Consulting

## RESULTS OF ANALYSIS

PAGE 1 OF 2

Client : TRC Environmental Corporation

Client Sample ID : GPU OUT 11995TB1

PAI Sample ID : 9500229 (Laboratory Duplicate)

Test Code : GC/MS Mod. EPA TO-14

Analyst : Chris Parnell

Instrument : Finnigan 4500C/Tekmar 5010

Matrix : Tedlar Bag

Date Sampled : 1/19/95

Date Received : 1/19/95

Date Analyzed : 1/19/95

Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
74-87-3	Chloromethane	ND	5.0	ND	2.4
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-00-3	Chloroethane	ND	5.0	ND	1.9
74-83-9	Bromomethane	ND	5.0	ND	1.3
67-64-1	Acetone	17 TR	20	7.3 TR	8.4
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-35-4	1,1-Dichloroethene	ND	5.0	ND	1.3
75-09-2	Methylene chloride	15	5.0	4.2	1.5
75-15-0	Carbon Disulfide	ND	5.0	ND	1.6
76-13-1	Trichlorotrifluoroethane	ND	5.0	ND	0.66
156-60-5	trans-1,2-Dichloroethene	ND	5.0	ND	1.3
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
1634-04-4	Methyl tert-Butyl Ether	ND	5.0	ND	1.4
108-05-4	Vinyl Acetate	ND	10	ND	2.8
78-93-3	2-Butanone	ND	10	ND	3.4
67-66-3	Chloroform	ND	5.0	ND	1.0
107-06-2	1,2-Dichloroethane	ND	5.0	ND	1.2
71-55-6	1,1,1-Trichloroethane	ND	5.0	ND	0.93
71-43-2	Benzene	2.9 TR	5.0	0.91 TR	1.6
56-23-5	Carbon Tetrachloride	ND	5.0	ND	0.80
78-87-5	1,2-Dichloropropane	ND	5.0	ND	1.1

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : RT

Date : 1/20/95

H-E19

20954 Osborne Street, Canoga Park, CA 91304 • Phone 818 709-1139 • Fax 818 709-2915



Performance Analytical Inc.  
Environmental Testing and Consulting

## RESULTS OF ANALYSIS

PAGE 2 OF 2

Client : TRC Environmental Corporation

Client Sample ID : GPU OUT 11995TB1

PAI Sample ID : 9500229 (Laboratory Duplicate)

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Chris Parnell  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : 1/19/95  
Date Received : 1/19/95  
Date Analyzed : 1/19/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
75-27-4	Bromodichloromethane	ND	5.0	ND	0.75
79-01-6	Trichloroethene	ND	5.0	ND	0.94
10061-01-5	cis-1,3-Dichloropropene	ND	5.0	ND	1.1
108-10-1	4-Methyl-2-pentanone	ND	10	ND	2.4
10061-02-6	trans-1,3-Dichloropropene	ND	5.0	ND	1.1
79-00-5	1,1,2-Trichloroethane	ND	5.0	ND	0.93
108-88-3	Toluene	8.3	5.0	2.2	1.3
124-48-1	Dibromochloromethane	ND	5.0	ND	0.59
591-78-6	2-Hexanone	ND	10	ND	2.4
106-93-4	1,2-Dibromoethane	ND	5.0	ND	0.66
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
75-25-2	Bromoform	ND	5.0	ND	0.49
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	5.3	5.0	1.2	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2
79-34-5	1,1,2,2-Tetrachloroethane	ND	5.0	ND	0.74
541-73-1	1,3-Dichlorobenzene	ND	5.0	ND	0.84
106-46-7	1,4-Dichlorobenzene	ND	5.0	ND	0.84
95-50-1	1,2-Dichlorobenzene	ND	5.0	ND	0.84

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : RT

Date : 1/20/95

H-E20



**Performance Analytical Inc.**  
Environmental Testing and Consulting

**RESULTS OF ANALYSIS**

PAGE 1 OF 2

**Client : TRC Environmental Corporation**

**Client Sample ID : GPU OUT 11995TB2**

**PAI Sample ID : 9500230**

**Test Code : GC/MS Mod. EPA TO-14**

**Analyst : Chris Parnell**

**Instrument : Finnigan 4500C/Tekmar 5010**

**Matrix : Tedlar Bag**

**Date Sampled : 1/19/95**

**Date Received : 1/19/95**

**Date Analyzed : 1/19/95**

**Volume(s) Analyzed : 1.00 (Liter)**

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
74-87-3	Chloromethane	ND	5.0	ND	2.4
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-00-3	Chloroethane	ND	5.0	ND	1.9
74-83-9	Bromomethane	ND	5.0	ND	1.3
67-64-1	Acetone	20 TR	20	8.3 TR	8.4
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-35-4	1,1-Dichloroethene	ND	5.0	ND	1.3
75-09-2	Methylene chloride	15	5.0	4.4	1.5
75-15-0	Carbon Disulfide	ND	5.0	ND	1.6
76-13-1	Trichlorotrifluoroethane	ND	5.0	ND	0.66
156-60-5	trans-1,2-Dichloroethene	ND	5.0	ND	1.3
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
1634-04-4	Methyl tert-Butyl Ether	ND	5.0	ND	1.4
108-05-4	Vinyl Acetate	ND	10	ND	2.8
78-93-3	2-Butanone	ND	10	ND	3.4
67-66-3	Chloroform	ND	5.0	ND	1.0
107-06-2	1,2-Dichloroethane	ND	5.0	ND	1.2
71-55-6	1,1,1-Trichloroethane	ND	5.0	ND	0.93
71-43-2	Benzene	3.1 TR	5.0	0.97 TR	1.6
56-23-5	Carbon Tetrachloride	ND	5.0	ND	0.80
78-87-5	1,2-Dichloropropane	ND	5.0	ND	1.1

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : RT

Date : 1/20/95

H-E21



**Performance Analytical Inc.**  
Environmental Testing and Consulting

**RESULTS OF ANALYSIS**

PAGE 2 OF 2

**Client : TRC Environmental Corporation**

**Client Sample ID : GPU OUT 11995TB2**

**PAI Sample ID : 9500230**

**Test Code : GC/MS Mod. EPA TO-14**

**Analyst : Chris Parnell**

**Instrument : Finnigan 4500C/Tekmar 5010**

**Matrix : Tedlar Bag**

**Date Sampled : 1/19/95**

**Date Received : 1/19/95**

**Date Analyzed : 1/19/95**

**Volume(s) Analyzed : 1.00 (Liter)**

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
75-27-4	Bromodichloromethane	ND	5.0	ND	0.75
79-01-6	Trichloroethene	ND	5.0	ND	0.94
10061-01-5	cis-1,3-Dichloropropene	ND	5.0	ND	1.1
108-10-1	4-Methyl-2-pentanone	ND	10	ND	2.4
10061-02-6	trans-1,3-Dichloropropene	ND	5.0	ND	1.1
79-00-5	1,1,2-Trichloroethane	ND	5.0	ND	0.93
108-88-3	Toluene	9.0	5.0	2.4	1.3
124-48-1	Dibromochloromethane	ND	5.0	ND	0.59
591-78-6	2-Hexanone	ND	10	ND	2.4
106-93-4	1,2-Dibromoethane	ND	5.0	ND	0.66
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
75-25-2	Bromoform	ND	5.0	ND	0.49
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	4.9 TR	5.0	1.1 TR	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2
79-34-5	1,1,2,2-Tetrachloroethane	ND	5.0	ND	0.74
541-73-1	1,3-Dichlorobenzene	ND	5.0	ND	0.84
106-46-7	1,4-Dichlorobenzene	ND	5.0	ND	0.84
95-50-1	1,2-Dichlorobenzene	ND	5.0	ND	0.84

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : RT

Date : 1/20/95

H-E22



Performance Analytical Inc.  
Environmental Testing and Consulting

## RESULTS OF ANALYSIS

PAGE 1 OF 2

Client : TRC Environmental Corporation

Client Sample ID : GPU OUT 11995TB3

PAI Sample ID : 9500231

Test Code : GC/MS Mod. EPA TO-14

Analyst : Chris Parnell

Instrument : Finnigan 4500C/Tekmar 5010

Matrix : Tedlar Bag

Date Sampled : 1/19/95

Date Received : 1/19/95

Date Analyzed : 1/19/95

Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
74-87-3	Chloromethane	ND	5.0	ND	2.4
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-00-3	Chloroethane	ND	5.0	ND	1.9
74-83-9	Bromomethane	ND	5.0	ND	1.3
67-64-1	Acetone	15 TR	20	6.4 TR	8.4
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-35-4	1,1-Dichloroethene	ND	5.0	ND	1.3
75-09-2	Methylene chloride	12	5.0	3.6	1.5
75-15-0	Carbon Disulfide	ND	5.0	ND	1.6
76-13-1	Trichlorotrifluoroethane	ND	5.0	ND	0.66
156-60-5	trans-1,2-Dichloroethene	ND	5.0	ND	1.3
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
1634-04-4	Methyl tert-Butyl Ether	ND	5.0	ND	1.4
108-05-4	Vinyl Acetate	ND	10	ND	2.8
78-93-3	2-Butanone	ND	10	ND	3.4
67-66-3	Chloroform	ND	5.0	ND	1.0
107-06-2	1,2-Dichloroethane	ND	5.0	ND	1.2
71-55-6	1,1,1-Trichloroethane	ND	5.0	ND	0.93
71-43-2	Benzene	2.9 TR	5.0	0.90 TR	1.6
56-23-5	Carbon Tetrachloride	ND	5.0	ND	0.80
78-87-5	1,2-Dichloropropane	ND	5.0	ND	1.1

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : RT

Date : 1/20/95

H-E23



Performance Analytical Inc.  
Environmental Testing and Consulting

## RESULTS OF ANALYSIS

PAGE 2 OF 2

Client : TRC Environmental Corporation

Client Sample ID : GPU OUT 11995TB3

PAI Sample ID : 9500231

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Chris Parnell  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : 1/19/95  
Date Received : 1/19/95  
Date Analyzed : 1/19/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
75-27-4	Bromodichloromethane	ND	5.0	ND	0.75
79-01-6	Trichloroethene	ND	5.0	ND	0.94
10061-01-5	cis-1,3-Dichloropropene	ND	5.0	ND	1.1
108-10-1	4-Methyl-2-pentanone	ND	10	ND	2.4
10061-02-6	trans-1,3-Dichloropropene	ND	5.0	ND	1.1
79-00-5	1,1,2-Trichloroethane	ND	5.0	ND	0.93
108-88-3	Toluene	8.4	5.0	2.2	1.3
124-48-1	Dibromochloromethane	ND	5.0	ND	0.59
591-78-6	2-Hexanone	ND	10	ND	2.4
106-93-4	1,2-Dibromoethane	ND	5.0	ND	0.66
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
75-25-2	Bromoform	ND	5.0	ND	0.49
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	4.9 TR	5.0	1.1 TR	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2
79-34-5	1,1,2,2-Tetrachloroethane	ND	5.0	ND	0.74
541-73-1	1,3-Dichlorobenzene	ND	5.0	ND	0.84
106-46-7	1,4-Dichlorobenzene	ND	5.0	ND	0.84
95-50-1	1,2-Dichlorobenzene	ND	5.0	ND	0.84

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by: RT

Date: 1/20/95

H-E24







**Performance Analytical Inc.**

Air Quality Laboratory

**LABORATORY REPORT**

<b>Client:</b>	<b>TRC ENVIRONMENTAL CORPORATION</b>	<b>Date of Report:</b>	<b>02/15/95</b>
<b>Address:</b>	<b>5 Waterside Crossing</b>	<b>Date Received:</b>	<b>01/20/95</b>
	<b>Windsor, CT 06095</b>	<b>PAI Project No:</b>	<b>P95-7646</b>
<b>Contact:</b>	<b>Mr. Jim Canora</b>	<b>Purchase Order:</b>	<b>026197</b>
<b>Client Project ID: IFC #2030-6</b>			

One (1) Tedlar Bag Sample labeled:

"GPU OUT 12095TB1"

The sample was received at the laboratory under chain of custody on January 20, 1995. The sample was received intact. The dates of analyses are indicated on the attached data sheets.

**Sulfur Compound Analysis**

The sample was analyzed for seven Sulfur Compounds and Total Reduced Sulfur as Hydrogen Sulfide by gas chromatography/flame photometric detection (FPD). The analytical system used was comprised of a Hewlett Packard Model 5890 equipped with a flame photometric detector (FPD). A thick film (5 micron) crossbonded 100% Dimethyl polysiloxane megabore column (60 meter x 0.53mm RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

**Volatile Organic Compound Analysis**

The sample was analyzed by combined gas chromatography/mass spectrometry (GC/MS) for selected Volatile Organic Compounds. The analyses were performed according to the methodology outlined in EPA Method TO-14 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, EPA 600/4-84-041, U.S. Environmental Protection Agency, Research Triangle Park, NC, April, 1984 and May, 1988. The method was modified for using Tedlar bags. The analyses were performed by gas chromatography/mass spectrometry, utilizing a direct cryogenic trapping technique. The analytical system used was comprised of a Finnigan Model 4500 GC/MS/DS interfaced to a Tekmar 5010 Automatic Desorber. A 100% Dimethyl polysiloxane capillary column (RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

The results of analyses are given on the attached data summary sheets.

Data Release Authorization:

Reviewed and Approved:

Kathleen Aguilera  
Analytical Chemist

Michael Tuday  
Laboratory Director

H-E26



**Performance Analytical Inc.**  
Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : N/A**

**PAI Sample ID : PAI Method Blank**

**Test Code : GC/FPD Reduced Sulfur Analysis**

**Analyst : Ku-Jih Chen**

**Instrument : HP5890A/FPD #4**

**Matrix : Tedlar Bag**

**Date Sampled : N/A**

**Date Received : N/A**

**Date Analyzed : 1/20/95**

**Volume(s) Analyzed : 10.0 (ml)**

CAS #	COMPOUND	RESULT	REPORTING	RESULT	REPORTING
		ug/m3	LIMIT ug/m3	ppb	LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	ND	9.80	ND	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	ND	5.60	ND	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SG

Date : 2/15/95

H-E27



**Performance Analytical Inc.**  
Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : GPU OUT 12095TB1**

**PAI Sample ID : 9500249**

**Test Code : GC/FPD Reduced Sulfur Analysis**

**Analyst : Ku-Jih Chen**

**Instrument : HP5890A/FPD #4**

**Matrix : Tedlar Bag**

**Date Sampled : 1/20/95**

**Date Received : 1/20/95**

**Date Analyzed : 1/20/95**

**Volume(s) Analyzed : 10.0 (ml)**

CAS #	COMPOUND	RESULT	REPORTING LIMIT	RESULT	REPORTING LIMIT
		ug/m3	ug/m3	ppb	ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	ND	9.80	ND	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	ND	5.60	ND	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SG

Date : 2/15/95

H-E28



Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : GPU OUT 12095TB1

PAI Sample ID : 9500249 (Laboratory Duplicate)

Test Code : GC/FPD Reduced Sulfur Analysis

Analyst : Ku-Jih Chen

Instrument : HP5890A/FPD #4

Matrix : Tedlar Bag

Date Sampled : 1/20/95

Date Received : 1/20/95

Date Analyzed : 1/20/95

Volume(s) Analyzed : 10.0 (ml)

CAS #	COMPOUND	RESULT	REPORTING	RESULT	REPORTING
		ug/m3	LIMIT ug/m3	ppb	LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	ND	9.80	ND	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	ND	5.60	ND	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : (S/G)

Date : 2/15/95

H-E29



**Performance Analytical Inc.**

Air Quality Laboratory

**RESULTS OF ANALYSIS**

PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : N/A**

**PAI Sample ID : PAI Method Blank**

**Test Code : GC/MS Mod. EPA TO-14**

**Analyst : Kathleen Aguilera**

**Instrument : Finnigan 4500C/Tekmar 5010**

**Matrix : Tedlar Bag**

**Date Sampled : N/A**

**Date Received : N/A**

**Date Analyzed : 1/20/95**

**Volume(s) Analyzed : 1.00 (Liter)**

**D.F. = 1.00**

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	ND	5.0	ND	1.5
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	ND	5.0	ND	1.3
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	ND	5.0	ND	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by :                     

Date :                     

2/15/95

H-E30



# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

**Client** : TRC Environmental Corporation

**Client Sample ID** : GPU OUT 12095TB1

**PAI Sample ID** : 9500249

**Test Code** : GC/MS Mod. EPA TO-14

**Analyst** : Kathleen Aguilera

**Instrument** : Finnigan 4500C/Tekmar 5010

**Matrix** : Tedlar Bag

**Date Sampled** : 1/20/95

**Date Received** : 1/20/95

**Date Analyzed** : 1/20/95

**Volume(s) Analyzed** : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	ND	5.0	ND	1.5
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	12	5.0	3.1	1.3
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	2.1 TR	5.0	0.49 TR	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	8.7	5.0	2.0	1.2
95-47-6	o-Xylene	3.7 TR	5.0	0.85 TR	1.2

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SLG

Date : 2/15/95

H-E31





**Performance Analytical Inc.**

Air Quality Laboratory

**LABORATORY REPORT**

<b>Client:</b>	<b>TRC ENVIRONMENTAL CORPORATION</b>	<b>Date of Report:</b>	<b>03/16/95</b>
<b>Address:</b>	<b>5 Waterside Crossing</b>	<b>Date Received:</b>	<b>01/25/95</b>
	<b>Windsor, CT 06095</b>	<b>PAI Project No:</b>	<b>P95-7671</b>
<b>Contact:</b>	<b>Mr. Jim Canora</b>	<b>Purchase Order:</b>	<b>026197</b>
<b>Client Project ID: IFC #2030-6</b>			

---

**One (1) Tedlar Bag Sample labeled: "GPU OUT 12595TB1"**

---

The sample was received at the laboratory under chain of custody on January 25, 1995. The sample was received intact. The dates of analyses are indicated on the attached data sheets.

**Sulfur Compound Analysis**

The sample was analyzed for seven Sulfur Compounds and Total Reduced Sulfur as Hydrogen Sulfide by gas chromatography/flame photometric detection (FPD). The analytical system used was comprised of a Hewlett Packard Model 5890 equipped with a flame photometric detector (FPD). A thick film (5 micron) crossbonded 100% Dimethyl polysiloxane megabore column (60 meter x 0.53mm RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

**Volatile Organic Compound Analysis**

The sample was also analyzed by combined gas chromatography/mass spectrometry (GC/MS) for selected Volatile Organic Compounds. The analyses were performed according to the methodology outlined in EPA Method TO-14 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, EPA 600/4-84-041, U.S. Environmental Protection Agency, Research Triangle Park, NC, April, 1984 and May, 1988. The method was modified for using Tedlar bags. The analyses were performed by gas chromatography/mass spectrometry, utilizing a direct cryogenic trapping technique. The analytical system used was comprised of a Finnigan Model 4500 GC/MS/DS interfaced to a Tekmar 5010 Automatic Desorber. A 100% Dimethyl polysiloxane capillary column (RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

The results of analyses are given on the attached data summary sheets.

---

**Data Release Authorization:**

**Kathleen Aguilera**  
Analytical Chemist

**Reviewed and Approved:**

**Michael Tuday**  
Laboratory Director

H-E33





# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

**Client** : TRC Environmental Corporation

**Client Sample ID** : N/A

**PAI Sample ID** : PAI Method Blank

**Test Code** : GC/FPD Reduced Sulfur Analysis

**Analyst** : Ku-Jih Chen

**Instrument** : HP5890A/FPD #4

**Matrix** : Tedlar Bag

**Date Sampled** : N/A

**Date Received** : N/A

**Date Analyzed** : 1/26/95

**Volume(s) Analyzed** : 10.0 (ml)

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	ND	9.80	ND	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	ND	5.60	ND	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : JB

Date : 2/10/95

H-E34



**Performance Analytical Inc.**

Air Quality Laboratory

**RESULTS OF ANALYSIS**

PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : GPU OUT 12595TB1**

**PAI Sample ID : 9500329**

**Test Code : GC/FPD Reduced Sulfur Analysis**

**Analyst : Ku-Jih Chen**

**Instrument : HP5890A/FPD #4**

**Matrix : Tedlar Bag**

**Date Sampled : 1/25/95**

**Date Received : 1/25/95**

**Date Analyzed : 1/26/95**

**Volume(s) Analyzed : 10.0 (ml)**

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	176	9.80	71.5	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	99.6	5.60	71.5	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SG

Date : 2/10/95

H-E35



**Performance Analytical Inc.**

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : GPU OUT 12595TB1**

**PAI Sample ID : 9500329 Laboratory Duplicate**

**Test Code : GC/FPD Reduced Sulfur Analysis**

**Analyst : Ku-Jih Chen**

**Instrument : HP5890A/FPD #4**

**Matrix : Tedlar Bag**

**Date Sampled : 1/25/95**

**Date Received : 1/25/95**

**Date Analyzed : 1/26/95**

**Volume(s) Analyzed : 10.0 (ml)**

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	193	9.80	78.4	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	109	5.60	78.4	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SG

Date : 2/10/95

H-E36



Performance Analytical Inc.  
Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : N/A

PAI Sample ID : PAI Method Blank

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Kathleen Aguilera  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : N/A  
Date Received : N/A  
Date Analyzed : 1/26/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT	REPORTING	RESULT	REPORTING
		ug/m3	LIMIT ug/m3	ppb	LIMIT ppb
75-71-8	Dichlorodifluoromethane	ND	5.0	ND	1.0
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	ND	5.0	ND	1.5
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	ND	5.0	ND	1.3
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	ND	5.0	ND	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by :

SG

Date :

3/16/95

H-E37



Performance Analytical Inc.  
Air Quality Laboratory

**RESULTS OF ANALYSIS**  
PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : GPU OUT 12595TB1**  
**PAI Sample ID : 9500329**

**Test Code : GC/MS Mod. EPA TO-14**  
**Analyst : Kathleen Aguilera**  
**Instrument : Finnigan 4500C/Tekmar 5010**  
**Matrix : Tedlar Bag**

**Date Sampled : 1/25/95**  
**Date Received : 1/25/95**  
**Date Analyzed : 1/26/95**  
**Volume(s) Analyzed : 1.00 (Liter)**

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
75-71-8	Dichlorodifluoromethane	ND	5.0	ND	1.0
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	ND	5.0	ND	1.5
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	5.9	5.0	1.6	1.3
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	3.2 TR	5.0	0.73 TR	1.2
95-47-6	o-Xylene	1.1 TR	5.0	0.25 TR	1.2

TR = Detected Below Indicated Reporting Limit  
ND = Not Detected

Verified by :                     

Date :                     

H-E38





**Performance Analytical Inc.**

Air Quality Laboratory

**LABORATORY REPORT**

<b>Client:</b>	<b>TRC ENVIRONMENTAL CORPORATION</b>	<b>Date of Report:</b>	<b>03/16/95</b>
<b>Address:</b>	<b>5 Waterside Crossing</b>	<b>Date Received:</b>	<b>01/26/95</b>
	<b>Windsor, CT 06095</b>	<b>PAI Project No:</b>	<b>P95-7675</b>
<b>Contact:</b>	<b>Mr. Jim Canora</b>	<b>Purchase Order:</b>	<b>026197</b>
<b>Client Project ID: IFC #2030-6</b>			

---

**One (1) Tedlar Bag Sample labeled:**

**"GPU OUT 12695TB1"**

---

The sample was received at the laboratory under chain of custody on January 26, 1995. The sample was received intact. The dates of analyses are indicated on the attached data sheets.

**Sulfur Compound Analysis**

The sample was analyzed for seven Sulfur Compounds and Total Reduced Sulfur as Hydrogen Sulfide by gas chromatography/flame photometric detection (FPD). The analytical system used was comprised of a Hewlett Packard Model 5890 equipped with a flame photometric detector (FPD). A thick film (5 micron) crossbonded 100% Dimethyl polysiloxane megabore column (60 meter x 0.53mm RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

**Volatile Organic Compound Analysis**

The sample was also analyzed by combined gas chromatography/mass spectrometry (GC/MS) for selected Volatile Organic Compounds. The analyses were performed according to the methodology outlined in EPA Method TO-14 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, EPA 600/4-84-041, U.S. Environmental Protection Agency, Research Triangle Park, NC, April, 1984 and May, 1988. The method was modified for using Tedlar bags. The analyses were performed by gas chromatography/mass spectrometry, utilizing a direct cryogenic trapping technique. The analytical system used was comprised of a Finnigan Model 4500 GC/MS/DS interfaced to a Tekmar 5010 Automatic Desorber. A 100% Dimethyl polysiloxane capillary column (RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

The results of analyses are given on the attached data summary sheets.

---

**Data Release Authorization:**

**Kathleen Aguilera**  
Analytical Chemist

**Reviewed and Approved:**

**Michael Tuday**  
Laboratory Director

**H-E40**



# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : N/A

PAI Sample ID : PAI Method Blank

Test Code : GC/FPD Reduced Sulfur Analysis

Analyst : Ku-Jih Chen

Instrument : HP5890A/FPD #4

Matrix : Tedlar Bag

Date Sampled : N/A

Date Received : N/A

Date Analyzed : 1/26/95

Volume(s) Analyzed : 10.0 (ml)

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	ND	9.80	ND	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	ND	5.60	ND	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by :

SG

Date :

2/10/95

H-E41

20954 Osborne Street, Canoga Park, CA 91304 • Phone 818 709-1139 • Fax 818 709-2915





# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : GPU OUT 12695TB1

PAI Sample ID : 9500337

Test Code : GC/FPD Reduced Sulfur Analysis

Analyst : Ku-Jih Chen

Instrument : HP5890A/FPD #4

Matrix : Tedlar Bag

Date Sampled : 1/26/95

Date Received : 1/26/95

Date Analyzed : 1/26/95

Volume(s) Analyzed : 10.0 (ml)

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	190	9.80	77.2	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	108	5.60	77.2	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : 96

Date : 2/10/95

H-E42

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Performance Analytical Inc.  
Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : N/A

PAI Sample ID : PAI Method Blank

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Kathleen Aguilera  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : N/A  
Date Received : N/A  
Date Analyzed : 1/26/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
75-71-8	Dichlorodifluoromethane	ND	5.0	ND	1.0
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	ND	5.0	ND	1.5
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	ND	5.0	ND	1.3
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	ND	5.0	ND	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SL

Date : 3/16/95

H-E43



Performance Analytical Inc.  
Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : GPU OUT 12695TB1

PAI Sample ID : 9500337

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Kathleen Aguilera  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : 1/26/95  
Date Received : 1/26/95  
Date Analyzed : 1/26/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
75-71-8	Dichlorodifluoromethane	ND	5.0	ND	1.0
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	ND	5.0	ND	1.5
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	3.7 TR	5.0	0.99 TR	1.3
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	ND	5.0	ND	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SG

Date : 3/16/95

H-E44

H-E45

[illegible]



Performance Analytical Inc.  
Air Quality Laboratory

### LABORATORY REPORT

Client:	TRC ENVIRONMENTAL CORPORATION	Date of Report:	03/02/95
Address:	5 Waterside Crossing	Date Received:	02/09/95
	Windsor, CT 06095	PAI Project No:	P95-7783
Contact:	Mr. Jim Canora	Purchase Order:	026197
Client Project ID:	IFC #2030-6		

---

One (1) Tedlar Bag Sample labeled:

"GPU OUT 20995TB1"

---

The sample was received at the laboratory under chain of custody on February 9, 1995. The sample was received intact. The dates of analyses are indicated on the attached data sheets.

#### Sulfur Compound Analysis

The sample was analyzed for seven Sulfur Compounds and Total Reduced Sulfur as Hydrogen Sulfide by gas chromatography/flame photometric detection (FPD). The analytical system used was comprised of a Hewlett Packard Model 5890 equipped with a flame photometric detector (FPD). A thick film (5 micron) crossbonded 100% Dimethyl polysiloxane megabore column (60 meter x 0.53mm RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

#### Volatile Organic Compound Analysis

The sample was analyzed by combined gas chromatography/mass spectrometry (GC/MS) for selected Volatile Organic Compounds. The analyses were performed according to the methodology outlined in EPA Method TO-14 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, EPA 600/4-84-041, U.S. Environmental Protection Agency, Research Triangle Park, NC, April, 1984 and May, 1988. The method was modified for using Tedlar bags. The analyses were performed by gas chromatography/mass spectrometry, utilizing a direct cryogenic trapping technique. The analytical system used was comprised of a Finnigan Model 4500 GC/MS/DS interfaced to a Tekmar 5010 Automatic Desorber. A 100% Dimethyl polysiloxane capillary column (RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

The results of analyses are given on the attached data summary sheets.

---

Data Release Authorization:

J-Jih Chen  
Principal Chemist

Reviewed and Approved:

Michael Tuday  
Laboratory Director

H-E46



**Performance Analytical Inc.**

Air Quality Laboratory

**RESULTS OF ANALYSIS**

PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : N/A**

**PAI Sample ID : PAI Method Blank**

**Test Code : GC/FPD Reduced Sulfur Analysis**

**Analyst : Ku-Jih Chen**

**Instrument : HP5890A/FPD #4**

**Matrix : Tedlar Bag**

**Date Sampled : N/A**

**Date Received : N/A**

**Date Analyzed : 2/9/95**

**Volume(s) Analyzed : 10.0 (ml)**

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	ND	9.80	ND	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	ND	5.60	ND	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SLG

Date : 2/13/95

H-E47



**Performance Analytical Inc.**  
Air Quality Laboratory

**RESULTS OF ANALYSIS**  
PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : GPUOUT20995TB1**  
**PAI Sample ID : 9500780**

**Test Code : GC/FPD Reduced Sulfur Analysis**  
**Analyst : Ku-Jih Chen**  
**Instrument : HP5890A/FPD #4**  
**Matrix : Tedlar Bag**

**Date Sampled : 2/9/95**  
**Date Received : 2/9/95**  
**Date Analyzed : 2/9/95**  
**Volume(s) Analyzed : 10.0 (ml)**

CAS #	COMPOUND	RESULT	REPORTING	RESULT	REPORTING
		ug/m3	LIMIT ug/m3	ppb	LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	424	9.80	173	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	241	5.60	173	4.00

TR = Detected Below Indicated Reporting Limit  
ND = Not Detected

Verified by : SLG  
Date : 2/13/95

H-E48



# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : GPUOUT20995TB1

PAI Sample ID : 9500780 (Laboratory Duplicate)

Test Code : GC/FPD Reduced Sulfur Analysis

Analyst : Ku-Jih Chen

Instrument : HP5890A/FPD #4

Matrix : Tedlar Bag

Date Sampled : 2/9/95

Date Received : 2/9/95

Date Analyzed : 2/9/95

Volume(s) Analyzed : 10.0 (ml)

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	411	9.80	167	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	233	5.60	167	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SLG

Date : 2/13/95

H-E49





Performance Analytical Inc.  
Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : N/A

PAI Sample ID : PAI Method Blank

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Chris Casteel  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : N/A  
Date Received : N/A  
Date Analyzed : 2/10/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT	REPORTING	RESULT	REPORTING
		ug/m3	LIMIT ug/m3	ppb	LIMIT ppb
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	ND	5.0	ND	1.5
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	ND	5.0	ND	1.3
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	ND	5.0	ND	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by :                     

Date :                     

2/23/95

H-E50



# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : GPU OUT 20995TB1

PAI Sample ID : 9500780

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Chris Parnell  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : 2/9/95  
Date Received : 2/9/95  
Date Analyzed : 2/10/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT	REPORTING	RESULT	REPORTING
		ug/m3	LIMIT ug/m3	ppb	LIMIT ppb
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	ND	5.0	ND	1.5
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	15	5.0	4.0	1.3
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	ND	5.0	ND	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2

TR = Detected Below Indicated Reporting Limit  
ND = Not Detected

Verified by : SG

Date : 2/23/95

H-E51

Ship To: Performance Analytical  
Attn: Michael Turkey

Page 1 of 1  
Project Name: IFC  
Project No.: 2030-6  
Site Location: Pentose Landfill  
Date: February, 9, 1995

### CHAIN OF CUSTODY RECORD

## Analysis

9957783

Boring/Well No.	Sample No.	Depth	Date	Time	Sample Type			Comp.	Grab.	Sample Containers			
					Water	Solid	Other			Vol.	No.	Type	Pres.
GP000T20995781	—	2/9/51	10:41			1.2		X	12L	1	T.O.		

Subj: [REDACTED] -  
FPA 16

Analysis

### Remarks

6P5 OUTLET 9500780

**Total Number of Samples Shipped:**

**Shipper's Signature:**

*John Linn*

Signature \_\_\_\_\_

Relinquished by: Har Pierce \_\_\_\_\_

Received by: Kim Spauldt K. Spauldt

Company  
Environmental Solutions, Inc.  
PAI

Date  
2/9/95  
2/9/95

Time  
11:16  
11:16

**Relinquished by:**

Received by:

Relinquished by:

Received by:

**Special Instructions / Shipment / Handling/ Storage Requirements:**

☒

**ENVIRONMENTAL SOLUTIONS, INC.**  
21 Technology Drive  
Irvine, California 92718



**ENVIRONMENTAL SOLUTIONS, INC.**  
2815 Mitchell Drive, Suite 103  
Walnut Creek, California 94598

**The material(s) listed are received for analysis and/or treatability evaluation and remain the property of the client and not Environmental Solutions, Inc. At the conclusion of the test work, all remaining material(s) will be returned to the client for eventual disposal at a licensed facility.**



**Performance Analytical Inc.**  
Air Quality Laboratory

### LABORATORY REPORT

Client:	TRC ENVIRONMENTAL CORPORATION	Date of Report:	03/02/95
Address:	5 Waterside Crossing	Date Received:	02/10/95
	Windsor, CT 06095	PAI Project No:	P95-7796
Contact:	Mr. Jim Canora	Purchase Order:	026197
Client Project ID:	IFC #2030-6		

---

One (1) Tedlar Bag Sample labeled:

"GPU OUT 21095TB1"

---

The sample was received at the laboratory under chain of custody on February 10, 1995. The sample was received intact. The dates of analyses are indicated on the attached data sheets.

#### Sulfur Compound Analysis

The sample was analyzed for seven Sulfur Compounds and Total Reduced Sulfur as Hydrogen Sulfide by gas chromatography/flame photometric detection (FPD). The analytical system used was comprised of a Hewlett Packard Model 5890 equipped with a flame photometric detector (FPD). A thick film (5 micron) crossbonded 100% Dimethyl polysiloxane megabore column (60 meter x 0.53mm RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

#### Volatile Organic Compound Analysis

The sample was also analyzed by combined gas chromatography/mass spectrometry (GC/MS) for selected Volatile Organic Compounds. The analyses were performed according to the methodology outlined in EPA Method TO-14 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, EPA 600/4-84-041, U.S. Environmental Protection Agency, Research Triangle Park, NC, April, 1984 and May, 1988. The method was modified for using Tedlar bags. The analyses were performed by gas chromatography/mass spectrometry, utilizing a direct cryogenic trapping technique. The analytical system used was comprised of a Finnigan Model 4500 GC/MS/DS interfaced to a Tekmar 5010 Automatic Desorber. A 100% Dimethyl polysiloxane capillary column (RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

The results of analyses are given on the attached data summary sheets.

---

Data Release Authorization:

Ku-Jih Chen  
Principal Chemist

Reviewed and Approved:

Michael Tuday  
Laboratory Director

H-E53



# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

**Client** : TRC Environmental Corporation

**Client Sample ID** : N/A

**PAI Sample ID** : PAI Method Blank

**Test Code** : GC/FPD Reduced Sulfur Analysis

**Analyst** : Ku-Jih Chen

**Instrument** : HP5890A/FPD #4

**Matrix** : Tedlar Bag

**Date Sampled** : N/A

**Date Received** : N/A

**Date Analyzed** : 2/10/95

**Volume(s) Analyzed** : 10.0 (ml)

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	ND	9.80	ND	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	ND	5.60	ND	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by :                     

Date :                     2/23/95                    

H-E54



# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : GPU OUT 21095TB1**

**PAI Sample ID : 9500846**

**Test Code : GC/FPD Reduced Sulfur Analysis**

**Analyst : Ku-Jih Chen**

**Instrument : HP5890A/FPD #4**

**Matrix : Tedlar Bag**

**Date Sampled : 2/10/95**

**Date Received : 2/10/95**

**Date Analyzed : 2/10/95**

**Volume(s) Analyzed : 10.0 (ml)**

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	945	9.80	385	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	536	5.60	385	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by :                     

Date :                     

H-E55



# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : GPU OUT 21095TB1

PAI Sample ID : 9500846 (Laboratory Duplicate)

Test Code : GC/FPD Reduced Sulfur Analysis

Analyst : Ku-Jih Chen

Instrument : HP5890A/FPD #4

Matrix : Tedlar Bag

Date Sampled : 2/10/95

Date Received : 2/10/95

Date Analyzed : 2/10/95

Volume(s) Analyzed : 10.0 (ml)

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	957	9.80	390	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	543	5.60	390	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by :                     

Date :                     

H-E56



**Performance Analytical Inc.**  
Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : N/A**

**PAI Sample ID : PAI Method Blank**

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Chris Casteel  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : N/A  
Date Received : N/A  
Date Analyzed : 2/10/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT	REPORTING	RESULT	REPORTING
		ug/m3	LIMIT ug/m3	ppb	LIMIT ppb
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	ND	5.0	ND	1.5
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	ND	5.0	ND	1.3
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	ND	5.0	ND	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by :                     

Date : 2/23/95

H-E57





# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : GPU OUT 21095TB1

PAI Sample ID : 9500846

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Chris Parnell  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : 2/10/95  
Date Received : 2/10/95  
Date Analyzed : 2/10/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	3.3 TR	5.0	0.95 TR	1.5
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	16	5.0	4.1	1.3
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	3.9 TR	5.0	0.91 TR	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	14	5.0	3.1	1.2
95-47-6	o-Xylene	4.8 TR	5.0	1.1 TR	1.2

TR = Detected Below Indicated Reporting Limit  
ND = Not Detected

Verified by :

Date :

2/23/95

H-E58





**Performance Analytical Inc.**

Air Quality Laboratory

**LABORATORY REPORT**

Client:	TRC ENVIRONMENTAL CORPORATION	Date of Report:	03/06/95
Address:	5 Waterside Crossing	Date Received:	02/17/95
	Windsor, CT 06095	PAI Project No:	P95-7833
Contact:	Mr. Jim Canora	Purchase Order:	026197
Client Project ID:	IFC #2030-6		

---

One (1) Tedlar Bag Sample labeled:

"GPU OUT 21795"

---

The sample was received at the laboratory under chain of custody on February 17, 1995. The sample was received intact. The dates of analyses are indicated on the attached data sheets.

Sulfur Compound Analysis

The sample was analyzed for seven Sulfur Compounds and Total Reduced Sulfur as Hydrogen Sulfide by gas chromatography/flame photometric detection (FPD). The analytical system used was comprised of a Hewlett Packard Model 5890 equipped with a flame photometric detector (FPD). A thick film (5 micron) crossbonded 100% Dimethyl polysiloxane megabore column (60 meter x 0.53mm RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

Volatile Organic Compound Analysis

The sample was also analyzed by combined gas chromatography/mass spectrometry (GC/MS) for selected Volatile Organic Compounds. The analyses were performed according to the methodology outlined in EPA Method TO-14 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, EPA 600/4-84-041, U.S. Environmental Protection Agency, Research Triangle Park, NC, April, 1984 and May, 1988. The method was modified for using Tedlar bags. The analyses were performed by gas chromatography/mass spectrometry, utilizing a direct cryogenic trapping technique. The analytical system used was comprised of a Finnigan Model 4500 GC/MS/DS interfaced to a Tekmar 5010 Automatic Desorber. A 100% Dimethyl polysiloxane capillary column (RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

The results of analyses are given on the attached data summary sheets.

---

Data Release Authorization:

Kathleen Aguilera  
Analytical Chemist

Reviewed and Approved:

Michael Tuday  
Laboratory Director

H-E60



# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : N/A**

**PAI Sample ID : PAI Method Blank**

**Test Code : GC/FPD Reduced Sulfur Analysis**

**Analyst : J. Dan Taliaferro**

**Instrument : HP5890A/FPD #4**

**Matrix : Tedlar Bag**

**Date Sampled : N/A**

**Date Received : N/A**

**Date Analyzed : 2/17/95**

**Volume(s) Analyzed : 10.0 (ml)**

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	ND	9.80	ND	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	ND	5.60	ND	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SLG

Date : 3/2/95

H-E61



# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : GPU OUT 21795**

**PAI Sample ID : 9500994**

**Test Code : GC/FPD Reduced Sulfur Analysis**

**Analyst : J. Dan Taliaferro**

**Instrument : HP5890A/FPD #4**

**Matrix : Tedlar Bag**

**Date Sampled : 2/17/95**

**Date Received : 2/17/95**

**Date Analyzed : 2/17/95**

**Volume(s) Analyzed : 10.0 (ml)**

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	149	9.80	60.5	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	84.3	5.60	60.5	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by :                     

Date :                     

H-E62



# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

**Client** : TRC Environmental Corporation

**Client Sample ID** : GPU OUT 21795

**PAI Sample ID** : 9500994 (Laboratory Duplicate)

**Test Code** : GC/FPD Reduced Sulfur Analysis

**Analyst** : J. Dan Taliaferro

**Instrument** : HP5890A/FPD #4

**Matrix** : Tedlar Bag

**Date Sampled** : 2/17/95

**Date Received** : 2/17/95

**Date Analyzed** : 2/17/95

**Volume(s) Analyzed** : 10.0 (ml)

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	154	9.80	62.9	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	87.6	5.60	62.9	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SG

Date : 3/2/95

H-E63



**Performance Analytical Inc.**  
Air Quality Laboratory

**RESULTS OF ANALYSIS**  
PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : N/A**  
**PAI Sample ID : PAI Method Blank**

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Kathleen Aguilera  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : N/A  
Date Received : N/A  
Date Analyzed : 2/17/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT	REPORTING	RESULT	REPORTING
		ug/m3	LIMIT ug/m3	ppb	LIMIT ppb
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	ND	5.0	ND	1.5
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	ND	5.0	ND	1.3
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	ND	5.0	ND	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2

TR = Detected Below Indicated Reporting Limit  
ND = Not Detected

Verified by : SG

Date : 3/2/95

H-E64



Performance Analytical Inc.  
Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : GPU OUT 21795

PAI Sample ID : 9500994

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Kathleen Aguilera  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : 2/17/95  
Date Received : 2/17/95  
Date Analyzed : 2/17/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT	REPORTING	RESULT	REPORTING
		ug/m3	LIMIT ug/m3	ppb	LIMIT ppb
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	4.9 TR	5.0	1.4 TR	1.5
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	6.5	5.0	1.7	1.3
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	3.3 TR	5.0	0.75 TR	1.2
95-47-6	o-Xylene	1.3 TR	5.0	0.31 TR	1.2

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SG

Date : 3/2/95





# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client: TRC Environmental Corporation

Client Project ID: #2030-0000-00006

PAI Project ID: #P957833

Test Code: GC/MS Mod. EPA TO-14  
Instrument ID: HP5972/Entech 7000

Analyst: Chris Parnell

Matrix: Tedlar Bag

Date Sampled: 2/17/95

Date Received: 2/17/95

Date Analyzed: 2/17/95

Volume(s) Analyzed: 1.00 (Liter)  
0.050 (Liter)

Client Sample ID	PAI Sample ID	Result ug/m3	Dichlorodifluoromethane		Detection Limit ppb
			Detection Limit ug/m3	Result ppb	
GPU OUT 21795	9500994	ND	20	ND	4.1
N/A (2/17/95)	Method Blank	ND	1.0	ND	0.20

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SGC

Date : 3/2/95



## **SUB-APPENDIX F**

### **CALIBRATION DATA AND CERTIFICATIONS**

## **Appendix F-1**

### **Example Calibration Report of the On-Line Heat Content Analyzer**

# ATTACHMENT

## DAILY CALIBRATION

1 OF 3

CALIBRATION

PAGE 1 OF 1

DATE: 06/06/74 ANALYSIS TITLE: 220 EFFORT: OLD BENCH 11  
TIME: 07:45 CYCLE TIME: 240 CAL GAS STROKE: 5  
QTY: PENROSE NODE: REMOTE CYCLE START TIME: 07:46

COMP NAME	COMP CODE	CAL CONC	RAW DATA	OLD RF	NEW* RF	% DEV	OLD RT	NEW* RT	% DEV
C O 2	117	39.6010	1.41088+6	35560.2	35627.3	0.1	46.97	47.03	0.1
OXYGEN	116	6.39700	12668.0	31709.0	31749.4	0.5	74.23	74.37	0.1
NITROGEN	114	15.1000	508770	33626.2	33693.4	0.2	104.67	104.63	0.0
METHANE	100	44.9000	1.340822+6	27142.5	27136.2	0.0	121.77	121.57	0.0

COMP CODE

NAME

↑  
CERTIFIED  
CAL BOTTLE

↑  
RESPONSE  
FACTOR

↑  
RETENTION  
TIME

↑  
DAILY  
DEVIATION  
IN RESPONSE  
(METHANE ~ 0%)

# ATTACHMENT

2 OF 3

## ANALYSIS

ARM CIL GAS - GALLA ANALYSIS  
DOWE REPORT ON LFG FUEL  
240 SEC

ANALYSIS TIME: 220 STREAM NUMBER: 12  
CYCLE TIME: 240 STREAM: 3  
CODE: PENWSE MODE: REMOTE CYCLE START TIME: 07:46

COMP NAME	COMP CODE	MOLE %	GAL/MCF**	B.T.U.*	SP. GR.*
2	117	39.6253	0.0000	0.00	0.6021
ACETON	116	0.39671	0.0000	0.00	0.6044
ETHYLENE	114	15.1195	0.0000	0.00	0.1462
PROPANE	100	44.8585	0.0000	453.97	0.2030
TOTAL		100.0000	0.0000	453.97	1.0012

ARM CIL GAS - GALLA ANALYSIS - UNCORRECTED FOR COMPRESSIBILITY

ARM CIL GAS - GALLA ANALYSIS - UNCORRECTED FOR COMPRESSIBILITY

ARM CIL GAS - GALLA ANALYSIS - UNCORRECTED FOR COMPRESSIBILITY

ARM CIL GAS - GALLA ANALYSIS - UNCORRECTED FOR COMPRESSIBILITY	=	1.0000
ARM CIL GAS - GALLA ANALYSIS - UNCORRECTED FOR COMPRESSIBILITY	=	453.97
ARM CIL GAS - GALLA ANALYSIS - UNCORRECTED FOR COMPRESSIBILITY	=	0.6021
ARM CIL GAS - GALLA ANALYSIS - UNCORRECTED FOR COMPRESSIBILITY	=	0.6044
ARM CIL GAS - GALLA ANALYSIS - UNCORRECTED FOR COMPRESSIBILITY	=	0.1462
ARM CIL GAS - GALLA ANALYSIS - UNCORRECTED FOR COMPRESSIBILITY	=	0.2030
ARM CIL GAS - GALLA ANALYSIS - UNCORRECTED FOR COMPRESSIBILITY	=	1.0012

## CALIBRATION

F I N A L

DATE: 10/26/94 ANALYSIS TIME: 220 STREAM SEQUENCE: 13  
TIME: 07:47 CYCLE TIME: 240 CAL GAS STREAM: 3  
MODE: REMOTE CYCLE START TIME: 07:46

	CORP	CORP	CAL	RAW	OLD	NEW	%	OLD	NEW	%
	NAME	CODE	CONC	DATA	RF	RF	DEV	RT	RT	DEV
1	CO2	117	39.5010	1.41068+6	35530.2	35627.3	* 0.1	46.97	47.03*	0.1
2	HYDROGEN	116	6.39700	12668.0	31939.0	31749.4	* 0.5	94.23	94.37*	0.1
3	HYDROGEN	114	15.1000	568770	33626.2	33693.4	* 0.2	104.67	104.63*	0.0
4	ETHANE	106	44.0000	1.30022+6	29142.5	29136.2	* 0.0	121.77	121.57*	0.2

**Appendix F-2**

**Electric Meter Calibration Data**



## APPENDIX (A)

### Pacific Energy Co-Generation Penrose Landfill Metering Summary

- The major components of the revenue billing meter system are a bi-directional, multifunction meter, two potential transformers, and two current transformers monitoring a 3Ø, 3 wire, delta service. (See Page 1 of the Attachment)
- The billing meter, PMG30018-15 is programmed to display the information shown on Page 2 of the Attachment.
- The billing meter is tested in the Meter Laboratory prior to installation. Test results are shown on Page 3 of the Attachment. These results are within the  $\pm 2\%$  of the accuracy called for in the American National Standard Code for Electricity Metering (ANSI C12). LADWP rules call for all meters to be within  $\pm 1\%$  accuracy before being installed. Test Lab policy is to calibrate each meter within  $\pm .5\%$  accuracy.
- Each potential transformer (ratio 300 to 1) was tested in the Standards Laboratory before installation. Each was tested at O, W, X, Y, and Z burden. As indicated on Pages 3 and 4 of the Attachment, each was within  $\pm 1\%$  accuracy.
- Each current transformer (ratio 150 to 5) was tested in the Standards Laboratory before installation. Each was tested at burdens from 0 to B2.0. As indicated on Pages 5 through 8 of the Attachment, each was within  $\pm 1\%$  accuracy.
- After the metering system was installed on the customers service, an install test was performed on the system. As shown on Page 9 of the Attachment, this test indicates the meter was 100% accurate.

Also attached is a brochure for the Transdata EMS 96 Meter installed at this location.

AMG:sls

Attachments

Post-It™ brand fax transmittal memo 7571		# of pages > 11
To	Larry Preston	
From	Bob Briffett	
Co.	IFC	
Dept.		
Phone	213 3670395	
Fax	(203) 727 2319	

Larry,

This is information for existing Pacific Energy meters at Penrose Landfill. The setup for Penrose fuel cell will be the same.

Call me if you have questions

Bob Briffett

62104

JUL 1 '94 09:08 FROM INTL FUEL CELLS A  
LADWP RES PLAN&DEV TEL: 213-367-0210

TD 92986399  
JUN 27, 94

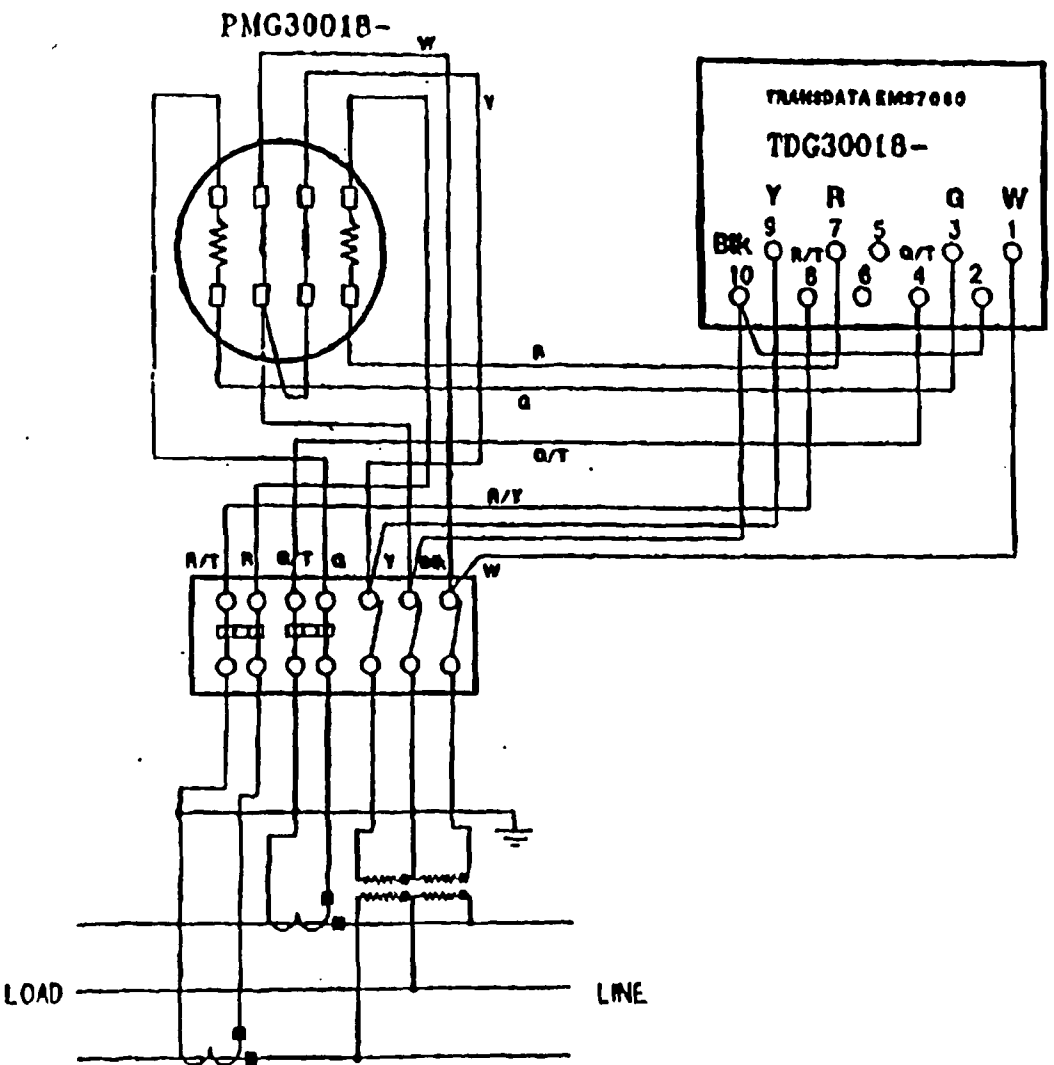
PAGE.003  
9:55 NO.003 P.02

# ENGINEERING DATA SHEET

Penrose Landfill - Pacific Energy Co-Gen.  
8301 Tunjunga Ave. IS.2197

Sheet No.	2053	Date
Prepared	Brian Hassard	12-17-94
Checked		
Approved		

PAGE 1 of ATTACH 10



REAR PANEL VIEW

JUL 1 '94 09:09  
LADWP RES PLAN&DEV

FROM INTL FUEL CELLS A  
TEL:213-367-0210

TO 92986399  
Jun 27,94

PAGE.004  
9:55 No.003 P.03

PAGE 2 of ATTACHMENT  
10

PARALLEL GENERATION - LARGE (PG-3)

BI-DIRECTIONAL KWH/KVARH METER

	METER DISPLAY CHECK			
01	DATE			
02	TIME			
03	KW	MAXIMUM DEMAND	HIGH PEAK	DELIVERED
04	KWH	CONSUMPTION	HIGH PEAK	DELIVERED
05	KVARH	CONSUMPTION	HIGH PEAK	DELIVERED
09	KW	MAXIMUM DEMAND	LOW PEAK	DELIVERED
10	KWH	CONSUMPTION	LOW PEAK	DELIVERED
11	KVARH	CONSUMPTION	LOW PEAK	DELIVERED
15	KW	MAXIMUM DEMAND	BASE	DELIVERED
16	KWH	CONSUMPTION	BASE	DELIVERED
17	KVARH	CONSUMPTION	BASE	DELIVERED
21	KWH	CONSUMPTION	HIGH PEAK	RECEIVED
25	KWH	CONSUMPTION	LOW PEAK	RECEIVED
29	KWH	CONSUMPTION	BASE	RECEIVED
39	KWH	CONSUMPTION	TOTAL	DELIVERED
40	KVARH	CONSUMPTION	TOTAL	DELIVERED

3/10

Meter Laboratory Meter Rsprot

Penrose Landfill  
8301 Tujunga Ave IS 2197  
PMG30018-15  
9-22-93

Meter Form: 5S Meter Register: EMS96 Rotation: ABC

9-17-93 07:20:01 Dowty

Test Setting 1: Volts=120.0 Amps=5.00 Pf Offset=60  
P.F.=0.5

KWH Del

Series Full Load: 99.99  
Series Power: 100.04  
Series Light Load: 99.99

KWh Rec

Series Full Load: -100.05  
Series Power: -100.13  
Series Light Load: -100.03

Test Setting 2: Volts=120.0 Amps=5.00 Pf Offset=12  
P.F.=0.2

KVAR Del

Series Full Load: 100.05  
Series Power: 100.03  
Series Light Load: 100.11

Test Setting 3: Volts=120.0 Amps=5.00 Pf Offset=0  
P.F.=1.0

KVAR Del

Series Full Load: 100.06  
Series Power: 100.06  
Series Light Load: 100.10

**Appendix F-3**

**GPU Gas Flowmeter Calibration Data**

YFCT Flow Computing Totalizer (Style B)				TAG NO :		
1	Function specification(1)	201601		18	Flowmeter temperature coefficient	-2.672 $\times 10^{-5}$
2	Function specification(2)	000100		19	Pulse retransmission presetting	— Hz
3	Function specification(3)	101000		20	Analog retransmission presetting	— %
4	Flowmeter K-Factor or Flow input span $K_F$ or $F_S$	80	SCFM	21	Maximum measured temperature	257 $^{\circ}\text{F}$
5	Volumetric unit conv. or Flow in. span factor $K_F$ or $K_S$	1		22	Minimum measured temperature	32 $^{\circ}\text{F}$
6	Totalize factor(flow 1) $K_{T1}$	1		23	Reference compensation temperature	64 $^{\circ}\text{F}$
7	Flow span(flow 1) $S_1$	80	SCFM	24	Operating temperature presetting	64 $^{\circ}\text{F}$
8	Span factor(flow 1) $K_{S1}$	1		25	Maximum measured pressure or density	1 PSIG
9	Density at STP $\rho_w$	0.042	lb/cuft	26	Minimum measured pressure or density	0 PSIG
10	Totalize factor(flow 2) $K_{T2}$	1		27	Reference compensation pressure or density	0.5 PSIG
11	Flow span(flow 2) $S_2$	3.36	lb/hr	28	Operating pressure or density presetting	0.5 PSIG
12	Span factor(flow 2) $K_{S2}$	1		29	Atmospheric pressure	14.7 PSIA
13	Pulse retransmission K-Factor $K_F$	1		30	Compensation factor $k$	
14	Flow high limit alarm setting	80	SCFM	31	Dryness fraction	1
15	Flow low limit alarm setting	0		32	Specific weight at normal operating conditions $\gamma_l$	
16	Damping time constant	3	Second	33	Specific enthalpy at normal operating conditions $h_l$	
17	Flowmeter calibration temperature	64		34	Deviation factor at normal operating conditions $K$	1

35	Humidity compensation factor $K_h$	1		51	Totalize factor(flow 3) $K_{T3}$	
36	Critical temperature $T_c$			52	Flow span(flow 3) $S_3$	
37	Critical pressure $P_c$			53	Span factor(flow 3) $K_{S3}$	
38	Critical compressibility factor $Z_c$			54	Flow totalizer display(flow 3)	
39	Compressibility factor at normal operating conditions $Z_l$			55	Flow rate display(flow 3)	
40	Specific gravity $G$			56	Rev. No. for ROM	
41	CO <sub>2</sub> mol% $M_c$		%	57	Key code	77
42	N <sub>2</sub> mol % $M_n$		%	58	Function specification(4)	00000
43	Supercompressibility factor at normal operating conditions					
44	1st-order compensation coefficient $B_1$					
45	2nd-order compensation coefficient $B_2$					
For Dual Temperature Input version : 46 to 48						
46	Heat coefficient value $C$					
47	Temp. at normal (TEMP. IN AUX.) operating conditions					
48	Temperature difference					
—	—	—	—			
—	—	—	—			

Yokagawa Flowmeter  
0.11 lb/hr. L/min.

## Function Specification

## Function Specification(1)

A B C D O F

## A Fluid

- 0 : (For factory use only)  
 1 : Steam  
 2 : Gas  
 3 : Liquid  
 4 : Water energy(option)

## B Compensation computation

## Steam

- 0 : Temperature, Saturated steam  
 1 : Pressure, Saturated steam  
 2 : Temp. and Press., Superheated steam (including saturated status)

## Gas

- 0 : General gases(set a constant K)  
 1 : General gases("Z" table is used)  
 2 : Natural gas

## Liquid

- 0 : Temperature(quadratic equation)  
 1 : Density

## Water energy

- 0 :  $\Delta T = \text{Temp.} - \text{Temp. (AUX)}$   
 1 :  $\Delta T = \text{Temp. (AUX)} - \text{Temp.}$

## C Flow input signal

- 0 : Pulse  
 1 : Analog (4 to 20 mA)

## D Flow analog signal processing

Flowmeter signal		Low out-off
0	4 to 20 mA (linear)	1% or less
1	4 to 20 mA (linear)	0% or less
2	$\Delta P$	1% or less
3	$\Delta P$	0% or less
4	$\Delta P$ (square root extraction)	1% or less
5	$\Delta P$ (square root extraction)	0% or less

## F Flow rate time

- 0 : s/sec  
 1 : s/min  
 2 : s/h  
 3 : s/day

## Function Specification(2)

G H J K L O

## G Temperature compensation signal

- 0 : 4 to 20mA or Pt 100  $\Omega$   
 1 : Preset value

## H Temperature unit

- 0 : °F  
 1 : °C

## J Press./Density compensation signal

- 0 : 4 to 20mA  
 1 : Preset value

## K Pressure unit

- 0 : Psi a  
 1 : Psi g  
 2 : Kg/cm<sup>2</sup> abs.  
 3 : Kg/cm<sup>2</sup> G  
 4 : MPa abs.  
 5 : MPa G

## L Temp(AUX) compensation signal

- .... an  
 item valid only for the /DT.  
 1 : 4 to 20mA or Pt 100  $\Omega$   
 0 : Preset value

## Self-diagnostic Contents

Code	Diagnostic Contents	Alarm-lamp		Alarm output
Good		—		—
—	CPU failure	FAIL (red)	Light	ON
FAIL-0	RAM memory data lost			
Err-01	A/D converter failure			
Err-02	D/A converter failure	ALM (yellow)	Flash	—
Err-03	Pulse retransmission overflow			
Err-09	Battery not installed, or voltage too low			
Err-11	Flow low limit overrange			
Err-12	Flow high limit overrange	ALM (yellow)	Light	ON
Err-13	Analog flow input high limit overrange			
Err-21	Press./density low limit overrange			
Err-22	Press./density high limit overrange			
Err-23	Compensation press. overrange			
Err-31	Temp. low limit overrange			
Err-32	Temp. high limit overrange			
Err-33	Compensation temp. overrange			
Err-41	Temp. (AUX.) low limit overrange			
Err-42	Temp. (AUX.) high limit overrange			
Err-43	Negative temp. difference			

## Function Specification(3)

N P Q O S O

## N Pulse retransmission

- 0 : Preset value (for maintenance)  
 1 : Flow 1  
 2 : Flow 2  
 3 : Flow 3 (uncompensated)

## P Retransmission pulse width

- 0 : Duty ratio 50%  
 1 : 0.5mS  
 2 : 1mS  
 3 : 20mS  
 4 : 33mS  
 5 : 50mS  
 6 : 100mS

## Q Analog retransmission / Flow high and low limit alarm

- 0 : Preset value (for maintenance)  
 1 : Flow 1  
 2 : Flow 2  
 3 : Flow 3 (uncompensated)

## Totalizer reset

- 0 : Enable(for display value only)  
 1 : Enable(whole value)  
 2 : Inhibit

## **Appendix F-4**

### **Reference Method Calibration Gas Certifications**





# Scott Specialty Gases, Inc.

1290 COMBERMERE STREET, TROY, MI 48083

(810) 589-2950 FAX: (810) 589-2134

## CERTIFICATE OF ANALYSIS: EPA PROTOCOL GAS

### Customer

TRC ENVIRONMENTAL  
C/O ESI  
21 TECHNOLOGY DRIVE  
IRVINE, CA 92718

### Assay Laboratory

Scott Specialty Gases, Inc  
1290 Combermere  
Troy, MI 48083

Purchase Order : 25886

Scott Project # : 573696

### ANALYTICAL INFORMATION

This certification was performed according to EPA Traceability Protocol For Assay and Certification of Gaseous Calibration Standards; Procedure G1; September, 1993.

Cylinder Number : ALM048981

Certificate Date : 1/30/95

Expiration Date : 7/30/95

Cylinder Pressure + : 1900 psig

Previous Certificate Date : None

### ANALYZED CYLINDER

#### Components

Nitric Oxide  
Total Oxides of Nitrogen

#### Certified Concentration

2.34 ppm  
2.37 ppm

#### Analytical Uncertainty\*

±1% NIST Directly Traceable  
Reference Value Only

Balance Gas: Nitrogen

\*Do not use when cylinder pressure is below 150 psig.

\*Analytical accuracy is inclusive of usual known error sources which at least include precision of the measurement processes.

### REFERENCE STANDARD

Type	Expiration Date	Cylinder Number	Concentration
NTRM 0025	11/21/96	ALM-042671	24.39 ppm Nitric Oxide in Nitrogen

### INSTRUMENTATION

Instrument/Model/Serial #  
NO:Horiba/OPE-235/483814

Last Date Calibrated  
1/16/95

Analytical Principle  
Chemiluminescence

### ANALYZER READINGS (Z=Zero Gas R=Reference Gas T=Test Gas r=Correlation Coefficient)

#### Components

Nitric Oxide

#### First Triad Analysis

Date: 1/23/95 Response Units: mv  
Z1=0.00 R1=86.00 T1=8.30  
R2=86.00 Z2=0.00 T2=8.30  
Z3=0.00 T3=8.30 R3=86.00  
Avg. Conc. of Cust. Cyl. 2.34 ppm

#### Second Triad Analysis

Date: 1/30/95 Response Units: mv  
Z1=0.00 R1=86.00 T1=8.30  
R2=86.00 Z2=0.00 T2=8.30  
Z3=0.00 T3=8.30 R3=86.00  
Avg. Conc. of Cust. Cyl. 2.34 ppm

#### Calibration Curve

Concentration =  $A + Bx + Cx^2 + Dx^3 + Ex^4$   
r=1.00000 NTRM 0025  
Constants: A=-0.017292000  
B=0.283810000 C=0.000000000  
D=0.000000000 E=0.000000000

Special Notes

Cylinder

Analyst



# Scott Specialty Gases, Inc.

1290 COMBERMERE STREET, TROY, MI 48063

(810) 589-2950 FAX: (810) 589-2134

## CERTIFICATE OF ANALYSIS: EPA PROTOCOL GAS

**Customer**  
TRC ENVIRONMENTAL  
C/O ESI  
21 TECHNOLOGY DRIVE  
IRVINE, CA 92718

**Assay Laboratory**  
Scott Specialty Gases, Inc  
1290 Combermere  
Troy, MI 48083

**Purchase Order :** NI95233  
**Scott Project # :** 574285

### ANALYTICAL INFORMATION

This certification was performed according to EPA Traceability Protocol For Assay and Certification of Gaseous Calibration Standards; Procedure G1: September, 1993.

**Cylinder Number :** ALM050644  
**Cylinder Pressure + :** 1900 psig

**Certificate Date :** 12/14/94  
**Previous Certificate Date :** None

**Expiration Date :** 6/14/95

### ANALYZED CYLINDER

#### Components

Nitric Oxide  
Total Oxides of Nitrogen

#### Certified Concentration

1.59 ppm  
1.69 ppm

#### Analytical Uncertainty\*

±1% NIST Directly Traceable  
Reference Value Only

**Balance Gas:** Nitrogen

+Do not use when cylinder pressure is below 150 psig.

\*Analytical accuracy is inclusive of usual known error sources which at least include precision of the measurement processes.

### REFERENCE STANDARD

Type	Expiration Date	Cylinder Number	Concentration
NTRM 0025	11/21/96	ALM-042671	24.39 ppm Nitric Oxide in Nitrogen

### INSTRUMENTATION

**Instrument/Model/Serial #**  
NO:Horiba/OPE-235/483814

**Last Date Calibrated**  
11/29/94

**Analytical Principle**  
Chemiluminescence

### ANALYZER READINGS (Z=Zero Gas R=Reference Gas T=Test Gas r=Correlation Coefficient)

#### Components

Nitric Oxide

#### First Triad Analysis

Date: 12/7/94 Response Units: mv  
Z1=0.00 R1=86.00 T1=5.70  
R2=86.00 Z2=0.00 T2=5.70  
Z3=0.00 T3=5.65 R3=86.00  
Avg. Conc. of Cust. Cyl: 1.60 ppm

#### Second Triad Analysis

Date: 12/14/94 Response Units: mv  
Z1=0.00 R1=86.00 T1=5.65  
R2=86.00 Z2=0.00 T2=5.65  
Z3=0.00 T3=5.65 R3=86.00  
Avg. Conc. of Cust. Cyl: 1.59 ppm

#### Calibration Curve

Concentration=A+Bx+Cx<sup>2</sup>+Dx<sup>3</sup>+Ex<sup>4</sup>  
r=1.00000 NTRM 0025  
Constants: A=-0.017292000  
B=0.283810000 C=0.000000000  
D=0.000000000 E=0.000000000

#### Special Notes

Interference Free Multi-Component EPA Protocol Gas

Mail

H-F16

Analyst

*Tina Sanderson*



# Scott Specialty Gases, Inc.

500 WEAVER PARK ROAD, LONGMONT, CO 80501 (303) 442-4700, (303) 651-3094 FAX (303) 772-7673

## CERTIFICATE OF ANALYSIS: EPA PROTOCOL GAS

**Customer**  
TRC ENVIRONMENTAL  
GEORGE MUNYER  
C/O E.S.I.  
21 TECHNOLOGY DRIVE  
IRVINE, CA 92718

**Assay Laboratory**  
Scott Specialty Gases, Inc.  
500 Weaver Park Road  
Longmont, CO 80501

**Purchase Order** 25886  
**Scott Project #** 08-16764  
**CGA Fitting** 350  
**QC Number** 26059422  
**File Number** 16764-02

### ANALYTICAL INFORMATION

This certification was performed according to EPA Traceability Protocol to Assay and certification of Gaseous Calibration Standards; Procedure G1; September, 1993.

**Cylinder Number** ALM-038592 **Certification Date** 12/05/94 **Expiration Date** 12/05/97  
**Cylinder Pressure** 2000 psig **Previous Certification Dates** None

### ANALYZED CYLINDER

**Components**  
(Carbon Monoxide)  
(Nitrogen)

**Certified Concentration**  
90.4 ppm  
Balance

**Analytical Uncertainty\***  
±1% NIST Directly Traceable

\* Analytical uncertainty is inclusive of usual known error sources which at least include precision of the measurement processes.

### REFERENCE STANDARD

Type	Expiration Date	Cylinder Number	Concentration
NTRM 1679	08/11/94	ALM-041528	97.10ppm CO / N2
GMIS	NONE	AAL-5975	47.20ppm CO / N2

### INSTRUMENTATION

Instrument/Model/Serial #	Last Date Calibrated	Analytical Principle
Horiba AIA 24 564163071	11/03/96	Non-Dispersive Infrared

### ANALYZER READINGS

(Z=Zero Gas R=Reference Gas T=Test Gas r=Correlation Coefficient)

Components	First Triad Analysis	Second Triad Analysis	Calibration Curve
(Carbon Monoxide)	<p>Date: 11/28/94 Response Units: mv</p> <p>Z1 = 0.0000 R1 = 0.2030 T1 = 0.4440</p> <p>R2 = 0.2030 Z2 = 0.0000 T2 = 0.4440</p> <p>Z3 = 0.0000 T3 = 0.4440 R3 = 0.2030</p> <p>Avg. Conc. of Cust. Cyl = 90.81 ppm</p>	<p>Date: 12/05/94 Response Units: mv</p> <p>Z1 = 0.0000 R1 = 0.2030 T2 = 0.4390</p> <p>R2 = 0.2030 Z2 = 0.0000 T2 = 0.4390</p> <p>Z3 = 0.0000 T3 = 0.4390 R3 = 0.2030</p> <p>Avg. Conc. of Cust. Cyl = 89.96 ppm</p>	<p>Concentration = A+Bx+Cx<sup>2</sup>+Dx<sup>3</sup>+Ex<sup>4</sup></p> <p>r = 0.999850 NTRM 1679</p> <p>Constants: A = 3.2072</p> <p>B = 243.78 C = -146.611</p> <p>D = 94.8572 E = 0</p>

**Special Notes** Do not use when cylinder pressure is below 150 psig.

Analyst: Diana L. Beehler



# Scott Specialty Gases, Inc.

500 WEAVER PARK ROAD, LONGMONT, CO 80501 (303) 442-4700, (303) 651-3094 FAX (303) 772-7673

## CERTIFICATE OF ANALYSIS: EPA PROTOCOL GAS

**Customer**  
TRC ENVIRONMENTAL  
GEORGE MUNYER  
C/O E.S.I.  
21 TECHNOLOGY DRIVE  
IRVINE, CA 92718

**Assay Laboratory**  
Scott Specialty Gases, Inc.  
500 Weaver Park Road  
Longmont, CO 80501

**Purchase Order** 25886  
**Scott Project #** 08-16764  
**CGA Fitting** 660  
**QC Number** 26069408  
**File Number** 16764-01

### ANALYTICAL INFORMATION

This certification was performed according to EPA Traceability Protocol to Assay and certification of Gaseous Calibration Standards; Procedure G1; September, 1993.

**Cylinder Number** ALM-043127 **Certification Date** 12/06/94 **Expiration Date** 12/06/96  
**Cylinder Pressure** 2000 psig **Previous Certification Dates** None

### ANALYZED CYLINDER

**Components**  
(Nitric Oxide)  
(Nitrogen Oxides)  
(Nitrogen)

**Certified Concentration**  
94.2 ppm  
94.2 ppm  
Balance

**Analytical Uncertainty\***  
±1% NIST Directly Traceable  
Reference Value Only

\* Analytical uncertainty is inclusive of usual known error sources which at least include precision of the measurement processes.

### REFERENCE STANDARD

Type	Expiration Date	Cylinder Number	Concentration
GMIS	12/09/95	ALM-038821	483.6ppm NO / N2
NTRM 1684	08/13/96	ALM-024460	95.2ppm NO / N2

### INSTRUMENTATION

**Instrument/Model/Serial #**  
Nicolet FTIR / 8220 / AAB9400251

**Last Date Calibrated**  
08/18/94

**Analytical Principle**  
Scott Enhanced FTIR™

### ANALYZER READINGS

(Z=Zero Gas R=Reference Gas T=Test Gas r=Correlation Coefficient)

**Components**  
(Nitric Oxide)

#### First Triad Analysis

Date: 11/28/94 Response Units: mv  
Z1 = 0.000 R1 = 95.220 T1 = 94.170  
R2 = 95.220 Z2 = 0.000 T2 = 94.170  
Z3 = 0.000 T3 = 94.170 R3 = 95.220  
Avg. Conc. of Cust. Cyl. = 94.2 ppm

#### Second Triad Analysis

Date: 12/06/94 Response Units: mv  
Z1 = 0.000 R1 = 95.220 T2 = 94.216  
R2 = 95.220 Z2 = 0.000 T2 = 94.216  
Z3 = 0.000 T3 = 94.216 R3 = 95.220  
Avg. Conc. of Cust. Cyl. = 94.2 ppm

#### Calibration Curve

Concentration =  $A + Bx + Cx^2 + Dx^3 + Ex^4$   
 $r = 0.999978$  GMIS  
Constants: A = 0.07613710  
B = 0.54383300 C = 0.00042472  
D = 0.00000049 E = 0

**Special Notes** Do not use when cylinder pressure is below 150 psig.

Analyst: Diana L. Beehler



# Scott Specialty Gases, Inc.

500 WEAVER PARK ROAD, LONGMONT, CO 80501 (303) 442-4700, (303) 651-3094 FAX (303) 772-7673

## CERTIFICATE OF ANALYSIS: EPA PROTOCOL GAS

**Customer**  
TRC ENVIRONMENTAL  
GEORGE MUNYER  
C/O E.S.I.  
21 TECHNOLOGY DRIVE  
IRVINE, CA 92718

**Assay Laboratory**  
Scott Specialty Gases, Inc.  
500 Weaver Park Road  
Longmont, CO 80501

**Purchase Order** 25886  
**Scott Project #** 08-16764  
**CGA Fitting** 660  
**QC Number** 26079408  
**File Number** 16764-03

### ANALYTICAL INFORMATION

This certification was performed according to EPA Traceability Protocol to Assay and certification of Gaseous Calibration Standards; Procedure G1; September, 1993.

**Cylinder Number** ALM-036593 **Certification Date** 12/06/94 **Expiration Date** 12/06/96  
**Cylinder Pressure** 2000 psig **Previous Certification Dates** None

### ANALYZED CYLINDER

**Components**  
(Sulfur Dioxide)  
(Nitrogen)

**Certified Concentration**  
90.7 ppm  
Balance

**Analytical Uncertainty\***  
+1% NIST Directly Traceable

\* Analytical uncertainty is inclusive of usual known error sources which at least include precision of the measurement processes.

### REFERENCE STANDARD

Type	Expiration Date	Cylinder Number	Concentration
NTRM 1662	06/18/95	ALM-032684	947.7ppm SO <sub>2</sub> / N <sub>2</sub>
NTRM 1694	05/10/95	ALM-024092	93.6ppm SO <sub>2</sub> / N <sub>2</sub>

### INSTRUMENTATION

**Instrument/Model/Serial #**  
Nicolet FTIR / 8220 / AAB9400251

**Last Date Calibrated**  
08/18/94

**Analytical Principle**  
Scott Enhanced FTIR™

### ANALYZER READINGS

(Z=Zero Gas R=Reference Gas T=Test Gas r=Correlation Coefficient)

#### Components

(Sulfur Dioxide)

#### First Triad Analysis

Date: 11/29/94 Response Units: mv  
Z1 = 0.000 R1 = 93.600 T1 = 90.520  
R2 = 93.600 Z2 = 0.000 T2 = 90.520  
Z3 = 0.000 T3 = 90.520 R3 = 93.600  
Avg. Conc. of Cust. Cyl. = 90.5 ppm

#### Second Triad Analysis

Date: 12/06/94 Response Units: mv  
Z1 = 0.000 R1 = 93.600 T2 = 90.881  
R2 = 93.600 Z2 = 0.000 T2 = 90.881  
Z3 = 0.000 T3 = 90.881 R3 = 93.600  
Avg. Conc. of Cust. Cyl. = 90.9 ppm

#### Calibration Curve

Concentration = A + Bx + Cx<sup>2</sup> + Dx<sup>3</sup> + Ex<sup>4</sup>  
r = 0.999994 NTRM 1662  
Constants: A = 0.33897300  
B = 0.94412400 C = 0.00002656  
D = 0 E = 0

**Special Notes**

Do not use when cylinder pressure is below 150 psig.

Analyst: Diana L. Beehler



# Scott Specialty Gases, Inc.

1290 COMBERMERE STREET, TROY, MI 48083

(810) 589-2950 FAX: (810) 589-2134

## CERTIFICATE OF ANALYSIS: EPA PROTOCOL GAS

**Customer**  
TRC ENVIRONMENTAL  
C/O ESI  
21 TECHNOLOGY DRIVE  
IRVINE, CA 92718

**Assay Laboratory**  
Scott Specialty Gases, Inc  
1290 Combermere  
Troy, MI 48083

**Purchase Order :** 25886  
**Scott Project # :** 573696

### ANALYTICAL INFORMATION

This certification was performed according to EPA Traceability Protocol For Assay and Certification of Gaseous Calibration Standards; Procedure G1; September, 1993.

**Cylinder Number :** ALM022962  
**Cylinder Pressure + :** 1900 psig

**Certificate Date :** 11/21/94  
**Previous Certificate Date :** None

**Expiration Date :** 11/21/97

### ANALYZED CYLINDER

#### Components

Oxygen  
Carbon Dioxide

#### Certified Concentration

20.1 %  
20.2 %

#### Analytical Uncertainty\*

±1% NIST Directly Traceable  
±1% NIST Directly Traceable

**Balance Gas:** Nitrogen

+Do not use when cylinder pressure is below 150 psig.

\*Analytical accuracy is inclusive of usual known error sources which at least include precision of the measurement processes.

### REFERENCE STANDARD

Type	Expiration Date	Cylinder Number	Concentration
SRM 2659A	3/7/98	CLM-006904	20.72 % Oxygen in Nitrogen
NTRM 1674	9/28/95	ALM032599	6.981 % Carbon Dioxide in Nitrogen

### INSTRUMENTATION

**Instrument/Model/Serial #**  
O2: Beckman/755/1001192  
HORIBA /PIR 2000/02609015

**Last Date Calibrated**  
10/25/94  
11/21/94

**Analytical Principle**  
Paramagnetic  
Non-Dispersive Infrared

### ANALYZER READINGS (Z=Zero Gas R=Reference Gas T=Test Gas r=Correlation Coefficient)

Components	First Triad Analysis	Second Triad Analysis	Calibration Curve
Oxygen	<div>Date: 11/21/94 Response Units: mv Z1=0.00 R1=100.00 T1=96.80 R2=100.00 Z2=0.00 T2=96.80 Z3=0.00 T3=96.80 R3=100.00 Avg. Conc. of Cust. Cyl. 20.1 %</div>		<div>Concentration=A+Bx+Cx<sup>2</sup>+Dx<sup>3</sup>+Ex<sup>4</sup> r=1.00000 SRM 2659A Constants A=-0.001203800 B=0.207210000 C=0.000000000 D=0.000000000 E=0.000000000</div>
Carbon Dioxide	<div>Date: 11/21/94 Response Units: mv Z1=0.00 R1=69.10 T1=139.30 R2=69.10 Z2=0.00 T2=139.30 Z3=0.00 T3=139.30 R3=69.10 Avg. Conc. of Cust. Cyl. 20.2 %</div>		<div>Concentration=A+Bx+Cx<sup>2</sup>+Dx<sup>3</sup>+Ex<sup>4</sup> r=0.99999 NTRM 1674 Constants A=-2.548840000 B=1.165265300 C=0.000000000 D=0.000005683 E=0.000000000</div>

Special Notes

Mail

H-F20

Analyst



# Scott Specialty Gases, Inc.

500 WEAVER PARK ROAD, LONGMONT, CO 80501 (303) 442-4700, (303) 851-3094 FAX (303) 772-7673

## CERTIFICATE OF ANALYSIS: Interference-Free Multi-Component EPA Protocol Gas

Customer  
TRC ENVIRONMENTAL  
GEORGE MUNYER  
C/O E.S.I.  
21 TECHNOLOGY DRIVE  
IRVINE, CA 92718

Assay Laboratory  
Scott Specialty Gases, Inc.  
500 Weaver Park Road  
Longmont, CO 80501

Purchase Order 25886  
Scott Project # 08-16764  
CGA Fitting 660  
QC Number 26069412  
File Number 16764-04

### ANALYTICAL INFORMATION

This certification was performed according to EPA Traceability Protocol to Assay and certification of Gaseous Calibration Standards; Procedure G1; September, 1993.

Cylinder Number ALM-025536 Certification Date 12/06/94 Expiration Date 12/06/96  
Cylinder Pressure 2000 psig Previous Certification Dates None

### ANALYZED CYLINDER

Components	Certified Concentration	Analytical Uncertainty*
(Carbon Monoxide)	50.7 ppm	+1% NIST Directly Traceable
(Sulfur Dioxide)	49.6 ppm	+1% NIST Directly Traceable
(Nitric Oxide)	50.8 ppm	+1% NIST Directly Traceable
(Nitrogen Oxides)	50.8 ppm	Reference Value Only
(Nitrogen)	Balance	

\* Analytical uncertainty is inclusive of usual known error sources which at least include precision of the measurement processes.

### REFERENCE STANDARD

Type	Expiration Date	Cylinder Number	Concentration
NTRM 1679	08/11/94	ALM-041528	97.10ppm CO / N2
GMIS	NONE	AAL-5975	47.20ppm CO / N2
NTRM 1662	06/18/95	ALM-032684	947.7ppm SO2 / N2
NTRM 1693	12/17/94	ALM-021565	47.2ppm SO2 / N2
GMIS	12/09/95	ALM-038821	483.6ppm NO / N2
NTRM 1684	08/13/96	ALM-024460	95.2ppm NO / N2

### INSTRUMENTATION

Instrument/Model/Serial #	Last Date Calibrated	Analytical Principle
Horiba AIA 24 564163071	11/03/96	Non-Dispersive Infrared
Nicolet FTIR / 8220 / AAB9400251	11/18/94	Scott Enhanced FTIRTM
Nicolet FTIR / 8220 / AAB9400251	11/18/94	Scott Enhanced FTIRTM

### ANALYZER READINGS

(Z=Zero Gas R=Reference Gas T=Test Gas r=Correlation Coefficient)

Components	First Triad Analysis	Second Triad Analysis	Calibration Curve
(Carbon Monoxide)	<p>Date: 11/28/94 Response Units: mv</p> <p>Z1 = 0.0000 R1 = 0.2030 T1 = 0.2220</p> <p>R2 = 0.2030 Z2 = 0.0000 T2 = 0.2220</p> <p>Z3 = 0.0000 T3 = 0.2220 R3 = 0.2030</p> <p>Avg. Conc. of Cust. Cyl. = 50.91 ppm</p>	<p>Date: 12/05/94 Response Units: mv</p> <p>Z1 = 0.0000 R1 = 0.2020 T2 = 0.2190</p> <p>R2 = 0.2020 Z2 = 0.0000 T2 = 0.2190</p> <p>Z3 = 0.0000 T3 = 0.2190 R3 = 0.2020</p> <p>Avg. Conc. of Cust. Cyl. = 50.51 ppm</p>	<p>Concentration = A+Bx+Cx+Dx+Ex</p> <p>r = 0.999850 NTRM 1679</p> <p>Constants: A = 3.2072</p> <p>B = 243.78 C = -146.611</p> <p>D = 94.8572 E = 0</p>
(Sulfur Dioxide)	<p>Date: 11/29/94 Response Units: mv</p> <p>Z1 = 0.000 R1 = 47.200 T1 = 49.634</p> <p>R2 = 47.200 Z2 = 0.000 T2 = 49.634</p> <p>Z3 = 0.000 T3 = 49.634 R3 = 47.200</p> <p>Avg. Conc. of Cust. Cyl. = 49.6 ppm</p>	<p>Date: 12/06/94 Response Units: mv</p> <p>Z1 = 0.000 R1 = 47.200 T1 = 49.567</p> <p>R2 = 47.200 Z2 = 0.000 T2 = 49.567</p> <p>Z3 = 0.000 T3 = 49.567 R3 = 47.200</p> <p>Avg. Conc. of Cust. Cyl. = 49.6 ppm</p>	<p>Concentration = A+Bx+Cx+Dx+Ex</p> <p>r = 0.999994 NTRM 1662</p> <p>Constants: A = 0.55422400</p> <p>B = 0.95784200 C = -0.00005789</p> <p>D = 0.000000 E = 0</p>
(Nitric Oxide)	<p>Date: 11/29/94 Response Units: mv</p> <p>Z1 = 0.000 R1 = 95.220 T1 = 50.825</p> <p>R2 = 95.220 Z2 = 0.000 T2 = 50.825</p> <p>Z3 = 0.000 T3 = 50.825 R3 = 95.220</p> <p>Avg. Conc. of Cust. Cyl. = 50.8 ppm</p>	<p>Date: 12/06/94 Response Units: mv</p> <p>Z1 = 0.000 R1 = 95.220 T1 = 50.822</p> <p>R2 = 95.220 Z2 = 0.000 T2 = 50.822</p> <p>Z3 = 0.000 T3 = 50.822 R3 = 95.220</p> <p>Avg. Conc. of Cust. Cyl. = 50.8 ppm</p>	<p>Concentration = A+Bx+Cx+Dx+Ex</p> <p>r = 0.999978 GMIS</p> <p>Constants: A = -0.11614400</p> <p>B = 0.56526900 C = 0.00048048</p> <p>D = 0.00000053 E = 0</p>

Special Notes Do not use when cylinder pressure is below 150 psig.

Reviewer

Analyst: Diana L. Beehler



# Scott Specialty Gases, Inc.

500 WEAVER PARK ROAD, LONGMONT, CO 80501

(303) 442-4700, (303) 651-3094 FAX (303) 772-7573

## CERTIFICATE OF ANALYSIS: Interference-Free Multi-Component EPA Protocol Gas

**Customer**  
TRC ENVIRONMENTAL  
GEORGE MUNYER  
C/O E.S.I.  
21 TECHNOLOGY DRIVE  
IRVINE, CA 92718

**Assay Laboratory**  
Scott Specialty Gases, Inc.  
500 Weaver Park Road  
Longmont, CO 80501

**Purchase Order** 25886  
**Scott Project #** 08-16764  
**CGA Fitting** 660  
**QC Number** 26069413  
**File Number** 16764-05

### ANALYTICAL INFORMATION

This certification was performed according to EPA Traceability Protocol to Assay and certification of Gaseous Calibration Standards; Procedure G1; September, 1993.

Cylinder Number AAL-7595	Certification Date 12/06/94	Expiration Date 12/06/96
Cylinder Pressure 2000 psig	Previous Certification Dates None	

### ANALYZED CYLINDER

Components	Certified Concentration	Analytical Uncertainty*
(Carbon Monoxide)	25.8 ppm	±1% NIST Directly Traceable
(Sulfur Dioxide)	24.8 ppm	±1% NIST Directly Traceable
(Nitric Oxide)	26.7 ppm	±1% NIST Directly Traceable
(Nitrogen Oxides)	26.7 ppm	Reference Value Only
(Nitrogen)	Balance	

\* Analytical uncertainty is inclusive of usual known error sources which at least include precision of the measurement processes.

### REFERENCE STANDARD

Type	Expiration Date	Cylinder Number	Concentration
NTRM 1678	07/31/96	AAL-8680	45.70ppm CO / N2
GMIS	NONE	ALM-02484	24.94ppm CO / N2
NTRM 1662	06/18/95	ALM-032684	947.7ppm SO2 / N2
NTRM 1693	12/17/94	ALM-021565	47.2ppm SO2 / N2
GMIS	12/09/95	ALM-038821	483.6ppm NO / N2
NTRM 1684	08/13/96	ALM-024460	95.2ppm NO / N2

### INSTRUMENTATION

Instrument/Model/Serial #	Last Date Calibrated	Analytical Principle
Horiba AIA 24 564163071	0.039007	Non-Dispersive Infrared
Nicolet FTIR / 8220 / AAB9400251	08/18/94	Scott Enhanced FTIR™
Nicolet FTIR / 8220 / AAB9400251	08/18/94	Scott Enhanced FTIR™

### ANALYZER READINGS

(Z=Zero Gas R=Reference Gas T=Test Gas r=Correlation Coefficient)

Components	First Triad Analysis	Second Triad Analysis	Calibration Curve
(Carbon Monoxide)	Date: 11/29/94 Response Units: mv Z1 = 0.0000 R1 = 0.4220 T1 = 0.4410 R2 = 0.4220 Z2 = 0.0000 T2 = 0.4410 Z3 = 0.0000 T3 = 0.4410 R3 = 0.4220 Avg. Conc. of Cust. Cyl. = 25.86 ppm	Date: 12/06/94 Response Units: mv Z1 = 0.0000 R1 = 0.4220 T2 = 0.4390 R2 = 0.4220 Z2 = 0.0000 T2 = 0.4390 Z3 = 0.0000 T3 = 0.4390 R3 = 0.4220 Avg. Conc. of Cust. Cyl. = 25.77 ppm	Concentration = A+Bx+Cx <sup>2</sup> +Dx <sup>3</sup> +Ex <sup>4</sup> r = 0.999878 NTRM 1678 Constants: A = 1.1676 B = 65.868 C = -24.5470 D = 6.3325 E = 0
(Sulfur Dioxide)	Date: 11/29/94 Response Units: mv Z1 = 0.000 R1 = 47.200 T1 = 24.809 R2 = 47.200 Z2 = 0.000 T2 = 24.809 Z3 = 0.000 T3 = 24.809 R3 = 47.200 Avg. Conc. of Cust. Cyl. = 24.8 ppm	Date: 12/06/94 Response Units: mv Z1 = 0.000 R1 = 47.200 T1 = 24.718 R2 = 47.200 Z2 = 0.000 T2 = 24.718 Z3 = 0.000 T3 = 24.718 R3 = 47.200 Avg. Conc. of Cust. Cyl. = 24.7 ppm	Concentration = A+Bx+Cx <sup>2</sup> +Dx <sup>3</sup> +Ex <sup>4</sup> r = 0.999994 NTRM 1662 Constants: A = 0.33897300 B = 0.94412400 C = 0.00002656 D = 0 E = 0
(Nitric Oxide)	Date: 11/29/94 Response Units: mv Z1 = 0.000 R1 = 95.220 T1 = 26.803 R2 = 95.220 Z2 = 0.000 T2 = 26.803 Z3 = 0.000 T3 = 26.803 R3 = 95.220 Avg. Conc. of Cust. Cyl. = 26.8 ppm	Date: 12/06/94 Response Units: mv Z1 = 0.000 R1 = 95.220 T1 = 26.550 R2 = 95.220 Z2 = 0.000 T2 = 26.550 Z3 = 0.000 T3 = 26.550 R3 = 95.220 Avg. Conc. of Cust. Cyl. = 26.6 ppm	Concentration = A+Bx+Cx <sup>2</sup> +Dx <sup>3</sup> +Ex <sup>4</sup> r = 0.999978 GMIS Constants: A = 0.07813710 B = 0.54383300 C = 0.00042472 D = 0.00000049 E = 0

**Special Notes** Do not use when cylinder pressure is below 150 psig.

*Diana L. Beehler*  
Analyst: Diana L. Beehler





# Scott Specialty Gases, Inc.

Shipped From: 6141 EASTON ROAD  
 PLUMSTEADVILLE PA 18949-0310 PO BOX 310  
 Phone: 215-766-8861 Fax: 215-766-2070

## C E R T I F I C A T E O F A N A L Y S I S

TRC ENVIRONMENTAL

PROJECT #: 01-62683-002

PO#: 25886

C/O E.S.I.  
 21 TECHNOLOGY DRIVE  
 IRVINE CA 92718

ITEM #: 01046673 4EL  
 DATE: 11/23/94

CYLINDER #: SCOTTY-4EL

ANALYTICAL ACCURACY: +/- 10%

COMPONENT	REQUESTED GAS		ANALYSIS	
	CONC		(MOLES)	
CIS 1,2-DICHLOROETHYLENE	10.	PPB	11.9	PPB
1,2-DIBROMOETHANE	10.	PPB	10.3	PPB
1,1-DICHLOROETHANE	10.	PPB	12.1	PPB
1,2-DICHLOROETHANE	10.	PPB	11.6	PPB
TETRACHLOROETHYLENE	10.	PPB	11.2	PPB
1,1,1-TRICHLOROETHANE	10.	PPB	12.0	PPB
VINYL CHLORIDE	10.	PPB	11.2	PPB
VINYLDENE CHLORIDE	10.	PPB	12.3	PPB
NITROGEN		BALANCE		BALANCE

ANALYTICAL METHOD: MICROGRAV

ANALYST: Ted Neeme

TED NEEME

H-F23



# Scott Specialty Gases, Inc.

Shipped  
From:

6141 EASTON ROAD  
PLUMSTEADVILLE  
Phone: 215-766-8861

PA 18949-0310

PO BOX 310

Fax: 215-766-2070

## C E R T I F I C A T E O F A N A L Y S I S

TRC ENVIRONMENTAL

C/O E.S.I.  
21 TECHNOLOGY DRIVE  
IRVINE

CA 92718

PROJECT #: 01-62683-001  
PO#: 25886  
ITEM #: 01046663 4EL  
DATE: 11/23/94

CYLINDER #: SCOTTY-4EL

ANALYTICAL ACCURACY: +/- 5%

COMPONENT	REQUESTED GAS		ANALYSIS	
	CONC		(MOLES)	
ACETONITRILE	100.	PPB	120.0	PPB
1,3-BUTADIENE	100.	PPB	114.0	PPB
CARBON TETRACHLORIDE	100.	PPB	116.0	PPB
CHLOROFORM	100.	PPB	115.0	PPB
HALOCARBON 11	100.	PPB	99.2	PPB
METHYLENE CHLORIDE	100.	PPB	120.0	PPB
NITROGEN		BALANCE		BALANCE

ANALYTICAL METHOD: MICROGRAV

ANALYST:

Ted Neeme  
TED NEEME

H-F24

FREMONT, CA SAN BERNARDINO, CA LONGMONT, CO TROY, MI CHICAGO, IL SARNIA, ONTARIO AVON LAKE, OH HOUSTON, TX  
BATON ROUGE, LA MARIETTA, GA DURHAM, NC PLUMSTEADVILLE, PA SCOTTSVILLE, KY SARNIA, ONTARIO AVON LAKE, OH HOUSTON, TX

AVON LAKE, OH HOUSTON, TX  
AVON LAKE, OH HOUSTON, TX



# Scott Specialty Gases, Inc.

Shipped From: 6141 EASTON ROAD  
PLUMSTEADVILLE PA 18949-0310 PO BOX 310  
Phone: 215-766-8861 Fax: 215-766-2070

## C E R T I F I C A T E O F A N A L Y S I S

TRC ENVIRONMENTAL

PROJECT #: 01-62683-003

PO#: 25886

C/O E.S.I.

ITEM #: 0104260

4EL

21 TECHNOLOGY DRIVE

DATE: 11/28/94

IRVINE

CA 92718

CYLINDER #: SCOTTY 4EL

ANALYTICAL ACCURACY: +-5%

### COMPONENT

### REQUESTED GAS

### ANALYSIS

HYDROGEN SULFIDE

### CONC

### (MOLES)

NITROGEN

10.

PPM

10.1

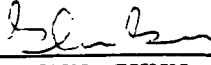
PPM

BALANCE

BALANCE

1 CAN BASED ON ANALYSIS OF  
LOT#431204

ANALYST:

  
GLENN GUNN

H-F25



# Scott Specialty Gases, Inc.

Shipped 2600 CAJON BLVD.  
 From: SAN BERNARDINO CA 92411  
 Phone: 909-887-2571

Fax: 909-887-0549

## CERTIFICATE OF ANALYSIS

ENVIRONMENTAL SOLUTIONS

21 TECHNOLOGY DR

IRVINE

CA 92718

PROJECT #: 02-35787-001

PO#: 2030-6

ITEM #: 02027111 4S2

DATE: 1/19/95

CYLINDER #: SCOTTY 11

ANALYTICAL ACCURACY: +/-2%

BLEND TYPE : CERTIFIED MASTER GAS

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
N-BUTANE	3.	%	3.05	%
CARBON DIOXIDE	1.	%	1.02	%
ETHANE	9.	%	8.98	%
HELIUM	.5	%	.50	%
ISOBUTANE	3.	%	3.04	%
ISOPENTANE	1.	%	.996	%
NITROGEN	5.	%	4.96	%
N-PENTANE	1.	%	.983	%
PROPANE	6.	%	6.03	%
METHANE		BALANCE		BALANCE 70.42

ANALYST: ES

H-F26

PLUMSTEADVILLE, PENNSYLVANIA / TROY, MICHIGAN / HOUSTON, TEXAS / DURHAM, NORTH CAROLINA  
 SOUTH PLAINFIELD, NEW JERSEY / FREMONT, CALIFORNIA / WAKEFIELD, MASSACHUSETTS / LONGMONT, COLORADO

MASSACHUSETTS / LONGMONT, COLORADO  
 MASSACHUSETTS / LONGMONT, COLORADO

## **SUB-APPENDIX G**

### **ASTM METHOD HEAT CONTENT ANALYSIS QA REPLICATES**

10669 RICHMOND AVENUE, SUITE 100, HOUSTON, TEXAS 77042  
P.O. BOX 741905, HOUSTON, TEXAS 77274

TEL: (713) 789-5593  
FAX: (713) 789-5593

<b>CLIENT:</b>	Environmental Solutions	<b>REQUESTED BY:</b>	Mr. Ken Pierce
<b>SAMPLE:</b>	GPU Out 11995 Btu-1 (1-19-95) 16:44	<b>REPORT DATE:</b>	February 6, 1995
<b>LABORATORY NO:</b>	4690 A	<b>PROJECT NAME:</b>	IFC, 2030-6
		<b>PURCHASE ORDER NO:</b>	P9-41038

**TEST**

**RESULTS**

Natural Gas Analysis by Gas Chromatography, ASTM D 1945:

	<u>MOL %</u>	<u>GPM @ 14.650 psia</u>
Nitrogen	16.266	
Carbon Dioxide	39.542	
Methane	44.165	
Ethane	0.024	0.006
Propane	NIL	NIL
Iso-butane	NIL	NIL
N-butane	NIL	NIL
Iso-pentane	NIL	NIL
N-pentane	NIL	NIL
Hexanes	NIL	NIL
Heptanes plus	<u>0.003</u>	<u>0.001</u>
	100.000	0.007

Specific Gravity @ 60°F (air = 1) 1.0050

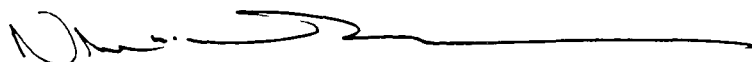
Calculated Btu/cu. ft. @ 14.650 psia and 60°F:

Dry basis 446

Wet basis 438

Z Factor 0.9978

Respectfully Submitted,



Nader M. Sorurbakhsh, P.E.  
Laboratory Director

10669 RICHMOND AVENUE, SUITE 100, HOUSTON, TEXAS 77042  
P.O. BOX 741905, HOUSTON, TEXAS 77274

TEL: (713) 789-5591  
FAX: (713) 789-5593

<b>CLIENT:</b>	Environmental Solutions	<b>REQUESTED BY:</b>	Mr. Ken Pierce
<b>SAMPLE:</b>	GPU Out 11995 Btu-2 (1-19-95) 16:49	<b>REPORT DATE:</b>	February 6, 1995
<b>LABORATORY NO:</b>	4690 B	<b>PROJECT NAME:</b>	IFC, 2030-6
		<b>PURCHASE ORDER NO:</b>	P9-41038

**TEST**

**RESULTS**

Natural Gas Analysis by Gas Chromatography, ASTM D 1945:

	<u>MOL %</u>	<u>GPM @ 14.650 psia</u>
Nitrogen	16.387	
Carbon Dioxide	39.546	
Methane	44.025	
Ethane	0.042	0.011
Propane	NIL	NIL
Iso-butane	NIL	NIL
N-butane	NIL	NIL
Iso-pentane	NIL	NIL
N-pentane	NIL	NIL
Hexanes	NIL	NIL
Heptanes plus	<u>NIL</u>	<u>NIL</u>
	100.000	0.011

Specific Gravity @ 60°F (air = 1) 1.0050


Calculated Btu/cu. ft. @ 14.650 psia and 60°F:

Dry basis 445

Wet basis 437

Z Factor 0.9978

Respectfully Submitted,



Nader M. Sorurbakhsh, P.E.  
Laboratory Director

10669 RICHMOND AVENUE, SUITE 100, HOUSTON, TEXAS 77042  
P.O. BOX 741905, HOUSTON, TEXAS 77274

TEL: (713) 789-5591  
FAX: (713) 789-5593

<b>CLIENT:</b>	Environmental Solutions	<b>REQUESTED BY:</b>	Mr. Ken Pierce
<b>SAMPLE:</b>	GPU Out 11995 Btu-3 (1-19-95) 16:54	<b>REPORT DATE:</b>	February 6, 1995
<b>LABORATORY NO:</b>	4690 C	<b>PROJECT NAME:</b>	IFC, 2030-6
		<b>PURCHASE ORDER NO:</b>	P9-41038

<b>TEST</b>	<b>RESULTS</b>
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Natural Gas Analysis by Gas Chromatography, ASTM D 1945:

	<u>MOL %</u>	<u>GPM @ 14.650 psia</u>
Nitrogen	16.304	
Carbon Dioxide	39.529	
Methane	44.125	
Ethane	0.042	0.011
Propane	NIL	NIL
Iso-butane	NIL	NIL
N-butane	NIL	NIL
Iso-pentane	NIL	NIL
N-pentane	NIL	NIL
Hexanes	NIL	NIL
Heptanes plus	<u>NIL</u>	<u>NIL</u>
	100.000	0.011

Specific Gravity @ 60°F (air = 1)	1.0051
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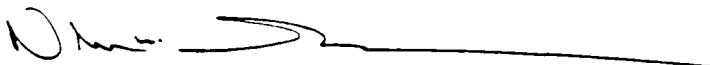
Calculated Btu/cu. ft. @ 14.650 psia and 60°F:

Dry basis	446
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Wet basis	438
-----------	-----

Z Factor	0.9978
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Respectfully Submitted,



Nader M. Sorurbakhsh, P.E.  
Laboratory Director



10669 RICHMOND AVENUE, SUITE 100, HOUSTON, TEXAS 77042  
P.O. BOX 741905, HOUSTON, TEXAS 77274

TEL: (713) 789-5591  
FAX: (713) 789-5593

<b>CLIENT:</b>	Environmental Solutions	<b>REQUESTED BY:</b>	Mr. Ken Pierce
<b>SAMPLE:</b>	RLG 11995 Btu-1 (1-19-95) 15:29	<b>REPORT DATE:</b>	February 6, 1995
<b>LABORATORY NO:</b>	4690 D	<b>PROJECT NAME:</b>	IFC, 2030-6
		<b>PURCHASE ORDER NO:</b>	P9-41038

**TEST**

**RESULTS**

Natural Gas Analysis by Gas Chromatography, ASTM D 1945:

	<u>MOL %</u>	<u>GPM @ 14.650 psia</u>
Nitrogen	16.181	
Carbon Dioxide	39.780	
Methane	43.959	
Ethane	0.038	0.010
Propane	0.008	0.001
Iso-butane	0.003	0.001
N-butane	0.003	0.001
Iso-pentane	0.002	0.001
N-pentane	0.001	0.001
Hexanes	0.001	0.000
Heptanes plus	<u>0.024</u>	<u>0.010</u>
	100.000	0.025

Specific Gravity @ 60°F (air = 1) 1.0078

Calculated Btu/cu. ft. @ 14.650 psia and 60°F:

Dry basis 446

Wet basis 438

Z Factor 0.9977

Respectfully Submitted,



Nader M. Sorurbakhsh, P.E.  
Laboratory Director

10669 RICHMOND AVENUE, SUITE 100, HOUSTON, TEXAS 77042  
P.O. BOX 741905, HOUSTON, TEXAS 77274

TEL: (713) 789-5591  
FAX: (713) 789-5593

<b>CLIENT:</b>	Environmental Solutions	<b>REQUESTED BY:</b>	Mr. Ken Pierce
<b>SAMPLE:</b>	RLG 11995 Btu-2	<b>REPORT DATE:</b>	February 6, 1995
	(1-19-95) 15:37	<b>PROJECT NAME:</b>	IFC, 2030-6
<b>LABORATORY NO:</b>	4690 E	<b>PURCHASE ORDER NO:</b>	P9-41038

<b>TEST</b>	<b>RESULTS</b>
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Natural Gas Analysis by Gas Chromatography, ASTM D 1945:


	<u>MOL %</u>	<u>GPM @ 14.650 psia</u>
Nitrogen	16.134	
Carbon Dioxide	39.720	
Methane	43.930	
Ethane	0.029	0.008
Propane	0.008	0.002
Iso-butane	0.003	0.001
N-butane	0.003	0.001
Iso-pentane	0.004	0.001
N-pentane	0.003	0.001
Hexanes	0.166	0.068
Heptanes plus	<u>NIL</u>	<u>NIL</u>
	100.000	0.082

Specific Gravity @ 60°F (air = 1)	1.0105
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Calculated Btu/cu. ft. @ 14.650 psia and 60°F:

Dry basis	452
Wet basis	444
Z Factor	0.9977

Respectfully Submitted,



Nader M. Sorurbakhsh, P.E.  
Laboratory Director

10669 RICHMOND AVENUE, SUITE 100, HOUSTON, TEXAS 77042  
P.O. BOX 741905, HOUSTON, TEXAS 77274

TEL: (713) 789-5591  
FAX: (713) 789-5593

<b>CLIENT:</b>	Environmental Solutions	<b>REQUESTED BY:</b>	Mr. Ken Pierce
<b>SAMPLE:</b>	RLG 11995 Btu-3 (1-19-95) 15:49	<b>REPORT DATE:</b>	February 6, 1995
<b>LABORATORY NO:</b>	4690 F	<b>PROJECT NAME:</b>	IFC, 2030-6
		<b>PURCHASE ORDER NO:</b>	P9-41038

**TEST**

**RESULTS**

Natural Gas Analysis by Gas Chromatography, ASTM D 1945:

	<u>MOL %</u>	<u>GPM @ 14.650 psia</u>
Nitrogen	16.195	
Carbon Dioxide	39.705	
Methane	44.012	
Ethane	0.047	0.012
Propane	0.013	0.004
Iso-butane	0.002	0.001
N-butane	0.002	0.001
Iso-pentane	0.001	NIL
N-pentane	0.001	NIL
Hexanes	0.022	0.009
Heptanes plus	<u>NIL</u>	<u>NIL</u>
	100.000	0.027

Specific Gravity @ 60°F (air = 1) 1.0071

Calculated Btu/cu. ft. @ 14.650 psia and 60°F:

Dry basis 447

Wet basis 439

Z Factor 0.9977

Respectfully Submitted,



Nader M. Sorurbakhsh, P.E.  
Laboratory Director

10669 RICHMOND AVENUE, SUITE 100, HOUSTON, TEXAS 77042  
P.O. BOX 741905, HOUSTON, TEXAS 77274TEL: (713) 789-5591  
FAX: (713) 789-5593

<b>CLIENT:</b>	Environmental Solutions	<b>REQUESTED BY:</b>	Mr. Ken Pierce
<b>SAMPLE:</b>	RLG 11995 Btu-4 (1-19-95) 16:00	<b>REPORT DATE:</b>	February 6, 1995
<b>LABORATORY NO:</b>	4690 G	<b>PROJECT NAME:</b>	IFC, 2030-6
		<b>PURCHASE ORDER NO:</b>	P9-41038

<b>TEST</b>	<b>RESULTS</b>
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Natural Gas Analysis by Gas Chromatography, ASTM D 1945:

	<u>MOL %</u>	<u>GPM @ 14.650 psia</u>
Nitrogen	16.374	
Carbon Dioxide	39.757	
Methane	43.907	
Ethane	0.020	0.005
Propane	0.007	0.002
Iso-butane	0.004	0.001
N-butane	0.002	0.001
Iso-pentane	0.003	0.001
N-pentane	0.001	NIL
Hexanes	0.029	0.012
Heptanes plus	<u>NIL</u>	<u>NIL</u>
	100.000	0.022

Specific Gravity @ 60°F (air = 1)	1.0080
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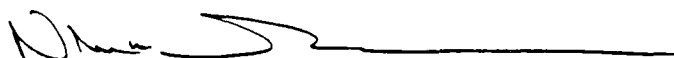
Calculated Btu/cu. ft. @ 14.650 psia and 60°F:

Dry basis	445
-----------	-----

Wet basis	437
-----------	-----

Z Factor	0.9977
----------	--------

Respectfully Submitted,

Nader M. Sorurbakhsh, P.E.  
Laboratory Director

## **SUB-APPENDIX H**

### **HALITE AND SULFUR COMPOUND AUDIT DATA**



## Performance Analytical Inc.

Air Quality Laboratory

### LABORATORY REPORT

Client:	TRC ENVIRONMENTAL CORPORATION	Date of Report:	02/15/95
Address:	5 Waterside Crossing	Date Received:	01/18/95
	Windsor, CT 06095	PAI Project No:	P95-7630
Contact:	Mr. Jim Canora	Purchase Order:	026197
Client Project ID:	IFC #2030-6		

---

#### Seven (7) Tedlar Bag Samples labeled:

"EPA 16-118-A1"	"EPA 16-118-A2"	"EPA 16-118-A3"
"TO14-118-A1"	"TO14-118-A2"	"TO14-118-A3"
"TO14-118-A4"		

---

The samples were received at the laboratory under chain of custody on January 18, 1995. The samples were received intact. The dates of analyses are indicated on the attached data sheets.

#### Sulfur Compound Analysis

Three of the samples were analyzed for seven Sulfur Compounds and Total Reduced Sulfur as Hydrogen Sulfide by gas chromatography/flame photometric detection (FPD). The analytical system used was comprised of a Hewlett Packard Model 5890 equipped with a flame photometric detector (FPD). A thick film (5 micron) crossbonded 100% Dimethyl polysiloxane megabore column (60 meter x 0.53mm RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

---

#### Data Release Authorization:

Kathleen Aguilera  
Analytical Chemist

#### Reviewed and Approved:

Michael Tuday  
Laboratory Director

H-H2



**Performance Analytical Inc.**  
Air Quality Laboratory

**Volatile Organic Compound Analysis**

Four of the samples were analyzed by combined gas chromatography/mass spectrometry (GC/MS) for selected Volatile Organic Compounds. The analyses were performed according to the methodology outlined in EPA Method TO-14 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, EPA 600/4-84-041, U.S. Environmental Protection Agency, Research Triangle Park, NC, April, 1984 and May, 1988. The method was modified for using Tedlar bags. The analyses were performed by gas chromatography/mass spectrometry, utilizing a direct cryogenic trapping technique. The analytical system used was comprised of a Finnigan Model 4500 GC/MS/DS interfaced to a Tekmar 5010 Automatic Desorber. A 100% Dimethyl polysiloxane capillary column (RT<sub>x</sub>-1, Restek Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

The results of analyses are given on the attached data summary sheets.



**Performance Analytical Inc.**  
Environmental Testing and Consulting

## RESULTS OF ANALYSIS

PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : N/A**

**PAI Sample ID : PAI Method Blank**

**Test Code : GC/FPD Reduced Sulfur Analysis**

**Analyst : Ku-Jih Chen**

**Instrument : HP5890A/FPD #4**

**Matrix : Tedlar Bag**

**Date Sampled : N/A**

**Date Received : N/A**

**Date Analyzed : 1/19/95**

**Volume(s) Analyzed : 10.0 (ml)**

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	ND	5.60	ND	4.00
463-58-1	Carbonyl Sulfide	ND	9.80	ND	4.00
74-93-1	Methyl Mercaptan	ND	7.90	ND	4.00
75-08-1	Ethyl Mercaptan	ND	10.0	ND	4.00
75-18-3	Dimethyl Sulfide	ND	10.0	ND	4.00
75-15-0	Carbon Disulfide	ND	6.20	ND	2.00
624-92-0	Dimethyl Disulfide	ND	7.70	ND	2.00
	Total Reduced Sulfur (as Hydrogen Sulfide)	ND	5.60	ND	4.00

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SG

Date : 1/19/95

H-H4





**Performance Analytical Inc.**  
Environmental Testing and Consulting

## RESULTS OF ANALYSIS

PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : EPA16-118-A1**

**PAI Sample ID : 9500193**

**Test Code : GC/FPD Reduced Sulfur Analysis**

**Analyst : Ku-Jih Chen**

**Instrument : HP5890A/FPD #4**

**Matrix : Tedlar Bag**

**Date Sampled : 1/18/95**

**Date Received : 1/18/95**

**Date Analyzed : 1/19/95**

**Volume(s) Analyzed : 0.20 (ml)**

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	18,400	280	13,200	200
463-58-1	Carbonyl Sulfide	ND	490	ND	200
74-93-1	Methyl Mercaptan	ND	390	ND	200
75-08-1	Ethyl Mercaptan	ND	510	ND	200
75-18-3	Dimethyl Sulfide	ND	510	ND	200
75-15-0	Carbon Disulfide	ND	310	ND	100
624-92-0	Dimethyl Disulfide	ND	390	ND	100
	Total Reduced Sulfur (as Hydrogen Sulfide)	18,400	280	13,200	200

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : 915

Date : 1/19/95

H-H5



**Performance Analytical Inc.**  
Environmental Testing and Consulting

## RESULTS OF ANALYSIS

PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : EPA16-118-A2**

**PAI Sample ID : 9500194**

**Test Code : GC/FPD Reduced Sulfur Analysis**

**Analyst : Ku-Jih Chen**

**Instrument : HP5890A/FPD #4**

**Matrix : Tedlar Bag**

**Date Sampled : 1/18/95**

**Date Received : 1/18/95**

**Date Analyzed : 1/19/95**

**Volume(s) Analyzed : 0.20 (ml)**

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	18,300	280	13,100	200
463-58-1	Carbonyl Sulfide	ND	490	ND	200
74-93-1	Methyl Mercaptan	ND	390	ND	200
75-08-1	Ethyl Mercaptan	ND	510	ND	200
75-18-3	Dimethyl Sulfide	ND	510	ND	200
75-15-0	Carbon Disulfide	ND	310	ND	100
624-92-0	Dimethyl Disulfide	ND	390	ND	100
	Total Reduced Sulfur (as Hydrogen Sulfide)	18,300	280	13,100	200

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SLC

Date : 1/19/95



Performance Analytical Inc.  
Environmental Testing and Consulting

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : EPA16-118-A3

PAI Sample ID : 9500195

Test Code : GC/FPD Reduced Sulfur Analysis

Analyst : Ku-Jih Chen

Instrument : HP5890A/FPD #4

Matrix : Tedlar Bag

Date Sampled : 1/18/95

Date Received : 1/18/95

Date Analyzed : 1/19/95

Volume(s) Analyzed : 0.20 (ml)

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	18,500	280	13,300	200
463-58-1	Carbonyl Sulfide	ND	490	ND	200
74-93-1	Methyl Mercaptan	ND	390	ND	200
75-08-1	Ethyl Mercaptan	ND	510	ND	200
75-18-3	Dimethyl Sulfide	ND	510	ND	200
75-15-0	Carbon Disulfide	ND	310	ND	100
624-92-0	Dimethyl Disulfide	ND	390	ND	100
	Total Reduced Sulfur (as Hydrogen Sulfide)	18,500	280	13,300	200

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : \_\_\_\_\_

Date : \_\_\_\_\_

*(Signature)*

1/19/95



## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : EPA16-118-A3

PAI Sample ID : 9500195 (Laboratory Duplicate)

Test Code : GC/FPD Reduced Sulfur Analysis

Analyst : Ku-Jih Chen

Instrument : HP5890A/FPD #4

Matrix : Tedlar Bag

Date Sampled : 1/18/95

Date Received : 1/18/95

Date Analyzed : 1/19/95

Volume(s) Analyzed : 0.20 (ml)

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
7783-06-4	Hydrogen Sulfide	18,300	280	13,100	200
463-58-1	Carbonyl Sulfide	ND	490	ND	200
74-93-1	Methyl Mercaptan	ND	390	ND	200
75-08-1	Ethyl Mercaptan	ND	510	ND	200
75-18-3	Dimethyl Sulfide	ND	510	ND	200
75-15-0	Carbon Disulfide	ND	310	ND	100
624-92-0	Dimethyl Disulfide	ND	390	ND	100
	Total Reduced Sulfur (as Hydrogen Sulfide)	18,300	280	13,100	200

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SG

Date : 1/19/95



Performance Analytical Inc.  
Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : N/A

PAI Sample ID : PAI Method Blank

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Kathleen Aguilera  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : N/A  
Date Received : N/A  
Date Analyzed : 1/19/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT	REPORTING	RESULT	REPORTING
		ug/m3	LIMIT ug/m3	ppb	LIMIT ppb
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	ND	5.0	ND	1.5
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	ND	5.0	ND	1.3
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	ND	5.0	ND	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by :                     

Date : 2/14/95

H-H9



# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : N/A

PAI Sample ID : PAI Method Blank

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Kathleen Aguilera  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : N/A  
Date Received : N/A  
Date Analyzed : 1/20/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	ND	5.0	ND	1.5
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	ND	5.0	ND	1.3
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	ND	5.0	ND	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SLG

Date : 2/14/95

H-H10



**Performance Analytical Inc.**  
Air Quality Laboratory

**RESULTS OF ANALYSIS**

PAGE 1 OF 1

**Client : TRC Environmental Corporation**

**Client Sample ID : TO14-118-A1**

**PAI Sample ID : 9500196**

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Kathleen Aguilera  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : 1/18/95  
Date Received : 1/18/95  
Date Analyzed : 1/19-20/1995  
Volume(s) Analyzed : 1.00 (Liter)  
0.20 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT	REPORTING	RESULT	REPORTING
		ug/m3	LIMIT ug/m3	ppb	LIMIT ppb
75-01-4	Vinyl Chloride	38	5.0	15	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	ND	5.0	ND	1.5
156-59-2	cis-1,2-Dichloroethene	54	5.0	14	1.3
75-34-3	1,1-Dichloroethane	50	5.0	13	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	4.6 TR	5.0	1.2 TR	1.3
127-18-4	Tetrachloroethene	96	5.0	14	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	ND	5.0	ND	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SG

Date : 2/14/95

H-H11



# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

**Client** : TRC Environmental Corporation

**Client Sample ID** : TO14-118-A2

**PAI Sample ID** : 9500197

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Kathleen Aguilera  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : 1/18/95  
Date Received : 1/18/95  
Date Analyzed : 1/19-20/1995  
Volume(s) Analyzed : 1.00 (Liter)  
0.20 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
75-01-4	Vinyl Chloride	39	5.0	15	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	ND	5.0	ND	1.5
156-59-2	cis-1,2-Dichloroethene	53	5.0	13	1.3
75-34-3	1,1-Dichloroethane	52	5.0	13	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	4.1 TR	5.0	1.1 TR	1.3
127-18-4	Tetrachloroethene	93	5.0	14	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	ND	5.0	ND	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SLC

Date : 2/14/95

H-H12





# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : TO14-118-A3

PAI Sample ID : 9500198

Test Code : GC/MS Mod. EPA TO-14  
Analyst : K. Aguilera/C. Casteel  
Instrument : Finnigan 4500C/Tekmar 5010  
Instrument : HP5989A/Entech 2000  
Matrix : Tedlar Bag

Date Sampled : 1/18/95  
Date Received : 1/18/95  
Date Analyzed : 1/19-20/1995  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
75-01-4	Vinyl Chloride	55	5.0	22	2.0
75-69-4	Trichlorofluoromethane	ND	5.0	ND	0.90
75-09-2	Methylene chloride	ND	5.0	ND	1.5
156-59-2	cis-1,2-Dichloroethene	61	5.0	15	1.3
75-34-3	1,1-Dichloroethane	58	5.0	15	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	4.9 TR	5.0	1.3 TR	1.3
127-18-4	Tetrachloroethene	110	5.0	16	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	ND	5.0	ND	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SG

Date : 2/14/95

H-H13



# Performance Analytical Inc.

Air Quality Laboratory

## RESULTS OF ANALYSIS

PAGE 1 OF 1

Client : TRC Environmental Corporation

Client Sample ID : TO14-118-A4

PAI Sample ID : 9500199

Test Code : GC/MS Mod. EPA TO-14  
Analyst : Kathleen Aguilera  
Instrument : Finnigan 4500C/Tekmar 5010  
Matrix : Tedlar Bag

Date Sampled : 1/18/95  
Date Received : 1/18/95  
Date Analyzed : 1/19/95  
Volume(s) Analyzed : 1.00 (Liter)

D.F. = 1.00

CAS #	COMPOUND	RESULT ug/m3	REPORTING LIMIT ug/m3	RESULT ppb	REPORTING LIMIT ppb
75-01-4	Vinyl Chloride	ND	5.0	ND	2.0
75-69-4	Trichlorofluoromethane	390	5.0	70	0.90
75-09-2	Methylene chloride	310	5.0	91	1.5
156-59-2	cis-1,2-Dichloroethene	ND	5.0	ND	1.3
75-34-3	1,1-Dichloroethane	ND	5.0	ND	1.2
71-43-2	Benzene	ND	5.0	ND	1.6
79-01-6	Trichloroethene	ND	5.0	ND	0.94
108-88-3	Toluene	3.8 TR	5.0	1.0 TR	1.3
127-18-4	Tetrachloroethene	ND	5.0	ND	0.75
108-90-7	Chlorobenzene	ND	5.0	ND	1.1
100-41-4	Ethylbenzene	ND	5.0	ND	1.2
100-42-5	Styrene	ND	5.0	ND	1.2
1330-20-7	m- & p-Xylenes	ND	5.0	ND	1.2
95-47-6	o-Xylene	ND	5.0	ND	1.2

TR = Detected Below Indicated Reporting Limit

ND = Not Detected

Verified by : SL

Date : 2/14/95

H-H14

Ship To: Performance Analytical  
Attn: Michael Tuley

Page 1 of 1  
Project Name: IFC  
Project No.: 2030-6  
Site Location: Burbank, CA.  
Date: January 18, 1995

## CHAIN OF CUSTODY RECORD

P957630

[illegible]

Total Number of Samples Shipped:

**Shipper's Signature:**

Signature	Company	Date	Time
Relinquished by: <i>Kay Force</i>	Environmental Solutions Inc.	1/18/95	13:00
Received by: <i>R. Renard</i>	ESI	1/18/95	13:00
Relinquished by: <i>R. Renard</i>	ESI	1/18/95	16:09
Received by:			
Relinquished by:			
Received by: <i>K. Schmidt</i>	PAI	1/18/95	16:10

Special Instructions / Shipment / Handling/ Storage Requirements:

For V.O.X. samples: Report 10 largest P.I.C.S

See Table 1-1 for a list of compounds of interest.

The material(s) listed are received for analysis and/or treatability evaluation and remain the property of the client and not Environment 1 Solutions, Inc. At the conclusion of the test work, all remaining material(s) will be returned to the client for eventual disposal at a licensed facility.

☒ ENVIRONMENTAL SOLUTIONS, INC.  
21 Technology Drive  
Irvine, California 92718

☐ **ENVIRONMENTAL SOLUTIONS, INC.**  
2815 Mitchell Drive, Suite 103  
Walnut Creek, California 94599

H-H15



# Scott Specialty Gases, Inc.

Shipped 6141 EASTON ROAD PO BOX 310  
 From: PLUMSTEADVILLE PA 18949-0310  
 Phone: 215-766-8861 Fax: 215-766-2070

## C E R T I F I C A T E O F A N A L Y S I S

TRC ENVIRONMENTAL

PROJECT #: 01-62683-002

PO#: 25886

C/O E.S.I.

ITEM #: 01046673

4EL

21 TECHNOLOGY DRIVE  
 IRVINE

CA 92718

DATE: 11/23/94

CYLINDER #: SCOTTY-4EL

ANALYTICAL ACCURACY: +/- 10%

COMPONENT	REQUESTED GAS		ANALYSIS	
	CONC		(MOLES)	
CIS 1,2-DICHLOROETHYLENE	10.	PPB	11.9	PPB
1,2-DIBROMOETHANE	10.	PPB	10.3	PPB
1,1-DICHLOROETHANE	10.	PPB	12.1	PPB
1,2-DICHLOROETHANE	10.	PPB	11.6	PPB
TETRACHLOROETHYLENE	10.	PPB	11.2	PPB
1,1,1-TRICHLOROETHANE	10.	PPB	12.0	PPB
VINYL CHLORIDE	10.	PPB	11.2	PPB
VINYLDENE CHLORIDE	10.	PPB	12.3	PPB
NITROGEN		BALANCE		BALANCE

ANALYTICAL METHOD: MICROGRAV

ANALYST: Ted Neeme

TED NEEME

H-H16



# Scott Specialty Gases, Inc.

Shipped  
From:

6141 EASTON ROAD  
PLUMSTEADVILLE  
Phone: 215-766-8861

PA 18949-0310

PO BOX 310  
Fax: 215-766-2070

## C E R T I F I C A T E O F A N A L Y S I S

TRC ENVIRONMENTAL

C/O E.S.I.  
21 TECHNOLOGY DRIVE  
IRVINE

CA 92718

PROJECT #: 01-62683-001  
PO#: 25886  
ITEM #: 01046663 4EL  
DATE: 11/23/94

CYLINDER #: SCOTTY-4EL

ANALYTICAL ACCURACY: +/- 5%

COMPONENT	REQUESTED GAS		ANALYSIS	
	CONC		(MOLES)	
ACETONITRILE	100.	PPB	120.0	PPB
1,3-BUTADIENE	100.	PPB	114.0	PPB
CARBON TETRACHLORIDE	100.	PPB	116.0	PPB
CHLOROFORM	100.	PPB	115.0	PPB
HALOCARBON 11	100.	PPB	99.2	PPB
METHYLENE CHLORIDE	100.	PPB	120.0	PPB
NITROGEN		BALANCE		BALANCE

ANALYTICAL METHOD: MICROGRAV

ANALYST:

*Ted Neeme*  
TED NEEME

H-H17



# Scott Specialty Gases, Inc.

Shipped From: 6141 EASTON ROAD  
PLUMSTEADVILLE PA 18949-0310 PO BOX 310  
Phone: 215-766-8861 Fax: 215-766-2070

## C E R T I F I C A T E O F A N A L Y S I S

TRC ENVIRONMENTAL

PROJECT #: 01-62683-003

PO#: 25886

C/O E.S.I.

ITEM #: 0104260

4EL

21 TECHNOLOGY DRIVE

DATE: 11/28/94

IRVINE

CA 92718

CYLINDER #: SCOTTY 4EL

ANALYTICAL ACCURACY: +-5%

### COMPONENT

### REQUESTED GAS CONC

### ANALYSIS (MOLES)

HYDROGEN SULFIDE  
NITROGEN

10. PPM  
BALANCE

10.1 PPM  
BALANCE

1 CAN BASED ON ANALYSIS OF  
LOT#431204

ANALYST:

Glenn Gunn  
GLENN GUNN

H-H18

## **SUB-APPENDIX I**

### **FUEL CELL EMISSIONS QA DATA**

# CYLINDER GAS AUDIT DATA SHEET

CLIENT: IFC

TEST LOCATION: FUEL CELL

INSTRUMENT: FUJI CO<sub>2</sub>

POLLUTANT: \_\_\_\_\_

MODEL: \_\_\_\_\_

RANGE: 0-20%

DATE: FEB 16, 95

AUDITOR CRAIG SCOTT

MID-RANGE AUDIT <u>Cylinder # CC88851</u>					
	AUDIT RESPONSE 1	AUDIT RESPONSE 2	AUDIT RESPONSE 3	AVERAGE RESPONSE	CYLINDER VALUE
RESPONSE	<u>6.2</u>	<u>6.2</u>	<u>6.2</u>	<u>6.2</u>	<u>6.12</u>
TIME	<u>15:38</u>	<u>15:54</u>	<u>16:01</u>	ACCURACY = <u>1.3%</u>	

HIGH-RANGE AUDIT					
	AUDIT RESPONSE 1	AUDIT RESPONSE 2	AUDIT RESPONSE 3	AVERAGE RESPONSE	CYLINDER VALUE
RESPONSE					
TIME				ACCURACY =	

COPY OF GAS CERTIFICATES AVAILABLE? Y ✓ N \_\_\_\_\_  
 HARD COPY OF RESPONSES AVAILABLE? Y ✓ N \_\_\_\_\_

## ACCURACY CALCULATION

$$\text{ACCURACY} = \frac{C_m - C_a}{C_a} \times 100$$

Where:

$C_m$  = Analyzer Response during audit in units of Applicable Standard or Appropriate Concentration

$C_a$  = Average Audit Value, in this case  $C_a$  = Calibration Gas Cylinder Concentration



# CYLINDER GAS AUDIT DATA SHEET

CLIENT: JFC

TEST LOCATION: FUEL CELL

INSTRUMENT: O<sub>2</sub> s/n 90737

POLLUTANT: \_\_\_\_\_

MODEL: TELEDYNE

RANGE: 0-25 %

DATE: FEB 16, 95

AUDITOR CRAIG SCOTT

MID-RANGE AUDIT <i>Cylinder # CC 97847</i>					
	AUDIT RESPONSE 1	AUDIT RESPONSE 2	AUDIT RESPONSE 3	AVERAGE RESPONSE	CYLINDER VALUE
RESPONSE	12.1	12.1	12.1	12.1	12.0
TIME	15:42	15:58	16:04	ACCURACY = 0.8 %	

HIGH-RANGE AUDIT					
	AUDIT RESPONSE 1	AUDIT RESPONSE 2	AUDIT RESPONSE 3	AVERAGE RESPONSE	CYLINDER VALUE
RESPONSE					
TIME				ACCURACY =	

COPY OF GAS CERTIFICATES AVAILABLE? Y ✓ N \_\_\_\_\_  
 HARD COPY OF RESPONSES AVAILABLE? Y ✓ N \_\_\_\_\_

## ACCURACY CALCULATION

$$\text{ACCURACY} = \frac{C_m - C_a}{C_a} \times 100$$

Where:

$C_m$  = Analyzer Response during audit in units of Applicable Standard or Appropriate Concentration

$C_a$  = Average Audit Value, in this case  $C_a$  = Calibration Gas Cylinder Concentration

# CYLINDER GAS AUDIT DATA SHEET

CLIENT: IFC

TEST LOCATION: FUEL CELL

INSTRUMENT: BOVAR SO2

POLLUTANT: SO2

MODEL: 721M

RANGE: 0-100 ppm

DATE: FEB 16, 1995

AUDITOR C. SCOTT

MID-RANGE AUDIT CYLINDER# <u>AAL7595</u>					
	AUDIT RESPONSE 1	AUDIT RESPONSE 2	AUDIT RESPONSE 3	AVERAGE RESPONSE	CYLINDER VALUE
RESPONSE	<u>23.7</u>	<u>23.9</u>	<u>23.9</u>	<u>23.8</u>	<u>24.8</u>
TIME	<u>10:03</u>	<u>10:13</u>	<u>10:23</u>	ACCURACY = <u>4.0 %</u>	

HIGH-RANGE AUDIT CYLINDER# <u>ALM25536</u>					
	AUDIT RESPONSE 1	AUDIT RESPONSE 2	AUDIT RESPONSE 3	AVERAGE RESPONSE	CYLINDER VALUE
RESPONSE	<u>46.3</u>	<u>46.5</u>	<u>46.6</u>	<u>48.5</u>	<u>49.6</u>
TIME	<u>09:58</u>	<u>10:09</u>	<u>10:18</u>	ACCURACY = <u>6.3 %</u>	

COPY OF GAS CERTIFICATES AVAILABLE? Y ✓ N       
 HARD COPY OF RESPONSES AVAILABLE? Y ✓ N     

## ACCURACY CALCULATION

$$\text{ACCURACY} = \frac{C_m - C_a}{C_a} \times 100$$

Where:

$C_m$  = Analyzer Response during audit in units of Applicable Standard or Appropriate Concentration

$C_a$  = Average Audit Value, in this case  $C_a$  = Calibration Gas Cylinder Concentration

## CYLINDER GAS AUDIT DATA SHEET

CLIENT: IFCTEST LOCATION: FUEL CELLINSTRUMENT: 500 CO FUJIPOLLUTANT: CO

MODEL: \_\_\_\_\_

RANGE: 0-100DATE: FEB 16, 1995AUDITOR C. SCOTT

MID-RANGE AUDIT CYLINDER# AAL7595					
	AUDIT RESPONSE 1	AUDIT RESPONSE 2	AUDIT RESPONSE 3	AVERAGE RESPONSE	CYLINDER VALUE
RESPONSE	24.6	24.2	24.3	24.4	25.8
TIME	10:03	10:13	10:23	ACCURACY = 5.6 %	

HIGH-RANGE AUDIT CYLINDER# ALM25536					
	AUDIT RESPONSE 1	AUDIT RESPONSE 2	AUDIT RESPONSE 3	AVERAGE RESPONSE	CYLINDER VALUE
RESPONSE	49.4	49.5	49.4	49.4	50.7
TIME	09:58	10:09	10:18	ACCURACY = 2.5 %	

COPY OF GAS CERTIFICATES AVAILABLE? Y \_\_\_\_\_ N \_\_\_\_\_  
HARD COPY OF RESPONSES AVAILABLE? Y \_\_\_\_\_ N \_\_\_\_\_

## ACCURACY CALCULATION

$$\text{ACCURACY} = \frac{C_m - C_a}{C_a} \times 100$$

Where:

$C_m$  = Analyzer Response during audit in units of Applicable Standard or Appropriate Concentration

$C_a$  = Average Audit Value, in this case  $C_a$  = Calibration Gas Cylinder Concentration

# CYLINDER GAS AUDIT DATA SHEET

CLIENT: IFC

TEST LOCATION: Penrose

INSTRUMENT: Thermo Environmental

POLLUTANT: NO<sub>x</sub>

MODEL: 10

RANGE: 0-2.5

DATE: 2-16-95

AUDITOR C. Scott

ALM048981

## MID-RANGE AUDIT

	AUDIT RESPONSE 1	AUDIT RESPONSE 2	AUDIT RESPONSE 3	AVERAGE RESPONSE	CYLINDER VALUE
RESPONSE	1.46			1.46	1.40
TIME	11:18			ACCURACY =	4.3

## HIGH-RANGE AUDIT

	AUDIT RESPONSE 1	AUDIT RESPONSE 2	AUDIT RESPONSE 3	AVERAGE RESPONSE	CYLINDER VALUE
RESPONSE	0.76			0.76	0.70
TIME	11:20			ACCURACY =	8.6

COPY OF GAS CERTIFICATES AVAILABLE? Y / N       
HARD COPY OF RESPONSES AVAILABLE? Y ✓ N     

## ACCURACY CALCULATION

$$\text{ACCURACY} = \frac{C_m - C_a}{C_a} \times 100$$

Where:

$C_m$  = Analyzer Response during audit in units of Applicable Standard or Appropriate Concentration

$C_a$  = Average Audit Value, in this case  $C_a$  = Calibration Gas Cylinder Concentration

# CYLINDER GAS AUDIT DATA SHEET

CLIENT: IFC TEST LOCATION: Penrose  
 INSTRUMENT: Thermo Environmental POLLUTANT: NOx  
 MODEL: 10 RANGE: 0-2.5 ppm  
 DATE: 2-16-95 AUDITOR: C. Scott

MID-RANGE AUDIT					
	AUDIT RESPONSE 1	AUDIT RESPONSE 2	AUDIT RESPONSE 3	AVERAGE RESPONSE	CYLINDER VALUE
RESPONSE	1.84			1.84	2.37 <sup>①</sup>
TIME	12:03			ACCURACY =	22.4

HIGH-RANGE AUDIT					
	AUDIT RESPONSE 1	AUDIT RESPONSE 2	AUDIT RESPONSE 3	AVERAGE RESPONSE	CYLINDER VALUE
RESPONSE	1.88			1.88	2.37 <sup>②</sup>
TIME	12:08			ACCURACY =	20.7

COPY OF GAS CERTIFICATES AVAILABLE? Y ✓ N       
 HARD COPY OF RESPONSES AVAILABLE? Y ✓ N     

## ACCURACY CALCULATION

$$\text{ACCURACY} = \frac{C_m - C_a}{C_a} \times 100$$

Where:

$C_m$  = Analyzer Response during audit in units of Applicable Standard or Appropriate Concentration

$C_a$  = Average Audit Value, in this case  $C_a$  = Calibration Gas cylinder Concentration

- ① Gas generated with Environic Calibrator using 30.8 ppm NO stock  
 ② Gas generated with Environic Calibrator using 26.7 ppm NO stock

**PILVER  
VARIFKATION**

Nox  
1.7

## AUDIT #2

AUDIT #1

ART

02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
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02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
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02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
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CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
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02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
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02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR	0.99PPM	CO 1HR	1.3%
SO2 1HR	10.0PPM	SO2 1HR	1.8%	SO2 1HR	0.99PPM	SO2 1HR	1.3%
02 30m	0.1%	02 30m	1.86PPM	02 30m	0.1%	02 30m	5.3PPM
CO 1HR	10.3PPM	CO 1HR	1.8%	CO 1HR			

CO2 1HR	0.12PPM	02 1HR	0.0%	NOx 1HR	0.15PPM	CO2 1HR	0.1%
SO2 1HR	0.23PPM						
MANUAL	Feb. 15, 95	09:10					
CO	0.12PPM	02	0.0%	NOx	0.17PPM	CO2	0.1%
SO2	0.14PPM	HEUTEMP	77°F	CO 5min	0.7PPM	CO2 5min	0.0%
NOx 5min	0.1%	CO2 5min	0.1%	SO2 5min	0.7PPM	CO 30min	0.7PPM
CO 30min	0.1%	NOx 30min	0.17PPM	CO2 30min	0.1%	SO2 30min	0.2PPM
CO 1HR	0.2PPM	CO2 1HR	0.0%	NOx 1HR	0.17PPM	CO2 1HR	0.1%
SO2 1HR	0.2PPM						
MANUAL	Feb. 15, 95	09:19					
CO	0.2PPM	02	0.0%	NOx	0.23PPM	CO2	0.1%
SO2	0.24PPM	HEUTEMP	75°F	CO 5min	0.7PPM	CO2 5min	0.0%
NOx 5min	0.1%	CO2 5min	0.1%	SO2 5min	0.7PPM	CO 30min	0.7PPM
CO 30min	0.1%	NOx 30min	0.25PPM	CO2 30min	0.1%	SO2 30min	0.7PPM
CO 1HR	0.18PPM	CO2 1HR	1.5%	NOx 1HR	0.23PPM	CO2 1HR	1.5%
SO2 1HR	1.26PPM						
MANUAL	Feb. 15, 95	09:17					
CO	0.42PPM	02 30	0.40%	NOx 50	0.60PPM	CO2	0.1%
SO2	0.4PPM	HEUTEMP	75°F	CO 5min	0.7PPM	CO2 5min	0.0%
NOx 5min	0.1%	CO2 5min	0.1%	SO2 5min	0.7PPM	CO 30min	0.7PPM
CO 30min	0.1%	NOx 30min	1.38PPM	CO2 30min	0.1%	SO2 30min	0.7PPM
CO 1HR	0.3PPM	CO2 1HR	1.6%	NOx 1HR	0.39PPM	CO2 1HR	1.7%
SO2 1HR	10.2PPM						
MANUAL	Feb. 15, 95	09:15					
CO	0.2PPM	02	0.0%	NOx	0.24PPM	CO2	0.1%
SO2	0.24PPM	HEUTEMP	76°F	CO 5min	0.7PPM	CO2 5min	0.0%
NOx 5min	0.1%	CO2 5min	0.1%	SO2 5min	0.7PPM	CO 30min	0.7PPM
CO 30min	0.1%	NOx 30min	1.38PPM	CO2 30min	0.1%	SO2 30min	0.7PPM
CO 1HR	0.8PPM	CO2 1HR	1.7%	NOx 1HR	0.91PPM	CO2 1HR	1.7%
SO2 1HR	10.3PPM						
MANUAL	Feb. 15, 95	09:14					
CO	0.2PPM	02	0.0%	NOx	0.14PPM	CO2	0.1%
SO2	0.2PPM	HEUTEMP	76°F	CO 5min	0.7PPM	CO2 5min	0.3%
NOx 5min	0.1%	CO2 5min	0.1%	SO2 5min	0.7PPM	CO 30min	0.7PPM
CO 30min	0.1%	NOx 30min	1.48PPM	CO2 30min	0.1%	SO2 30min	0.7PPM
CO 1HR	0.9PPM	CO2 1HR	1.7%	NOx 1HR	0.94PPM	CO2 1HR	1.8%
SO2 1HR	10.2PPM						
MANUAL	Feb. 15, 95	09:11					
CO	0.2PPM	02	0.0%	NOx	0.21PPM	CO2	0.1%
SO2	0.24PPM	HEUTEMP	77°F	CO 5min	0.7PPM	CO2 5min	0.6%
NOx 5min	0.1%	CO2 5min	0.1%	SO2 5min	0.7PPM	CO 30min	0.7PPM
CO 30min	0.1%	NOx 30min	1.51PPM	CO2 30min	0.1%	SO2 30min	0.7PPM
CO 1HR	10.3PPM	CO2 1HR	1.8%	NOx 1HR	0.99PPM	CO2 1HR	1.8%
SO2 1HR	10.0PPM						

25.0

ZERO

SO2  
75.0

ZERO

SO2  
25.0

ZERO

SO2  
75.0

0	MANUAL	10	Feb 20, 95	3009:32	40	50	60	70	80	90	100
	SO2		-0.3PPM	HETEMP	76°F	CO 5m	0.11PPM	CO2	0.1%		
	NOx 5m		0.19PPM	CO2 5m	0.1%	SO2 5m	0.7PPM	CO 30m	0.0%		
	CO2 30m		0.0%	NOx 30m	0.21PPM	CO2 30m	0.1%	SO2 30m	9.8PPM		
	CO 1HR		0.7PPM	CO2 1HR	0.0%	NOx 1HR	0.21PPM	CO2 1HR	0.1%		
	SO2 1HR		9.8PPM								

CGA  
ZERO

	MANUAL		Feb 16, 95	09:30							
	SO2		24.9PPM	HETEMP	77°F	NOx 5m	0.17PPM	CO2	0.2%		
	NOx 5m		0.17PPM	CO2 5m	0.1%	CO 5m	0.7PPM	CO2 5m	0.0%		
	CO2 30m		0.0%	NOx 30m	0.22PPM	SO2 5m	24.9PPM	CO 30m	0.7PPM		
	CO 1HR		0.7PPM	CO2 1HR	0.0%	CO2 30m	0.1%	SO2 30m	22.5PPM		
	SO2 1HR		22.5PPM			NOx 1HR	0.22PPM	CO2 1HR	0.1%		

SO2  
25.0

	MANUAL		Feb 16, 95	09:28							
	SO2		-0.3PPM	HETEMP	77°F	NOx 5m	0.13PPM	CO2	0.1%		
	NOx 5m		0.26PPM	CO2 5m	0.1%	CO 5m	0.7PPM	CO2 5m	0.0%		
	CO2 30m		0.0%	NOx 30m	0.22PPM	SO2 5m	33.1PPM	CO 30m	0.7PPM		
	CO 1HR		0.7PPM	CO2 1HR	0.0%	CO2 30m	0.1%	SO2 30m	23.4PPM		
	SO2 1HR		23.4PPM			NOx 1HR	0.22PPM	CO2 1HR	0.1%		

ZERO

	MANUAL		Feb 16, 95	09:26							
	SO2		24.9PPM	HETEMP	76°F	NOx 5m	0.23PPM	CO2	0.1%		
	NOx 5m		0.23PPM	CO2 5m	0.1%	CO 5m	0.3PPM	CO2 5m	0.0%		
	CO2 30m		0.0%	NOx 30m	0.23PPM	SO2 5m	24.9PPM	CO 30m	0.7PPM		
	CO 1HR		0.7PPM	CO2 1HR	0.0%	CO2 30m	0.1%	SO2 30m	26.9PPM		
	SO2 1HR		26.9PPM			NOx 1HR	0.23PPM	CO2 1HR	0.1%		

SO2  
75.0

0	MANUAL	10	Feb 20, 95	3009:24	40	50	60	70	80	90	100
	SO2		-0.3PPM	HETEMP	76°F	CO 5m	0.23PPM	CO2	0.2%		
	NOx 5m		0.19PPM	CO2 5m	0.1%	SO2 5m	0.7PPM	CO 30m	0.7PPM		
	CO2 30m		0.0%	NOx 30m	0.19PPM	CO2 30m	0.1%	SO2 30m	9.8PPM		
	CO 1HR		0.7PPM	CO2 1HR	0.0%	NOx 1HR	0.19PPM	CO2 1HR	0.1%		
	SO2 1HR		9.8PPM								

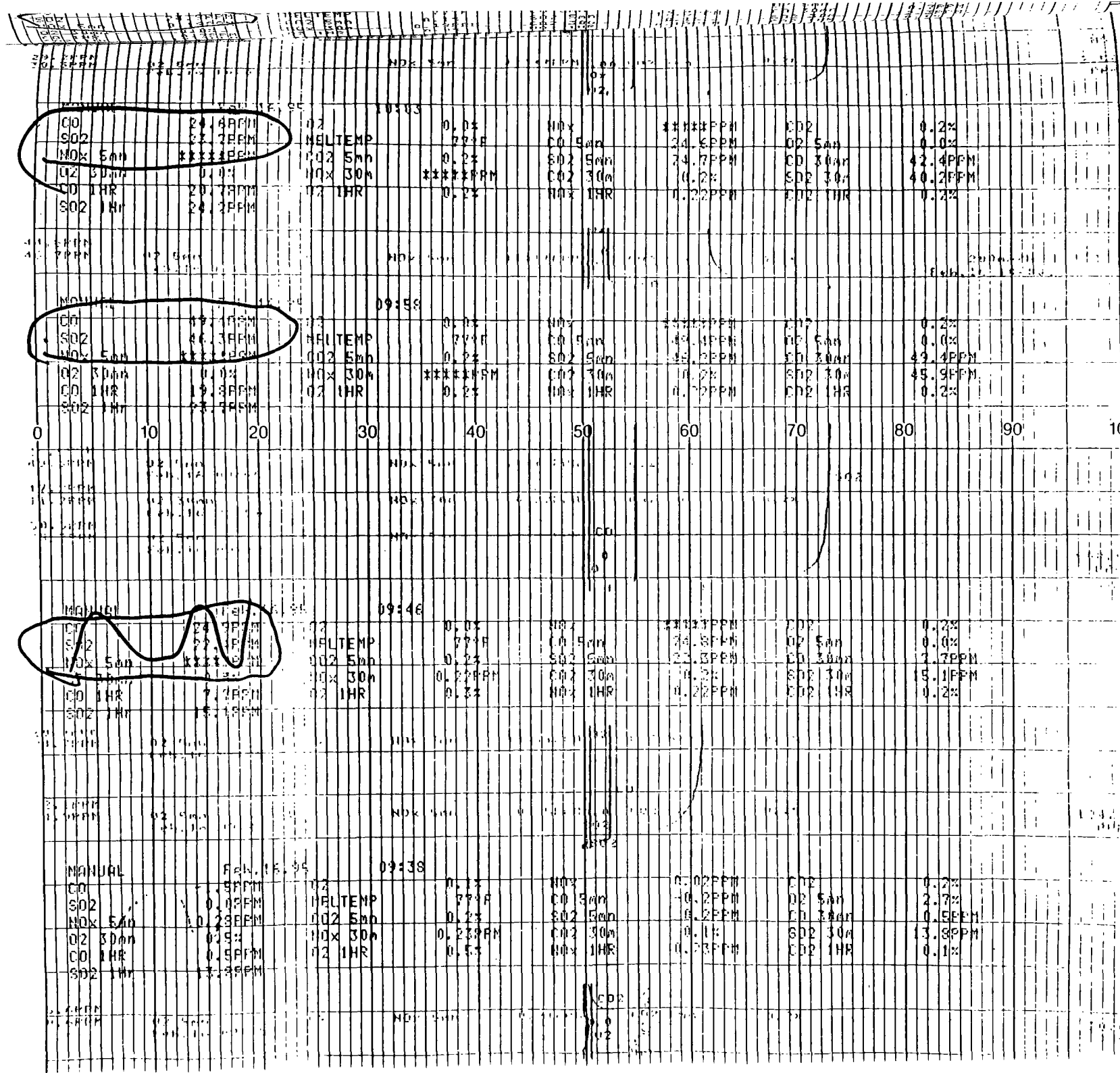
ZERO

	MANUAL		Feb 16, 95	09:23							
	SO2		22.3PPM	HETEMP	77°F	NOx 5m	0.13PPM	CO2	0.1%		
	NOx 5m		0.13PPM	CO2 5m	0.1%	CO 5m	0.7PPM	CO2 5m	0.0%		
	CO2 30m		0.0%	NOx 30m	0.19PPM	SO2 5m	17.3PPM	CO 30m	0.7PPM		
	CO 1HR		0.7PPM	CO2 1HR	0.0%	CO2 30m	0.1%	SO2 30m	12.3PPM		
	SO2 1HR		12.3PPM			NOx 1HR	0.19PPM	CO2 1HR	0.1%		

SO2  
25.0



H-111



MID

HIGH

MID

LOW

MONITOR									
Feb. 16, 95									
10:23									
CO	24.3PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	23.9PPM	HEITEMP	76°F	CO 5min	24.6PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	24.5PPM	CO2 30min	24.6PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	24.5PPM		
CO 1HR	24.4PPM	CO2 1HR	0.0%	NOx 1HR	****PPM	CO2 1HR	0.2%		
SO2 1HR	24.5PPM								
Feb. 16, 95									
10:18									
CO	47.4PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.6PPM	HEITEMP	77°F	CO 5min	45.2PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	45.7PPM	CO2 30min	41.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	39.3PPM		
CO 1HR	26.1PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	28.0PPM								
Feb. 16, 95									
10:13									
CO	24.2PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	23.9PPM	HEITEMP	77°F	CO 5min	25.0PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	24.6PPM	CO2 30min	31.3PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	39.2PPM		
CO 1HR	24.3PPM	CO2 1HR	0.240	NOx 50HR	0.602PPM	CO2 1HR	80 0.2%	90	100
SO2 1HR	24.5PPM								
Feb. 16, 95									
10:09									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:05									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:01									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.2%		
SO2 1HR	26.5PPM								
Feb. 16, 95									
10:00									
CO	49.5PPM	02	0.0%	NOx	****PPM	CO2	0.2%		
SO2	46.5PPM	HEITEMP	76°F	CO 5min	45.5PPM	CO2 5min	0.0%		
NOx 5min	****PPM	CO2 5min	0.2%	SO2 5min	46.2PPM	CO2 30min	43.8PPM		
CO2 30min	0.0%	NOx 30min	****PPM	CO2 30min	0.2%	SO2 30min	41.0PPM		
CO 1HR	24.0PPM	CO2 1HR	0.2%	NOx 1HR	0.22PPM	CO2 1HR	0.		

M17

H164

M17

H164

## **SUB-APPENDIX J**

### **FUEL CELL EMISSIONS CALIBRATION ERROR DATA**

MANUAL		Feb. 15, 95		07:42		CO		9.1 PPM		NOx		0.1%		CO 5min		1.7 PPM		CO2 5min		0.1%			
CO		7.9 PPM		HETEMP		75°F		CO 5min		7.6 PPM		CO2 5min		20.1%		CO 30min		2.8 PPM		CO2 30min		6.7%	
SO2		7.4 PPM		CO2 5min		20.1%		SO2 5min		3.3 PPM		CO2 30min		11.5 PPM		SO2 30min		3.8 PPM		CO2 1HR		1.4%	
NOx 5min		0.1 PPM		NOx 30min		0.05 PPM		CO2 1HR		1.2%		NOx 1HR		0.05 PPM		CO2 1HR		1.2%					
CO 30min		0.0%																					
CO 1HR		1.2 PPM																					
SO2 1HR		8.8 PPM																					

MANUAL		Feb. 15, 95		07:43		CO		7.2 PPM		NOx		0.02 PPM		CO 5min		3.7 PPM		CO2 5min		0.0%			
CO		7.2 PPM		HETEMP		75°F		CO 5min		3.7 PPM		CO2 5min		0.0 PPM		CO 30min		3.0 PPM		CO2 30min		6.5 PPM	
SO2		0.0 PPM		CO2 5min		0.1%		SO2 5min		0.0 PPM		CO2 30min		0.0%		SO2 30min		6.5 PPM		CO2 1HR		0.0%	
NOx 5min		0.02 PPM		NOx 30min		0.04 PPM		CO2 1HR		0.0%		NOx 1HR		0.04 PPM		CO2 1HR		0.0%					
CO 30min		0.0%																					
CO 1HR		3.0 PPM																					
SO2 1HR		6.5 PPM																					

MANUAL		Feb. 15, 95		07:24		CO		8.2 PPM		NOx		0.03 PPM		CO 5min		7.3 PPM		CO2 5min		0.0%			
CO		8.2 PPM		HETEMP		75°F		CO 5min		7.3 PPM		CO2 5min		23.1 PPM		CO 30min		2.3 PPM		CO2 30min		22.1 PPM	
SO2		5.4 PPM		CO2 5min		0.0%		SO2 5min		23.1 PPM		CO2 30min		0.0%		SO2 30min		22.1 PPM		CO2 1HR		0.0%	
NOx 5min		0.03 PPM		NOx 30min		0.03 PPM		CO2 1HR		0.0%		NOx 1HR		0.03 PPM		CO2 1HR		0.0%					
CO 30min		0.0%																					
CO 1HR		2.1 PPM																					

SO2  
90.7 ppm

O2 CO2  
20.1 20.2

CO  
90.4

ZERO

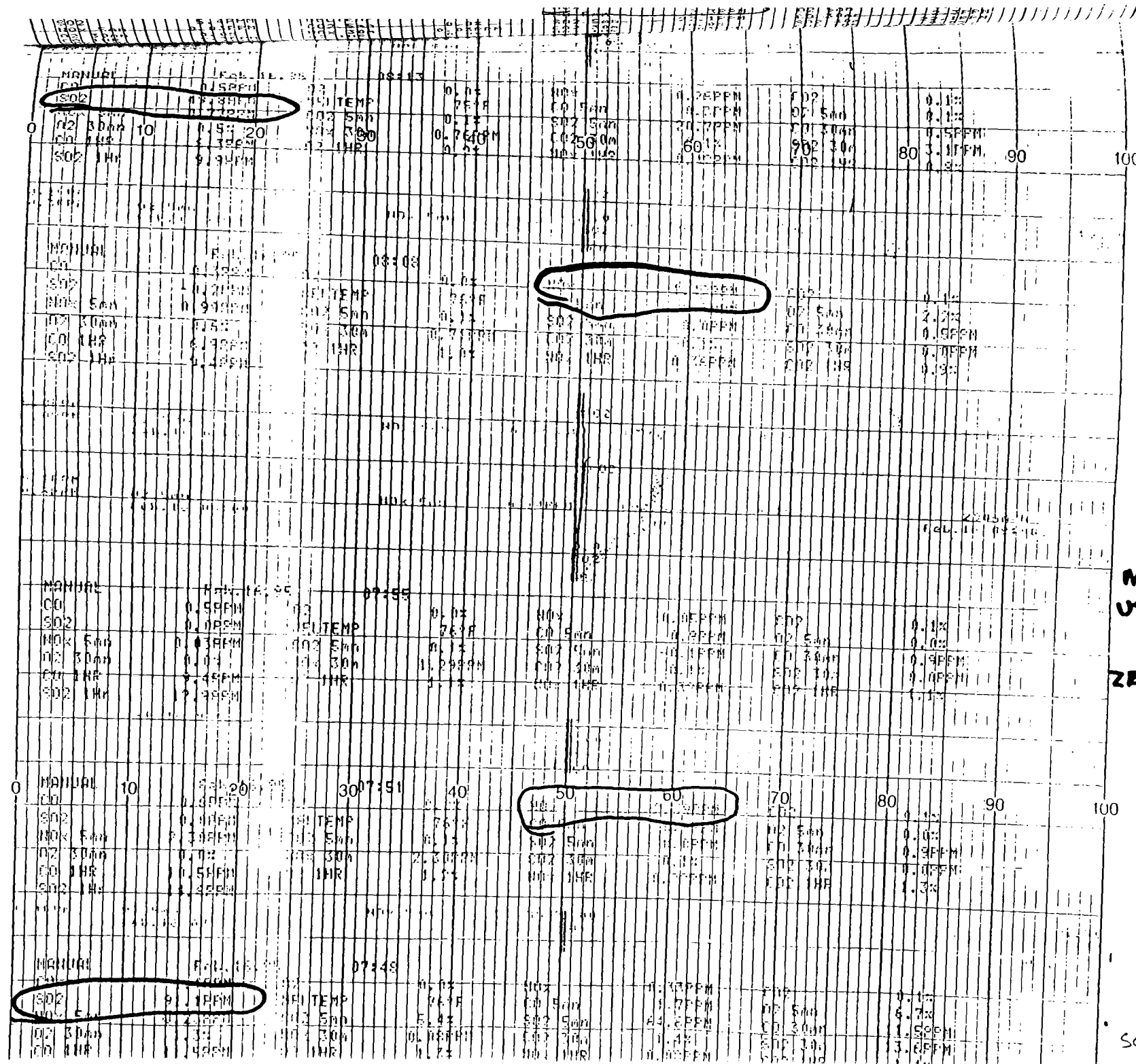
CAL ERROR  
DATA

CAL  
ERROR  
DATA

RACK  
CAL

H-12

H-13

SO2  
49.96NOx  
1.25MID POINTS  
USING DIALS

ZERO

SO2



TRC Environmental Corporation  
CEM Data Sheet

Firm IFC Ambient Temp, deg. F = 75  
 Location Penrose MEL Temp, deg. F = 75  
 Tester C. Scott Bar. Pressure, in Hg = 29.24  
 Test No. 1-120 KW Vacuum Gauge = NA  
 Location Fuel Cell Flowrate (lpm) 6  
 Date 2-17-95  
 TIME 0800-0900

Calibration Gases			
Mid Cal	High Cal	TankID	
		Mid	High
CO	50	90.4	ALM38592
O2	10	20.1	ALM022962
CO2	10	20.2	ALM022962
NOx	1.25	2.37	ALM43127
SO2	50	90.7	ALM36593
THC			

	(Rack) Analyzer Cal.	Initial Values		Final Values		Drift % of Span	Analyzer Range & Units	Avg. Gas Conc.	Corrected Gas Conc.
		System Cal. Response	System Cal. Bias % of Span	System Cal. Response	System Cal. Bias % of Span				
CO	Zero	-0.8	-0.6	0.02	-2	-0.12	-0.14	ppm	-
	Upscale	87.9	88	0.01	87.7	-0.02	-0.03	1000	0.2
O2	Zero	0.2	0.1	-0.4	0.1	-0.4	0	PERCENT	-
	Upscale	20.1	20.1	0	20	-0.4	-0.4	25	8.00
CO2	Zero	0.1	0.1	0	0.2	0.5	0.5	PERCENT	-
	Upscale	20.1	20.2	0.5	20.2	0.5	0	20	12.6
NOx	Zero	-0.04	0.09	0.052	0.51	0.22	0.168	ppm	-
	Upscale	2.41	2.41	0	2.68	0.108	0.108	250	0.61
SO2	Zero	0.7	-0.1	-0.32	-0.2	-0.36	-0.04	ppm	-
	Upscale	89.8	88.5	-0.52	89.4	-0.16	0.36	250	0
THC	Zero		0		0	0	0	ppm	-
	Upscale		0		0	0	100		ERR
LIMITS		+/- 5%		+/- 5%		+/- 3%			

	Cal. Back Analyzer Response	Cal. Upstream Analyzer Response	Bias Check % of Span
CO	Zero		0
	Upscale		0
NOx	Zero		0
	Upscale		0
LIMIT		+/- 5%	

	ZERO Cal. Gas Analyzer Response	Analyzer Calib. Error	MID Cal. Gas Analyzer Response	Analyzer Calib. Error	HIGH Cal. Gas Analyzer Response	Analyzer Calib. Error
CO	1.2	0.12	51.8	0.18	90.4	0.00
O2	0	0.00	9.7	-1.20	20.2	0.40
CO2	0.1	0.50	10	0.00	20.1	-0.50
NOx	0.08	0.03	1.42	0.07	2.36	-0.00
SO2	0	0.00	49.8	-0.08	91.1	0.16
THC		0.00		0.00		0.00
LIMIT		+/- 2%		+/- 2%		+/- 2%

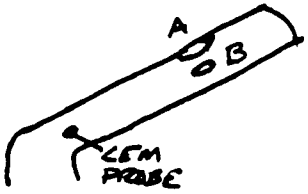
40 CFR 60, Appendix A, Method 6C, subpart 4.1

## **SUB-APPENDIX K**

### **FUEL CELL EXHAUST GAS FLOWRATE DATA**



## VELOCITY TRAVERSE

Plant: <b>IFC</b>	Date: <b>FEB 17, 95</b>
Unit Number: <b>FUEICELL</b>	Stack Diameter (in.): <b>10" = .545 ft<sup>2</sup></b>
Load Condition: <b>120 KW</b>	Stack Gauge Pressure ("H <sub>2</sub> O):
Run No.: <b>RUN 02</b>	Operators: <b>CRAIG SCOTT</b>
Project No.: <b>02030</b>	<b>JIM CANORA</b>
Barometric Pressure at Ground Level ("Hg): <b>29.30</b>	
Pitot Tube ID: <b>1/4"</b>	Time: <b>1015</b>
Pitot Tube Coefficient: <b>.99</b>	Port Change Pitot Leak Check
Estimated Stack CO <sub>2</sub> %: <b>12.0 %</b> O <sub>2</sub> %: <b>9</b> H <sub>2</sub> O %: <b>9</b>	Pass Fail
Platform Elevation (feet):	Port #1 <input checked="" type="checkbox"/> <input type="checkbox"/>
Schematic of Stack Cross Section:	Port #2 <input checked="" type="checkbox"/> <input type="checkbox"/>
	Port #3 <input type="checkbox"/> <input type="checkbox"/>
	Port #4 <input type="checkbox"/> <input type="checkbox"/>
	$\sqrt{V_{Pave}} = .193$
	13.72 fpm 449 acfm
	823 fpm 390 acfm
	356 acfm
	<b>900 FPM by KURTZ</b>

Traverse Point Number	Velocity Head (In H <sub>2</sub> O)	Stack Temp. (F)
A 1	.04	134
2	.04	134
3	.035	134
4	.04	134
5	.04	134
6	.04	134
7	.04	134
8	.04	134
Average:		

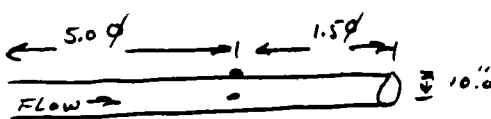
Traverse Point Number	Velocity Head (In H <sub>2</sub> O)	Stack Temp. (F)
B 1	.03	134
2	.035	134
3	.04	134
4	.04	134
5	.04	134
6	.04	134
7	.03	134
8	.03	134
Average:	$\sqrt{V_{Pave}} = .193$	

Plant: IFC Penrose Landfill	Date: 2/17/95
Unit Number: Fuel Cell	Stack Diameter (in.): 10.0"
Load Condition: 115 kW	Stack Gauge Pressure ("H <sub>2</sub> O): - 0.030"
Run No.: 3	Operators: K. Prince
Project No.: 95-112 / 02030	
Barometric Pressure at Ground Level ("Hg): 29.42	
Pitot Tube ID: 2 FT Stagnation.	
Pitot Tube Coefficient:	Port Change Pitot Leak Check      Pass      Fail
Estimated Stack CO <sub>2</sub> %: 12.5%, O <sub>2</sub> %: 7.91%, H <sub>2</sub> O%: 9.0%	Port #1      —      —
Platform Elevation (feet): 10'	Port #2      —      —
Schematic of Stack Cross Section:	Port #3      —      —
<p>A schematic diagram of a stack cross-section. It shows a horizontal pipe with an arrow labeled "Flow" pointing from left to right. Inside the pipe, there are two points marked with dots. The distance between these two points is labeled as 5φ. The distance from the second point to the right end of the pipe is labeled as 1.5φ. The diameter of the pipe at the right end is labeled as 10".</p>	Port #4      —      —
	Vel (FTE) = 11.48 Acfm FTH = 375.68 Scfm = 311.89 Kwz 444 = 900 F7/min

Traverse Point Number	Velocity Head (In H <sub>2</sub> O)	Stack Temp. (F)
A1	0.020	108
2	0.025	108
3	0.030	108
4	0.030	108
5	0.030	108
6	0.030	109
7	0.035	109
8	0.035	109
Average:		

Traverse Point Number	Velocity Head (In H <sub>2</sub> O)	Stack Temp. (F)
81	0.025	110
2	0.020	110
3	0.025	110
4	0.025	109
5	0.030	109
6	0.030	109
7	0.030	108
8	0.030	108
Average:	$\sqrt{0.167}$	108.8

## VELOCITY TRAVERSE

Plant: <i>IFC Pentase Landfill</i>	Date: <i>2/17/95</i>
Unit Number: <i>Fuel Cell</i>	Stack Diameter (in.): <i>10.0"</i>
Load Condition: <i>120 kW</i>	Stack Gauge Pressure ("H <sub>2</sub> O): <i>-0.030</i>
Run No.: <i>4</i>	Operators: <i>K. Price</i>
Project No.: <i>95-112 / 02030</i>	
Barometric Pressure at Ground Level ("Hg): <i>29.42</i>	
Pitot Tube ID: <i>Manometer Range 0 To 0.25 "H<sub>2</sub>O</i>	
Pitot Tube Coefficient: <i>0.99</i>	Port Change Pitot Leak Check
Estimated Stack CO <sub>2</sub> %: <i>12%</i> O <sub>2</sub> %: <i>8.5</i> H <sub>2</sub> O %: <i>90%</i>	Pass
Platform Elevation (feet): <i>10'</i>	Fail
Schematic of Stack Cross Section:	Port #1
	Port #2
	Port #3
	Port #4
	vel (ft/s) = <i>12.22</i>
	Acfm = <i>400.03</i>
	Scfm = <i>331.24</i>
	Kurz 444 = 1000 ft/min or 16.67 ft/sec

Traverse Point Number	Velocity Head (In H <sub>2</sub> O)	Stack Temp. (F)
1	0.025	110
2	0.025	111
3	0.030	110
4	0.035	110
5	0.040	110
6	0.040	111
7	0.040	110
8	0.040	110
Average:		

Traverse Point Number	Velocity Head (In H <sub>2</sub> O)	Stack Temp. (F)
1	0.025	111
2	0.030	110
3	0.030	110
4	0.030	110
5	0.030	110
6	0.030	110
7	0.030	111
8	0.030	111
Average:	$\sqrt{0.178}$	110.3

## **SUB-APPENDIX L**

### **ASTM HEAT CONTENT ANALYSIS AUDIT DATA**

10669 RICHMOND AVENUE, SUITE 100, HOUSTON, TEXAS 77042  
P.O. BOX 741905, HOUSTON, TEXAS 77274

TEL: (713) 789-5591  
FAX: (713) 789-5593

<b>CLIENT:</b>	Environmental Solutions	<b>REQUESTED BY:</b>	Mr. Ken Pierce
<b>SAMPLE:</b>	Audit 12395 Btu-1	<b>REPORT DATE:</b>	February 6, 1995
	(1-23-95) 9:20	<b>PROJECT NAME:</b>	IFC, 2030-6
<b>LABORATORY NO:</b>	4690 J	<b>PURCHASE ORDER NO:</b>	P9-41038

<b>TEST</b>	<b>RESULTS</b>
-------------	----------------

Natural Gas Analysis by Gas Chromatography, ASTM D 1945:

	<u>MOL %</u>	<u>GPM @ 14.650 psia</u>
Nitrogen	5.083	
Carbon Dioxide	0.994	
Methane	67.969	
Ethane	8.791	2.338
Propane	7.163	NIL
Iso-pentane butane	4.844	1.576
N-butane	4.829	1.514
Iso-pentane	0.159	0.058
N-pentane	0.159	0.057
Hexanes	0.009	0.004
Heptanes plus	<u>NIL</u>	<u>NIL</u>
	100.000	7.510

Specific Gravity @ 60°F (air = 1)	0.8470
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Calculated Btu/cu. ft. @ 14.650 psia and 60°F:

Dry basis	1353
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Wet basis	1329
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Z Factor	0.9954
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Respectfully Submitted,



Nader M. Sorurbakhsh, P.E.  
Laboratory Director



# Scott Specialty Gases, Inc.

Shipped 2600 CAJON BLVD.  
From: SAN BERNARDINO CA 92411  
Phone: 909-887-2571

Fax: 909-887-0549

## CERTIFICATE OF ANALYSIS

ENVIRONMENTAL SOLUTIONS

21 TECHNOLOGY DR

IRVINE

CA 92718

PROJECT #: 02-35787-001

PO#: 2030-8

ITEM #: 02027111 4S2

DATE: 1/19/95

CYLINDER #: SCOTTY 11

ANALYTICAL ACCURACY: +/-2%

BLEND TYPE : CERTIFIED MASTER GAS

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
N-BUTANE	3.	%	3.05	%
CARBON DIOXIDE	1.	%	1.02	%
ETHANE	9.	%	8.98	%
HELIUM	.5	%	.50	%
ISOBUTANE	3.	%	3.04	%
ISOPENTANE	1.	%	.996	%
NITROGEN	5.	%	4.96	%
N-PENTANE	1.	%	.983	%
PROPANE	6.	%	6.03	%
METHANE		BALANCE		BALANCE 70.421

ANALYST: 55

H-L3

TECHNICAL REPORT DATA (Please read instructions on the reverse before completing)			
1. REPORT NO. EPA-600/R-98-002b		3. RECIPIENT'S ACCESSION NO.	
4. TITLE AND SUBTITLE Demonstration of Fuel Cells to Recover Energy from Landfill Gas; Phase III. Demonstration Tests, and Phase IV. Guidelines and Recommendations*		5. REPORT DATE January 1998	
7. AUTHOR(S) J. C. Troccoliola and J. L. Preston		6. PERFORMING ORGANIZATION CODE	
9. PERFORMING ORGANIZATION NAME AND ADDRESS International Fuel Cells Corporation 195 Governors Highway South Windsor, Connecticut 06074		8. PERFORMING ORGANIZATION REPORT NO. F CR-13524E	
12. SPONSORING AGENCY NAME AND ADDRESS EPA, Office of Research and Development Air Pollution Prevention and Control Division Research Triangle Park, NC 27711		10. PROGRAM ELEMENT NO.	
		11. CONTRACT/GRANT NO. 68-D1-0008	
		13. TYPE OF REPORT AND PERIOD COVERED Final; 1/93 - 4/95	
		14. SPONSORING AGENCY CODE EPA/600/13	
15. SUPPLEMENTARY NOTES APPCD project officer is Ronald J. Spiegel, Mail Drop 63, 919/541-7542. (*) Volume 2. Appendices. Volume 1 is the technical report.			
16. ABSTRACT The report summarizes the results of a four-phase program to demonstrate that fuel cell energy recovery using a commercial phosphoric acid fuel cell is both environmentally sound and commercially feasible. Phase I, a conceptual design and evaluation study, addressed the technical and economic issues associated with operating the fuel cell energy recovery system of landfill gas. Phase II included the design, construction, and testing of a landfill gas pretreatment unit (GPU) to remove critical fuel poisons such as sulfur and halides from the landfill gas, and the design of fuel cell modifications to permit operating on low heating value (LHV) landfill gas. Phase III was the demonstration test of the complete fuel cell energy recovery system. Phase IV described how the commercial fuel cell power plant could be further modified to achieve full rated power on LHV landfill gas. The demonstration test successfully demonstrated operation of the energy recovery system, including the GPU and the commercial phosphoric acid fuel cell modified for operation on landfill gas. Demonstration output included operation up to 137 kW; 37.1% efficiency at 120 kW; exceptionally low secondary emissions (dry gas, 15% O <sub>2</sub> ) of 0.77 ppmV carbon monoxide, 0.12 ppmV nitrogen oxides, and undetectable sulfur dioxide; no forced outages with adjusted availability of 98.5%; and 709 hours operation on landfill gas.			
17. KEY WORDS AND DOCUMENT ANALYSIS			
a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution Methane		Pollution Prevention	13B 07C
Energy Carbon Dioxide		Stationary Sources	14G
Fuel Cells Sulfur		Global Warming	10B
Phosphoric Acids Halides			07B
Earth Fills			13C
Gases			07D
18. DISTRIBUTION STATEMENT  Release to Public		19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 462
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