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Final Report

Demonstration of Base Catalyzed Decomposition Process, Navy Public Works Center, Guam, Mariana Islands

February 1996

Prepared for
Pacific Division Naval Facilities Engineering Command
under the U.S. Department of Energy
Contract DE-AC06-76RLO 1830

Pacific Northwest National Laboratory
Operated for the U.S. Department of Energy
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Final Report
Demonstration of Base Catalyzed Decomposition Process, Navy Public Works Center, Guam, Mariana Islands

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(a) Battelle-Columbus Laboratory

Summary

A new technology to remediate soils contaminated with polychlorinated biphenyls (PCB) has been demonstrated and deployed at the U.S. Navy's Public Works Center (PWC) in Guam by engineers from Pacific Northwest National Laboratory (PNNL). A 1 to 2 ton per hour continuous system was designed and built by engineers at PNNL and Battelle-Columbus Laboratory (BCL) to utilize the Base Catalyzed Decomposition (BCD) process. The process is the culmination of nearly 10 years of laboratory research at the U.S. Environmental Protection Agency (EPA); 1 year of successful testing of chemical dechlorination technology at PWC-Guam by the Naval Facility Engineering Service Center (NFESC); followed by 2 years of design and fabrication of the continuous system by the development team, which was composed of PNNL, BCL, NFESC, and EPA's Risk Reduction Engineering Laboratory.

The BCD technology is a low-temperature chemical dehalogenation process that can transform PCB, pesticides, dioxins, furans, and other halogenated compounds to nonhazardous materials. The process employs an inexpensive base (sodium bicarbonate) for soil treatment. Process residuals are treated in a second step with base, a hydrogen donor solvent (usually a hydrocarbon oil), and a catalyst.

The continuous soil treatment system employs a crushing plant to produce the proper size of feed, a mixing plant to evenly distribute the sodium bicarbonate in the soil, and a rotary kiln to react and remove PCB to below 2 parts per million (ppm) per resolvable congener in accordance with EPA treatment standards. Offgas treatment is handled by a cyclone, baghouse, and a venturi scrubber followed by activated carbon canisters. All residues that contain PCB are treated in a stirred-tank reactor (STR) to complete the decomposition process.

Two successful test campaigns using contaminated soils were completed on the Guam site in February and November 1994 as the final demonstration before transferring the system to the Navy and the Navy's Remedial Action Contractor (RAC), International Technologies (IT) Corporation. During the two campaigns, over 70 tons of soil containing an average of 950 ppm PCB were treated. The treated soil had less than 2 ppm residual PCB and in most cases was nondetectable (less than 0.5 ppm per congener). In the November testing, over 50 tons of soil were treated in 48 consecutive hours of operation. Following the November demonstration, the BCD system is being used at PWC-Guam by the Navy's RAC to treat an estimated 3058 m^3 [4000 yd^3 (5500 tons)] of contaminated soil containing greater than 25 ppm PCB.

In May 1995, additional testing of the BCD residual treatment process was conducted. Five bench-scale STR (2-L capacity) tests and two full-scale (400-gal) STR tests were completed. Results from the bench-scale testing showed that PCB concentrations can be reduced from 42,000 ppm to less than 2 ppm per congener. Testing with the 400-gal STR demonstrated the efficacy of the BCD process at a large scale by reducing PCB from approximately 1000 ppm to below the treatment standard for both the reactor contents and the condensate generated from the reactor.

An economic evaluation was performed to estimate the treatment cost for the deployment of a BCD system (equivalent to the BCD system in Guam) in the continental U.S. Based on this analysis, it was estimated that the total treatment cost (soils and residues) would be approximately $360/ton. This evaluation confirmed earlier projections that predicted the BCD process displays favorable economics, even at the relatively small scale of 1 to 2 ton/hr.

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Contents

Summary iii

Acknowledgments v

Acronyms and Initialisms xiii

1.0 Introduction 1.1

2.0 Overview of Project History 2.1

2.1 Evolution of the BCD Process 2.4

2.2 BCD Demonstration Project 2.5

2.2.1 Process Design, Procurement, and Pre-assembly (March - December 1990) 2.5

2.2.2 Predeployment Operations in Stockton, California (February 1991-July 1992) ... 2.6

2.2.3 Guam Operations (August 1992 - November 1994) 2.7

3.0 Process Chemistry 3.1

3.1 Two-Stage Process 3.2

3.2 Process Design Testing 3.3

3.2.1 Solid Phase Treatment 3.4

3.2.2 Liquid Phase Treatment 3.7

4.0 BCD Equipment Descriptions 4.1

4.1 Size Reduction 4.1

4.2 Mixing Plant 4.1

4.3 Reactor Feed Conveyor 4.6

4.4 Rotary Kiln Reactor 4.6

4.4.1 Reactor Description 4.8

4.4.2 Operation During BCD Demonstration 4.9

4.5 Offgas Treatment System 4.10

4.5.1 Air Cyclone and Baghouse 4.11

4.5.2 Wet Venturi Scrubber and Associated Equipment 4.12

4.6 Water Treatment System 4.17

4.7 Stirred-Tank Reactor 4.18

4.8 Automated Data Acquisition 4.21

Contents (contd)

4.9 Support Facilities 4.24
4.9.1 Portable Laboratory 4.24
4.9.2 Portable Shop 4.25
5.0 BCD Deployment and Operation 5.1
5.1 Initial Equipment Setup and Shakedown in Stockton, California 5.1
5.1.1 Equipment Setup 5.2
5.1.2 Stockton Runs (October - November 1991) 5.2
5.1.3 Cancellation of Stockton Hot Tests 5.4
5.1.4 Conclusions from Stockton Operations 5.4
5.2 Guam Operations 5.5
5.2.1 Receiving and Assembly 5.5
5.2.2 Equipment Shakedown (Cold Testing) 5.7
5.2.3 February 1994 Testing 5.8
5.2.4 November 1994 Hot Tests 5.20
5.2.5 STR Testing 5.34
6.0 Economic Assessment 6.1
6.1 Capital Costs 6.1
6.2 Operating Costs 6.3
6.3 Total Treatment Costs 6.5
7.0 Conclusions and Recommendations 7.1
7.1 Conclusions 7.1
7.1.1 Process Chemistry 7.1
7.1.2 Equipment 7.2
7.1.3 Demonstration Testing Campaigns 7.3
7.1.4 Stirred-Tank Reactor Operations 7.3
7.1.5 Health and Safety 7.3
7.1.6 Economics 7.4

Contents (contd)

7.2 Recommendations 7.4

7.2.1 Chemistry 7.4

7.2.2 Equipment 7.4

7.2.3 Process Demonstration 7.5

8.0 References 8.1

Appendix A - Equipment List A.1

Appendix B - Instrument List B.1

Appendix C - Equipment Drawings C.1

Appendix D - Run Data D.1

Appendix E - Analytical Data E.1

Figures

1.1	Basic BCD Process Flow Diagram	1.2
2.1	Location of Guam and BCD Demonstration Site	2.2
2.2	PWC Maintenance Compound	2.3
3.1	Major Steps in the BCD Process, Solid and Liquid Phases	3.3
4.1	Equipment Integration and Process Streams	4.2
4.2	Portable Crushing Plant	4.3
4.3	Portable Pugmill Mixing Plant	4.4
4.4	Twin Mixing Shafts in Pugmill	4.4
4.5	Flexicon Screw Conveyor	4.5
4.6	Electric Feed Conveyor	4.7
4.7	Heyl Patterson Rotary Kiln Reactor	4.7
4.8	Discharge Conveyor for Rotary Kiln Reactor	4.9
4.9	Cyclone and Baghouse Used to Remove Particulates in Offgas Treatment System	4.12
4.10	Wet Venturi Scrubber	4.13
4.11	Heat Exchanger Used to Cool Water Recycle Stream	4.15
4.12	Oil/Water Separator Used in November 1994 Extended Hot Run	4.15
4.13	Drawing of Great Lakes SRC Separator Showing Internal Components	4.16
4.14	Cross Section of SRC Separator Showing Operating Principles	4.16
4.15	Stainless Steel Settling and Mixing Tanks	4.18
4.16	Filter Press and Activated Carbon Water Polishing Drums	4.19
4.17	Stirred-Tank Reactor	4.20
4.18	Schematic of Current Data Acquisition System	4.22
4.19	GC-MS System in OnsitePortable Analytical Laboratory	4.25
4.20	Portable Shop Facility	4.26
5.1	Equipment Layout at Naval Communications Station - Stockton, California	5.3
5.2	Equipment Layout at PWC Maintenance Compound in Guam	5.6
5.3	Temperature History of Soil at Selected Locations in the Reactor	5.9
5.4	Soil Feed and Discharge Rate During 5 February 1994 Hot Run	5.12
5.5	Soil Temperatures in Rotary Kiln Reactor During 5 February 1994 Hot Run	5.13
5.6	Range of Temperatures Measured in Furnace Control Zones	5.13

Figures (contd)

5.7 PCB Concentration in Feed Composite Samples During 5 February 1994 Hot Run 5.15
5.8 Typical Distribution of PCB Chlorination Levels in Feed Soil 5.15
5.9 Dioxin Balance for 5 February 1994 ..... 5.16
5.10 Temperature History in the Furnace Control Zones 5.23
5.11 Temperature History of Soil in Reactor Using the Wireless Data Temperature Monitor 5.24
5.12 Temperature History of Offgas Stream 5.25
5.13 Temperature History of Water Recycle Stream 5.26
5.14 Water Levels in Condensate Collection Tanks 5.27
5.15 Differential Pressure Between Inlet and Outlet of Reactor Kiln 5.28
5.16 Cumulative Feed and Discharge Weights from November 1994 Hot Run 5.29
5.17 STR Temperatures and Condensate Generation for 28 November 1994 ..... 5.39
5.18 STR Temperatures and Condensate Rate 25 May 1995 ..... 5.47
5.19 The 2-L STR Setup in Guam 5.49
5.20 2-L STR Temperature Profiles and Condensate Rates for MSTR2 (17 May 1995) 5.51

Tables

3.1	Solid-Phase BCD Process Experiments (April 1990)	3.5
3.2	Solid-Phase BCD Process Experiments (June 1990)	3.6
3.3	Liquid-Phase BCD Process Experiments (October 1990)	3.9
4.1	Major Components on Stirred-Tank Reactor Skid	4.21
4.2	Sensor Locations and Types Monitored with Automated Data Acquisition System	4.23
5.1	Significant Operational Issues Identified in July 1993 Cold Run	5.10
5.2	List of Sampling Procedures and Analyses for Initial Hot Run	5.14
5.3	Summary of PCB Analysis for Cyclone and Baghouse Dust	5.16
5.4	PCB Material Balance for 5 February 1994 Hot Run	5.16
5.5	Summary of PCB Analytical Results for 10 February 1994 Hot Run	5.18
5.6	Results of Fugitive Dust Emissions Monitoring During February 1994	5.19
5.7	Estimated PCB Concentrations in Offgas Stack from BCD Operations in Guam	5.19
5.8	Modifications Made to Support November 1994 Extended Hot Run	5.21
5.9	PCB Analysis Results for November 1994 Hot Run	5.31
5.10	Dioxin Analysis for November 1994 Hot Run	5.32
5.11	PCB Material Balance for November 1994 Hot Run	5.32
5.12	Total Organic Carbon in Scrubwater	5.33
5.13	Modifications Made to STR in October/November 1994	5.37
5.14	Summary of 400-gal STR Tests, November 1994 and May 1995	5.43
5.15	Summary of 2-L STR Tests, May 1995	5.50
6.1	BCD Equipment Purchase Costs	6.2
6.2	Ratio Factors Used in Estimated Fixed Capital Investment Costs for 1.25 ton/hr BCD Process	6.3
6.3	Estimated Costs for BCD Treatment of Contaminated Soil (7700 ton/yr) in Continental U.S.	6.4

Acronyms and Initialisms

APEGs	Alkali metal polyethylene glycols
ARARs	Applicable or Relevant and Appropriate Requirements
BCD	Base Catalyzed Decomposition
BCL	Battelle-Columbus Laboratory
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
COMNAVMAR	Commander Naval Forces Marianas
DMSO	dimethyl sulfoxide
DRMO	Defense Reutilization and Marketing Office
EDB	ethylene dibromide
EPA	U. S. Environmental Protection Agency
EPA-RREL	EPA's Risk Reduction Engineering Laboratory
FCI	Fixed capital investment
GAC	granular activated carbon
GC-MS	gas chromatography-mass spectroscopy
HEME	high efficiency mist eliminator
HLA	Harding-Lawson Associates
ID	induced draft (fan)
IT Corporation	International Technologies Corporation
KPEG	potassium polyethylene glycol
MTR	moisture test receiver
NCEL	U.S. Naval Civil Engineering Laboratory
NCS	Naval Communications Station
NaPEG	sodium polyethylene glycol
NEESA	Naval Energy and Environmental Support Agency
NFESC	Naval Facilities Engineering Service Center (formerly NCEL)
OPPT	Office of Pollution Prevention and Toxics (formerly OTS)
OSHA	Occupational Safety and Health Administration
OTS	Office of Toxic Substances
PACDIV	Pacific Division, Naval Facilities Engineering Command
PC	personal computer

PCB	polychlorinated biphenyls
PEG	polyethylene glycol
PCP	pentachlorophenol
PEL	permissible exposure limit
PNNL	Pacific Northwest National Laboratory
PWC	Public Works Center
PWO	Public Works Officer
RAC	Remedial Action Contractor
RCRA	Resource Conservation and Recovery Act
R&D	Research and development
RD&D	Research, development, and demonstration
SARA	Superfund Amendments and Reauthorization Act
SRC	slant rib coalescing
STR	stirred-tank reactor
SWRI	Southwest Research Institute
TDC	Total direct costs
TIC	Total indirect costs
TOC	total organic carbon
TPH	total petroleum hydrocarbon
TSCA	Toxic Substance Control Act
TWA	time-weighted average
UPS	uninterruptable power supply

1.0 Introduction

Base Catalyzed Decomposition (BCD) is a chemical dehalogenation process designed for treating soils and other substrate contaminated with polychlorinated biphenyls (PCB), pesticides, dioxins, furans, and other hazardous organic substances. PCBs are heavy organic liquids once widely used in industry as lubricants, heat transfer oils, and transformer dielectric fluids. In 1976, production was banned when PCBs were recognized as carcinogenic substances (Erickson 1992). It was estimated that significant quantities (1 billion tons) of U.S. soils, including areas on U.S. military bases outside the country, were contaminated by PCB leaks and spills, and cleanup activities began. The BCD technology was developed in response to these activities.

For treating contaminated soils, the BCD process combines the soil with sodium bicarbonate as a catalyst, and the mixture is processed through a rotary reactor at 330°C to 350°C (633°F to 662°F). When the mixture passes through the reactor, the PCB is dechlorinated and stripped from the soil and transferred to the reactor offgas. Typically, a portion of the contaminants (30% to 70%) are destroyed in the reactor, while the unreacted and partially reacted contaminants are collected in the offgas treatment train. The collected contaminants are then loaded into a stirred-tank reactor (STR), mixed with reagents, and heated to approximately 350°C to 360°C (662°F to 680°F), where final dechlorination occurs. Figure 1.1 is a simplified illustration of the BCD system.

The research and development (R&D) that led to the BCD process was conducted throughout the 1980s, beginning with the U.S. Environmental Protection Agency's (EPA) Risk Reduction Engineering Laboratory (RREL). This work was initiated in conjunction with the Naval Civil Engineering Laboratory (NCEL) [now the Naval Facility Engineering Service Center (NFESC)] to develop a method for remediating PCB-contaminated soils at a Naval facility on the Island of Guam (and other sites). In 1989, the Navy contracted with Pacific Northwest National Laboratory (PNNL) to design and demonstrate a full-scale system based on the EPA process that would ultimately be deployed by the Navy's Remedial Action Contractor (RAC), International Technologies (IT) Corporation, for the actual site remediation in Guam. PNNL is operated[(a)] for the U.S. Department of Energy by Battelle Memorial Institute, and much of the PNNL work was conducted in conjunction with the Battelle-Columbus Laboratory (BCL).

This report details the evolution of the process, from inception to deployment in Guam, and describes the process and system components provided to the Navy to meet the remediation requirements. The report is divided into several sections to cover the range of development and demonstration activities. Section 2.0 gives an overview of the project history. Section 3.0 describes the process chemistry and remediation steps involved. Section 4.0 provides a detailed description of each component and specific development activities. Section 5.0 details the testing and deployment operations and provides

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the results of the individual demonstration campaigns. Section 6.0 gives an economic assessment of the process. Section 7.0 presents the conclusions and recommendations from this project. The appendices contain equipment and instrument lists, equipment drawings, and detailed run and analytical data.

In this report, both English and metric units of measurement are given for temperature, pressure, mass, etc. Exceptions include standard equipment commonly expressed in English units and feedstock amounts and feed rates (reported in tons and ton/hr, respectively). Analytical data and small measurements are given primarily in metric units, per convention. For clarity, units in tables and figures are reported as most commonly used/understood for the information being presented.

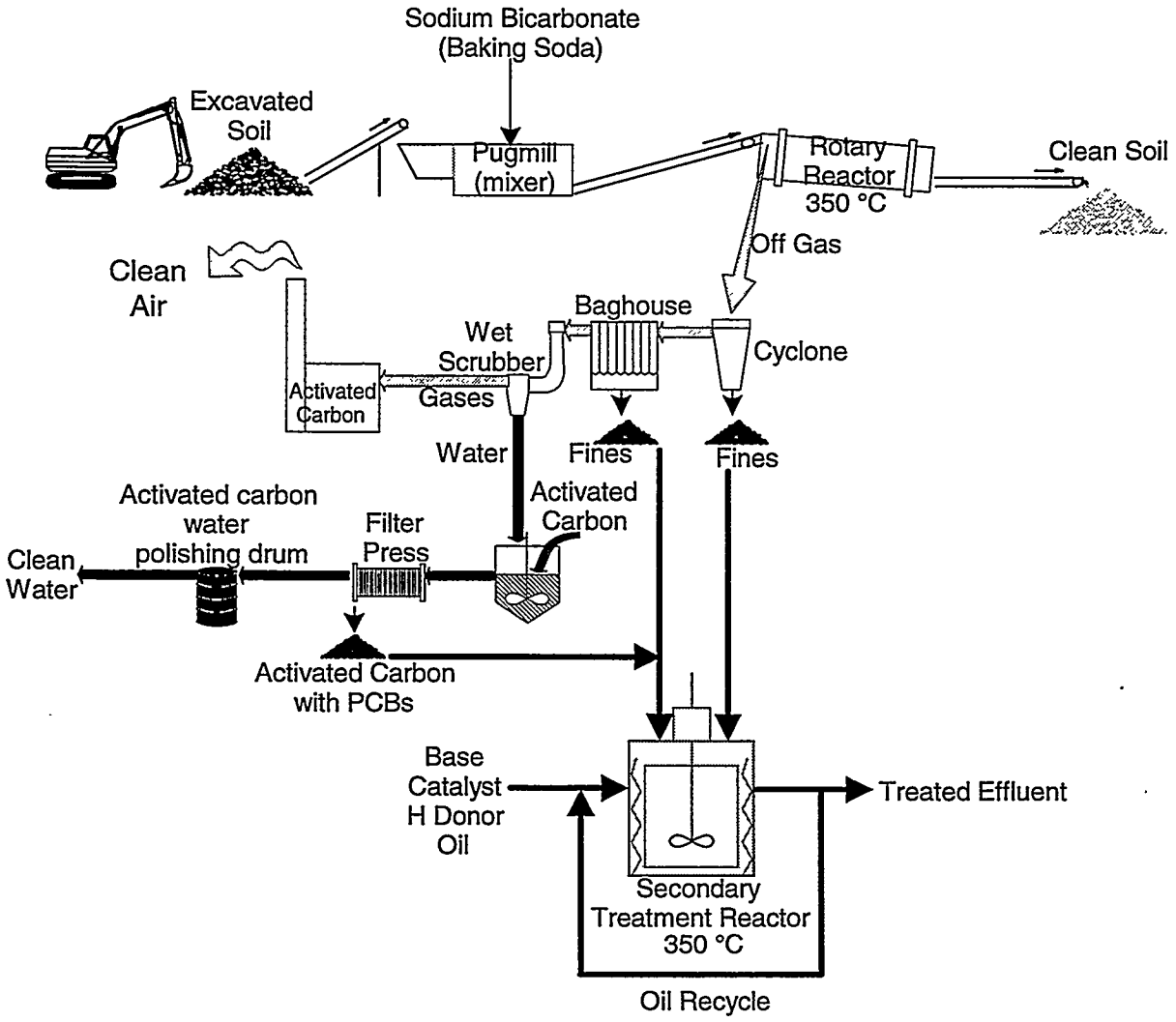


Figure 1.1. Basic BCD Process Flow Diagram

2.0 Overview of Project History

The U.S. Navy is required by the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), the Superfund Amendments and Reauthorization Act (SARA), the Toxic Substance Control Act (TSCA), and the Resource Conservation and Recovery Act (RCRA) to clean up hazardous substances that have been released in the past and to minimize the amount of hazardous wastes that are currently produced. These laws further provide for research, development, and demonstration (RD&D) of methods to clean up and reduce the toxicity of hazardous substances in the environment.

The NFESC manages RD&D projects involving the decontamination of groundwater and soil at various sites on Naval bases and stations. The NFESC has the responsibility of developing and transferring appropriate PCB treatment technology for use at U.S. Navy facilities. There are over 100 PCB-contaminated sites on U.S. Navy Shore Facilities/Installations throughout the world, including Guam.

Guam is an island of approximately 549 km^2 (212 square miles) located in the South Pacific republic of Micronesia. It is near the equator, but still in the Northern Hemisphere (~13°N and ~144°E), about 5300 km (3300 miles) west of Hawaii and 2500 km (1550 miles) south of Japan. Many agencies of the U.S. Department of Defense have had a significant mission on Guam since 1944. One of the many Navy installations on the island is the Public Works Center (PWC) at the Naval Station. This arm of the Navy is responsible for facilities, utilities, housing, and other activities normally associated with running a large city. PWC-Guam is located on the southwestern corner of the island, near Apra Harbor (Figure 2.1).

Electrical transformer maintenance for the entire Western Fleet was conducted for nearly 40 years at Building 3009 at PWC-Guam (Figure 2.2). At this facility, transformers were cleaned and repaired, and transformer oils were filtered and reused and/or stored and recycled. The transformer oil storage and recycling systems were removed from service in 1977 when the EPA started to regulate the handling of PCB under TSCA. In the early years, PCB was not recognized as a health hazard and spills occasionally occurred; these spills were not containerized and/or removed before enaction of the law. PCB transformer oils entered the environment through a series of floor drains that discharged through a pipe to a storm ditch immediately to the south and east of Building 3009. The extent and level of this contaminated area were determined through a series of soil samplings.

The most comprehensive set of samples was taken in January 1990 by Harding-Lawson Associates at deeper borings than previous samplings (HLA 1990). A detailed analysis showed PCB concentrations in the soil ranging from 0 to 6500 ppm (predominantly Aroclor 1260; Aroclor is a trademark of Monsanto Corporation). The volume of contaminated soil is estimated at about 3058 m^3 [4000 yd^3 (5500 tons)] based on the 25-ppm PCB threshold for soils requiring excavation and treatment.

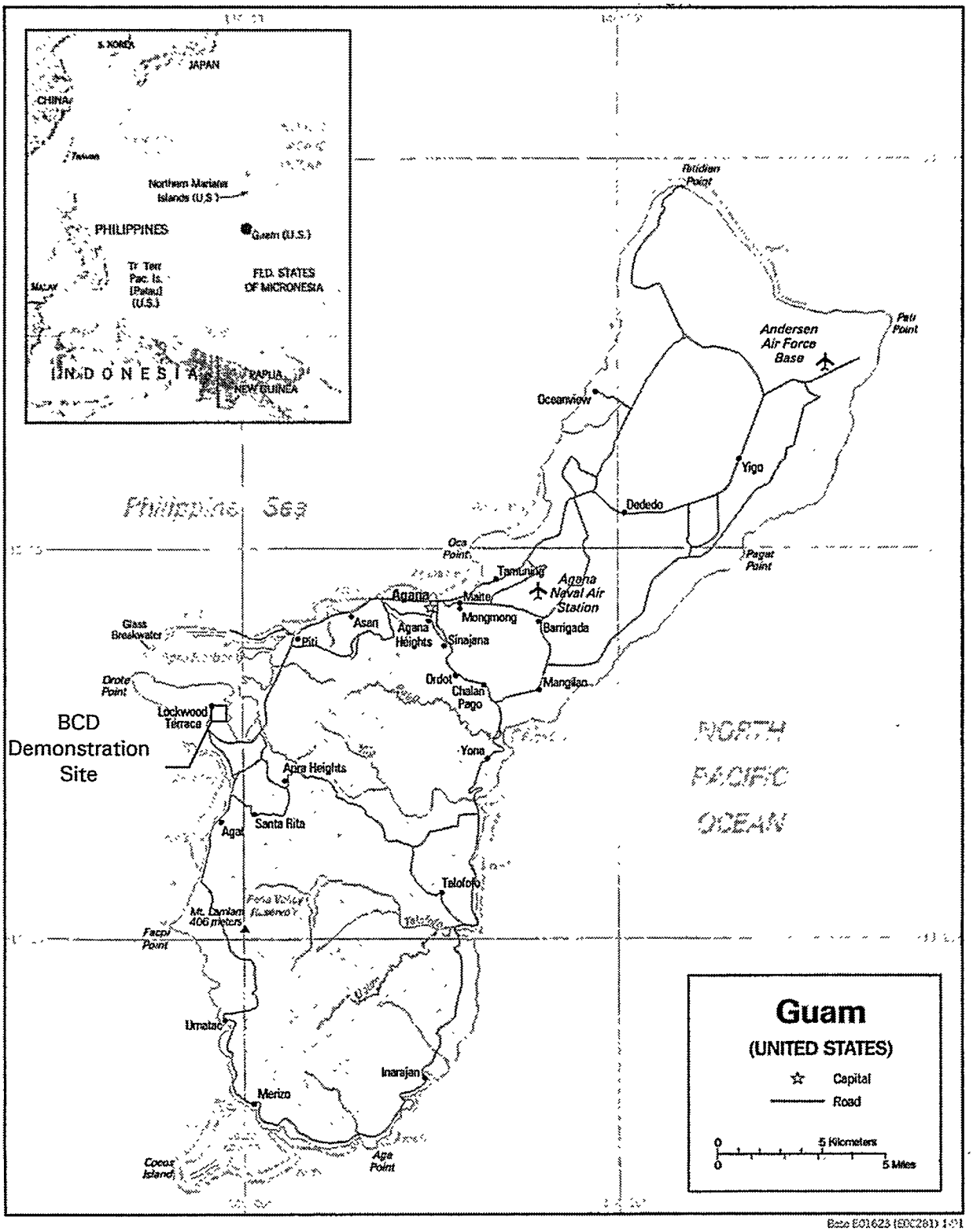


Figure 2.1. Location of Guam and BCD Demonstration Site

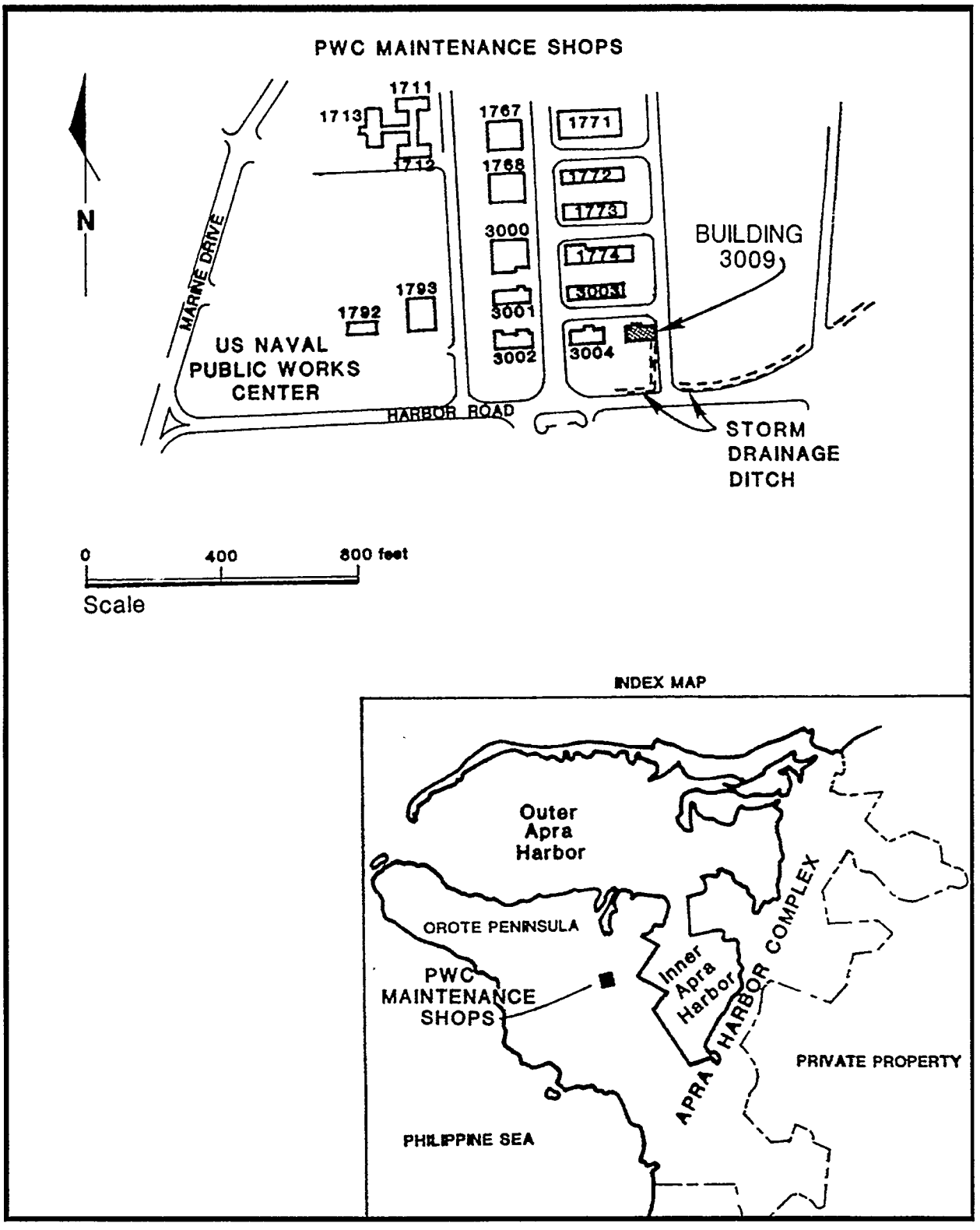


Figure 2.2. PWC Maintenance Compound (modified from Figure 8-12, NEESA 1983)

2.1. Evolution of the BCD Process

In the early 1980s, a variety of processes employing alkali metal polyethylene glycolates (APEGs), which include potassium polyethylene glycol (KPEG) and sodium polyethylene glycol (NaPEG) were developed by EPA-RREL for dechlorination of PCB-contaminated soils. These reagents act as phase transfer catalysts and functional nucleophiles under alkaline conditions (see Section 3.0 for more details on the process chemistry). As a result of that research, a series of patents were granted to the Franklin Research Center, who was performing research and development work under contract to EPA-RREL [U.S. Patents 4,337,368 (Pytlewski et al. 1982); 4,353,793 (Brunelle 1982); 4,327,027 (Howard and Sidwell 1982); and 4,400,552 (Pytlewski et al. 1983)]. A second variation of the process, developed by the Galson Company, uses dimethyl sulfoxide (DMSO) as a co-solvent to improve reaction rate kinetics and is covered by U.S. Patent 4,574,013 (Peterson 1986).

In 1987, EPA approved the establishment of KPEG as the best developed alternative treatment technology for PCB, ethylene dibromide (EDB), pentachlorophenol (PCP), and spent solvents contaminated with dioxins and furans (U.S. Patent 4,675,464; Rogers and Kornel 1987). Field testing began in late 1987, with a 40-gal reactor (150 L) at Moreau, New York, reducing soil containing 140 to 7000 ppm PCB to 1.1 to 12.4 ppm (Taylor et al. 1989). A variety of treatment times between 0.25 hr and 7 hr were used. At the same time, work continued to improve the technology by developing various "base catalyzed" decomposition processes to overcome drawbacks seen in the KPEG and DMSO methods. DMSO is a solvent that readily penetrates the skin, carrying other constituents commingled with it into the human body. If a leak or spill occurred with the KPEG reactor, PCB mixed with DMSO could be carried into personnel.

KPEG laboratory tests carried out in 1988 using contaminated Guam soil showed reduction of PCB from thousands of ppm (consisting of Aroclors 1248, 1254, 1260, and 1262) to levels below the 2 ppm per congener treatment standard. The maximum reactor temperature for testing was 150°C (302°F), and KPEG reagent was added at a level of 50% of the soil weight. Another sample of domestic soil (Mechanicsburg, Pennsylvania) was tested in November 1988 using similar reaction conditions. This sample showed a reduction of from 500 to 800 ppm to less than 1 ppm (Kornel 1988).

Also in late 1988, NCEL joined with EPA to contract with PEI Associates (now IT Corporation) to conduct a KPEG process technology demonstration. Soil batch size ranged from 1272 to 2318 kg (2800 to 5100 lb) and contained PCB levels from 2500 to 4500 ppm, which were reduced to 0.2 to 6.5 ppm following a single pass treatment. Typical treatment times were 4 to 6 hr at 150°C (302°F). Several batches containing more than the 2 ppm per congener treatment standard were re-treated. Deficiencies identified for improvement included, but were not limited to 1) need for recovery or reuse of excessive chemicals (PEG and NaOH) or substitute reagents that were less toxic and were required at a lower quantity; 2) need for proper sizing of the feed material to maximize heat exchange efficiency; 3) need for change from a batch operating mode to a continuous process. In response to the improvements

required, EPA-RREL initiated advanced research in developing a new process later called Base Catalyzed Decomposition.

In early 1990, EPA and BCL conducted tests at EPA-RREL in Cincinnati, Ohio, with a new proprietary base and solvent system that offered the potential of significantly reducing reagent requirements, improving processing efficiencies, and reducing processing costs [U.S. Patents 5,019,175; 5,039,350; and 5,064,526 (Rogers et al. 1991a-c)]. The process was successfully demonstrated at the laboratory scale on a wide variety of substances, including oils, sediments, and sludges containing PCB, PCP, tetrachlorophenol, lindane, BHC isomers, heptachlor and its epoxide, chlorofurans and dioxins, Dieldrin, Aldrin, and other chlorinated compounds.

All laboratory and field testing of BCD technology to that point had been in a batch mode where stoichiometric excesses of reagents were mixed with the soil to be treated; the resulting slurry mixture placed into a reaction vessel; and the mixture heated to drive off any water and then further heated to reaction temperature. To demonstrate the process on a larger-scale and continuous operation, the Navy contracted with PNNL to design, procure, and integrate a full-scale process for demonstration and deployment on Guam.

2.2. BCD Demonstration Project

The BCD Demonstration Project was a cooperative program that began in 1989 involving participation by the U.S. Navy, PNNL, and EPA-RREL. The funding and oversight was provided by NFESC (Port Hueneme, California) and the Pacific Division of the Naval Facilities Engineering Command (PACDIV) located in Honolulu, Hawaii. As the technical support contractor, PNNL had responsibility for the design, procurement, construction, and testing of the demonstration system. BCL acted as a support subcontractor to PNNL in this effort. EPA-RREL, as the inventor of the process, was responsible for development and refinement of the process chemistry. Key staff from RREL retired in 1993 and formed BCD Group, Inc. They continued to provide support to the project. IT Corporation, the Navy's RAC for site remediation, participated in the demonstration to obtain experience in system operation.

2.2.1. Process Design, Procurement, and Pre-assembly (March - December 1990)

Following the 1988 batch KPEG pilot-scale test in Guam, a scaled-up KPEG system was conceptually designed by BCL for a field technology demonstration, using design criteria generated from the pilot study and from additional laboratory tests conducted by EPA-RREL and BCL. In September 1989, PNNL was authorized by the Navy to initiate design and fabrication of a 1 to 2 ton/hr continuous KPEG system. Design and procurement activities were then initiated and continued through July. During these activities, further development testing at EPA-RREL was underway on APEG (January 1990). In April 1990, an order was placed with Heyl Patterson, Inc., for a 1 to 2 ton/hr rotary kiln. Also in April, the

third round of laboratory testing of the new process, BCD, was underway at EPA-RREL. By July 1990, BCD became the baseline technology for the demonstration project, and the overall design of the BCD demonstration system was completed. In November 1990, equipment procured began arriving at PNNL's facilities in Richland, Washington, and at BCL in Columbus, Ohio.

In December 1990, the rotary kiln arrived at BCL, and testing and modification activities were initiated. Also in December, results from additional testing at EPA-RREL were received on the liquid-phase BCD process for treating residuals. These results were integrated into the design of the STR and its operating strategy. By February 1991, purchase orders for all major pieces of equipment had been placed, and significant assembly and integration activities were underway at PNNL and BCL. Equipment receiving, assembly, and integration continued at both PNNL and BCL from March through August 1991. During August, equipment was packaged and shipped to Stockton, California, for predeployment testing.

2.2.2. Predeployment Operations in Stockton, California (February 1991 - July 1992)

In February 1991, plans were set to conduct a predeployment test of the BCD process in Stockton, California. The rationale behind the predeployment exercise was that it would be less costly and provide greater assurance of success if the system could be set up, integrated, and tested in the continental U.S., where better access to material, equipment, and vendors was available. For the BCD demonstration, uncontaminated soil (termed "cold testing") and up to 80 tons of PCB-contaminated soil (termed "hot testing") were to be treated under a TSCA Research and Development (R&D) permit. The site selected for this work was the Naval Communications Station (NCS) in Stockton. A spill occurred there in April 1984 from equipment stored inside a warehouse. The spill consisted of approximately 76 L (20 gal) of PCB-laden hydraulic oil (approximately 910,000 ppm PCB), which affected the concrete floor and underlying fill. Sampling of the contaminated area, conducted in January 1987, revealed that Aroclor 1242 was most abundant. Aroclors 1248, 1252, and 1260 were also present.

By June 1991, a Heath and Safety Plan for operations in Stockton had been approved, and meetings with the City of Stockton Waste Water Treatment Plant and with the San Joaquin Unified Air Pollution Control Authority were held to obtain the necessary permits, waivers, and approvals for the R&D testing. In September 1991, utilities were installed at the site, and the BCD processing equipment was shipped to Stockton, then integrated and connected. On 24 September, EPA's Office of Toxic Substances (OTS) [now Office of Pollution Prevention and Toxics (OPPT)] granted approval to conduct R&D tests. In October, several runs with noncontaminated soil were conducted for initial equipment shakedown. During these runs, it was determined that the rotary kiln and offgas treatment system performed as designed, although some modifications were made to the kiln retaining dam to minimize backflow of soil out of the reactor.

Before testing began with PCB-contaminated soil, a potential problem was identified pertaining to transporting a contaminated processing unit to Guam. Additionally, funding for this phase of the project was nearly exhausted. Consequently, testing with PCB-containing soils was not performed in Stockton; instead, the BCD processing equipment was disassembled, packaged, and shipped to Guam in August 1992.

2.2.3. Guam Operations (August 1992 - November 1994)

Initially it was believed that the demonstration at PWC-Guam would be performed under a TSCA Demonstration Permit. Upon further investigations and analysis by NFESC and PACDIV, it was determined that the PCB remediation activities at PWC-Guam would be conducted as an On-Site CERCLA Response Action, with the Navy acting as the lead agency, and that no federal, regional, or local permits would be necessary. Instead, the Navy complied with the substantive requirements of Applicable or Relevant and Appropriate Requirements (ARARs). This strategy was discussed and agreed on in a meeting that included staff from NFESC, PACDIV, and EPA Region 9 on 25 May 1993. EPA-HQ Branch Chief, Superfund Enforcement, was also informed of the strategy on 30 August 1993, and confirmed that no permits were necessary. EPA-OPPT was verbally notified that NFESC no longer intended to conduct the initial hot testing under a TSCA demonstration permit; however, at a later date, it was indicated that a commercial permit for the BCD process may be sought from OPPT. Although the demonstration would not be done under an EPA-OPPT permit, the EPA's "Draft Guidelines for Demonstration Test Plans for PCB Disposal by Non-Thermal Alternative Methods" was used as guidance in the preparation of the Demonstration Test Plan.

2.2.3.1. Receiving and Assembly (August 1992 - July 1993). In August 1992, the BCD equipment (9 containers and 3 flat rack loads, nearly 200 tons total) was shipped to PWC-Guam. On 28 August 1992, Typhoon Omar hit Guam with winds reportedly exceeding 240 km/hr (150 mph). The eye of the storm passed over the center of the island, resulting in severe damage to all portions of the island. Civil Defense authorities reported damage to 75% to 90% of the buildings on Guam. Inspections of the BCD equipment revealed no significant damage. However, lack of power and infrastructure support on Guam required that system setup be postponed to January 1993.

In January 1993, site preparation activities began and included installation of electrical services to supply power to the laboratory and shop trailers. In February and March 1993, PNNL installed the equipment. During this time, major modifications were made to the rock crushing plant and rotary kiln reactor feeder. IT staff enlarged the concrete pad to provide a suitable surface for the crushing plant, mixing plant, and rotary kiln. Site preparation and equipment modification activities continued in April. In June and early July, modifications to the equipment were completed.

2.2.3.2. Initial Shakedown and Cold Testing of Rotary Kiln Reactor (July 1993). A total of five experimental runs processed approximately 30 tons of uncontaminated soil during July 1993. These five tests included a troubleshooting test without any catalyst, an initial shakedown test with 10% by weight sodium bicarbonate, and three full-day experimental runs that closely simulated actual hot operations. Several operating problems were discovered during the course of initial shakedown and cold testing. Corrections and modifications were made, and on 23 July 1993 the last cold test was conducted in which more than 10 tons of material were successfully processed in 8 hr. The objectives and results of the experimental runs are summarized below.

The primary objective of the initial shakedown test (Run 1) was to perform a slow reactor heatup to dry the saturated cast refractory without major thermal expansion and spalling problems. Several other goals included resetting burner controls, observing feed preparation equipment operation without sodium bicarbonate catalyst, observing gas treatment system operation, and correcting any major deficiencies or operating problems. Run 1 successfully processed 3 to 4 tons of material at feed rates of 0.5 to 0.75 ton/hr. Both the crusher and mixing plant appeared to work reliably; however, several materials handling issues were observed. These issues included bridging and clogging of soil in hoppers and in the reactor feeding system because the material was saturated with water and susceptible to sticking. Another problem identified was that soil spilled from the crusher and mixing plant belts.

In Run 2 the primary objective was to integrate the sodium bicarbonate catalyst into the materials preparation scheme and observe the effect of moisture on feed handling characteristics. This was an opportune test of moisture effects since heavy showers persisted throughout the day. Initially the feed rate was only 0.6 ton/hr. This rate was later increased to approximately 0.8 ton/hr, and a total of 4 to 5 tons of soil were processed. There were many materials handling problems because of the excess moisture, and the operation was complicated by the sludge-like behavior of the feed material.

Run 3 was designed to be the first full-scale operation at design conditions. The objective was to increase the feed rate to the design condition of 1 ton/hr. The weather was clear and very hot, but the soil was still wet from the previous day and minor materials handling problems continued. Approximately 4 tons of soil were processed at a maximum feed rate of 0.77 ton/hr. Additional adjustment of the burners to achieve uniform heating of the soil continued without complete success. Attempts to increase the feed rate were also thwarted by several emergency shutdowns due to overheating of the reactor rotation motor.

Several adjustments were made for Run 4 to allow better materials handling. The feed valve cycle time was reduced from 60 to 30 sec. With these adjustments, much smaller batches of soil were fed to the reactor, which reduced bridging. Despite heavy showers during the day, feed problems were reduced. The reactor rotation speed was increased to allow higher feed rates. Approximately 4 to 5 tons were processed at 1.31 ton/hr. However, even though the feed residence in the reactor was near the

required 1 hr, it did not reach the target operating temperature of 350°C (662°F). Additional adjustments of the burners were necessary.

During Run 5 the feed valve cycle was further reduced to 20 sec to decrease batch sizes. The reactor rotation was lowered to its original setting, and the rotation motor was periodically cooled by a water spray. This increased the soil residence time to an estimated 1.5 hr. Approximately 10 tons of material were successfully processed at an average feed rate of 1.17 ton/hr. With a fairly dry feedstock and short feed cycles, materials handling was adequate until heavy showers started during the last hour of operation. Shutdown (when all the feed had been processed) was normal. Burner adjustments appeared adequate and soil temperatures reached the 350°C (662°F) target.

These tests successfully demonstrated the operability of the BCD system while processing approximately 30 tons of material. This testing also served to identify areas of operational difficulty, and equipment and operational strategies that required modification. In addition, a full complement of PNNL and IT staff were fully trained or re-familiarized in the operation and handling of the BCD system.

2.2.3.3. Equipment Modifications (August 1993 - January 1994). In August 1993, a major earthquake (8.1 on the Richter scale) struck Guam. Severe damage was inflicted to several structures on the island. In September 1993, a PNNL representative traveled to Guam to inspect the equipment for damage. Only minor damage occurred as a result of the earthquake; however, further inspection revealed that lightning strikes associated with tropical storms had damaged some of the electronic equipment, including phones and the modem. In December 1993, additional materials and equipment procured for further testing were packed into a 20-ft container and shipped to Guam.

In January 1994, a number of equipment modifications were made, including installation of wipers on belts and vibrators on various bins for materials handling; replacement of the reactor rotation drive motor; and installation of new burner instrumentation. In addition, to address a safety concern, scaffolding was installed around the reactor feed lockhopper. Also in January, it was found that the damage from the lightning strikes was much more extensive than thought during the September 1993 inspection. The datalogging system had been destroyed, and process data were to be logged by hand. Further cold testing was conducted in early February to verify the effectiveness of the modifications.

2.2.3.4. February 1994 Hot Runs. On 5 February 1994, approximately 10 tons of soil containing 200 to 1500 ppm PCB were processed successfully through the crushing plant, pugmill, and rotary reactor. PCB concentrations in the treated soil were less than 0.5 ppm. Inspection of the reactor following the successful run revealed the thermocouple assembly had fallen from its supports and was creating further damage with each revolution of the reactor. Consequently, the thermocouple assembly was removed from the reactor.

An additional 6-ton run (on 10 February) was successfully completed without thermocouples in the rotary reactor. In this run, reduced sodium bicarbonate concentrations of 5% by weight were tested. The outlet temperature from the reactor during this run was lower than in the previous run. All but one sample of treated soil contained less than 0.5 ppm PCB. The outlying sample showed 12 ppm PCB, but this sample was collected during a low-temperature excursion and was not believed to be representative of the actual performance of the system.

2.2.3.5. November 1994 Tests. The cold shakedown testing and hot operation testing established the operability and destruction efficiency of the BCD system. Viability of extended operation was necessary to explore steady-state operating conditions, analyze performance through day/night cycles and shift changes, and examine the overall operability of the system for longer periods.

PNNL staff arrived in Guam on 18 October 1994 to begin receiving equipment, performing system modifications, and preparing for a 50-ton continuous run. Activities were delayed several days because Guam was placed under Typhoon Condition 1 from Super Typhoon Wanda, and power to the island was shut down. After power was restored, work was initiated for site modifications and contingency repairs to the existing system and quick shakedown/training testing. Major modifications were made as follows: the datalogging system and many electronic indicators (level sensors, thermocouple readers, etc.), destroyed by the direct lightning strike to the site, were repaired and replaced. An improved wireless thermocouple train for the primary reactor (rotary kiln) was installed to replace the previous train that was damaged in the first run of the Hot Testing (February 1994). After these modifications were finished, a shakedown test was performed. Prior to the kiln operation, a structure was erected that enabled a sufficient amount of soil to be stored and protected from the weather since the testing was being conducted during the rainy season on Guam.

During November, a team composed of PNNL and IT staff completed a 40-hr continuous hot test of the BCD system in which approximately 50 tons of PCB-contaminated soil (average concentration 1250 ppm) were successfully treated to less than 2 ppm per congener. During the last 4 hr of the run, no sodium bicarbonate was added to the feed material. This material was also successfully treated; however, because of back-mixing and residual holdup of sodium bicarbonate in the system, this test did not conclusively determine whether sodium bicarbonate addition could be eliminated from the process.

The originally unknown level of soil organic present in the feed (in addition to the PCB) was shown to have a major effect on the operation of the equipment (especially the offgas treatment equipment) during prolonged operations. Pyrolysis oil aerosols and mist were generated from heating large amounts of roots and other vegetation, as well as other naturally occurring organics. These oils and tars showed some deposition in the baghouse and plugged the cyclone star-gate valve. In addition, some oils were able to penetrate through the liquid scrubbers and were collected (through impaction) in the induced draft (ID) fan, which indicated that the aerosol/mists were too small to be effectively removed in a wet scrubber.

Following several equipment and instrumentation modifications, a cold test and the first hot test of the 400-gal STR (1514 L) were performed using contaminated particulates and loaded granular activated carbon (GAC). These tests successfully demonstrated the slow but safe operability of the equipment at design conditions of 350°C (662°F) and 2 to 3 hr residence time. Results from the hot test showed that the PCB concentration was reduced from 7000 ppm to 1000 ppm (thus, the target treatment level of 2 ppm per congener was not achieved). However, dioxin/dibenzofurans were reduced from ppm levels to below detection limits. Upon successful demonstration of Stage 1 of the BCD system under sustained operations in November, the equipment and operations were transferred to the U.S. Navy and the Navy's RAC.

2.2.3.6. Additional STR Testing (May 1995). Because the target treatment levels (2 ppm per congener) were not met during the November 1994 hot testing of the 400-gal STR, PNNL staff traveled to Guam again in May 1995 to perform additional testing with both the 400-gal STR and a 2-L bench-scale STR. Staff from NFESC, IT Corporation, and BCD Group, Inc., also participated/observed the testing. During a 2-1/2 week period, five tests were completed with the 2-L STR, and two tests were completed with the 400-gal STR.

Major findings from the 2-L STR testing were that BCD can reduce PCB concentrations in the oil phase from approximately 42,000 ppm to less than 2 ppm per congener. Testing also indicated that fresh catalyst is necessary for the BCD process to successfully destroy PCB to target levels in the matrices tested. In second test with the 400-gal STR, samples of both feed and condensate contained no detectable PCB, which further demonstrated the efficacy of the BCD process.

3.0 Process Chemistry

The development of a dehalogenation process began in 1978 when the Franklin Research Center synthesized a new chemical reagent for the destruction of PCB (EPA 1992). Eventually, a group of reagents generically referred to as "APEGs" (alkali metal polyethylene glycolates) were developed (EPA 1989, 1990). These reagents were based on the reaction of alkali metals [such as sodium (Na) or potassium (K)] or their hydroxides with polyethylene glycols (PEG) or their derivatives, as shown in Reaction (1). The reagents prepared by reacting sodium (or potassium) hydroxide and polyethylene glycol were known as NaPEG (or KPEG). Proposed mechanisms for dechlorination with APEGs involved nucleophilic substitution and oxidative dehalogenation of organic compounds under mild conditions [75°C to 120°C (167°F to 248°F)]. Hydroxide and alkoxide ions displace halides of halogenated aromatics to yield phenols and aromatic ethers, respectively. One disadvantage of the APEG process was that increased moisture content reduced its effectiveness and increased reagent consumption. Also, the reaction byproducts remained in the treated waste matrix, and their long-term stability was not known.

$$R\text{-}Cl_x + A\text{-}PEG \xrightarrow{\Delta H} R\text{-}(Cl)_y\text{-}OR' + ACL + R\text{-}(Cl)_y\text{-}OH \qquad (1)$$

In July 1987, pilot-scale testing of the APEG process was conducted by EPA with a 40-gal reactor at Moreau, New York (Taylor et al. 1989). During the testing, PCB-contaminated soil (140 to 7000 ppm - averaging 1990 ppm PCB) was treated in four batches, each weighing approximately 16 kg (35 lb). The PCB concentration in the treated product ranged from 1.1 to 12.4 ppm and averaged 5.6 ppm, yielding an overall destruction rate of greater than 99%. This testing demonstrated the feasibility of the APEG process and provided the data used to design a larger pilot-scale reactor for subsequent testing by the EPA and the Navy in Guam.

In April and October 1988, a 400-gal Littleford mixer (modified as a batch APEG reactor) was field-tested on 27 tons of soil at PWC-Guam with soil containing 2500 to 4500 (averaging 3430) ppm PCB. Eight runs with approximately 1700 kg (3700 lb) of soil each were conducted in which the soil and reagents were heated to 150°C (302°F), held there for 4 hr, and then allowed to cool overnight. For each ton of soil treated, approximately 410 kg (910 lb) of polyethylene glycol (PEG-400) and 77 kg (170 lb) of potassium hydroxide were added. After cooldown of the reactor contents, approximately 73 kg (160 lb) of sulfuric acid (H_2SO_4) per ton of soil were added to neutralize the soil for pH adjustment to the 7 - 9 range as specified in the TSCA Research, Development, and Demonstration (RD&D) Permit. The treatment resulted in a PCB reduction of greater than 99%; however, in four of the runs, a tetra-chlorobiphenyl congener concentration in the treated matrix was slightly above the 2 ppm per congener treatment criterion specified in the permit. Batches not meeting the 2 ppm per congener criterion were reloaded into the reactor with fresh reagent and successfully re-treated to meet the permit standard.

An evaluation of data from APEG treatment of soil in Guam showed that additional research and process development were needed if halo-organic contaminated sites were to be remediated by dehalogenation technology. The following improvements were identified as essential, and criteria were established for a new dehalogenation technology (Rogers et al. 1991d; Rogers 1994):

- Eliminate the need for reagent recovery.
- Utilize low-cost reagents (i.e., base, catalyst, hydrogen donor, reaction medium) in the treatment process.
- Develop continuous processing capabilities.
- Reduce process treatment time from the 4 to 6 hr required by the APEG process.
- Destroy or remove nonhalogenated pollutants from contaminated matrices.
- Completely dehalogenate pollutants with high and low degrees of halogenation.
- Pollutants in treated matrices must be destroyed to regulatory compliance where residues can be disposed of onsite.

Based on the conclusions from the APEG testing, investigations of catalytic transfer hydrogenation were conducted in which organic materials were used as hydrogen donors in the presence of a catalyst for dehalogenating organic contaminants. The catalytic transfer hydrogenation reaction is generalized in Reaction (2).

$$\text{Donor-H} + \text{Acceptor} \xrightarrow[>300°C]{\text{base catalyst}} \text{Donor} + \text{Acceptor-H} \qquad (2)$$

In 1989, experimental laboratory data confirmed a chemical reaction involving the hydrogen transfer for the removal of halogens from a variety of compounds (Rogers et al. 1991d; Rogers 1994), and in 1991 three U.S. Patents (5,019,175; 5,039,350; 5,064,526) were awarded to EPA (see Section 2.1). From this work, the eventual two-stage BCD process evolved (EPA 1991). BCD Group, Inc. (see Section 2.2) continued to work on enhancements to this process.

3.1. Two-Stage Process

As illustrated in Figure 3.1, the process combines solid-phase and liquid-phase reactions in two separate stages.

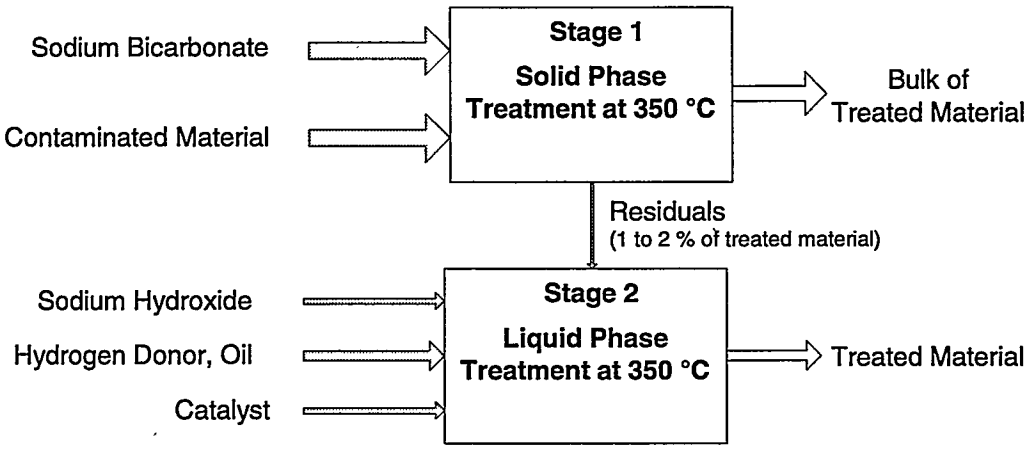
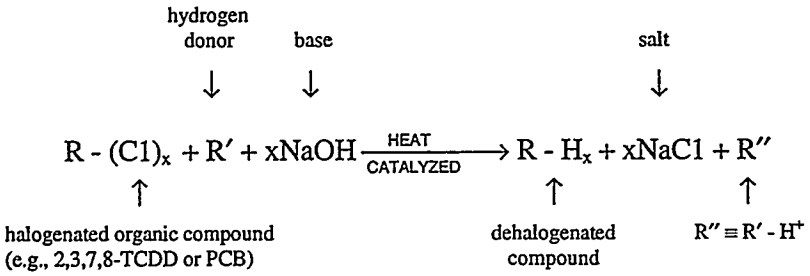


Figure 3.1. Major Steps in the BCD Process, Solid and Liquid Phases

In Stage 1 of the process, material containing halogenated contaminants are mixed with sodium bicarbonate and heated to approximately 350°C (662°F) to vaporize and partially decompose the PCB or other halogenated contaminants. The volatilized halogenated contaminants (e.g., PCB, dioxins, furans), which are collected in a small volume of particulates and GAC (from water treatment), are decomposed by the liquid-phase reaction (Stage 2) in the stirred-tank (slurry) reactor (STR), using a high-boiling-point hydrocarbon oil medium, with addition of a hydrogen donor, sodium hydroxide, and a catalyst. It is important to note that for most applications of the BCD process, the mass of the residuals going into Stage 2 will only be several percent of the contaminated material entering Stage 1 (also see Section 5.2.5).

The base-catalyzed dechlorination reaction conceptualized is illustrated in Reaction (3). The dehalogenation reaction that occurs in Stage 2 is also expected to take place to some degree in Stage 1 if there is a natural hydrogen donor in the waste matrix.



(3)

3.2. Process Design Testing

To provide design data for the scaleup of the BCD process for deployment in Guam, BCL and EPA-RREL conducted laboratory experiments on both the solid-phase and liquid-phase reactions.

3.2.1. Solid Phase Treatment

The solid-phase reaction experiments were conducted in April and June 1990 with a sample of Guam soil (16% by weight moisture) contaminated with Aroclor 1260. The tests were conducted in 500-mL flasks with a Vigeru-style fractionation column, a condenser, and a receiver for the condensate. Condensate was collected during the reaction from the experimental reactor unit. The condenser was rinsed with a solvent after the reaction was completed. The condensate and the rinse solution were combined and analyzed to determine the amount of PCB volatilized during the reaction. Experimental conditions and results are summarized in Tables 3.1 and 3.2.

The first series of tests summarized in Table 3.1 were conducted to investigate the effect of sodium bicarbonate, reaction temperature, and reaction time. Sodium bicarbonate was added by first dissolving it in water and then mixing the solution with the soil sample. By wetting the soil particles with the sodium bicarbonate solution, good mixing was ensured. The experimental results given in Table 3.1 show that the target residual PCB concentration of 2 ppm per PCB congener can be achieved with sodium bicarbonate at 320°C (608°F) and 60 min (Test 4-8), or at 340°C (644°F) and 30 and 90 min reaction time (Tests 4-5 and 4-6). These three tests showed volatilization of about 50% to 70% of the PCB initially present in the sample. Without sodium bicarbonate, the target cleanup level could not be achieved even at a higher temperature of 360°C (680°F) and 60 min (Tests 4-9). The beneficial effect of sodium bicarbonate in PCB removal can be seen from Tests 4-8 and 4-10, performed at 320°C (608°F) and 60 min, showing total residual PCB concentrations of 166 ppm without sodium bicarbonate and 6.6 ppm with sodium bicarbonate. A similar trend can be seen from Tests 4-3 and 4-4 performed at a lower temperature of 300°C (572°F) and 60 min, showing total residual concentrations of 265 ppm without sodium bicarbonate and 26.4 ppm with sodium bicarbonate.

Recent laboratory-scale testing by EBARA Corporation (Japan) has further confirmed the role of sodium bicarbonate and effects of temperature in the BCD Stage 1 reaction (Taniguchi et al. 1995). [EBARA Corporation is a licensee of the BCD process in Japan by BCD Group, Inc.] Using an experimental setup similar to that of EPA-RREL, Taniguchi's results indicated that, at 335°C (635°F), 3% by weight sodium bicarbonate and a 1-hr residence time, 40% to 70% of the PCB was dechlorinated. More highly chlorinated PCB-containing soil was more effectively dechlorinated than soil containing lower chlorinated PCB (e.g., greater dechlorination was observed with soil containing Aroclor 1248 than for soil containing Aroclor 1242). Taniguchi also examined the relationship between sodium bicarbonate addition and PCB concentration in the treated soil. Sodium bicarbonate concentrations were tested at 0, 3%, and 6%. The PCB concentration in treated soil with sodium bicarbonate was 1/10 of that from soil treated with no sodium bicarbonate. The effectiveness of using 6% vs. 3% sodium bicarbonate was only marginally better.

Table 3.1. Solid-Phase BCD Process Experiments (April 1990)

PCB Congener	Residual Concentration in Soil, ppm[a]									
	Test 4-1	Test 4-2	Test 4-3	Test 4-4	Test 4-5	Test 4-6	Test 4-7	Test 4-8	Test 4-9	Test 4-10
1C1BP	NA[b]	NA	NA	ND[c]	ND	ND	ND	1.0	NA	NA
1C1BP	NA	NA	NA	ND	ND	ND	ND	0.5	NA	NA
2C1BP	NA	NA	NA	ND	ND	0.2	1.8	1.7	NA	NA
2C1BP	NA	NA	NA	ND	ND	ND	ND	1.2	NA	NA
3C1BP	NA	NA	NA	ND	ND	0.3	0.8	0.1	NA	NA
3C1BP	NA	NA	NA	ND	ND	ND	ND	0.7	NA	NA
3C1BP	NA	NA	NA	ND	ND	ND	ND	ND	NA	NA
3C1BP	NA	NA	NA	ND	ND	ND	ND	ND	NA	NA
4C1BP	NA	NA	NA	0.7	ND	ND	0.8	0.4	NA	NA
4C1BP	NA	NA	NA	0.8	ND	0.7	2.5	0.5	NA	NA
4C1BP	NA	NA	NA	1.2	ND	ND	0.5	ND	NA	NA
4C1BP	NA	NA	NA	0.7	ND	ND	ND	ND	NA	NA
4C1BP	NA	NA	NA	ND	ND	ND	ND	ND	NA	NA
5C1BP	NA	NA	NA	3.9	ND	0.4	3.5	0.2	NA	NA
5C1BP	NA	NA	NA	0.9	ND	0.2	0.9	0.3	NA	NA
5C1BP	NA	NA	NA	3.9	ND	ND	6.5	ND	NA	NA
5C1BP	NA	NA	NA	1.6	ND	ND	ND	ND	NA	NA
5C1BP	NA	NA	NA	ND	ND	ND	ND	ND	NA	NA
5C1BP	NA	NA	NA	ND	ND	ND	ND	ND	NA	NA
6C1BP	NA	NA	NA	1.6	ND	0.3	0.7	ND	NA	NA
6C1BP	NA	NA	NA	5.0	ND	0.2	4.4	ND	NA	NA
6C1BP	NA	NA	NA	1.9	ND	ND	1.3	ND	NA	NA
6C1BP	NA	NA	NA	3.0	ND	ND	4.0	ND	NA	NA
6C1BP	NA	NA	NA	1	ND	ND	1.7	ND	NA	NA
7C1BP	NA	NA	NA	0.2	ND	ND	0.7	ND	NA	NA
Aroclor 1260 in Soil, ppm										
Initial	4167	4167	4167	4167	4167	4167	4167	4167	4167	4167
Final	1110	224	265	26.4	0.0	2.3	30.1	6.6	179	166
Aroclor 1260 in Condensate + Rinse, ppm										
	1052	3381	3083	3583	2893	2226	3369	2667	2405	3560
Aroclor 1260 Volatilized, %										
	25.3	81.1	74.0	86.0	69.4	53.4	80.9	64.0	57.7	85.4
Temp., °C	250	250	300	300	340	340	300	320	360	320
Time, min	30	90	60	60	90	30	60	60	60	60
$NaHCO_3$, g/g dry soil										
	0.12	0.12	0.00	0.12	0.12	0.12	0.12	0.12	0.00	0.00
Water Added, g/g dry soil										
	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14

(a) All PCB concentrations expressed on a dry soil basis; all tests performed with 25-g samples of Guam soil, minus 1/4-in. size, and containing 16% moisture.
(b) NA = Not analyzed.
(c) ND = Not detected (less than 0.1 ppm).

Table 3.2. Solid-Phase BCD Process Experiments (June 1990)

	Residual Concentration in Soil, ppm[a]				
PCB Congener	**Test 6-1**	**Test 6-2**	**Test 6-3**	**Test 6-4**	**Test 6-5**
1C1BP	0.3	ND[b]	ND	0.5	0.6
1C1BP	0.3	ND	ND	ND	ND
2C1BP	0.5	0.6	ND	0.6	0.7
2C1BP	0.4	ND	ND	ND	ND
2C1BP	0.3	ND	ND	ND	ND
3C1BP	0.6	0.2	ND	0.2	ND
3C1BP	2.0	0.6	ND	ND	ND
3C1BP	0.2	ND	ND	ND	ND
3C1BP	0.1	ND	ND	ND	ND
4C1BP	0.8	0.1	ND	ND	ND
4C1BP	0.2	ND	ND	ND	ND
4C1BP	0.5	ND	ND	ND	ND
4C1BP	0.8	ND	ND	ND	ND
5C1BP	0.1	ND	ND	ND	ND
5C1BP	0.3	ND	ND	ND	ND
Aroclor 1260 in Soil, ppm					
Initial	2917	2917	2917	2917	2917
Final	7.4	1.5	0.0	1.3	1.3
Aroclor 1260 in Condensate + Rinse, ppm	NA[c]	NA	1351	NA	NA
Aroclor 1260 Volatilized, %	NA	NA	46.3	NA	NA
Temp., °C	340	340	360	340	360
Time, min	60	60	60	60	60
$NaHCO_3$, g/g dry soil	0.12[d]	0.12[d]	0.12[d]	0.12[e]	0.12[e]
Water Added, g/g dry soil	0.14	0.00	0.00	0.00	0.00

(a) All PCB concentrations expressed on a dry soil basis; all tests performed with 25-g samples of Guam soil, minus 1/4-in. size, and containing 16% moisture.
(b) ND = Not detected (less than 0.1 ppm).
(c) NA = Not analyzed.
(d) Fine powder; 100% minus 325-mesh (44 microns).
(e) Coarse powder; 65% minus 200-mesh (74 microns), 22.5% minus 325-mesh (44 microns).

The series of tests summarized in Table 3.2 were conducted to optimize the reaction by investigating the effect of water addition to the reactant mixture and the effect of the particle size of sodium bicarbonate used. In Test 6-1, sodium bicarbonate was added to the soil sample with water to form a wet feed. In Tests 6-2 through 6-5, sodium bicarbonate was added to the soil sample without water to form a dry feed. The PCB cleanup target was achieved in all the tests, but slightly lower residual PCB concentrations were obtained with the dry feed than with the wet feed. This result indicated that adding water during mixing of sodium bicarbonate and soil had no beneficial effect on PCB removal, which was also better operationally since a dry feed would be easier to handle and would cause less sticking and plugging problems than a wet feed.

Comparison of Tests 6-2 and 6-3 with a fine sodium bicarbonate powder and Tests 6-4 and 6-5 with a coarse sodium bicarbonate powder showed very little difference in the PCB removal efficiencies obtained. This result indicated that a coarse sodium bicarbonate could be used in the system, which would help minimize entrainment of fines in the gas stream from the rotary reactor.

From the results for the laboratory-scale Stage 1 at EPA-RREL (Tables 3.1 and 3.2), the following recommendations were incorporated into the design and operation strategy of the BCD system for treatment of contaminated soils in Guam:

- Design basis for rotary kiln (Stage 1 Reactor) was 350°C (662°F) with residence time of approximately 60 min.

- Confirmed that 10% by weight sodium bicarbonate addition to soil (dry) effectively removed/ destroyed PCB in treated soil.

- Sodium bicarbonate should be added dry at a coarse grain size to minimize entrainment.

- Because significant PCB was volatilized, an effective offgas system had to be designed to capture the PCB.

3.2.2. Liquid Phase Treatment

The liquid-phase reaction experiments were performed in September 1990 jointly by EPA-RREL and BCL at the EPA-RREL facilities in Cincinnati to obtain experimental data that could be utilized to design a slurry reactor for the BCD process demonstration in Guam. The test apparatus consisted of 100- or 250-mL flasks, a Vigeru-style fractionation column, a condenser, and a receiver for the condensate. Aroclor 1260 was used in this testing as the source of PCB. A refined petroleum oil (Sunpar LW-107, manufactured by Sun Refining and Marketing Co.) was predistilled to remove the lighter fraction, and the heavier fraction was used in the experiments to minimize volatilization during

the reaction. Other reactants included sodium hydroxide and a proprietary catalyst. Clay, activated carbon, and water were added as inert constituents to simulate the composition of the PCB waste generated in the process.

Experimental conditions and results are presented in Table 3.3. All three tests were run at 350°C (662°F) and 2 hr reaction time, using 50 mL of the predistilled LW-107 oil. Condensate was collected during the reaction. After the reaction, the experimental unit, including the condenser, was rinsed with a solvent to determine the amount of PCB volatilized. Results showed no detectable PCB left in the oil (i.e., less than 0.1 ppm) after the reaction in all three tests. Destruction efficiencies estimated from the amounts of PCB volatilized ranged from 99.93% in Test 10-2 to 99.98% in Test 10-1. Destruction efficiencies in Tests 10-1 and 10-3 were very close at 99.98% and 99.97%, respectively. Test 10-1 was run with 0.5 g PCB, 10 g NaOH/g PCB, 4 g catalyst/g PCB, and without water and clay. Test 10-3 was run with twice as much PCB, half as much NaOH and the catalyst, and with water and clay. Hence, Test 10-3 represents the preferred reaction conditions that served as the basis for the design of the STR system for use in the Guam demonstration. Subsequent testing by the BCD process inventors has shown it to be effective in destroying other chlorinated contaminants, including dioxins and furans.

From the results of the laboratory-scale Stage 2 testing at EPA-RREL (Table 3.3), the following recommendations were incorporated into the design and operation strategy of the BCD system for treatment of residues resulting from the treatment of contaminated soils (Stage 1) in Guam:

- Design basis for Stage 2 STR was 350°C (662°F) and residence time of 2 hr.
- Design basis reagent loadings were 5 g NaOH/g PCB and 2 g catalyst/g PCB.
- Continuously recycling the condensate during the reaction was planned to achieve higher destruction efficiencies.

Table 3.3. Liquid-Phase BCD Process Experiments (October 1990)

	Test 10-1	Test 10-2	Test 10-3
PCB, g[(a)]	0.506	0.998	0.997
Oil, mL[(b)]	50	50	50
NaOH, g/g PCB	10	2.5	5
Catalyst, g/g PCB	4	2	2
Clay, g/mL oil	0	0.04	0.04
Carbon, g/mL oil[(c)]	0.1	0.1	0.1
Water, g/mL oil	0	0.2	0.2
Temperature, °C	350	350	350
Reaction time, hr	2	2	2
Residual PCB in Oil, ppm	ND[(d)]	ND[(d)]	ND[(d)]
PCB in Condensate/Rinse, mg			
1C1BP	0.040	0.300	0.100
1C1BP	0.050	0.140	0.140
2C1BP	0.020	0.030	0.020
2C1BP		0.040	
2C1BP		0.040	
2C1BP		0.020	
3C1BP	0.008	0.020	0.020
3C1BP		0.030	0.010
4C1BP		0.040	0.020
Total	0.118	0.660	0.310
PCB Volatilized, %	0.023	0.066	0.031
PCB Destruction, %	99.977	99.934	99.969

(a) Aroclor 1260.
(b) Sunpar LW-107 predistilled at 676°F to 584°F to remove light fraction.
(c) Calgon Type BL powdered activated carbon.
(d) ND = Not detected by gas chromatography-mass spectroscopy.

4.0 BCD Equipment Descriptions

The BCD system consists of a number of commercially available and custom-designed pieces of equipment that are integrated at the processing site. Together, these components perform the various unit operations to reduce the feed (contaminated soil) to a suitable size, mix sodium bicarbonate with the soil, feed soil into the rotary kiln reactor, and heat the soil to the desired temperature for the required time. The equipment is integrated in the system as shown in the flow diagram in Figure 4.1. The following text describes the equipment individually in order of operation within the BCD system.

4.1. Size Reduction

The excavated soil is crushed in the Eagle AR-125G portable crushing plant (Figure 4.2) to a nominal -3.8 cm (-1.5-in.) size. This plant is capable of crushing up to 20 ton/hr of material. Crushing the soil provides a suitable feed and exposes internal contaminated surfaces that may not otherwise have sufficient time to react. The feed to the crusher is fed through a 6-in. hydraulically operated grizzly, which keeps large boulders and debris from entering the crusher and damaging or plugging the crushing chamber. The feed is crushed by a number of rotating hardened manganese steel hammers, then falls through the opening in the discharge chute when crushed to a small enough size. The discharge conveyor is covered with galvanized panels to minimize fugitive dust emissions and to help keep the feed dry during rainstorms. Water misting nozzles are also mounted on the grizzly to reduce dust emissions when the feed material is dry.

Generally, the crushing plant worked as designed without excessive maintenance. However, when the moisture content of the feed was too high, the crushing chamber had a tendency to clog. Also, there was a higher fraction of +5.1 cm (+2-in.) material than desired, but this larger material did not cause any major materials handling problems for the rest of the equipment.

4.2. Mixing Plant

The crushed feed is mixed with 10% by weight sodium bicarbonate to react with the PCB in the rotary kiln. The sodium bicarbonate is mixed into the soil using a Kolberg Model 50 portable twin pugmill mixing plant (Figures 4.3 and 4.4). This plant is capable of processing up to 20 ton/hr of material. The sodium bicarbonate is fed to the pugmill using a Flexicon Model 1450 screw conveyor (Figure 4.5).

The amount of sodium bicarbonate added to the soil is controlled by the speed of the pugmill feed belt and the speed of the sodium bicarbonate screw conveyor. For the demonstration phase of this

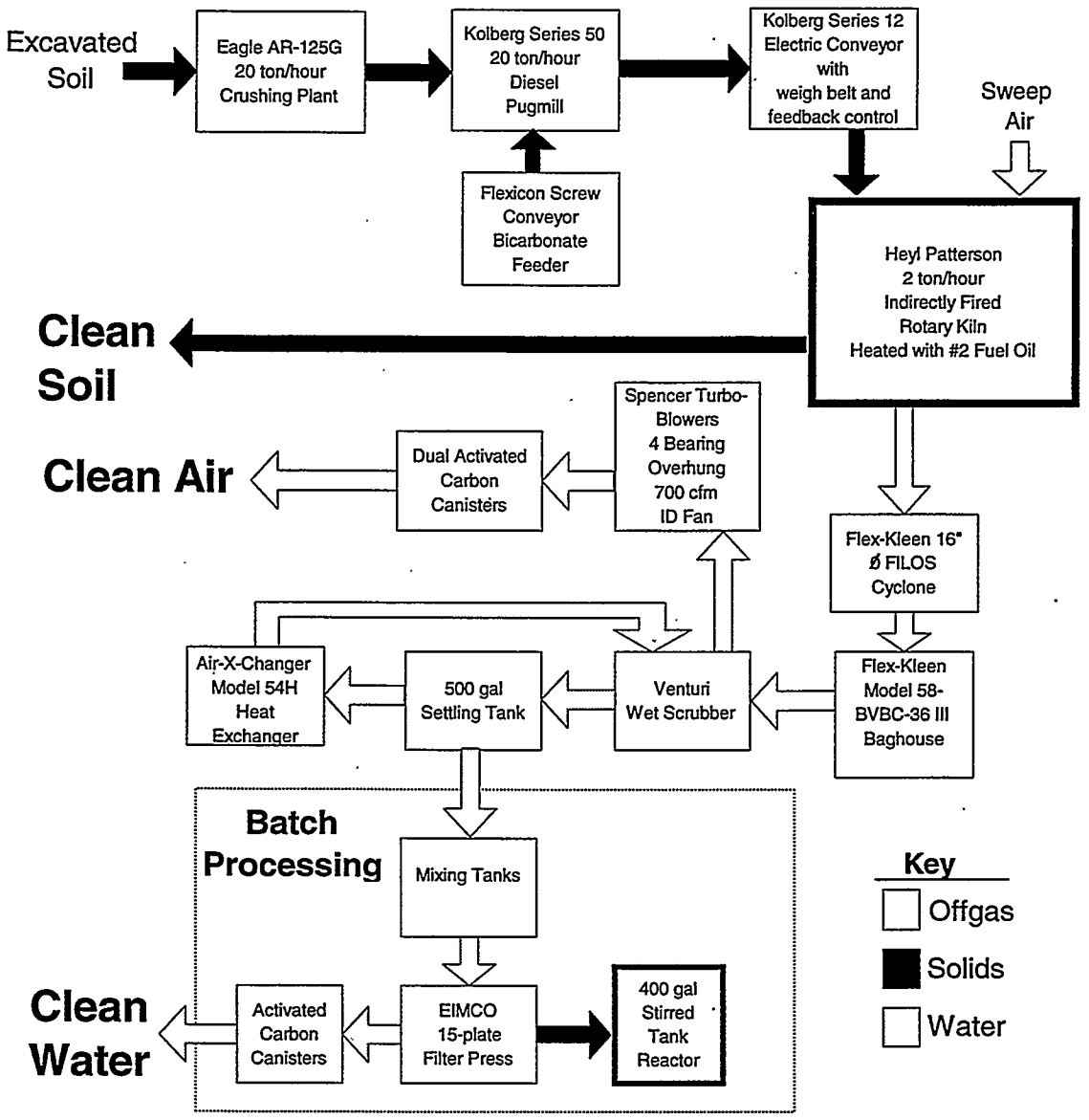


Figure 4.1. Equipment Integration and Process Streams

Figure 4.2. Portable Crushing Plant

project no automatic control of the sodium bicarbonate was attempted. Automatic control based on the feed rate of the pugmill can be easily implemented with standard controller technology. The pugmill has a weigh scale on the feed belt that indicates the feed rate to the pugmill. A hydraulic control valve on the operator control console adjusts the speed of the feed belt. An adjustable strike-off plate at the exit of the feed hopper allows further adjustment of feed rate by controlling the height of the soil on the feed belt. The sodium bicarbonate content was controlled by calibrating the feed rate of the screw conveyor and setting the appropriate feed rate to achieve the desired content with the pugmill running at 10 ton/hr.

The mixing time of the sodium bicarbonate and the soil is controlled by the feed rate of soil and the position of an adjustable dam at the outlet of the mixing chamber. The mixed soil flows over the dam onto a conveyor belt where is transported to the feed hopper of the feed conveyor. Because the feed conveyor hopper only holds 3 to 5 tons of material, the mixing campaigns were conducted for short durations (~ 30 min). The mode of operation of this equipment is much different in a production environment where a much larger quantity of material would be processed and stockpiled for transfer to the feed hopper by a front end loader or a separate conveyor. It was this mode of operation that was assumed when sizing the equipment. A week's worth of feed could easily be prepared in an 8-hr shift if the equipment were operated at its design capacity.

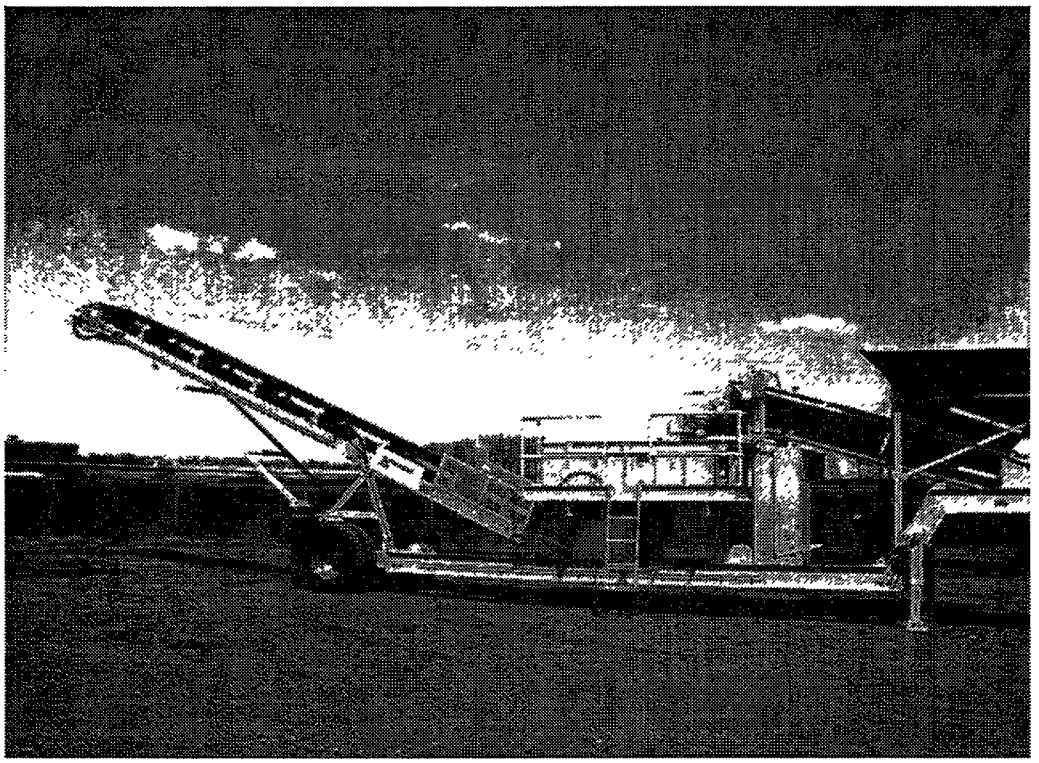


Figure 4.3. Portable Pugmill Mixing Plant

Figure 4.4. Twin Mixing Shafts in Pugmill

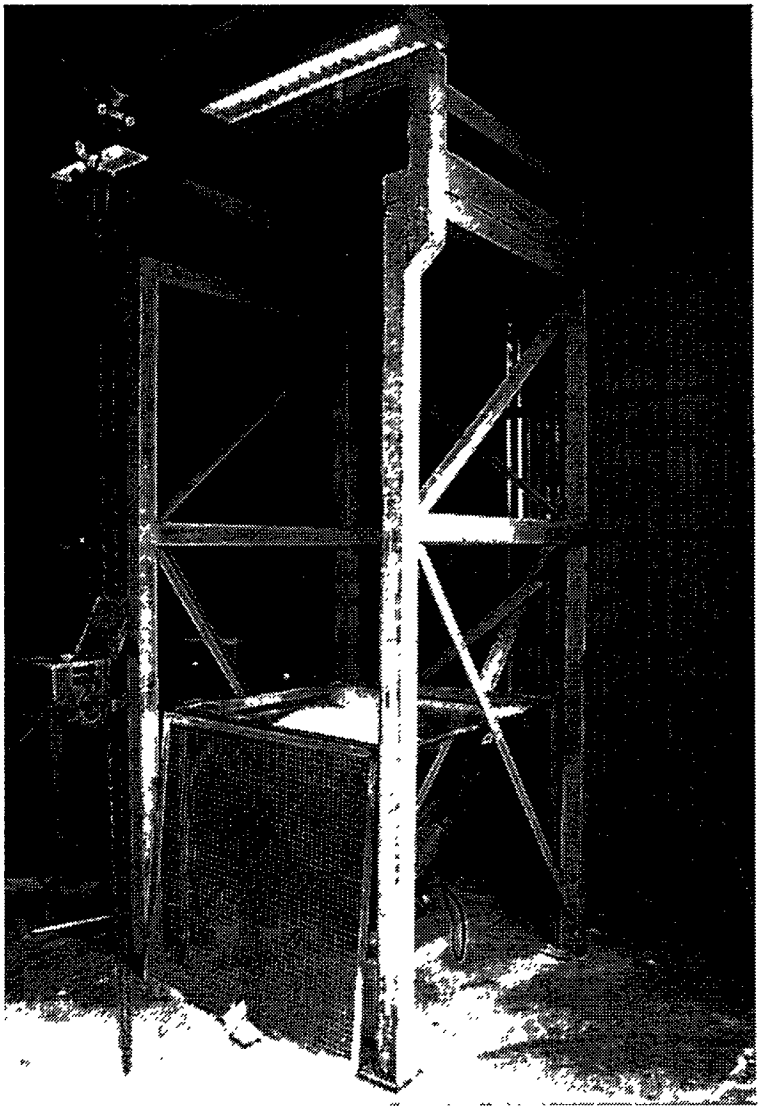


Figure 4.5. Flexicon Screw Conveyor

The Flexicon screw conveyor is used to feed a controlled amount of sodium bicarbonate to the pugmill. The system uses 1-ton super-sacks of sodium bicarbonate, which are suspended above a stainless steel hopper by a steel superstructure. The sodium bicarbonate is gravity-fed to the hopper and fed to the pugmill by a stainless steel screw contained in a 6-in.-diameter polyethylene tube. The screw is driven by a 5 hp DC motor mounted on the pugmill at the discharge end of the screw conveyor. The motor speed is controlled by a simple potentiometer dial adjustment but can be interfaced to a controller if desired. An electric bin vibrator is periodically used to prevent bridging of the sodium bicarbonate in the hopper.

The sodium bicarbonate mixing system operated sufficiently well to prepare all of the feed in the cold and hot runs during 1993 and 1994. However, a number of minor problems were encountered that

made feed preparation more difficult than anticipated. Some of these problems were related to weather conditions on Guam: 1) high humidity caused sodium bicarbonate to cake, resulting in inconsistent feeding to the pugmill, which then required constant attention; 2) high soil moisture content and higher-than-anticipated clay content of soil caused occasional plugging of the pugmill; and 3) corrosion of the equipment caused minor component failures, which led to shutdowns during feed preparation. Mixing problems can be controlled by minimizing the amount of time the sodium bicarbonate is exposed to air, using properly dried soil, and incorporating an aggressive maintenance program to make sure corrosion does not cause failure of critical components.

Some difficulty was also experienced in the pugmill weigh belt and display. The feed rate display unit was mounted in a location inaccessible to the operator, which meant an extra person was required to relay readings to the operator, who manually adjusted the speed of the soil feed. The final plant provided an additional feed rate display unit at the operator's station.

4.3. Reactor Feed Conveyor

A Kolberg Series 12 Electric Feed Conveyor (Figure 4.6) is used to transport the soil/sodium bicarbonate mixture to the inlet of the rotary reactor, which is ~4.5 m (15 ft) above the ground. The feed conveyor is used to meter the feed to the reactor and provide a cumulative total of the weight of soil fed. The feed conveyor has a hopper capable of holding ~ 3 to 5 tons of feed. The feed is transferred from the hopper to the feed conveyor by a small horizontal electric conveyor mounted under the hopper. The speed of this conveyor can be controlled either manually or automatically. The automatic speed is controlled by a programmable controller that monitors a weigh scale on the main conveyor. The main conveyor is 18.3 m (60 ft) long and is driven by an electric motor mounted at the discharge end of the conveyor. The speed of the main conveyor is not adjustable.

The feed conveyor operated as designed with a minimum amount of maintenance. The only problems encountered were associated with wet feed bridging in the hopper. An electric bin vibrator was mounted on the side of the hopper to help with the bridging problem, but manual assistance of feed flow was often required. This is primarily due to the sticky nature of wet feed and not a design flaw of the equipment.

4.4. Rotary Kiln Reactor

The centerpiece of the BCD soil treatment system in Guam is an indirectly fired rotary kiln reactor built by Heyl Patterson (Figure 4.7). The primary purpose of this reactor for the BCD process is to heat the soil/sodium bicarbonate feed to a temperature of 350°C (662°F) for a residence time of 1 hr to

Figure 4.6. Electric Feed Conveyor

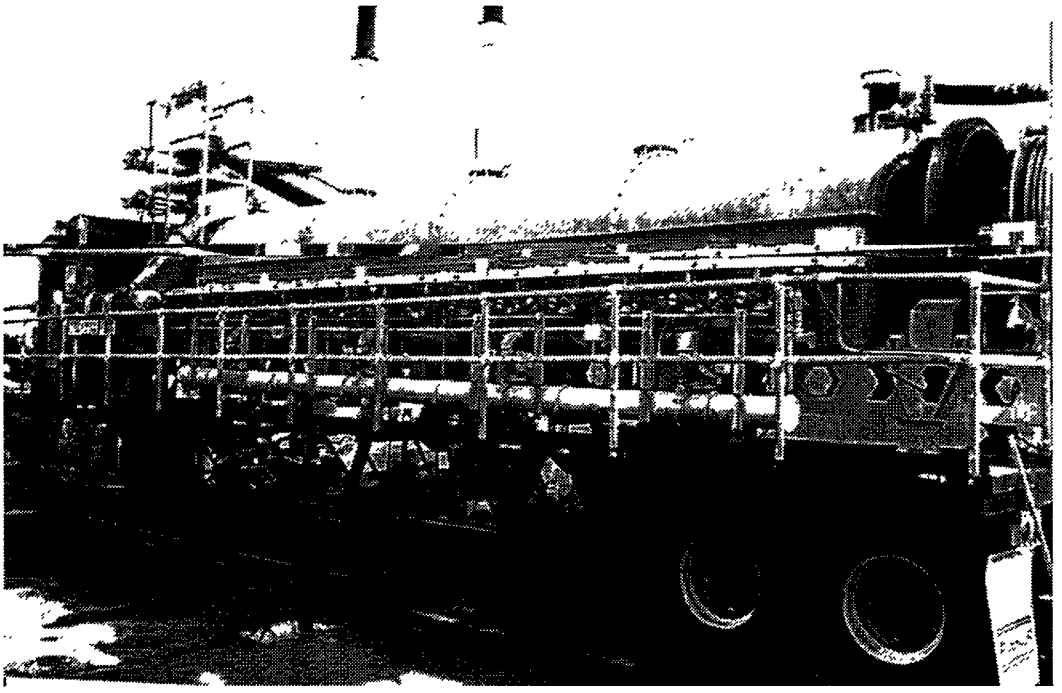


Figure 4.7. Heyl Patterson Rotary Kiln Reactor

decompose and desorb PCB in soil. The kiln reactor was designed to process 1 to 2 tons per hour of soil (20% by weight moisture) and operate continuously for several months without the need for a maintenance shutdown.

4.4.1. Reactor Description

The rotary kiln reactor includes a ~0.91-m-diameter by 11.6-m-long (3-ft-diameter by 38-ft-long) rotating shell constructed of mild steel, with a furnace surrounding approximately 8.8 m (29 ft) of the shell. The furnace consists of a stationary refractory with 14 Hauck high-velocity burners (fired with #2 diesel) firing tangentially around the shell. The burners are spark ignited with propane gas (pilot gas for lighting) and are divided into four separate zones for accurate temperature profiling/control. The total burner thermal heat input capacity is rated at approximately 7 million Btu/hr.

The four zones of the shell temperature have individual temperature controllers set to the indicated shell temperatures that provide adjustable set-point temperature in each zone. Soil bed temperatures inside the reactor are monitored by eight stationary thermocouples placed in the flow of the soil inside the shell.

During soil treatment, the contaminated soil is mixed with sodium bicarbonate and is fed into the rotary kiln reactor through two knife-gate valves. The knife-gate valves ensure negative pressure is maintained in the unit. The mixture is introduced into the rotating shell just over a retaining dam; the dam prevents soil from spilling into the feed breaching. Once the soil mixture is inside the reactor, the BCD reaction and thermal desorption processes begin.

The soil is heated as it slowly flows through the rotating kiln reactor (at about 1 RPM with a 3 degree tilt). Spiral feed flights and turning bars combined with the continuous rotation of the shell cause the mixture to cascade through the hot reactor gases. This cascading exposes the individual particles to the intense heat, which evaporates any moisture present and heats the soil to BCD reaction temperatures. Steam, organic vapors, and fine particulates (dust) are carried away from the soil by a countercurrent flow of sweep gas being drawn through the reactor into the offgas treatment system. Sweep gas is provided by pulling a slip stream of burner exhaust gas into the reactor. Through the use of the burner exhaust gas for sweeping the reactor, the hot, oxygen-depleted stream further excludes the potential for oxidation reactions in generating dioxins and furans, and possibly provides supplemental heat.

After the BCD reaction is completed, the treated soil migrates to the discharge end of the rotating shell (Figure 4.8), where the dried material flows into the discharge section. The treated soil is removed from the reactor through two knife-gate valves to a conveyor where it is loaded into bins, while awaiting cooling, and is carried away for final disposal.

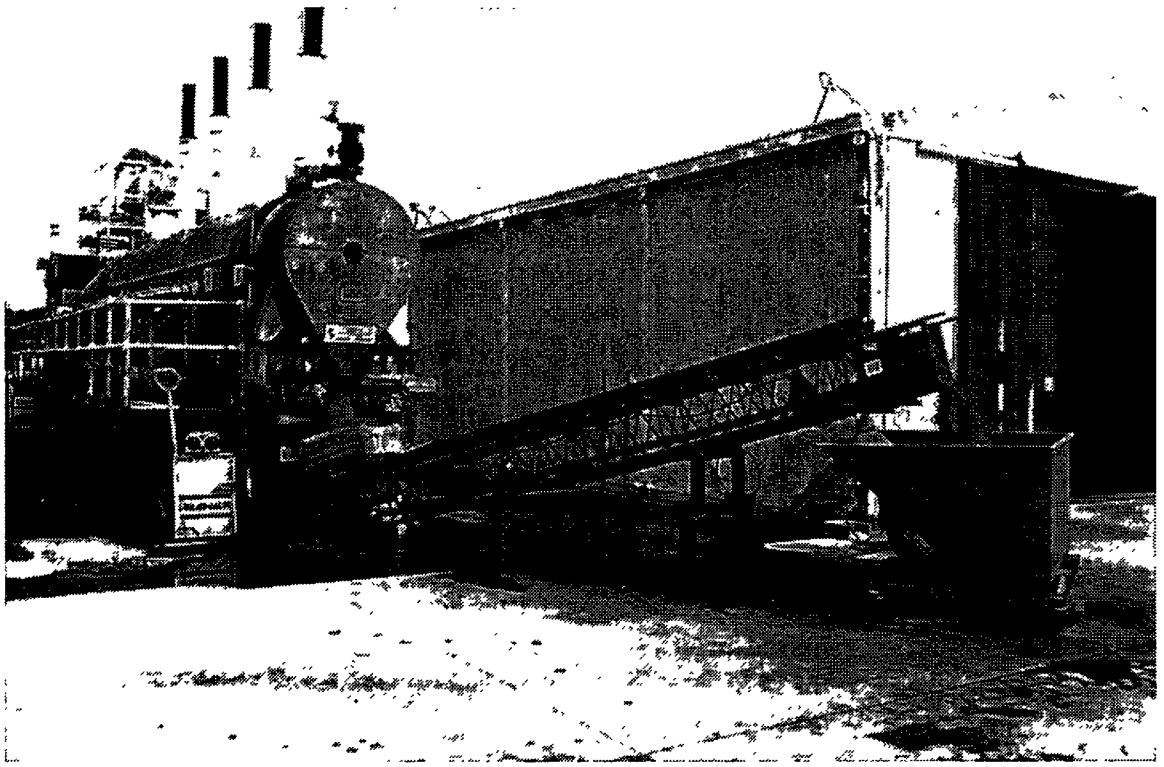


Figure 4.8. Discharge Conveyor for Rotary Kiln Reactor

4.4.2. Operation During BCD Demonstration

Only a few design and operation problems were encountered during the BCD demonstration. A particular problem was the failure of the thermocouple train inside the reactor for monitoring soil temperature. The thermocouple train fell off its hangers during the initial test run with contaminated soil in February 1994. This problem was attributed to stresses placed on the thermocouple guide sheaths (40 gauge 1/4-in. tubing) by the constant rotational force applied from the flowing soil and rocks, coupled with the different expansion rates between the thermocouple train and the reactor body (where its hangers were located). A completely wireless thermocouple system, designed to rotate with the kiln and transmit the temperature data to a stationary receiving unit, was installed but operated only intermittently during the testing conducted in November 1994. However, the wireless thermocouple system performed well during subsequent operations.

During predeployment testing in Stockton, fines entrainment in the sweep gas flow through the shell collected at the feed entrance (head) of the reactor. A large dead space inside the head of the reactor (where the air is exiting the reactor and the soil is entering) caused much of the entrained fines in the sweep gas to lose velocity and accumulate in the dead space. Very high velocities of sweep gas

tended to compound this problem. Extending the sweep gas exit port into the reactor forward of the dead space significantly minimized the buildup of fines.

The soil in Guam caused some difficulties in feeding to the reactor. Plugging occurred at the feed knife gates of the reactor when the soil was very wet. The following corrective actions minimized the plugging problems: feed conveyors were covered to keep rain away from the soil being fed; the speed of the knife gate cycling was increased to limit the amount of self compaction as the soil fell on the top of the knife gate; and a small vibrator was installed on the hopper above the knife-gate valves.

Inclement weather and long idle times affected equipment operability. A number of components, specifically in the burner train, that were not constructed with stainless steel had to be replaced. In addition, some rotating and moving parts associated with the reactor required replacement or significant attention after idle periods.

In addition to keeping the burner train ready for operation, selecting the optimal number of burners was important because the train is overdesigned for the heat input required. Furthermore, the four shell thermocouples were mounted directly in line with the area where specific burners impinged on the shell, which resulted in difficult control. During the extended hot operations (November 1994), it was determined that only 9 to 11 of the 14 burners were necessary for successful soil treatment, as that number allowed the reactor logic to operate the burners above idling flow rate. With more than 11 burners operating, all of them would hover near idling flow, which would result in frequent "flame outs" because of carbon buildup.

The 9 to 11 burners, depending on the moisture content of the feed, were also required to allow for maximum heat transfer with even heating of the reactor. When only the shell temperatures are used as guidelines, the shell can "appear" to be operating at temperature with only the four burners located directly below the four shell thermocouples. However, heat transfer is actually not sufficient to raise the soil to the desired reaction temperature. During the November 1994 testing, operating the reactor with 9 to 11 burners successfully heated the soil to the BCD reaction temperature with minimal operator intervention.

4.5. Offgas Treatment System

The offgas treatment system is where the PCB and reaction products stripped from the soil in the rotary kiln reactor are collected for further treatment in the STR. An ID fan in the offgas treatment system maintains a slight vacuum in the rotary kiln, which pulls the kiln offgas through the offgas treatment components. The major offgas cleaning components are also under vacuum, which prevents the release of partially treated offgas (i.e., all leakage is pulled into the system). Particulates from the kiln are removed by the cyclone, baghouse, and wet scrubber. The wet scrubber also condenses water vapor, biomass oils, and any remaining PCB. The contaminants captured in the scrubber are eventually

removed from the scrub water by activated carbon. From the scrubber, the offgas is passed through two activated carbon canisters before being discharged out a 6-m (20-ft)-tall stack to the atmosphere. The following sections describe each piece of equipment in the offgas treatment system in the order that the offgas stream progresses.

4.5.1. Air Cyclone and Baghouse

After exiting the rotary kiln reactor at ~240°C (460°F) the offgas is diluted with ambient air (to cool it to an appropriate temperature for the baghouse) and is passed through a Flex-Kleen Model 16" FILOS cyclone. The underflow of the cyclone contains particles greater than 5 to 7.5 μm (microns), which are removed and dropped into a 55-gal drum (208 L) through a star-gate valve. The smaller particulates exit the overflow of the cyclone with the main flow and pass through a Flex-Kleen Model 58-BVBS-36, No. III baghouse containing thirty-six 1.5-m (58-in.) Nomex bags (JL Technical, Inc.), which gives 24 m^2 (259 ft^2) of filter area. The offgas flows from the outside to the interior of the bag where particles smaller than 1 to 2 μm (microns) are retained. An automatic pneumatic air pulse is periodically applied to the insides of the bags to cause the particulates to flake off the elements and fall to the collection chamber where the solids are discharged through a star-gate valve into a second 55-gal drum. The cyclone and baghouse are shown in Figure 4.9.

The performance of the cyclone is based on the particle size and densities, the flowrate of the air, and the diameter and shape of the cyclone. The baghouse is simple in operation and contains minimal controls. The performance of the baghouse is determined by the number and types of filter elements used, the characteristics of particulates (e.g., are they sticky or do they easily flake off the outer surface of the filter element?), and the flowrate of air through the system. The only controls associated with the system involve the magnitude and frequency of the air pulse used to dislodge the particulates from the surface of the filter elements.

The solids collected by the cyclone and baghouse contain high concentrations of PCB and dioxins that have sorbed onto the high surface area of these very fine particles. The particles are contained through the use of star-gate valves, which discharge through a tube into sealed 55-gal drums. These drums are replaced periodically, and the collected solids become part of the feed for the STR where the contaminants (PCB, dioxins, and furans) are destroyed.

Overall, the performance of the cyclone and baghouse was good, as evidenced by the lack of solids/mud/dirt in the scrubber water. However, during the November 1994 testing, tars and oil (mixed with particulates) clogged the star-gate valves for both the cyclone and baghouse. Additionally, the bags in the baghouse were partially blocked due to buildup of sticky particulates (as evidenced by pressure drop increases during the run, and post-run inspection). It is believed that these problems could be minimized by insulating and/or heat tracing the cyclone and baghouse to maintain temperatures above the oil/tar (and water) condensation points. The Nomex bags may need to be replaced with higher-temperature fiber glass bags.

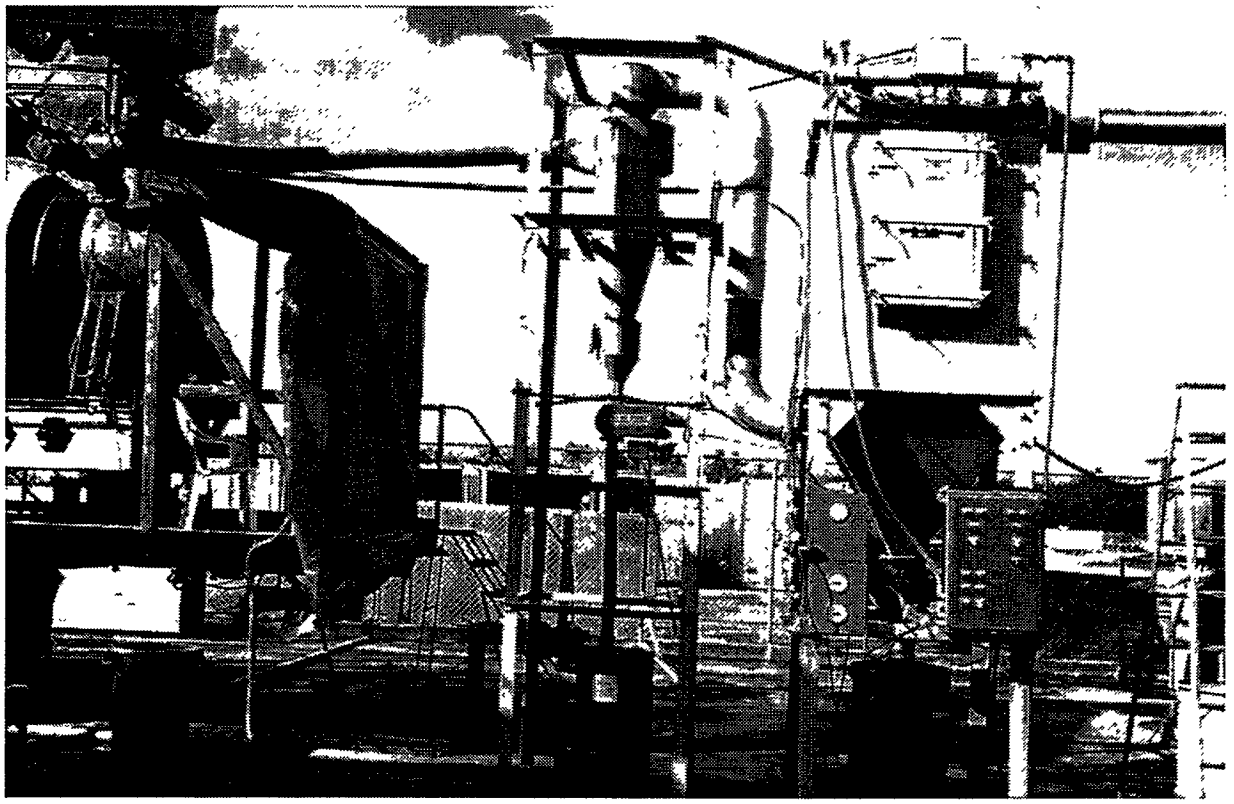


Figure 4.9. Cyclone and Baghouse Used to Remove Particulates in Offgas Treatment System

4.5.2. Wet Venturi Scrubber and Associated Equipment

The purpose of the wet venturi scrubber (Figure 4.10) is to cool the offgas stream, remove fine particulates that remain in the offgas stream, and condense water vapor and PCB. The offgas stream is passed through a venturi where a water jet is introduced to scrub out particulates and cool the gas stream. The offgas stream then makes a 180 degree turn where particulates impinge on a water surface. The offgas next passes through a series of bubble plates sprayed with water where further offgas scrubbing occurs. The offgas stream then passes through a demisting pad before exiting the scrubber and passing through the ID fan [the ID fan raises the temperature 5.5°C (10°F) to 11°C (20°F) above dew point]. After it is passed through the ID fan, the offgas is passed through two activated carbon canisters in series as a final polishing step before it is discharged out the stack.

Each activated carbon canister contains 140 kg (300 lb) of carbon and is designed for a pressure drop of 7.5 mm Hg (4 in. H_2O) at a flowrate of 42 m^3/min (1500 cfm). The carbon beds are housed in rectangular cabinets (Nixtox Model N-1500), approximately 1.12 x 1.12 x 1.73 m (44 x 44 x 68 in.) with airtight gasketed doors, and are rated for 3 psig (155 mm Hg).

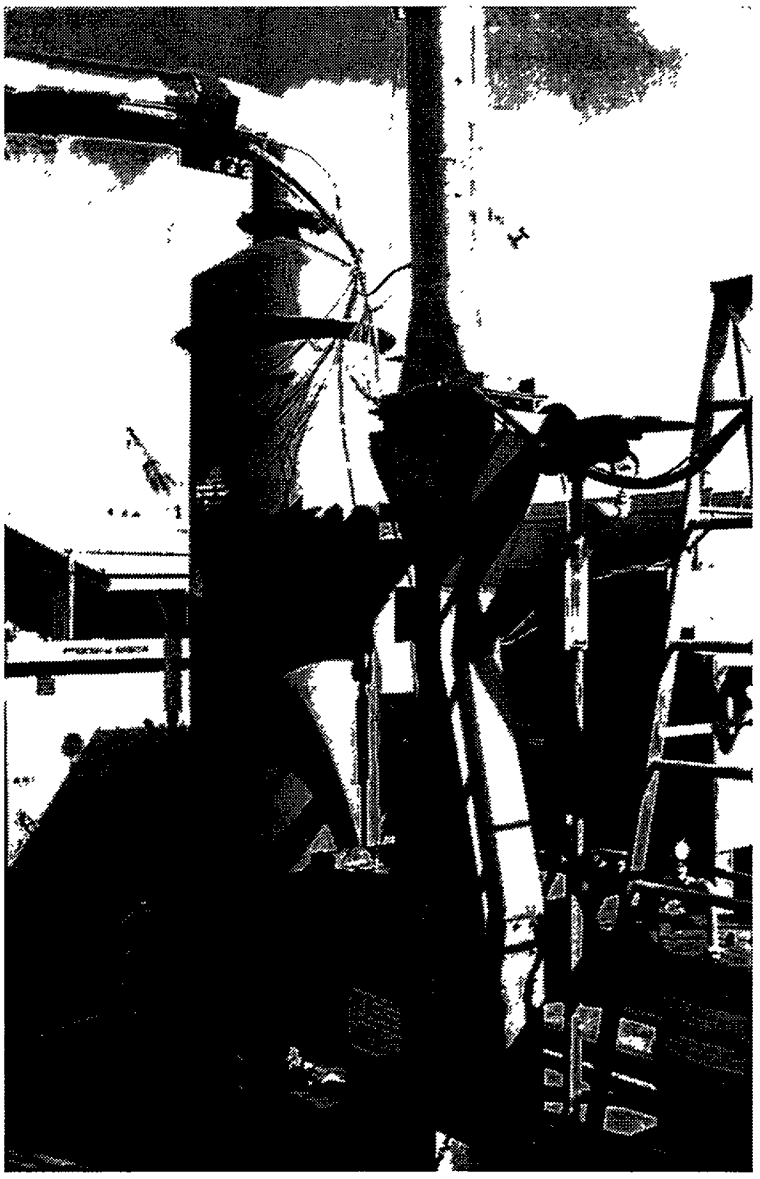


Figure 4.10. Wet Venturi Scrubber

Throughout the course of all testing, leaking problems occurred with the activated carbon canisters (allowing small quantities of offgas to bypass one of the carbon beds). Some of the leaks were the result of corrosion of the canisters. Frequent modifications were necessary in attempts to minimize leaks. Because the leaks occurred in the last component of the offgas cleaning equipment train, and the quantities of offgas released prior to treatment in the final carbon bed were small, risk to workers and the public were minimal. No measurable PCB was found in an offgas sample taken upstream of both carbon beds during the run conducted on 5 February 1994.

The water used in the venturi scrubber is collected in the base of the unit where it is pumped by pneumatic diaphragm pumps to a 500-gal (1900 L) settling tank. Particulates and heavy liquids accumulate in the bottom of this tank where they are eventually removed and treated. Water is drawn from the mid-level of the tank where it is passed through an Air-X-Changer Model 54 H heat exchanger (Figure 4.11) to cool the water. After passing through the heat exchanger, the water is fed back into the venturi scrubber to complete the water recycle stream.

In February 1994, an oily substance was observed leaking from the ID fan housing. Further investigation showed that it was an oil (possibly biomass oils) that had passed through the wet scrubber and condensed out in the ID fan because of the high centrifugal forces imparted by the turbine blades. Analysis of the oil showed it to contain high concentrations of PCB, which prompted PNNL to look for a method of removing the oils from the offgas stream more effectively. Removal of oils in the scrubber recycle water was determined as the most cost-effective way of dealing with the problem. The Navy's RAC (IT Corporation) suggested using a Great Lakes oil/water separator that they had in Guam for another project. This oil/water separator (Figure 4.12) was brought onsite and installed in November 1994 prior to conducting the 1994 extended hot runs. The operation of this unit is described below.

The Great Lakes slant rib coalescing (SRC) separator (Figures 4.13 and 4.14) separates oils and solids from water, where the oil and solids have a specific gravity different from that of water. Under design conditions, effluent concentrations of dispersed oil are less than 10 mg/L. The SRCs are installed in rectangular tanks containing special baffles and weirs designed to direct flow, skim oil, and control the liquid levels in the separator. Pitched sludge compartments are provided below the separation chamber for easy sludge removal.

Fine oil droplets impinge on or pass close to the plastic rib surface; they are attracted to it and adhere. Additional droplets continue to be attracted and coalesce or merge with previous droplets to produce much larger droplets. At a point, the droplets are large enough to break free and rise rapidly to the surface where they are skimmed or decanted. This coalescing action allows removal of smaller droplets than is possible with a regular gravity separator.

Flow enters the inlet chamber where it is dispersed through a non-clog diffuser across the width and depth of the media pack. Larger solids drop out here into the sludge chamber before entering the pack. The separation chamber is filled with the SRC media pack. The ribbed plates are arranged vertically in the direction of flow, spaced 1.91 cm (3/4 in.) apart. As viewed from the side of the media pack, the ribs run from the bottom of the inlet side to the top of the outlet side on a 45 degree angle. The depth of the ribs is more than twice the distance of the spacing, creating an overlap condition that causes the flow to zigzag around 90 degree corners throughout the pack, which in turn causes resistance to flow, collisions of the droplets 20 μm (microns) and larger with the plates, and coalescence. The coalesced oil has the least restricted path to exit the waste stream, and slides to the surface on the underside of the rib.

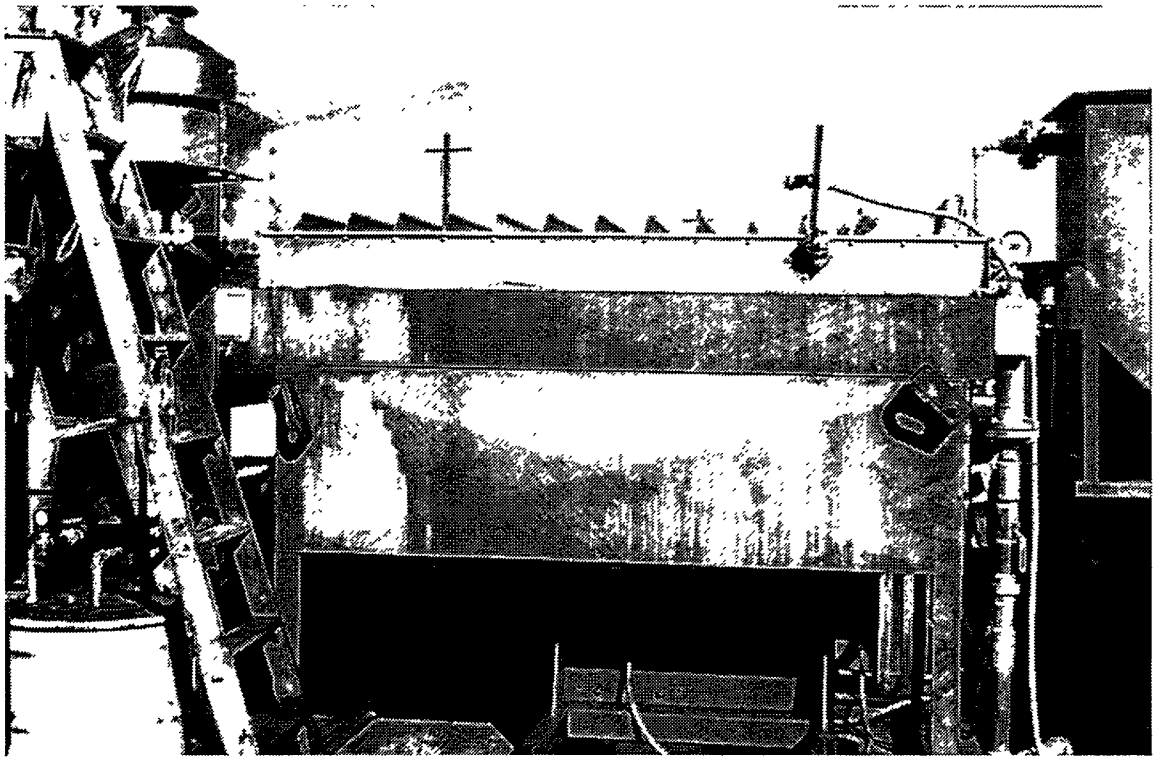


Figure 4.11. Heat Exchanger Used to Cool Water Recycle Stream

Figure 4.12. Oil/Water Separator Used in November 1994 Extended Hot Run

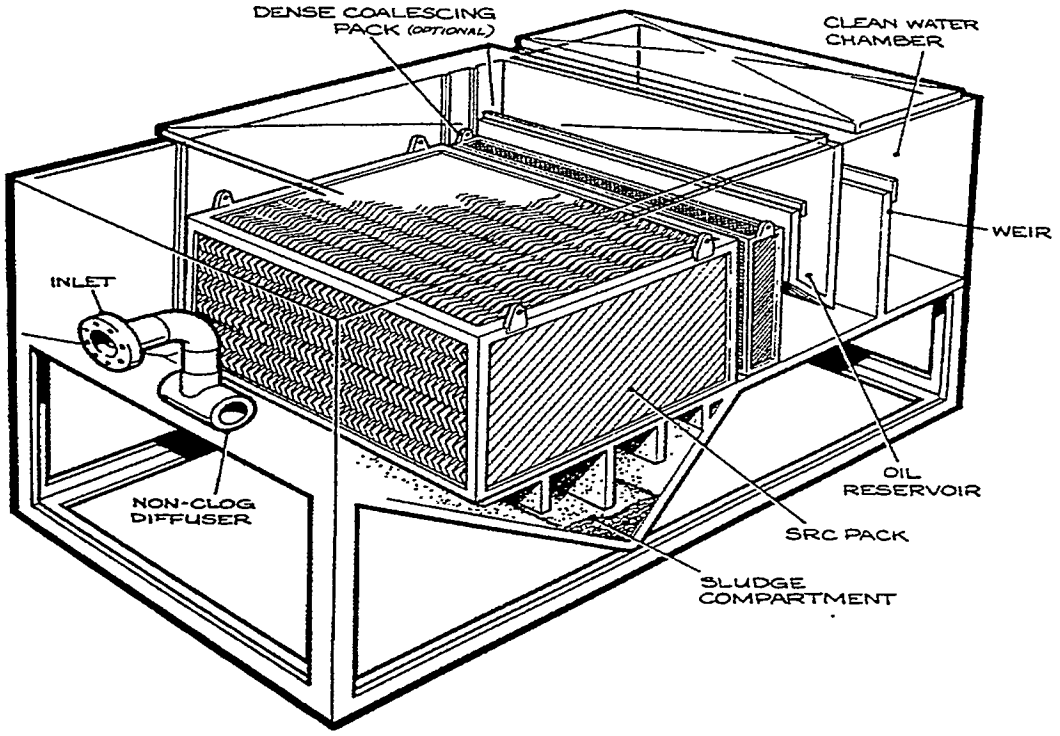


Figure 4.13. Drawing of Great Lakes SRC Separator Showing Internal Component

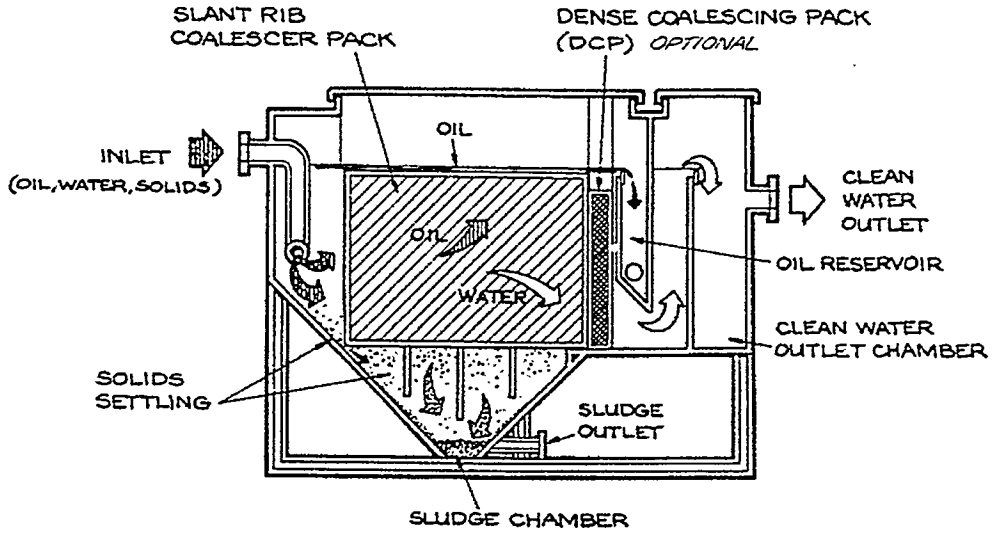


Figure 4.14. Cross Section of SRC Separator Showing Operating Principles

Solids entering the pack encounter a 55 degree angle of inclination created by the ribs, which is optimum for solids settling. The solids slide down the top of the rib and fall to the next rib, gathering mass and velocity as they near the bottom of the pack and drop into the sludge chamber. The horizontal projected area of the top side of the ribs provides a conservative 8.1 L/min/m^2 (0.20 gpm/ft^2) separation rate at design loading.

The sludge chamber is located directly beneath the separation chamber and provides adequate volume for the settled sludge. The sides of the sludge chamber are sloped 45 degrees to ensure easy and complete removal of the sludge. The separated oil accumulates at the surface of the separation chamber where it displaces the water. As the oil layer increases, oil spills over a weir into an oil reservoir where it can flow by gravity or be pumped automatically to remote storage tanks. The clean water leaving the SRC media pack passes under an oil retention baffle and into the effluent or clean water chamber. From there, the clean water passes over a weir that maintains the liquid level in the separator. The clean water flows by gravity back to the settling tank where it is pumped back to the scrubber.

The SRC separator worked very well during the November 1994 testing. However, there was not as much separable oil in the water as suspected, so only a small amount of oil was collected. Some oil, heavier than water, was collected in the sludge chamber. This oil was 37% by weight PCB. Some oil was still observed seeping from the ID fan housing; consequently, additional measures to remove oil from the offgas stream may be necessary.

4.6. Water Treatment System

Water condensed in the venturi scrubber contains PCB that must be removed before the water can be discharged to the environment. The water is treated in 500-gal mixing tanks as a batch process. The frequency of this processing is determined by the amount of water in the soil, the amount of water that remains with the offgas stream, and the amount of water that evaporates during recycling.

Condensed water is collected in one of two mixing tanks that can be manually valved in or out of the process (Figure 4.15). When a mixing tank is nearly full, it is switched offline and the second tank put into service. Approximately 18 to 23 kg (40 to 50 lb) of GAC are then added to the mixing tank at a rate of 5 lb/lb PCB, and the slurry is mixed with an electric stirrer for at least 30 min to provide good contact between the water and GAC. Estimates of PCB content were made by assuming all PCB in the feed soil was captured in the scrubwater (or condensate). The slurry is recirculated through a plate-and-frame filter press (Eimco) for ~30 min to separate the GAC from the treated water. Samples are pulled from the filter press outlet and the clarity of the filtered water visually observed. If the clarity is sufficient, a slip-stream of the filtered water is then pumped through two 55-gal drum activated carbon canisters as a final water polishing step (Figure 4.16). Treated water is held in tanks and sampled to verify that it contains less than 1 ppb PCB (in accordance with authorization from COMNAVMAR) before discharging it to the local sewer system.

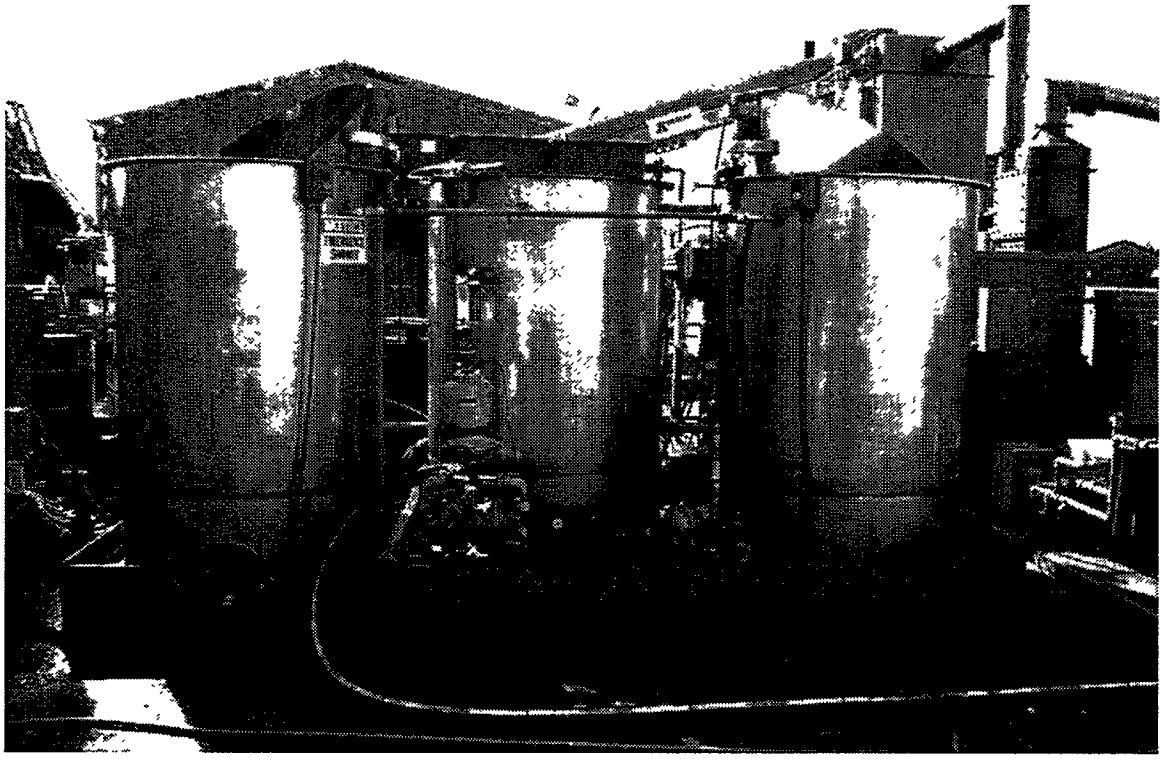


Figure 4.15. Stainless Steel Settling and Mixing Tanks

4.7. Stirred-Tank Reactor

The STR (Figure 4.17) is designed to treat the particulates collected by the cyclone and baghouse, the organic condensate/sludge collected in the oil/water separator, and the spent GAC from offgas cleaning and scrubber water treatment. In the STR, the PCB is completely decomposed, and the resulting slurry is suitable for recycle or disposal. The STR is a 400-gal batch kettle-type reactor heated with an external electric heater surrounding the vessel. The heater is controlled with a Chromalox temperature controller and a Chromalox high-temperature-limit switch. The temperature controller is operated with a thermocouple located inside the reactor. Table 4.1 provides a listing of the major components of the STR skid, along with a brief description of each component.

The GAC from the filter press and offgas cleaning is combined with the dust collected in the cyclone and the baghouse, and any collected oil. The combined wastes are batch-treated in the liquid-phase reaction developed by EPA-RREL (see Section 3.0). The reaction is carried out in the STR using reagents that consist of a high-boiling-point hydrocarbon oil, sodium hydroxide, a hydrogen donor material, and a proprietary catalyst. The solid wastes and the reagents are pumped or manually charged

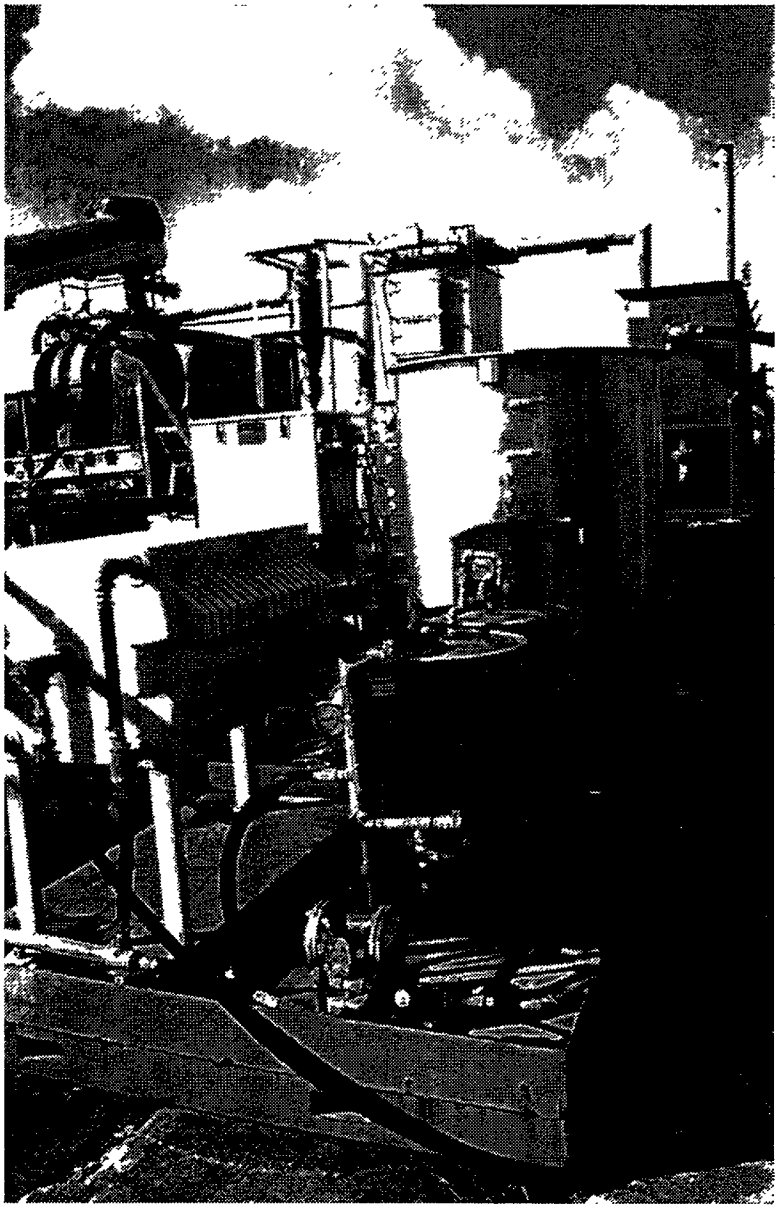


Figure 4.16. Filter Press and Activated Carbon Water Polishing Drums

into the reactor and mixed to obtain a slurry. The slurry is heated with constant agitation to approximately 350°C (662°F) and held at that temperature for 2 to 4 hr until the residual PCB concentration in the oil is reduced below the quantification level of 2 ppm per congener.

The reactor is purged with nitrogen during the reaction to eliminate the possibility of exceeding flammability limits in the vapor space of the STR. The reactor vent gas is cooled in an air-cooled heat exchanger to condense water and organic vapors. The condensate collected during the initial heatup of the reactor contains most of the water and light organics. This fraction is collected and treated with GAC

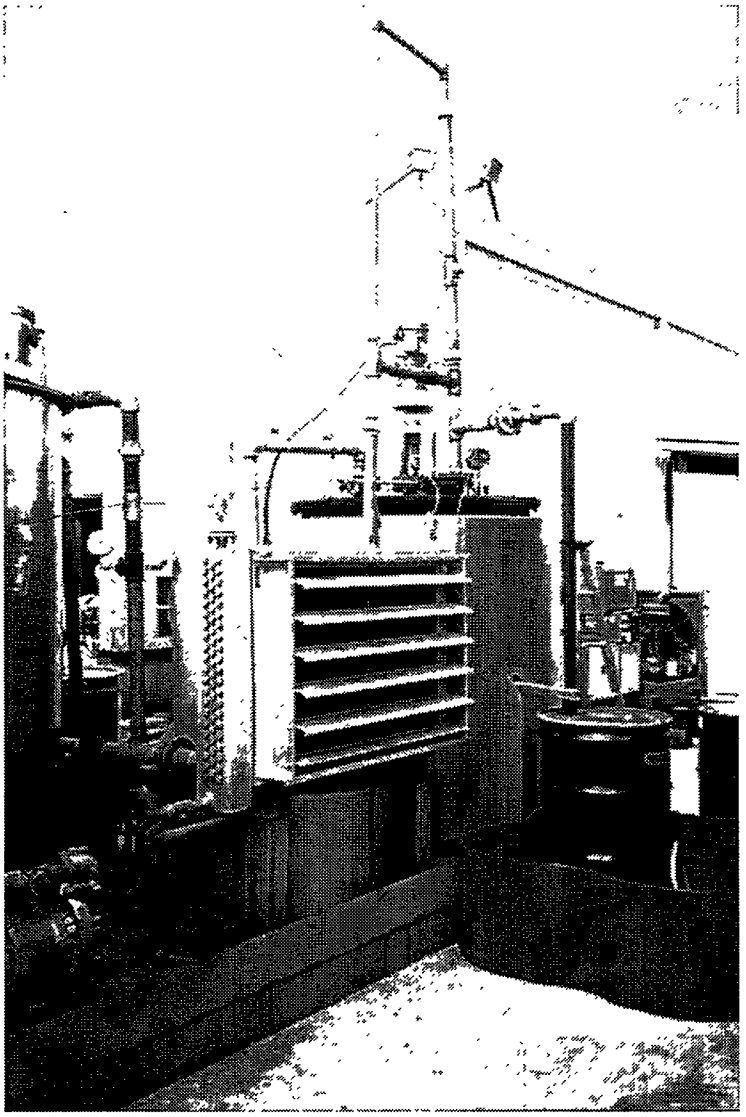


Figure 4.17. Stirred-Tank Reactor

before being discharged. The condensate subsequently collected at temperatures above 121°C (250°F) may be recycled/reprocessed in the reactor to destroy any volatilized PCB if present.

The small exit gas stream from the condenser is polished via activated carbon before it is vented. After the reaction has been completed, the reactor is cooled down, and the oily residue is transferred to a waste oil storage tank or drums. The treated slurry is allowed to settle for 24 hr or more so that clarified oil can be separated for reuse. From laboratory testing, it is estimated that approximately 80% (volume) of the oil can be reused for subsequent STR runs. The residual solids are analyzed to verify that PCB has been destroyed before recycle or disposal.

Table 4.1. Major Components on Stirred-Tank Reactor Skid

Item No.	Item Name	Item Description
T603	Stirred-Tank Reactor	48 in. D x 53 in. H x 3/8 in. wall; carbon steel, nickel lined
HR600	STR Heater	55 kW; 480 volt/3 phase input; heat to be transferred to 47-3/4 in. O.D. x 53 in. H reactor outer wall at 399°C (750°F)
MI603	Reactor Mixer	14 in. diam. impeller; 18 in. diam. rake, 3/4 in. x 55 in. shaft; 1-1/2 hp; 240/480 volt/3 phase input; carbon steel construction
T605	Waste Oil Tank	500 gal; stainless steel construction
MI604	Tank Mixer	12 in. diam. impeller; 3/4 in. x 36 in. shaft; 1/3 hp; 240/480 volt/3 phase input; stainless steel
HX600	Air-Cooled Condenser	200 lb/hr inlet steam at 100°C (212°F); 32°C (90°F) inlet air for cooling, aluminum fins on stainless steel tubes;
T604	Condensate Receiver	40 gal; stainless steel
CF600, CF601	Carbon Filters	<1 acfm inlet gas at 66°C (150°F)
P600	Filtrate Pump	20 gpm x 80 psi; air-powered diaphragm type; stainless steel construction
P620	Condensate Pump	5 gpm x 50 psi, air-powered diaphragm type; stainless steel construction
P621	STR Discharge Pump	50 gpm x 50 psi, air-powered diaphragm type; stainless steel
P622	Waste Oil Pump	50 gpm x 50 psi, air-powered diaphragm type; stainless steel

4.8. Automated Data Acquisition

Many of the critical process parameters during operation of the BCD system are monitored and recorded with automated data acquisition equipment. The use of the automated data acquisition equipment allows many temperatures, tank levels, and flowrates to be recorded much more frequently than would be possible manually. The data are recorded on an IBM-compatible personal computer (PC) where they can be easily reviewed and analyzed with standard spreadsheet software.

Originally, a Hewlett Packard Model 8564 Dataloggger interfaced to an IBM portable computer was used. The software used to interface to the datalogger was Labview for Windows. The software provided near real time data monitoring and storage to disk. However, the system was severely damaged in August 1993 by a direct hit by lightning, which traveled up the thermocouple leads into the datalogger.

A new data acquisition system was installed, using the same sensors. This system consists of a Campbell Scientific 21X Micrologger, two 32 channel multiplexers, and a PC running Campbell's Logger monitoring software included in the PC208 software package (Figure 4.18). This system was selected based on previous experience with these systems, its ability to run on battery power, and its ability to accept a wide range of sensors with a minimum amount of signal conditioning. The datalogger and multiplexers were mounted in the laboratory trailer for protection from the weather and easy access for interfacing to the PC. The system is also capable of being installed nearer the sensors with data being transmitted back to the computer via short haul or wireless modems. A list of location and type of sensors monitored is presented in Table 4.2.

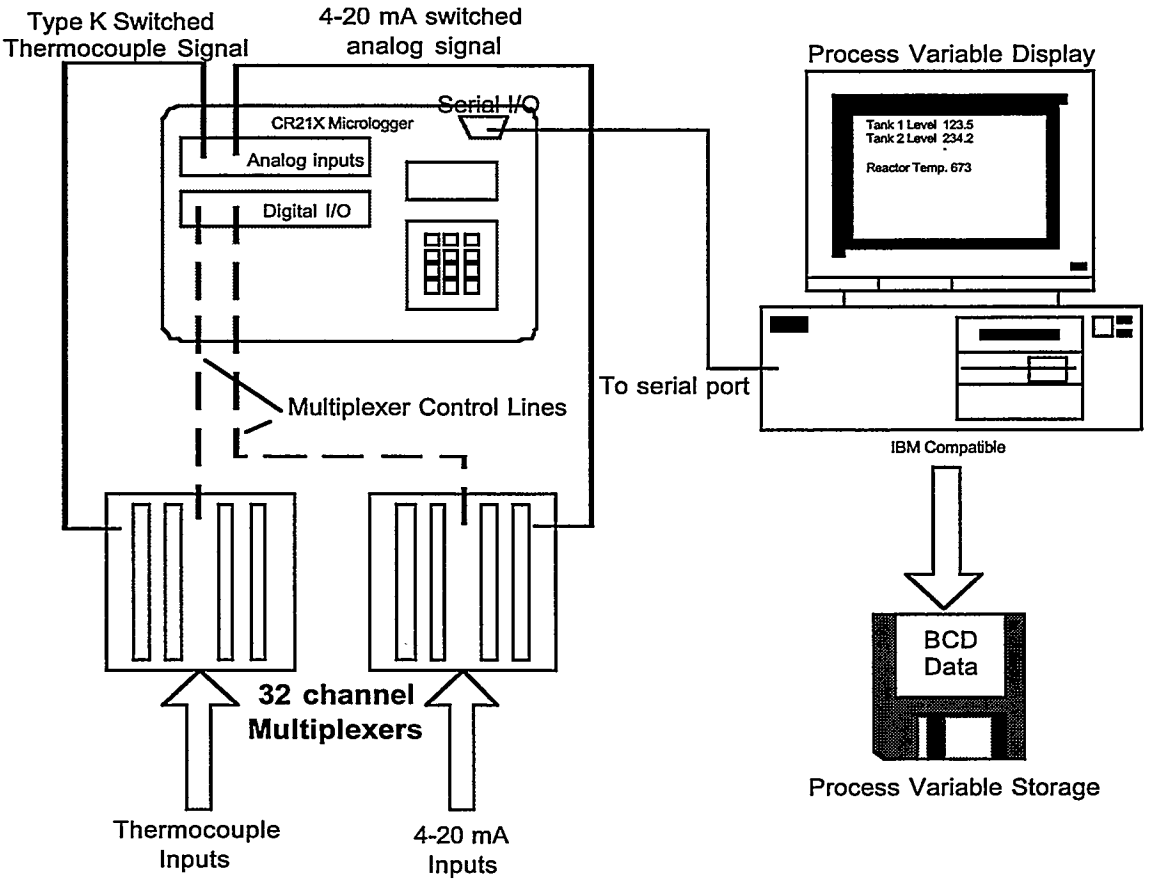


Figure 4.18. Schematic of Current Data Acquisition System

Table 4.2. Sensor Locations and Types Monitored with Automated Data Acquisition System

Description	Type	Units	Comments
Thermocouple Sensors			
21X Panel (Ref. Temp.)	Internal RTD	C	
Furnace Zone 1	Type K Thermocouple	F	
Furnace Zone 2	Type K Thermocouple	F	
Furnace Zone 3	Type K Thermocouple	F	
Furnace Zone 4	Type K Thermocouple	F	
Reactor Soil Temperature 5 ft from inlet	Type K Thermocouple	F	Used on all runs before 6 February 1994
Reactor Soil Temperature 9.5 ft from inlet	Type K Thermocouple	F	Used on all runs before 6 February 1994
Reactor Soil Temperature 13.5 ft from inlet	Type K Thermocouple	F	Used on all runs before 6 February 1994
Reactor Soil Temperature 18 ft from inlet	Type K Thermocouple	F	Used on all runs before 6 February 1994
Reactor Soil Temperature 22.5 ft from inlet	Type K Thermocouple	F	Used on all runs before 6 February 1994
Reactor Soil Temperature 27 ft from inlet	Type K Thermocouple	F	Used on all runs before 6 February 1994
Reactor Soil Temperature 31 ft from inlet	Type K Thermocouple	F	Used on all runs before 6 February 1994
Reactor Soil Temperature 35.5 ft from inlet	Type K Thermocouple	F	Used on all runs before 6 February 1994
TI-500 Scrubber Inlet Gas	Type K Thermocouple	F	
TI-501 Scrubber Outlet Gas	Type K Thermocouple	F	
TI-502 ID Fan Outlet	Type K Thermocouple	F	
TI-503 Scrubber Water Outlet	Type K Thermocouple	F	
TI-504 HX Inlet	Type K Thermocouple	F	
TI-505 HX Outlet	Type K Thermocouple	F	
TI-509 Stack Outlet	Type K Thermocouple	F	
TI-508 Carbon Canister Inlet (Air)	Type K Thermocouple	F	
TI-510 Reactor Outlet	Type K Thermocouple	F	
TI-511 Cyclone Inlet (Near Dilution Air T)	Type K Thermocouple	F	
TI-512 Baghouse Inlet	Type K Thermocouple	F	
TI-600 STR	Type K Thermocouple	F	
TI-601 STR Condenser Inlet	Type K Thermocouple	F	
I-602 STR Condenser Outlet	Type K Thermocouple	F	
4-20 mA Sensors			
Reactor Pressure	Omega Differential Pressure Sensor	in H2O	
LI-500 Scrubber Liquid Level	Level Sensor	gallons	
LI-502 Mix Tank 502 Liquid Level	Level Sensor	gallons	
LI-503 Mix Tank 503 Liquid Level	Level Sensor	gallons	
LI-602 Water Treatment Tank 602 Level	Level Sensor	gallons	
FI-503 Pressure Drop Across Stack Orifice	Differential Pressure Sensor	in H2O	
Feeder Scale	Reide Weigh belt	pounds	
Reactor Bed Temp. 8 ft from inlet	WDC Wireless Temperature Monitor	F	Installed in November 1994
Reactor Bed Temp. 12 ft from inlet	WDC Wireless Temperature Monitor	F	Installed in November 1994
Reactor Bed Temp. 16 ft from inlet	WDC Wireless Temperature Monitor	F	Installed in November 1994
Reactor Bed Temp. 20 ft from inlet	WDC Wireless Temperature Monitor	F	Installed in November 1994
Reactor Bed Temp. 24 ft from inlet	WDC Wireless Temperature Monitor	F	Installed in November 1994
Reactor Bed Temp. 32 ft from inlet	WDC Wireless Temperature Monitor	F	Installed in November 1994
Meteorological Data			
Wind Speed	RM Young	mph	
Wind Direction	RM Young	degrees	
Ambient Air Temp.	Type K Thermocouple	F	
Lab Trailer Air Temp.	Type K Thermocouple	F	

4.9. Support Facilities

Since material and advanced support facilities for the BCD system were not widely available on Guam, two portable facilities were designed to provide fabrication and maintenance capabilities and full analytical facilities for analyzing feed and product material for PCB. These facilities were fabricated in the continental U.S., tested in Stockton, and then shipped to Guam.

4.9.1. Portable Laboratory

The portable laboratory provides necessary onsite analytical capabilities to ensure fast turnaround of PCB analysis. The container also serves as an office and central location for datalogging equipment and analysis. The portable laboratory/office was incorporated into a standard, wooden-frame, 40-ft shipping container to allow easy shipment to Guam. The container is laid out into four rooms: the mechanical room, office, sample analysis, and sample preparation area. The mechanical room contains a 1-ton capacity air conditioning unit, required to cool and dehumidify the office and lab to protect sensitive equipment from the very humid Guam environment. The mechanical room also contains all electrical breaker and distribution panels.

The portable laboratory also contains a small office to conduct day-to-day administrative activities, store project records, and house datalogging equipment. Two personal computers are used in the office and networked with the computer used to control the GC-MS in the adjoining room. One computer is used for general office activities, and the other is used to display and log data from the datalogger. Specifics of the datalogging hardware were discussed in Section 4.8. The computers in the office are protected by a 3.5 kW uninterruptable power supply (UPS).

The main analytical room adjacent to the office houses the GC-MS system (Figure 4.19), provides storage for analytical supplies, and contains a refrigerator to store samples and standards. The GC-MS system is a state-of-the-art Hewlett-Packard Model 5980 Gas Chromatograph coupled to a Hewlett Packard Model 971 Mass Spectrometer with a Model HP7673A automatic sampler to allow unattended analysis of extracts. This analytical system also is protected by its own 3.5 kW UPS. This system was used to resolve the wide range of organic compounds found at the cleanup site. This system was used extensively during the February and November 1994 hot runs.

A sample preparation room adjacent to the analytical room contains a ventilated hood for performing extractions of soil, water, and oil to prepare samples for analysis by the GC-MS. Extraction from soils was performed with a six-station automated Soxtec extractor (Soxtec HT Extraction Unit, Model 1043). The room also contains a sink for cleaning glassware and an area to weigh samples with electronic balances.

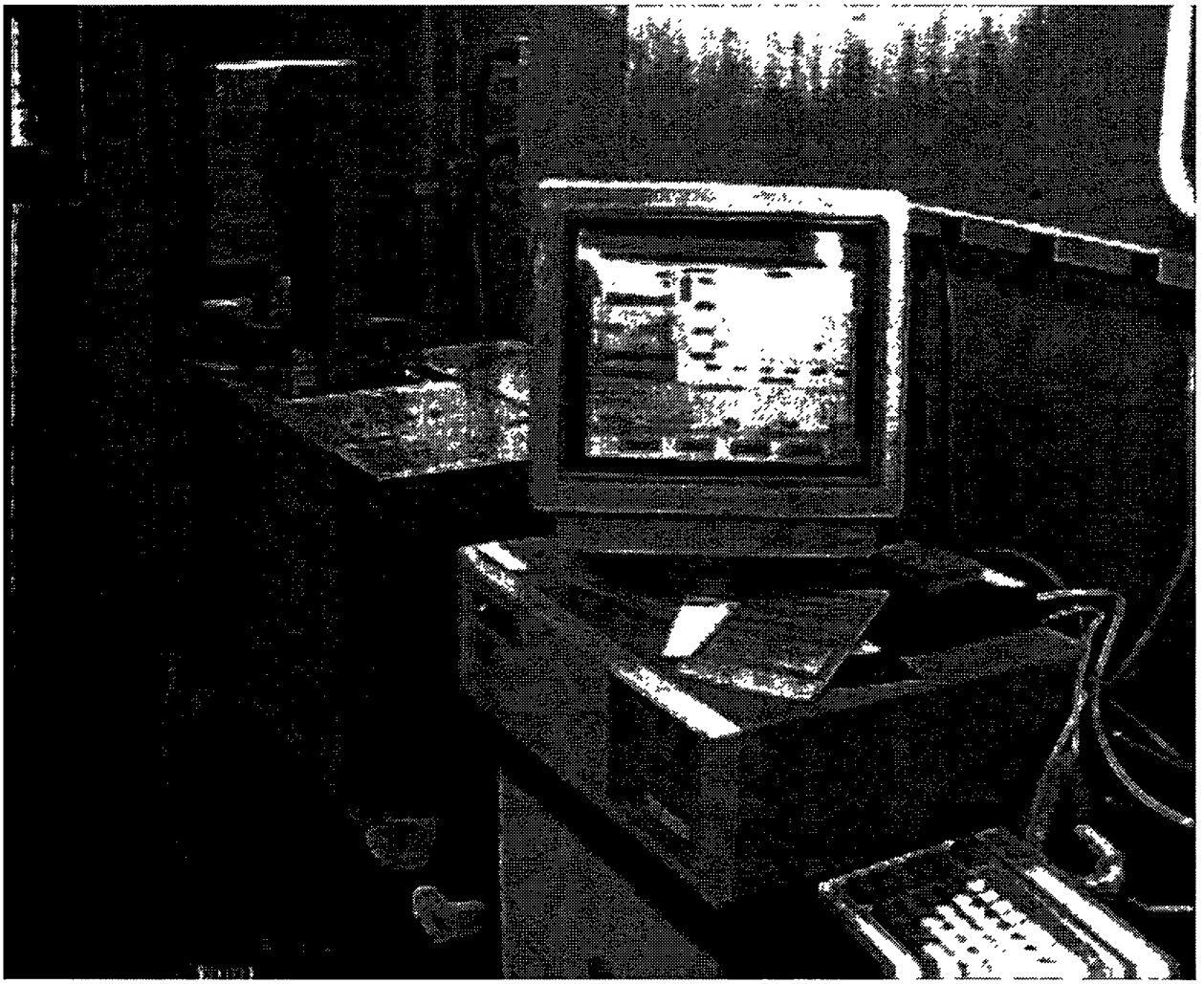


Figure 4.19. GC-MS System in Onsite Portable Analytical Laboratory

4.9.2. Portable Shop

The portable shop (Figure 4.20) provided facilities to assist in setting up the BCD system and fabricating specialty equipment. This shop continues to be used for performing onsite maintenance. The shop was constructed at PNNL from a standard 40-ft steel shipping container. It contains a large work-bench with extensive storage for spare parts, and a number of critical power tools. Power equipment used in construction and maintenance operations includes a drill press, welder, cutting torch, portable air compressor, portable band saw, and a variety of standard portable power tools. This facility was used extensively and was especially instrumental in allowing the equipment to be adapted to the requirements in Guam.

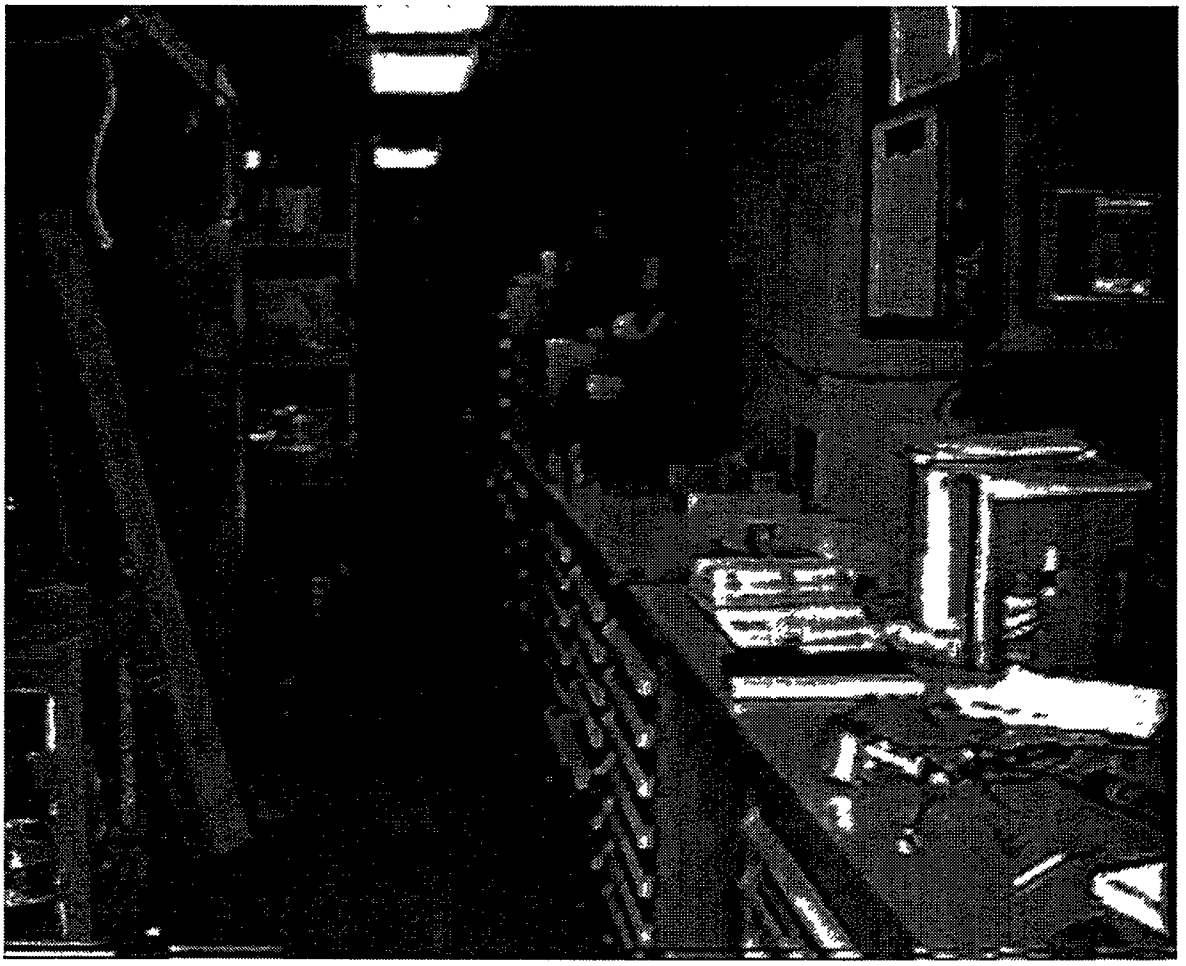


Figure 4.20. Portable Shop Facility

5.0 BCD Deployment and Operation

Over a 4-year period (February 1991 - May 1995), the BCD system was constructed and demonstrated to meet the objective of remediating PCB-contaminated soil. The initial equipment setup and process operation were conducted at a Navy site in Stockton, California, to demonstrate and test the system before shipping it overseas. Once it was shipped to Guam, the system was set up and deployed based on experience gained at the Stockton site and further refined as tests were run and conditions dictated. The work conducted and the results of tests in both Stockton and Guam are detailed below. This section expands on the activities summarized in Section 2.0, and some of the information is repeated here for continuity. Sections 5.1 through 5.4 describe deployment and operations for soil treatment. Section 5.5 describes operations for residual treatment in the STR.

5.1. Initial Equipment Setup and Shakedown in Stockton, California

In February 1991, plans were made to conduct a predeployment test of the BCD process in the continental U.S. before the system was set up in Guam. The rationale behind the predeployment exercise was that it would be less costly and would provide greater assurance of success if the system could be set up, integrated, and tested in the continental U.S., with better access to material, equipment, and vendors. The Naval Communications Station (NCS) in Stockton, California, was selected for the predeployment work. A PCB spill had occurred there in April 1984 from equipment stored inside Building 810, a large warehouse. The spill in the building caused contamination of the concrete floor and underlying fill. The original spill, which occurred in a room 61 x 61 m (200 ft x 200 ft), consisted of approximately 76 L (20 gal) of PCB-laden hydraulic oil (approximately 910,000 ppm PCB). Sampling of the contaminated area, which was conducted in January 1987, revealed that Aroclor 1242 was most abundant. Aroclors 1248, 1252, and 1260 were also present. For the BCD demonstration, uncontaminated soil (cold testing) and up to 80 tons of contaminated soil (hot testing) were to be treated under a TSCA R&D permit.

By June 1991, a Health and Safety Plan for operations in Stockton had been approved, and meetings were held with the City of Stockton Waste Water Treatment Plant and with the San Joaquin Unified Air Pollution Control Authority to obtain the necessary permits, waivers, and approvals for the R&D testing. On 24 September 1991, EPA's Office of Toxic Substances (OTS) granted an approval to NCEL (now NFESC) to conduct R&D tests to treat PCB by using the BCD process on the contaminated soil at the NCS.

Beginning in August 1991, five 40-ft containers containing the offgas and water treatment systems and other equipment and supplies were shipped from BCL's Columbus, Ohio, facilities and three 40-ft containers (portable laboratory, maintenance shop, supplies) were shipped from PNNL (Richland, Washington). In addition to the eight 40-ft containers, several other large pieces of equipment, including

the pugmill, feeder conveyor, crusher, and reactor were shipped to Stockton. Most of the equipment began arriving in September 1991, and setup and integration of the components began.

5.1.1. Equipment Setup

Much of the initial effort at the demonstration site was focused on installation of basic utilities. Existing electrical utilities near Building 810 were not of sufficient capacity. After several weeks, NCS personnel located a large transformer with sufficient capacity to support all of the BCD equipment. Additional delays in setup occurred when it was discovered that the only bridge leading to the NCS had been damaged and load size was restricted to 10 tons. The rotary kiln reactor was well above this limit; consequently, several meetings and a number of days were required to resolve the issue. Approval was finally received from the Navy to allow the reactor to cross the bridge. The crossing went without incident.

The components of the BCD system were set up and integrated during September and October 1991. The system layout is shown in Figure 5.1. Once the installation was complete, each piece of equipment was tested for full function and adjusted and calibrated when necessary. At the end of October, the system was ready for testing with uncontaminated soil.

5.1.2. Stockton Runs (October - November 1991)

The first operational test of the system was conducted on 29 October 1991. Approximately 7.6 m^3 (10 yd^3) of local concrete sand were obtained for use as a feed simulant. This sand was moist but relatively free flowing, representing an ideal feed material. During initial startup, the gate valves on the rotary reactor would not completely cycle. This problem turned out to be an automatic shutdown condition in the programmable logic controller, which was caused by excessive shell temperatures in one of the four zones monitored by the burner controllers. Several burners were shut off to reduce the temperatures, and only four to six burners were required to obtain the desired shell temperature. The soil temperature, however, was only ~216°C (430°F), well below the target of 350°C (662°F). Maximum soil feed rate was less than 0.5 ton/hr.

A second test was conducted on 30 October using the concrete sand as feed. The objective of this test was to increase throughput and soil temperature. Five to six burners were required to keep the shell temperature near the 538°C (1000°F) recommended operating temperature. Feed rates were determined by collecting the soil discharged from the reactor in 55-gal drums on a platform scale. The drums were replaced approximately every 15 to 20 min. Based on the discharge, throughput in the reactor reached a maximum of ~0.75 ton/hr. Difficulty in obtaining reliable soil temperature measurements prompted installation of a thermocouple directly in the discharge breach of the reactor. This thermocouple showed soil temperatures of over 325°C (617°F). It took approximately 4 hr from the time the feed was initiated before the discharge soil temperatures reached this level. A white tracer sand

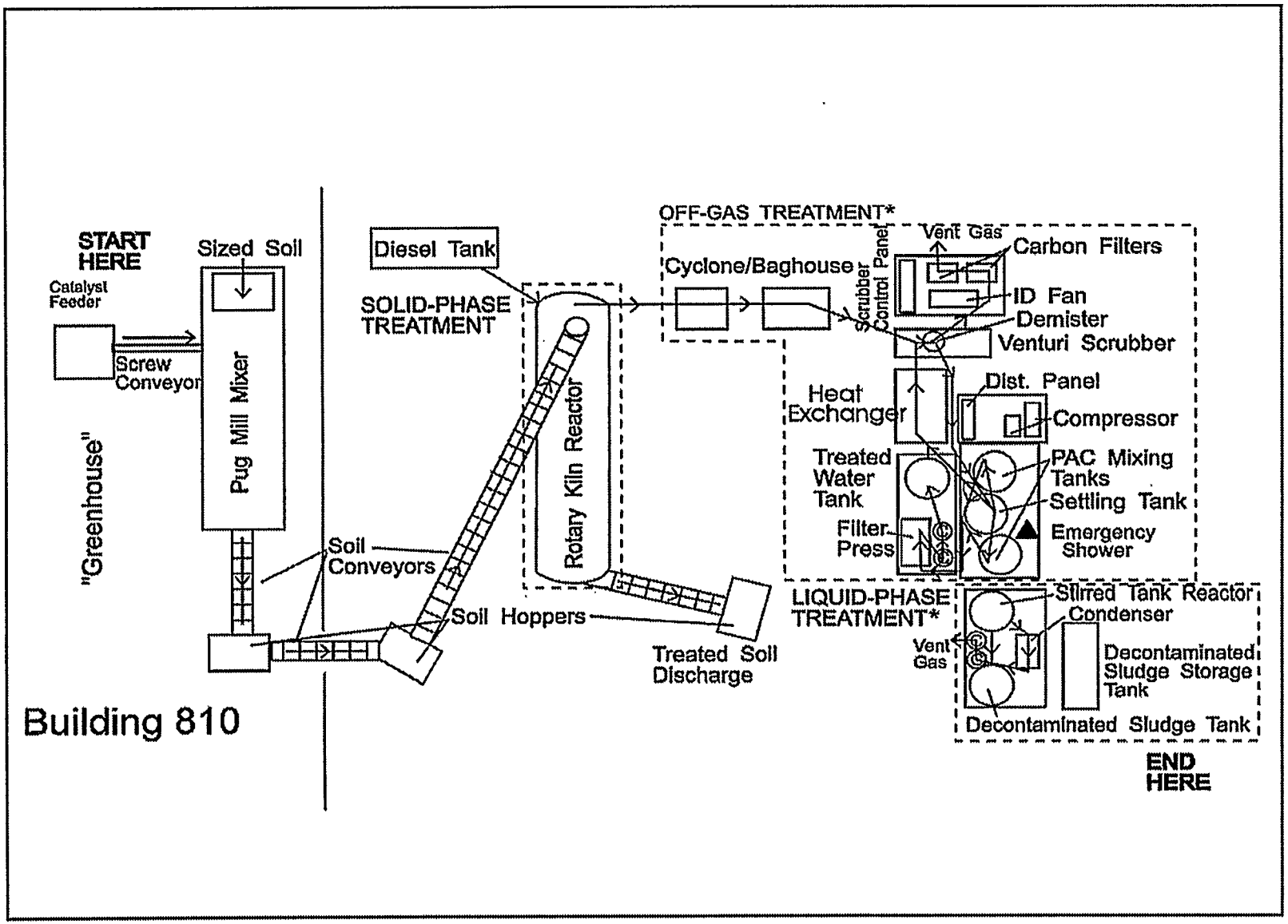


Figure 5.1. Equipment Layout at Naval Communications Station - Stockton, California

was introduced into the reactor near the end of the run to better determine the soil residence time. The sand indicated a 70-min residence time through the entire reactor, which is somewhat low if a 1-hr residence time at 350°C (662°F) is required.

The third shakedown run was conducted on 1 November. The objective of this test was to determine the behavior of a feed containing 10% by weight sodium bicarbonate. The main observations from this run were 1) the feed tended to bridge in the feed hopper, requiring frequent operator intervention to maintain flow, and 2) soil was leaking out of the front seal between the bellows and the kiln. The front access plate on the reactor was removed the next day, and a large buildup of soil was found in the feed plenum. Because the feed apparently was flowing over the shallow dam between the feed plenum and the reactor shell, the dam height was increased by welding a ring on the existing dam.

A fourth shakedown run was conducted on 5 November. The objective of this run was to increase residence time and soil temperatures; therefore, the slope of the reactor was decreased by using the front reactor jack adjustment. The slope was decreased by 5.1 cm (2 in.) from the front resting point to obtain a total of 41 cm (16 in.) elevation from level. The reactor shell was heated to an interior temperature of >370°C (700°F) before any soil was introduced. After 4 hr of operation, the outlet temperature of the feed was over the 350°C (662°F) target. Sand was again observed leaking from the front bellows seal, indicating that modifications had not entirely fixed the problem.

5.1.3. Cancellation of Stockton Hot Tests

Following successful completion of cold shakedown tests, the Navy elected to terminate the planned hot testing in Stockton, primarily due to a funding issue and a stringent decontamination requirement imposed by the Guam EPA. The hot tests would have treated an estimate 80 tons of PCB-contaminated soils. If the hot tests had been conducted, they would have been in compliance with all rules, regulations, and requirements prescribed in the R&D permit. The Navy elected to send the uncontaminated equipment directly to Guam and conduct the hot demonstration tests there.

5.1.4. Conclusions from Stockton Operations

The tests conducted at Stockton showed that the BCD equipment functioned as designed. Confirmation of the process chemistry with the equipment was not possible since it was not operated with contaminated soil. Key observations and recommended actions/modifications as a result of these tests are summarized below.

1. Spillover of feed into the front plenum had to be addressed.

2. Burners had more than enough heat output to operate the shell at maximum designed operating temperature.

3. The amount of fines collected from the cyclone and baghouse was very small, which may reduce the total amount of material that must be processed in the STR.

4. Burners on the reactor required further adjustment to provide more reliable operation.

5. Bridging of the feed material in the feed conveyor hopper needed to addressed before operation in Guam.

5.2. Guam Operations

The overall objectives of the PWC-Guam operations were to 1) set up the BCD system near Building 3009, 2) demonstrate that it operated as designed by conducting a series of equipment shake-down and full-scale tests with noncontaminated soil (cold tests) and contaminated soil (hot tests), and 3) transfer the BCD system to the Navy and the Navy's Remedial Action Contractor (IT Corporation) for the cleanup of the soil near Building 3009. The following sections detail how these objectives were met.

5.2.1. Receiving and Assembly

In late August 1992, the BCD equipment (9 containers, 3 flat rack loads, nearly 200 tons total) was shipped to PWC-Guam and delivered to the demonstration site. An approaching storm prevented access to the necessary cranes to unload and position the containers. On 28 August 1992, Typhoon Omar, with winds reportedly exceeding 240 km/hr (150 mph), struck Guam and caused severe damage to all portions of the island. Fortunately, no significant damage to the BCD equipment occurred. However, lack of power and water and general disarray of the island required that system setup be postponed to January 1993.

In January 1993, site preparation activities got underway, including the installation of electrical services to supply power to the laboratory and shop trailers. In February and March 1993, PNNL began installing the equipment. During this time, modifications were made to the rock crushing plant and rotary kiln reactor feeder by covering conveyor belts with corrugated galvanized panels to prevent contaminated soil from blowing off the conveyors and to protect the soil from rain. The discharge conveyor on the crusher was lengthened to allow direct discharge into the pugmill feed hopper. IT staff enlarged the concrete pad to provide a suitable surface for the crushing plant and mixing plant. Site preparation and equipment modification activities continued in April. In June and early July, the modifications were completed. An overview of the system is shown in Figure 5.2.

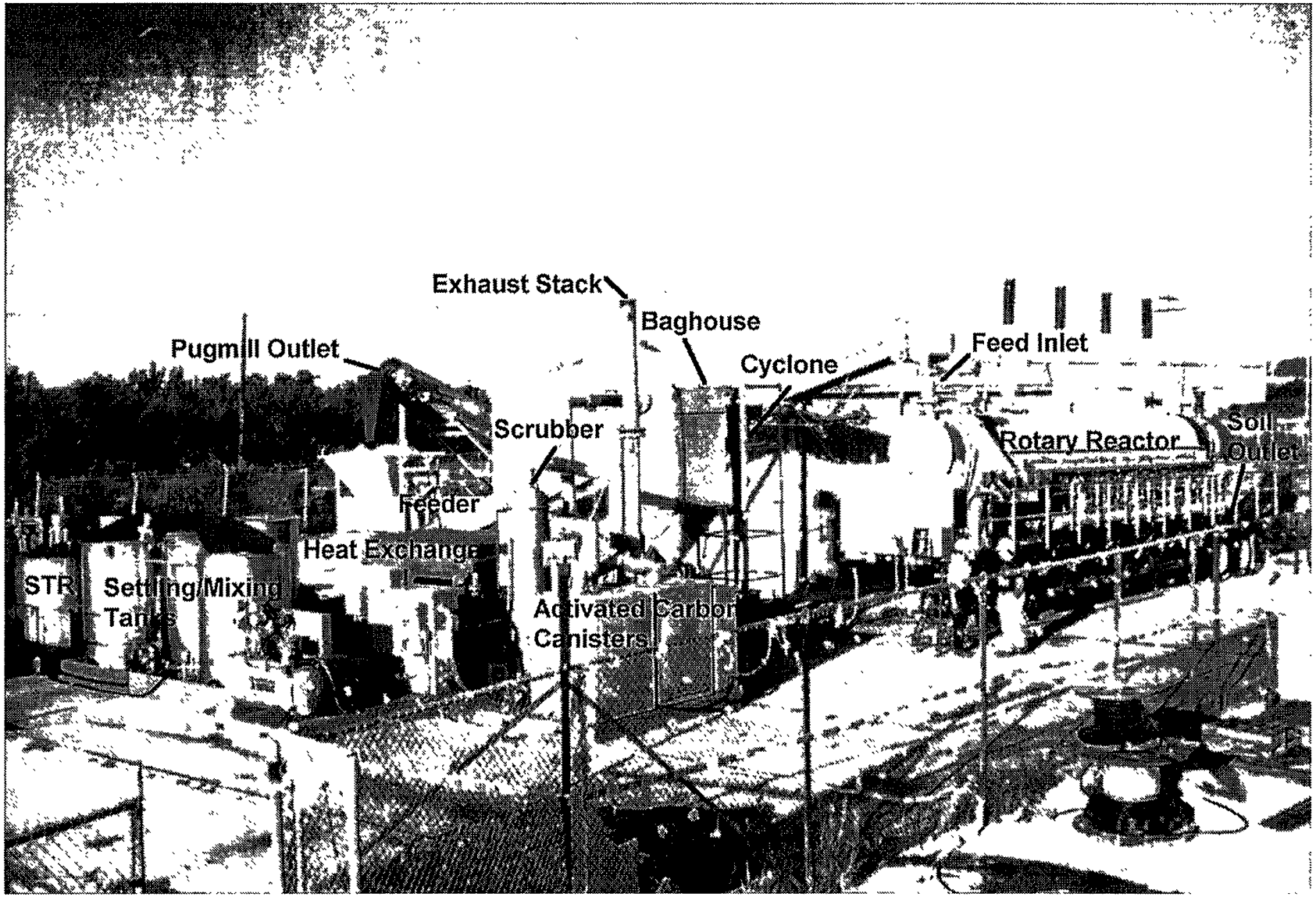


Figure 5.2. Equipment Layout at PWC Maintenance Compound in Guam

5.2.2. Equipment Shakedown (Cold Testing)

The objectives of the July 1993 cold runs were to perform equipment shakedowns and adjustments, demonstrate the operability of the integrated system, and identify any further modifications and repairs needed before testing with contaminated material. A total of five experimental runs processed approximately 30 tons of uncontaminated soil during July 1993. The five tests included a shakedown test without any sodium bicarbonate, an initial test with 10% by weight sodium bicarbonate, and three full-day experimental runs that closely simulated actual hot operations. Several operating problems were discovered during the course of initial shakedown and cold testing. Corrections and modifications were made, and on 23 July 1993 the final cold test was conducted in which more than 10 tons of material were successfully processed in 8 hr. The objectives and results of the experimental runs are summarized below. Detailed run data are given in Appendix D.

5.2.2.1. Run 1- Initial Shakedown (15 July 1993). The primary objective of the initial shakedown test was to perform a slow reactor heatup to dry the saturated cast refractory without major thermal expansion and spalling problems. Other goals included resetting burner controls, observing feed preparation equipment operation without sodium bicarbonate catalyst, observing gas treatment system operation, and correcting any major deficiencies or operating problems. Three to four tons of material were successfully processed at feed rates of 0.5 to 0.75 ton/hr. Both the crusher and mixing plant appeared to work reliably, but several other materials handling issues were observed. The most significant of these issues was bridging and clogging problems in the hoppers and reactor feeding system as a result of the high water content of the feed. Another problem identified was the soil spilling off the crusher and mixing plant conveyor belts.

5.2.2.2. Run 2 - Sodium Bicarbonate Feed Test (17 July 1993). In Run 2 the primary objective was to integrate the sodium bicarbonate catalyst into the materials preparation scheme and observe the effect of moisture on feed handling characteristics. This was a opportune test of moisture effects since heavy showers persisted throughout the day. Initially the feed rate was only 0.6 ton/hr, but was later increased to approximately 0.8 ton/hr. A total of 4 to 5 tons of soil were processed in 6 hr. There were many materials handling problems because of the excess moisture, and the operation was complicated by the sludge-like behavior of the feed material. In addition, water condensation in the cyclone and baghouse was observed. This experience showed the need for a covered feed storage and for protecting the feed from rain during preparation.

5.2.2.3. Run 3 - Full-Scale Operations (19 July 1993). Run 3 was planned as the first full-scale operation at design conditions. The objective was to increase the feed rate to the design condition of 1 ton/hr. The weather was clear and very hot, but the soil was still wet from the previous day, and minor materials handling problems continued. Approximately 4 tons of soil were processed at a maximum feed rate of 0.77 ton/hr. Additional adjustment of the burners to achieve uniform heating of the soil continued without complete success. Attempts to increase the feed rate were also thwarted by several emergency shutdowns due to overheating of the reactor rotation motor.

5.2.2.4. Run 4 - Full-Scale Operations (21 July 1993). Several adjustments were made for Run 4 to allow better materials handling. First, the feed valve cycle time on the reactor inlet was reduced from 60 to 30 sec. With these adjustments, much smaller batches of soil were fed to the reactor, which reduced bridging. Even though heavy showers persisted during the day, feed problems were reduced. Secondly, the reactor rotation speed was increased to 1.5 RPM to allow higher feed rates. Approximately 4 to 5 tons were processed at 1.31 ton/hr. However, even though the residence time in the reactor was near the required 1 hr, the soil did not reach the required temperature of 350°C (662°F). Additional adjustments of the burners were necessary.

5.2.2.5. Run 5 - Final Full-Scale Operations (23 July 1993). During Run 5 the feed valve cycle was further reduced to 20 sec to decrease batch sizes. The reactor rotation was lowered to its original setting (1.1 RPM), and the rotation motor was periodically cooled by a water spray. This increased the soil residence time to an estimated 1.5 hr. Approximately 10 tons of material were successfully processed at an average feed rate of 1.17 ton/hr. With a fairly dry feedstock and short feed cycles, materials handling was adequate until heavy showers started during the last hour of operation. Shutdown was normal and initiated when all prepared feed had been processed. Burner adjustments appeared adequate. Soil temperatures in the last half of the reactor were at target levels 350°C (662°F) as shown in Figure 5.3.

5.2.2.6. Shakedown Summary. The shakedown testing and initial cold testing successfully demonstrated the operability of the BCD system while processing approximately 30 tons of material. This testing also served to identify areas of operational difficulty and equipment and operational strategies that required modification. In addition, a full complement of PNNL and IT Corporation staff was fully trained or re-familiarized in the operation and handling of the system. The operational issues identified for resolution before hot testing commenced are summarized in Table 5.1.

5.2.3. February 1994 Testing

Soon after the July 1993 cold shakedown tests, a major earthquake (8.1 on the Richter scale) struck Guam (8 August 1993), causing severe damage to hotels and other structures on the island. In September 1993, a PNNL representative traveled to Guam to inspect the equipment for damage. Only minor damage appeared to have occurred as a result of the earthquake; the inspection indicated that lightning strikes had destroyed some of the electronic equipment. In December, materials and equipment procured for hot testing the BCD system were packed into a 20-ft container and shipped to Guam.

Many of the issues identified in the July 1993 cold run were addressed, and equipment modifications were made before hot testing with PCB-contaminated soils. Equipment modifications included installation of wipers on the crusher and pugmill conveyor belts; addition of pneumatic and electric vibrators on the sodium bicarbonate, pugmill, and feeder hoppers; replacement of the reactor rotation

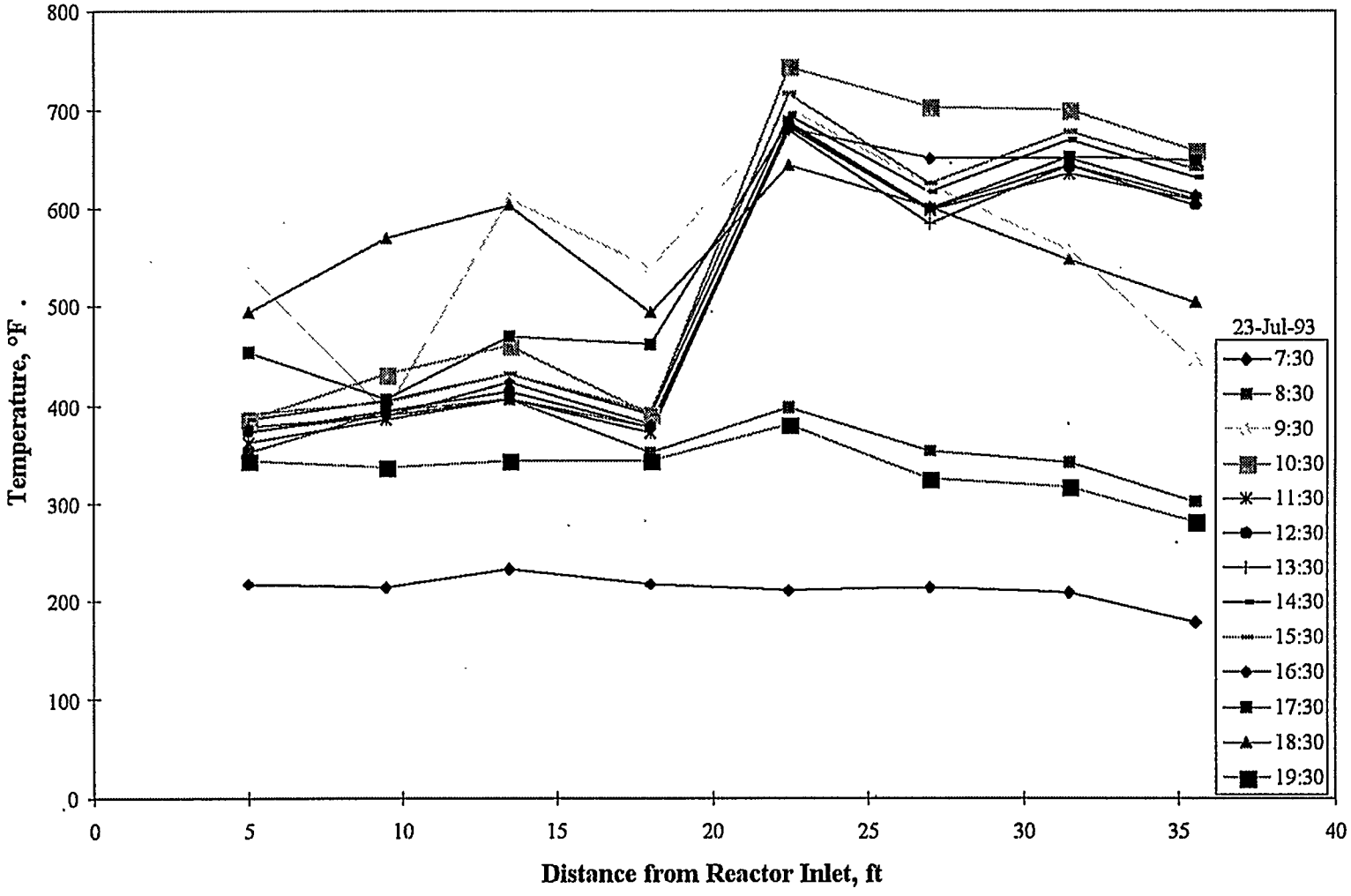


Figure 5.3. Temperature History of Soil at Selected Locations in the Reactor

Table 5.1. Significant Operational Issues Identified in July 1993 Cold Run

Issue Identified	Proposed Solution
Soil sticks to crusher and pugmill conveyors and falls on ground.	Install heavy duty wiper at top of conveyor.
Dust generated at crusher hopper.	Install water spray system on grizzly.
Soil bridges in pugmill and feeder hoppers.	Install hopper vibrators.
Rain causes soil in hoppers to become too wet.	Install tarps temporarily and eventually build feed prep building.
Difficult to load sodium bicarbonate sacks with Bobcat loader.	Obtain large fork lift or redesign sodium bicarbonate feed system.
Bridging in feeder hopper.	Install electric vibrator on hopper.
Poor access to reactor feed inlet area to allow maintenance and clear feed clogs.	Build catwalk and ladder to service area.
Reactor rotation motor overheats.	Replace with lower RPM motor.
Soil falling into front plenum of reactor.	Modify deflector/dam.
Reactor burners still operate erratically.	Bring factory representative to Guam.
Hot material falls off reactor discharge conveyor.	Modify receiving bin on discharge conveyor.
Intermittent water condensation in cyclone discharge.	Insulate cyclone or keep operating temperature above 150°C (300°F).
Magnetic flowmeter on heat exchanger not functioning.	Replace with rotameter.
Offgas activated carbon canister cabinets leak.	Replace/repair cabinets.

drive motor with a lower RPM unit; and installation of new burner instrumentation. Scaffolding was installed around the reactor feed hopper to allow better and safer access when observing or unplugging the reactor feed inlet. A 1-ton trolley hoist was constructed to allow the sodium bicarbonate bags to be loaded onto the catalyst feeder frame. During the equipment modification work the lightning strikes during August 1993 were found to have inflicted more damage than originally thought. In particular, the Hewlett Packard Datalogger was no longer functioning, which required that process data be logged by hand. Also, a number of the electronic process indicators and controllers were not working. An equipment shakedown run was conducted in early February to verify the effectiveness of subsequent modifications.

5.2.3.1. Modified Equipment Shakedown. Two shakedown runs were conducted to test the equipment modifications and ensure that all of the equipment was fully operational prior to conducting operations with contaminated soil. The first run, conducted on 31 January 1994, was designed to test operability of the equipment. Very little process data were collected during the run. Approximately 5 tons of soil were processed without any major problems.

On 2 February, a cold run was conducted but treated as a mock hot run to provide training on sampling procedures, data recording, and final checkout of all of the equipment. The weather for the test was sunny, and feed material was relatively dry. The soil throughput, as measured by weighing the soil discharge, ran from 0.8 to 1.1 ton/hr, representing a 1.0 to 1.10 ton/hr of wet feed. The soil residence time was measured by dropping metal tracers into the feed hopper and measuring the time it took to exit the discharge of the reactor. Residence time was found to be about 1 hr and 40 min, and maximum soil temperatures were 343°C to 371°C (650°F to 700°F). A total of 4.4 tons of material were fed during the run. Fines collected from the cyclone and baghouse were 41 kg (90.5 lb) and 2.7 kg (6.0 lb), respectively, which represents approximately 1% of the feed. No net water was collected from the offgas, which is not surprising given the dry nature of the feed.

5.2.3.2. 5 February 1994 Hot Test. The objectives of the first hot run on 5 February 1994 were to demonstrate the efficacy and operability of the process while operating the system at optimum conditions (i.e., target feed rate of 1 ton/hr; sodium bicarbonate to dry soil ratio, 0.1:1; and residence time of 1 to 1.5 hr). The goal was to show that the process chemistry previously demonstrated on a laboratory scale under ideal conditions was capable of decontaminating the soil to less than 2 ppm per congener PCB in a large-scale system. This was the first time contaminated soil was processed by this BCD system.

Run Description. The inaugural hot run was initiated with the startup of the reactor at 07:30. The reactor was slowly heated over a 3-hr period using 7 of the 14 burners to obtain furnace temperatures of ~538°C (1000°F) across all four monitoring zones. At this point the internal temperature (air temperature) of the kiln was near 427°C (800°F). Feed was introduced into the reactor at 10:37, and an additional burner at the feed end of the reactor was turned on at 10:45. An additional burner was added at 11:20 followed by a tenth burner at 12:02. Two more burners were added at 12:31 to ensure sufficient soil exit temperatures. At 14:20 a burner was turned off when the shell temperature approached 577°C (1070°F). Additional burners were shut off at 19:18, 20:38, and 21:19. The last feed entered the reactor at 20:38, and the system was shut down at 22:00.

During the run approximately 10 tons of soil containing PCB ranging from 200 to 1500 ppm were processed successfully through the crushing plant, pugmill, and rotary reactor. Catalyst concentrations were ~10% by weight as were moisture levels in the soil. PCB concentrations measured in all samples of the treated soil were less than 0.5 ppm per congener. During the last part of the run, a cyclic, metallic noise came from inside the reactor. Inspection of the reactor following the run revealed the

thermocouple assembly had fallen from its supports and was severely damaged. The thermocouple assembly was subsequently removed from the reactor (and eventually replaced, see Section 5.2.4.1).

Run Data. During the run, nearly 10 tons of PCB-contaminated soil were fed to the reactor, as measured by both the feed conveyor totalizer and the discharge weigh scale. The cumulative amount of soil fed and discharged is shown in Figure 5.4. The only feed problems occurred during the end of the run when a root caught in the feed hopper and caused a plug, but only led to about a 10-min delay in feeding soil and no interruptions in the rest of the process.

The reactor performed very well during the hot run. Soil temperatures in the discharge half of the reactor were typically over 371°C (700°F) as shown in Figure 5.5. The range of temperatures measured in the four furnace zones is shown in Figure 5.6.

Offgas Treatment System Operations. Overall, offgas and scrubwater treatment equipment performed reasonably well. Some oil (10 to 100 g) penetrated the wet scrubber and was collected in the ID fan by impaction on the fan blades. Additionally, the carbon canisters for final offgas polishing leaked, allowing small quantities of offgas to bypass one of the carbon beds.

Sampling Procedures. Periodic samples were taken of various process streams to allow system performance and material balances to be determined. Table 5.2 shows the types of sampling conducted and the frequency of samples taken.

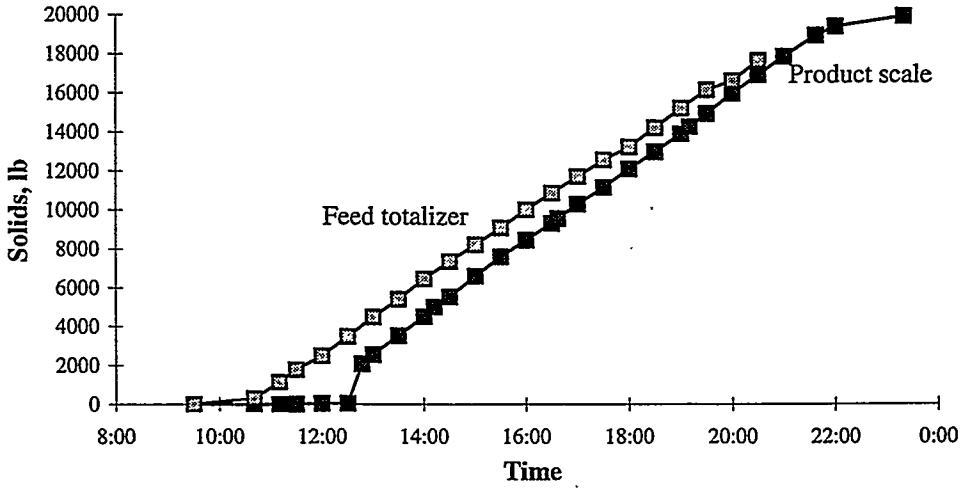


Figure 5.4. Soil Feed and Discharge Rate During 5 February 1994 Hot Run

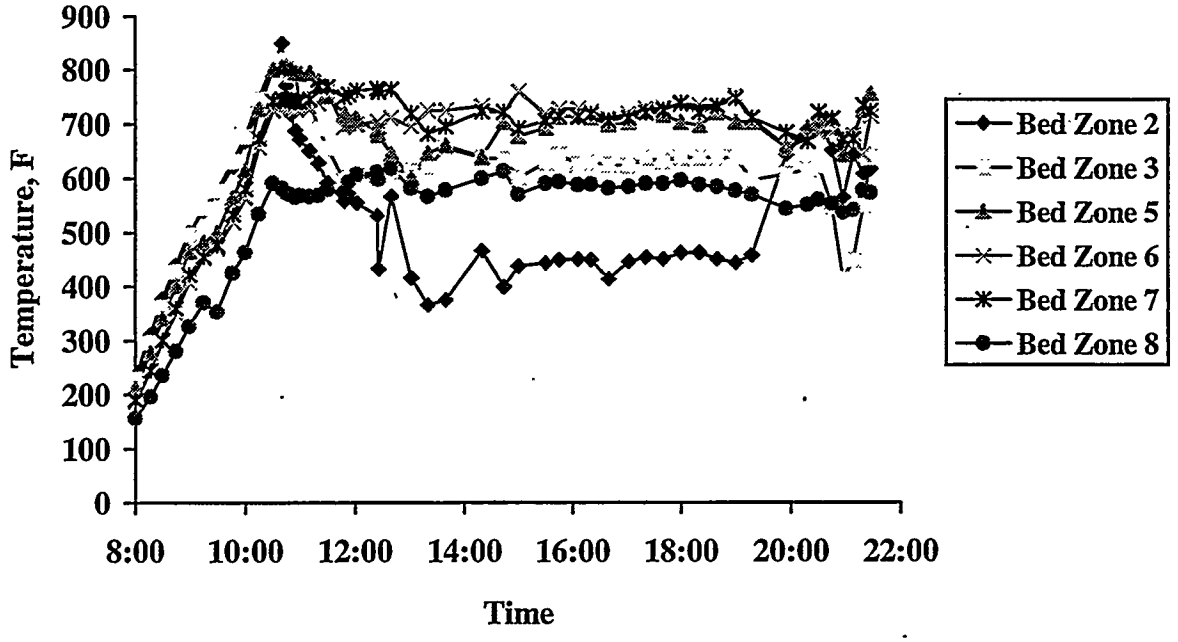


Figure 5.5. Soil Temperatures in Rotary Kiln Reactor During 5 February 1994 Hot Run

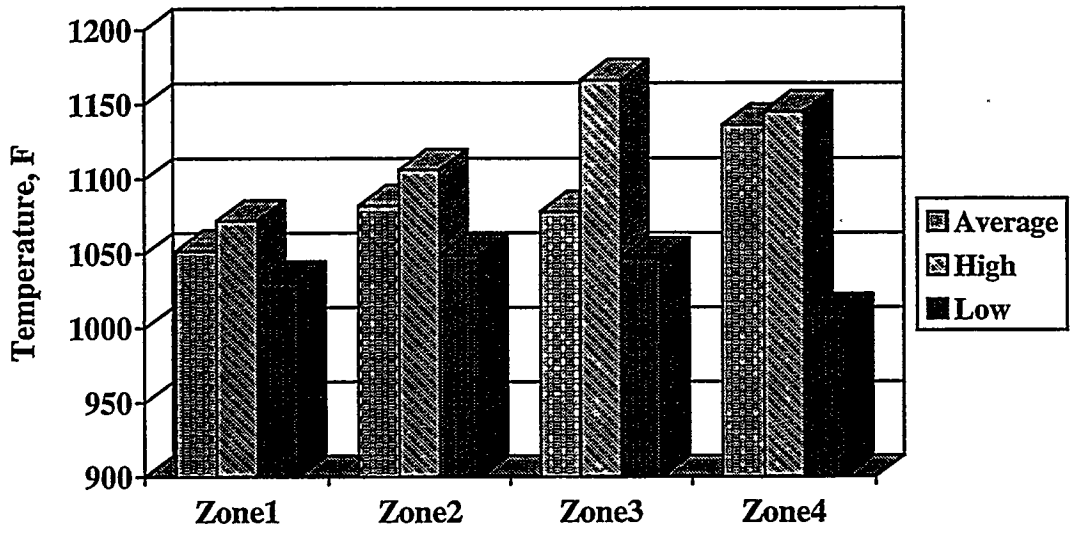


Figure 5.6. Range of Temperatures Measured in Furnace Control Zones

Table 5.2. List of Sampling Procedures and Analyses for Initial Hot Run

Sample Description	Frequency Taken	Analysis Performed
Soil feed samples	Grab samples taken every 30 min and composited every 2 hr. Only composites analyzed.	Moisture, PCB, Dioxins
Processed soil	Same as feed samples	PCB, Dioxins
Cyclone dust	Once at end of each run	PCB, Dioxins
Baghouse dust	Once at end of each run	PCB, Dioxins
Scrubber water	Once before and once after mixing in activated carbon	PCB
Activated carbon	After water treatment is completed	Moisture, PCB
Treated water	At end of water treatment cycle	PCB
Air discharge	Several during run	PCB

Samples were analyzed for PCB at the onsite lab by a chemist provided by the Navy. A selected number of samples (some duplicated) were then sent off-island for official confirmation by Southwest Research Institute (SWRI) in San Antonio, Texas. A summary of the analyses by both labs is given in Appendix E. Specific analytical data are discussed below.

PCB concentrations in the feed varied by nearly a factor of 4 over the course of the run, as shown in Figure 5.7. Overall, the average concentration of PCB in the feed soil was 630 +/- 100 ppm. A typical distribution of the PCB chlorination levels present in the feed soil is shown in Figure 5.8. This figure shows that the feed contained mainly hexachlorobiphenyls and heptachlorobiphenyls, typical of Aroclor 1260.

All product (treated soil) samples tested by the onsite lab and by SWRI showed nondetectable (<0.5 ppm) levels of PCB for all chlorination levels. These nondetectable levels demonstrated the effectiveness of the BCD process and represented a greater than 99% removal efficiency from the contaminated soil.

Analysis of the cyclone and baghouse dust showed increased levels of PCB as expected (Table 5.3). In addition, analysis for dioxins showed unexpected high levels. A material balance (Table 5.4) was performed on the dioxins to determine their origin (Figure 5.9). Based on the analytical data, definitive information does not exist to conclusively determine whether dioxins and furans in the cyclone and baghouse were concentrated from the feed or generated in the reactor.

5.2.3.3. 10 February 1994 Hot Run. On 10 February 1994, a 6-ton hot run was successfully completed to allow PACDIV personnel to observe system operation. In this run, catalyst concentrations were reduced to ~5% by weight. The outlet temperature from the reactor during this run was lower than in the previous run because information on the soil temperatures was lacking (i.e., the reactor thermocouple assembly had been destroyed on 5 February 1994). All but one sample of treated soil contained

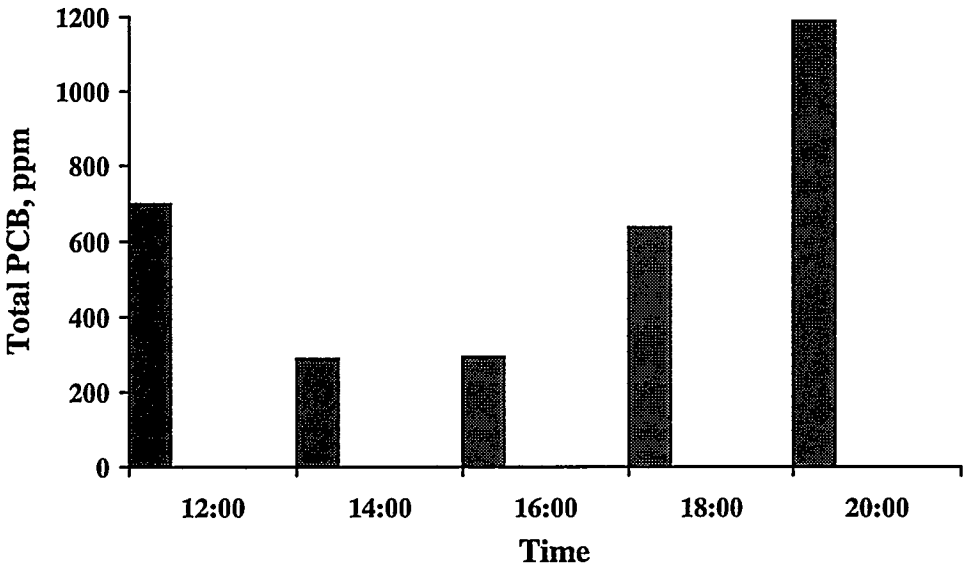


Figure 5.7. PCB Concentration in Feed Composite Samples During 5 February 1994 Hot Run

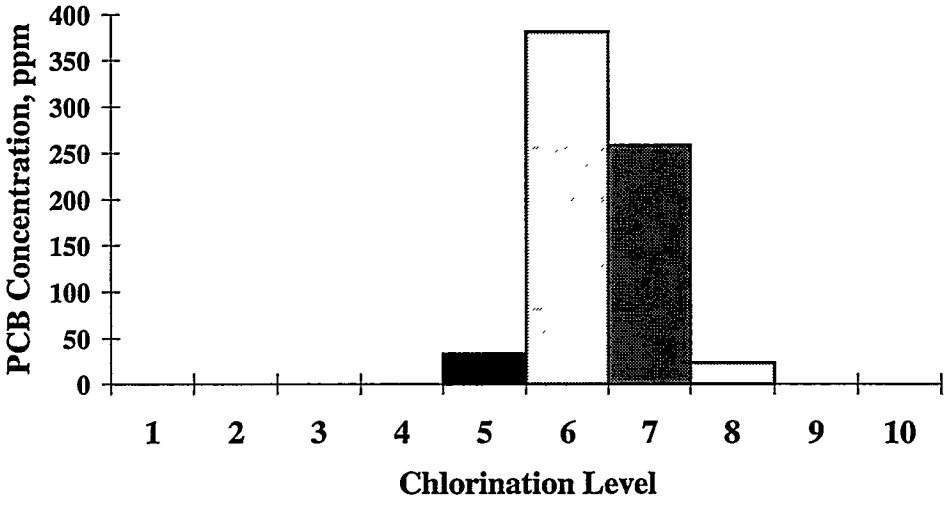


Figure 5.8. Typical Distribution of PCB Chlorination Levels in Feed Soil

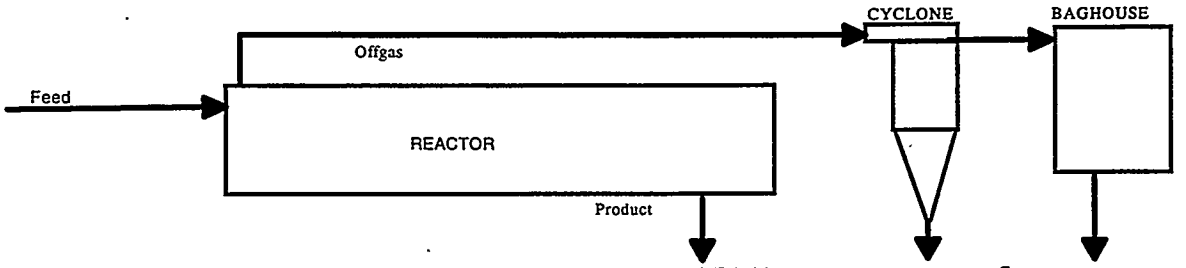
Table 5.3. Summary of PCB Analysis for Cyclone and Baghouse Dust

	Technique		
	Onsite Lab (GC-MS)[(a)], ppm	8080, ppm	680SIM, ppm
Cyclone	13,910	14,000	20,017
Baghouse	17,956	11,000	17,913

(a) gas chromatography - mass spectroscopy.

Table 5.4. PCB Material Balance for 5 February 1994 Hot Run

Stream	Total Stream Quantity	Mean PCB Concentration and Mass
Feed	20,000 lb	630 ppm 13 lb
Cyclone	65 lb	18,000 ppm 1.2 lb
Baghouse	22 lb	17,000 ppm 0.37 lb
Scrubber Water (untreated)	720 gal total (220 gal condensate); 6,000 lb total	1100 ppm 6.6 lb
Granular Activated Carbon from Press	100 lb	8,900 ppm 0.89 lb
Unaccounted PCB		4.8 lb (37%)



	5-Feb-94 Feed	10-Feb-94 Feed	5-Feb-94 Product	10-Feb-94 Product	Cyclone	Conc. Factor	Baghouse	Conc. Factor
TCDD	ND	ND	ND	ND	29.5	NA	52.3	NA
PeCDD	0.10	ND	ND	ND	113.2	1155	111.7	1140
HxCDD	2.60	1.99	ND	ND	194.1	75	170.3	65
HpCDD	11.31	9.92	ND	0.20	110.2	10	118.7	10
TCDF	3.77	4.56	ND	ND	6382.3	1692	11135.5	2951
PeCDF	21.21	25.73	ND	ND	7362.9	347	5898.4	278
HxCDF	27.40	29.96	ND	0.32	3519.8	128	1418.9	52
HpCDF	10.63	12.29	ND	0.24	173.5	16	77.7	7

Figure 5.9. Dioxin Balance for 5 February 1994

less than 0.5 ppm PCB. The outlying sample showed 12 ppm PCB. This sample was likely collected during a low-temperature excursion and was not considered representative of the actual performance of the system.

Run Description. The run was initiated at 06:50 with a slow heatup of the reactor with four burners. Additional burners were added over the next 40 min until seven burners, evenly spaced across the reactor, were running. At 09:30 shell temperatures were near 510°C (950°F), and feed was introduced into the system. The first soil exited the reactor at 10:15. At this time a total of 10 burners were online, and shell temperatures were near 538°C (1000°F). Two additional burners were brought online by 10:55 to keep zone temperatures above 538°C (1000°F). Soil temperature in the outlet of the reactor measured at 325°C (620°F), below the target temperature of 343°C (650°F). At 14:53 the last soil was fed into the reactor, and 30 min later the burners were slowly taken offline to keep shell temperatures within operational limits. The run was successfully completed at 16:28, and all systems were smoothly shut down.

During the run, a total of 6 tons of material were fed to the reactor, an average of ~1.1 ton/hr; and 5.75 tons of material were measured at the discharge bins. No significant feed problems were observed during the run. Lack of temperature information from the removed thermocouple tree led to lower temperatures in the outlet feed. Condensate generation in the mixing tank averaged ~83 L/hr (22 gal/hr), which would require treatment approximately every 20 hr [1700 L (450-gal) treatment volume].

Run Data. Fourteen process samples from this run were analyzed for PCB at the onsite lab and three samples at SWRI. Results of these tests showed that the average feed concentration was 1270 ppm PCB. All product samples except one showed <0.5 ppm PCB per congener (detection limit). One sample, obtained at 12:00, showed 12 ppm total PCB. It is likely that this low level of PCB was due to insufficient reactor temperatures because soil temperature monitoring capabilities were lacking. A summary of analytical results is presented in Table 5.5.

5.2.3.4. Air Emissions Monitoring. There are two primary potential sources for emissions of harmful substances to the air from the BCD process. The most likely point of dust emissions is at the discharge conveyor where hot dry material is dumped into the receiving bins. On the positive side, emissions from this source are not expected to have significant PCB concentrations associated with them. Most of the feed preparation and transportation emissions were eliminated by use of covers on the conveyors and water misting nozzles on the crusher.

The second potential air emission source is from the exhaust stack where any PCB not adsorbed in the activated carbon canisters could be discharged to the environment. Both of these sources were monitored during the February cold and hot runs to quantify the magnitude of these emissions. The results of these measurements are presented below.

Table 5.5. Summary of PCB Analytical Results for 10 February 1994 Hot Run

Sample Description	Onsite Lab Results	SWRI Results
Feed Composite for first 4 hr	1,223 ppm	1,865 ppm
Feed Composite for last 2 hr	1,366 ppm	NA
Product Grab Sample at 11:00	ND	NA
Product Grab Sample at 11:30	ND	NA
Product Grab Sample at 12:00	12 ppm	NA
Product Grab Sample at 13:00	ND	NA
Product Grab Sample at 15:00	ND	NA
Product Grab Sample at 16:30	ND	NA
Product Composite for 11:30 - 13:30	ND	0.01 ppm
Product Composite for 14:00 - 15:50	3.7 ppm	0.15 ppm
Cyclone Dust	4,045 ppm	NA
Condensate Water	94,342 µg/L	NA
Water After Filter Press, Before Carbon Filters	2,754 µg/L	NA
Final Treated Water	2.4 µg/L	NA

ND = Nondetectable (<0.5 ppm per congener).
NA = Not analyzed.

Fugitive Dust Monitoring. Fugitive dust emissions were monitored with two Wedding & Associates high-volume samplers. The monitoring height of the samplers was ~1.5 m (5 ft) to represent the breathing zone of workers. Table 5.6 shows that dust emissions were well below the Occupational Safety and Health Administration (OSHA) permissible explosive limit (PEL) of 15 mg/m^3.

Stack Sampling. The offgas upstream, downstream, and in between the carbon canisters was sampled using a slight modification of EPA Method 5. A vacuum pump was used to draw air at a rate of 1 to 1.75 L/min through an impinger filled with methylene chloride solution. To minimize volatilization, the methylene chloride filled impinger was placed in an ice bath. The methylene chloride solution was then concentrated and analyzed using the onsite GC-MS system. Results of these measurements are shown in Table 5.7. Assuming an offgas flowrate of 400 acfm, the total quantity of PCB being emitted from the stack per 24-hr day is approximately 290 mg/day.

The maximum PCB concentration seen in the offgas was approximately 18 µg/m^3 in Sample A020503. For comparison purposes, the OSHA time-weighted average (TWA) limit to workers for Aroclor 1254 is 0.5 mg/m^3. Therefore, the maximum PCB concentration seen in the stack was approximately 28 times less than the workplace standard. The actual concentration a worker would be exposed to from the stack would be much less than 18 µg/m^3, since the offgas leaves the stack at a velocity of 6.1 to 9.1 m/sec (20 to 30 ft/sec), and would be dispersed and effectively diluted before coming into contact with workers (subject to inhalation and skin adsorption).

Table 5.6. Results of Fugitive Dust Emissions Monitoring During February 1994

Sample Location	Date/Time	Volume Sample, m^3	Weight of Dust Collected, mg	Dust Concentration, mg/m^3
18 ft Downwind of Product Bin (dustiest point on site)	2 Feb 94 12:26 - 16:37	311	960	3.1
Fence Line near Bldg. 3009	2 Feb 94 12:26 - 16:37	298	230	0.77
Downwind 25 ft from Fence Line	5 Feb 94 08:25 - 23:34	1069	260	0.24
Upwind near Drums (background measurement)	5 Feb 94 08:34 - 00:03	1092	50	0.046
Downwind	10 Feb 94 07:15 - 17:45	741	90	0.12
Upwind	10 Feb 94 07:06 - 17:38	779	50	0.064

Table 5.7. Estimated PCB Concentrations in Offgas Stack from BCD Operations in Guam

Date 1994	Time	Sample ID	Location	Liters offgas sampled	Volume of collection medium, mL	Final volume of extract, mL	Conc. in extract, $\mu g/m^3$	Conc. in offgas, $\mu g/m^3$
2/5	12:13	A020501	upstream of carbon cans	86	64	64	<0.5	<370
2/5	13:49	A020502	between carbon cans	96	56	56	<0.5	<290
2/5	15:38	A020503	stack	130	49 (45 conc. for extract)	2	1.1	18
2/10	13:40	OG021001	stack	170	39	2	<0.5	<5.9

5.2.3.5. Conclusions and Recommendations from February 1994 Testing. The BCD process was shown to work as designed by successfully treating 10 tons of soil to less than 2 ppm per congener residual PCB levels. Soil throughput of 1 ton/hr is easily achieved when feed moisture levels are controlled to acceptable levels (i.e., 15% by weight or less). Temperature monitoring of soil inside the reactor is required to ensure effective BCD processing, which requires approximately 343°C (650°F) with a 1-hr residence time.

5.2.4. November 1994 Hot Tests

The cold shakedown testing and hot operation testing established the operability and destruction efficiency of the BCD system. Next, the ability of the system to operate over an extended time had to be determined by exploring steady-state operating conditions, analyzing performance through day/night cycles and shift changes, and examining the overall operability of the system for longer periods. A number of equipment modifications and additions were required to replace equipment damaged previously and to correct operational deficiencies. During this time period, IT Corporation staff were trained on all operational aspects of the system, including feed preparation; reactor, offgas system, and water treatment operations; and operation of the automated data acquisition system.

5.2.4.1. Equipment Modifications. PNNL staff arrived in Guam on 18 October 1994 to begin receiving equipment, performing system modifications, and preparing for an extended continuous hot run. Activities were delayed several days when Guam was placed under Typhoon Condition 1 from Super Typhoon Wanda, and power to the island was shut down. After restoration of power, work began on site modifications and contingency repairs to the existing system and quick shakedown/ training testing. Major modifications included the repair and replacement of the datalogging system and many electronic indicators (level sensors, thermocouple readers, etc.) that were destroyed by lightning. A list of modifications and objectives of each modification is shown in Table 5.8. An improved wireless thermocouple assembly for the primary reactor (rotary kiln) was installed to replace the one that was damaged in the first run of the Hot Testing (see Section 5.2.3.2). Shakedown tests were performed when the modifications were completed. Prior to the kiln operation, a 6.1 x 9.1 m (20 x 30 ft) structure was erected for storing a sufficient amount of soil and protecting it from the weather.

5.2.4.2. Run Description. During 18-20 November 1994, a team composed of both PNNL and IT staff completed a 40-hr continuous hot test of the BCD system in which approximately 50 tons of PCB-contaminated soil (average concentration 1250 ppm) were successfully treated to less than 2 ppm per congener. During the last 4 hr of the run, no sodium bicarbonate was added to the feed material. This material was also successfully treated, but this treatment did not necessarily indicate that sodium bicarbonate is not needed. Residual sodium bicarbonate in the material handling system most likely mixed with the soil, resulting in low concentrations of catalyst in the feed.

Table 5.8. Modifications Made to Support November 1994 Extended Hot Run

Modification Description	Objective of Modification	Comments
Install wireless temperature monitoring system.	Replace defective reactor thermocouple assembly to allow soil temperatures to be monitored.	Full function was never achieved. System worked intermittently during hot run.
Install new data acquisition system.	Replace HP 3852A datalogger which was damaged by lightning in 1993.	System was installed, but modifications to PC display and operator interface are still required.
Install a number of indicators, sensors and controllers on reactor and offgas treatment system.	Replace units damaged by 1993 lightning strike. Standardize controllers across entire BCD system.	Scrubber control panel was rewired to simplify troubleshooting system.
Replace motherboard on data acquisition computer.	Repair lightning damage and upgrade processor to ensure compatibility with current software.	
Install and paint new hinges on pugmill access doors.	Replace hinges that had rusted away.	Frequent painting is required for all exposed metal surfaces.
Install vibrators on catalyst feeder, pugmill, and feed conveyor hoppers.	Allow periodic soil bridging and sticking to be addressed without manual shoveling.	Only partially successful. Some shoveling was still required.
Install sideboards and other modifications to discharge conveyor.	Prevent treatment soil from spilling on ground around conveyor.	
Set up 20 x 30 ft portable building.	Protect excavated soil from rain before and during run.	Worked well. Capacity of this building was ~ 50 tons of soil.
Install Great Lakes oil/water separator.	Remove oils that build up in scrubber through generation of biomass oils from soil organic matter.	No separable light oils were generated; however ~10 lb of heavy oils laden with PCB were collected at bottom of separator.
Replace flex hose with SS hose, and patch holes on offgas canisters.	Flex hose degraded, canister cabinets leaked.	Carbon canisters still leaked.

The system was operated by two 3-person PNNL crews and two 4-person IT crews on 8-hr overlapping rotations. The reactor was put into operation on the evening of 18 November and was allowed to slowly heat up overnight with a 2-person crew on hand to ensure that the burners remained lit throughout the night. Feed preparation was initiated at 05:00 on 19 November 1994 when ~4 tons of soil were mixed with 10% by weight sodium bicarbonate. Soil was fed to the reactor starting at 07:00 at a rate of ~1.25 ton/hr. Seven burners were initially used to heat the reactor followed by the addition of four more burners an hour later. Some plugging of the feed in the inlet gate valves occurred at 10:50, but plugging occurred infrequently throughout the run.

New batches of feed were prepared ~ every 3 to 4 hr. Feed preparation time was typically less than 30 min when catalyst feed problems were not encountered. Occasionally, bridging in the sodium bicarbonate hopper occurred due to the hygroscopic nature of the material, which gave it an extremely high angle of repose (nearly 90 degrees). Use of the vibrator on the hopper usually solved the problem, but a break in the weld holding the vibrator to the hopper prevented its use during the later portions of the testing.

Grab samples of feed and product soil were taken once per hour and composited every 4 hr. The offgas was sampled before and after the carbon canisters to ensure PCB was not exiting the stack at levels above those allowed. At 16:00 on 20 November 1994, feed containing no added sodium bicarbonate was introduced into the reactor and was fed for the final 4 hr of the run. All excavated feed soil was processed by 20:00, and the system was shut down in an orderly manner over the next 2 hr.

Overall, the run went very smoothly, with a minimum of disturbances in the feed and reactor system. However, problems were experienced within the offgas treatment system. Approximately 18 hr into the run, the pressure drop across the baghouse increased from 0.94 to 4.7 mm Hg (0.5 to 2.5 in. H_2O). This pressure drop increased to 22 mm Hg (11.5 in. H_2O) 7 hr later. Since the rated pressure drop for the baghouse is 18.7 mm Hg (10 in. H_2O), corrective actions were taken. At 08:00 on 20 November 1994, the vacuum drawn on the rotary reactor was reduced from 1.7 to 0.94 mm Hg (0.9 to 0.5 in. H_2O). The reduction in the vacuum effectively reduced the offgas flowrate, and the pressure drop across the baghouse was lowered to 4 in. No further problems were encountered with pressure drop increases in the baghouse for the remainder of the run.

Oil mist again penetrated through the wet scrubber and was collected via impaction on the blades of the ID fan. This oil then seeped from the ID fan to the outside of the casing. Approximately 110 g (1/4 lb) of this oil seeped out during the run.

Although significant modifications were made to seal the carbon cabinets, the units leaked during the run, and limited quantities of offgas were able to bypass one of the carbon beds. Since the quantity of offgas bypassing the final carbon bed was small and had been cleaned in the wet scrubber and the first carbon bed, risk to workers and the public was minimal.

5.2.4.3. Run Data. Many of the process conditions were monitored automatically with the automated data acquisition system and stored in files for further analysis. In addition, process conditions were recorded by hand on a regular basis (usually hourly) as a backup. Since these are the only data available on steady-state operation of the system, most of the recorded data are presented below as time service charts (Figures 5.10 through 5.16). Significant findings from these data are discussed in Section 5.2.4.4.

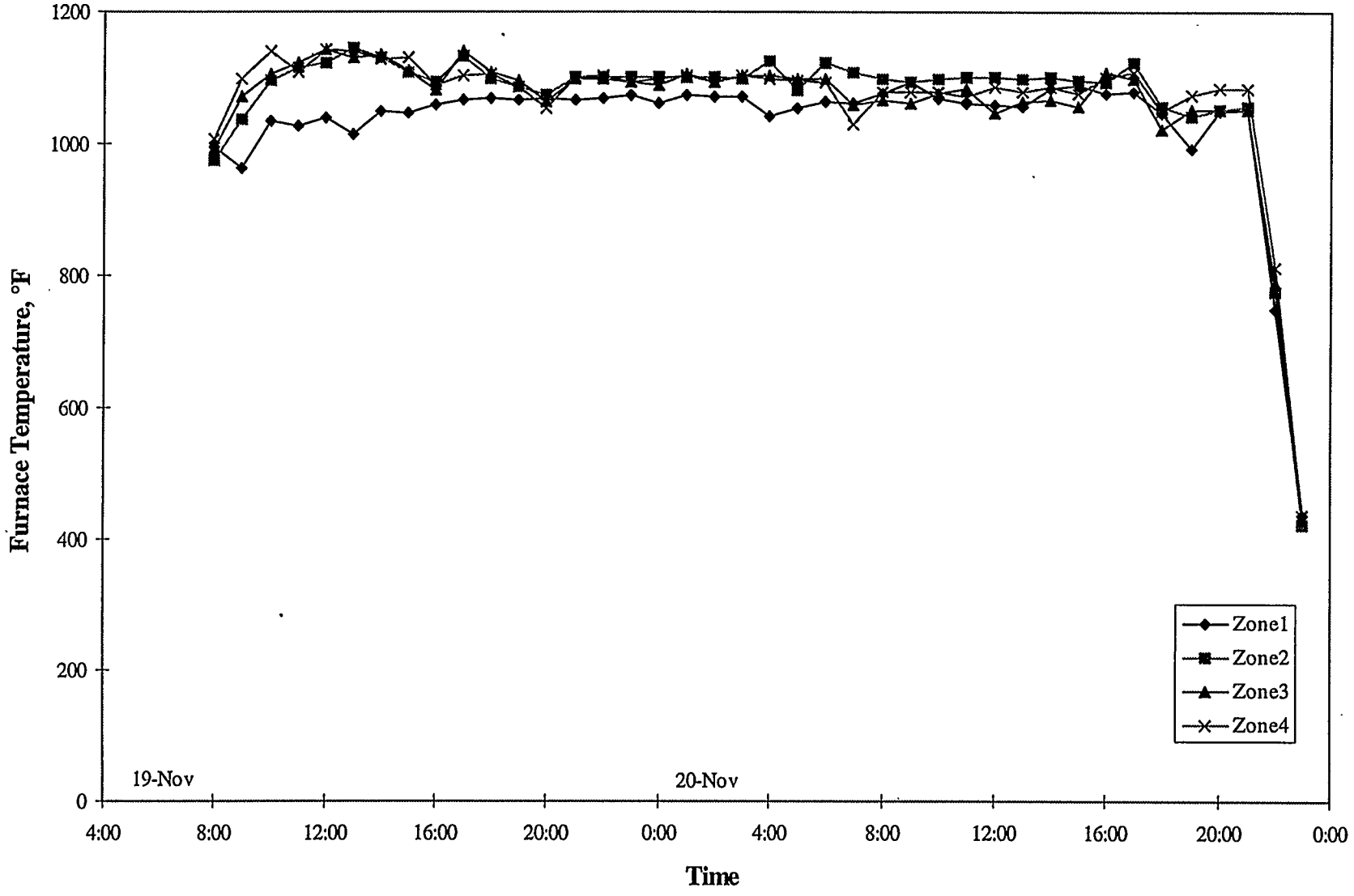


Figure 5.10. Temperature History in the Furnace Control Zones

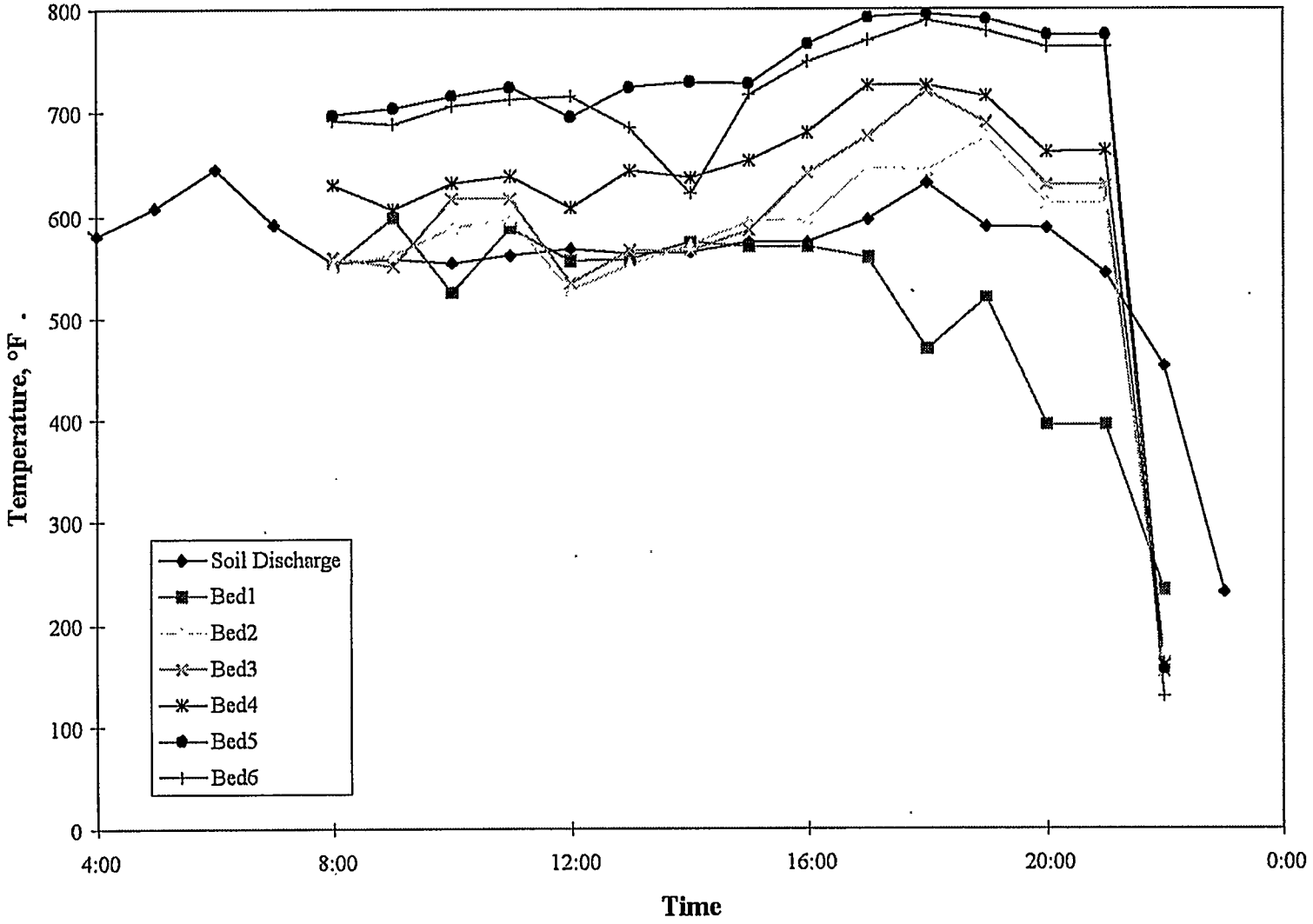


Figure 5.11. Temperature History of Soil in Reactor Using the Wireless Data Temperature Monitor

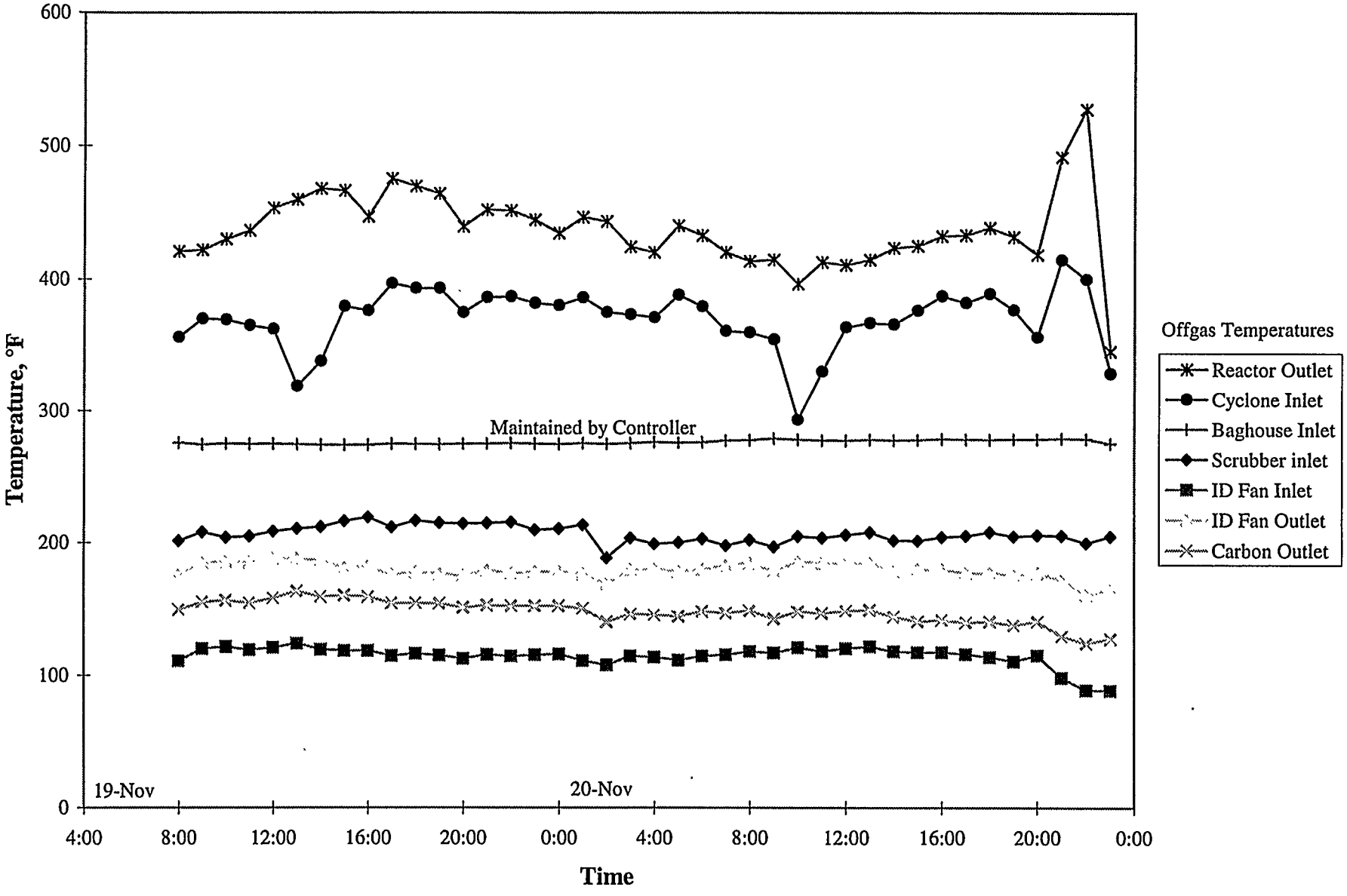


Figure 5.12. Temperature History of Offgas Stream

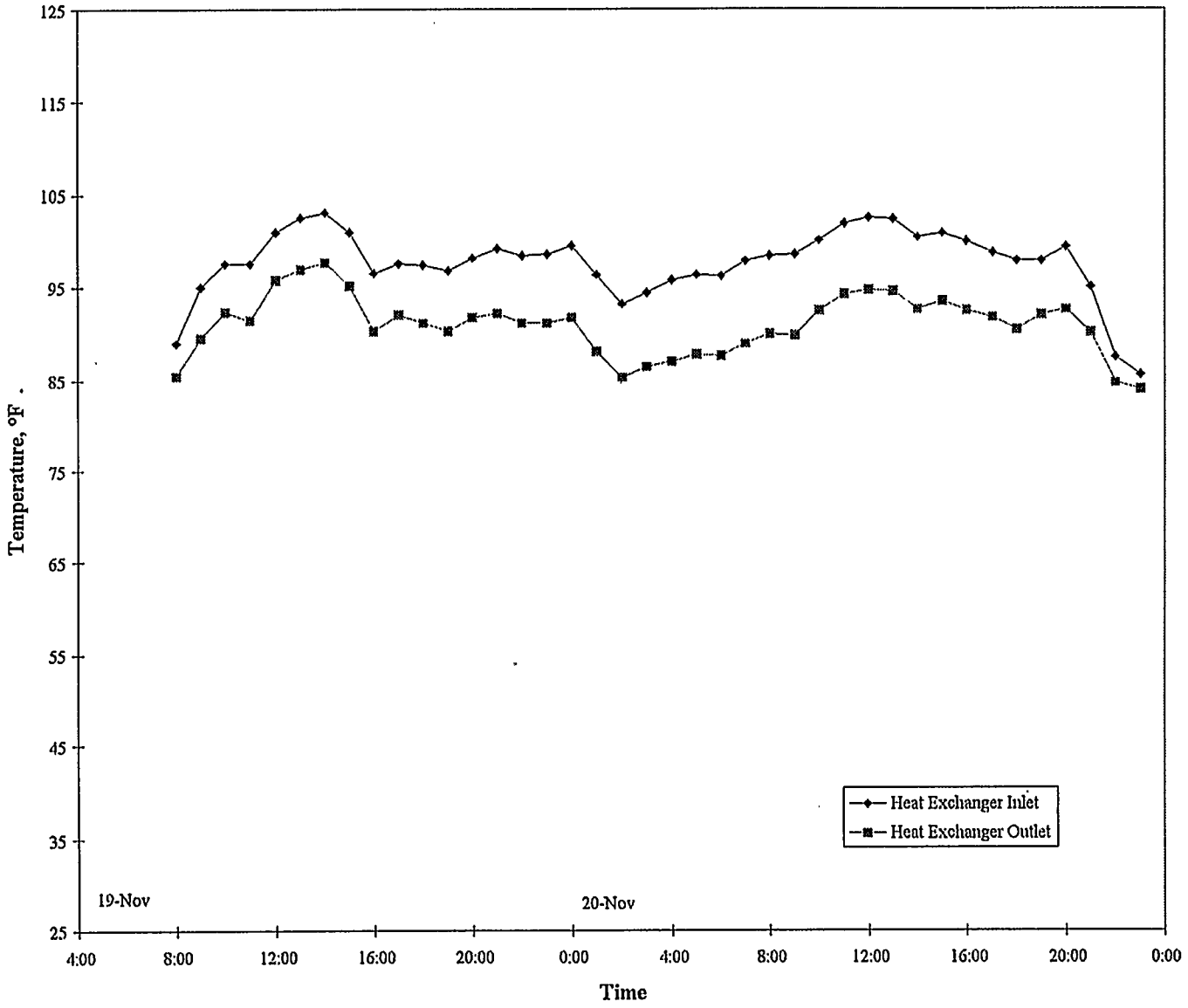


Figure 5.13. Temperature History of Water Recycle Stream

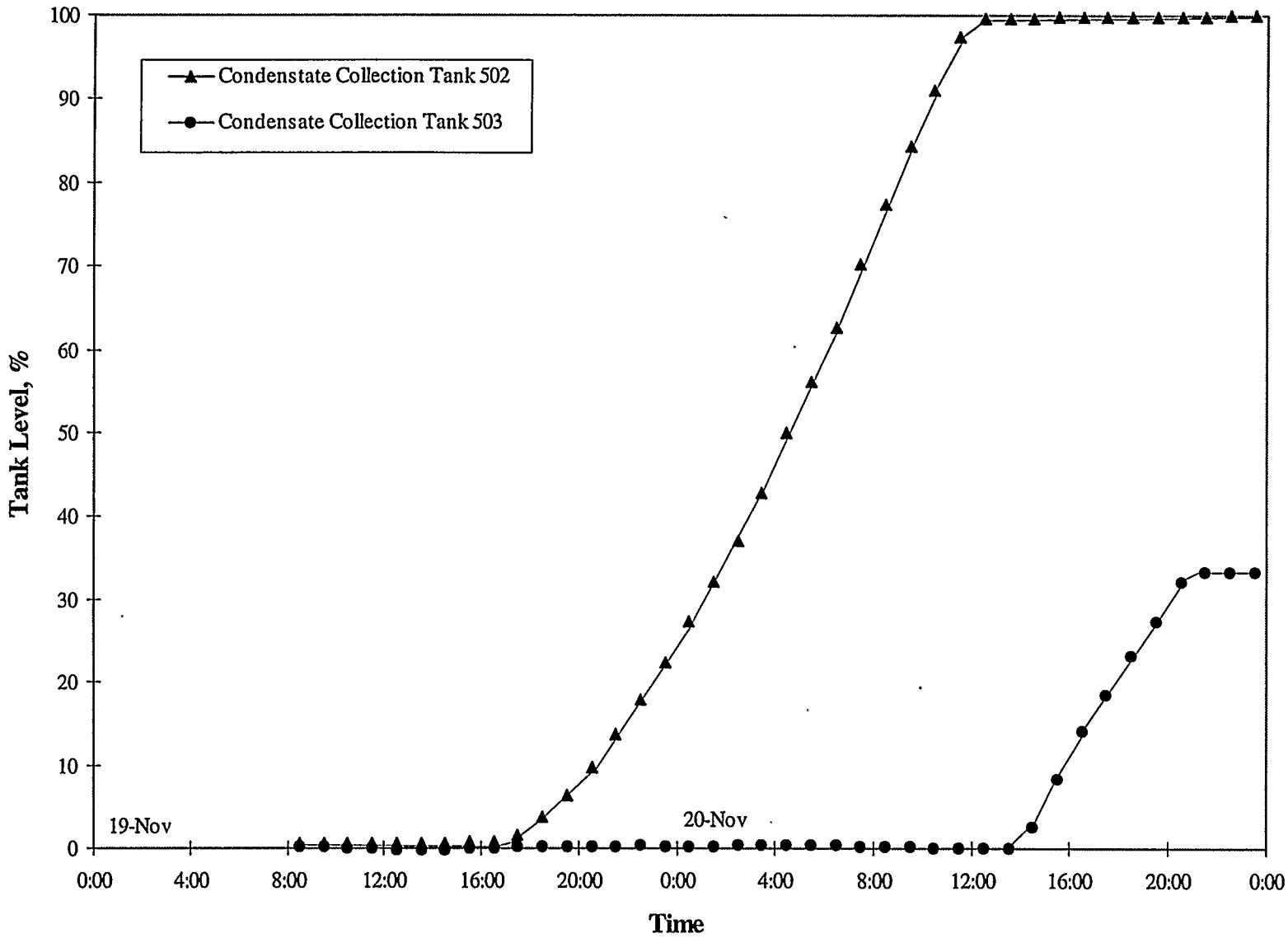


Figure 5.14. Water Levels in Condensate Collection Tanks

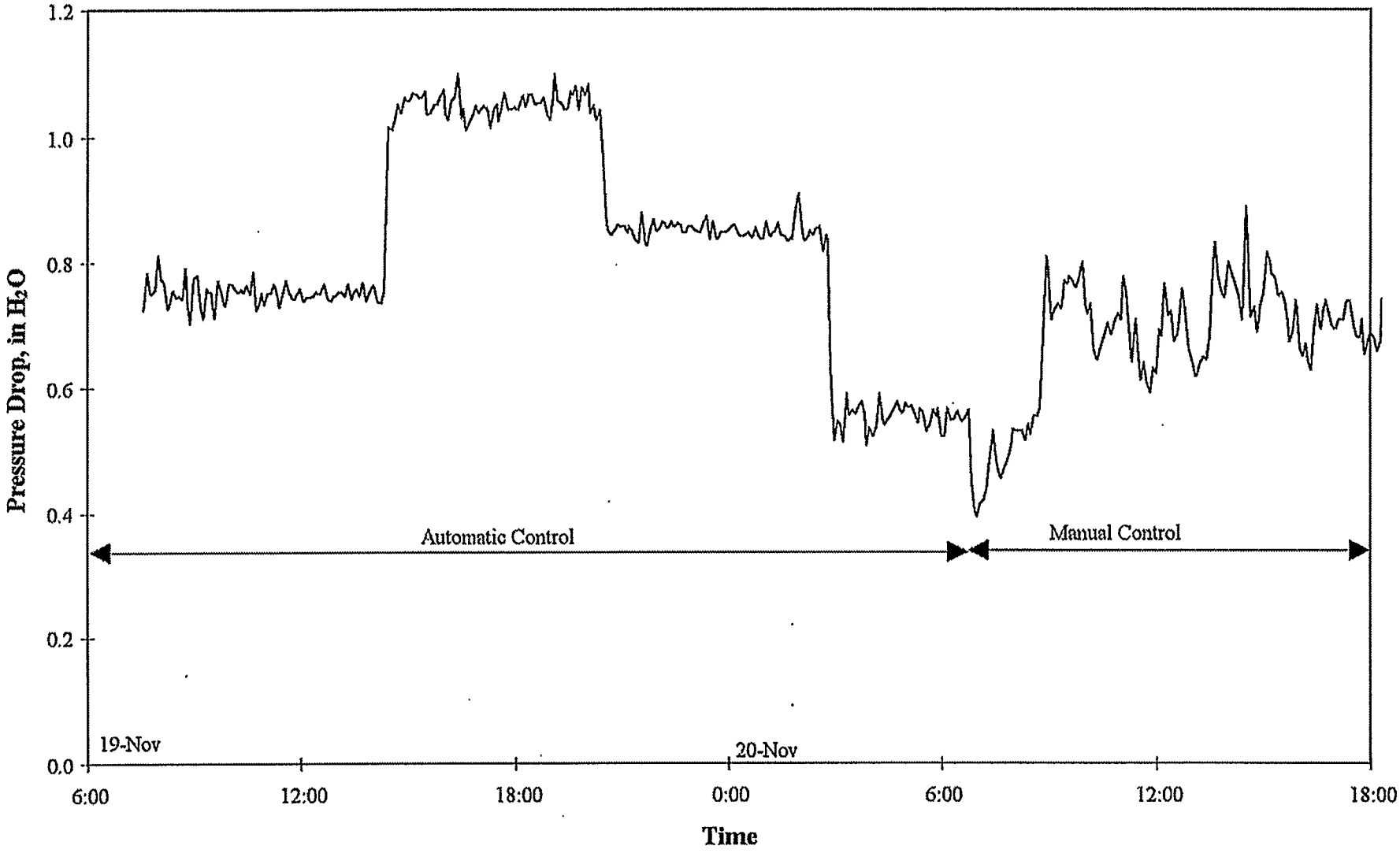


Figure 5.15. Differential Pressure Between Inlet and Outlet of Reactor Kiln

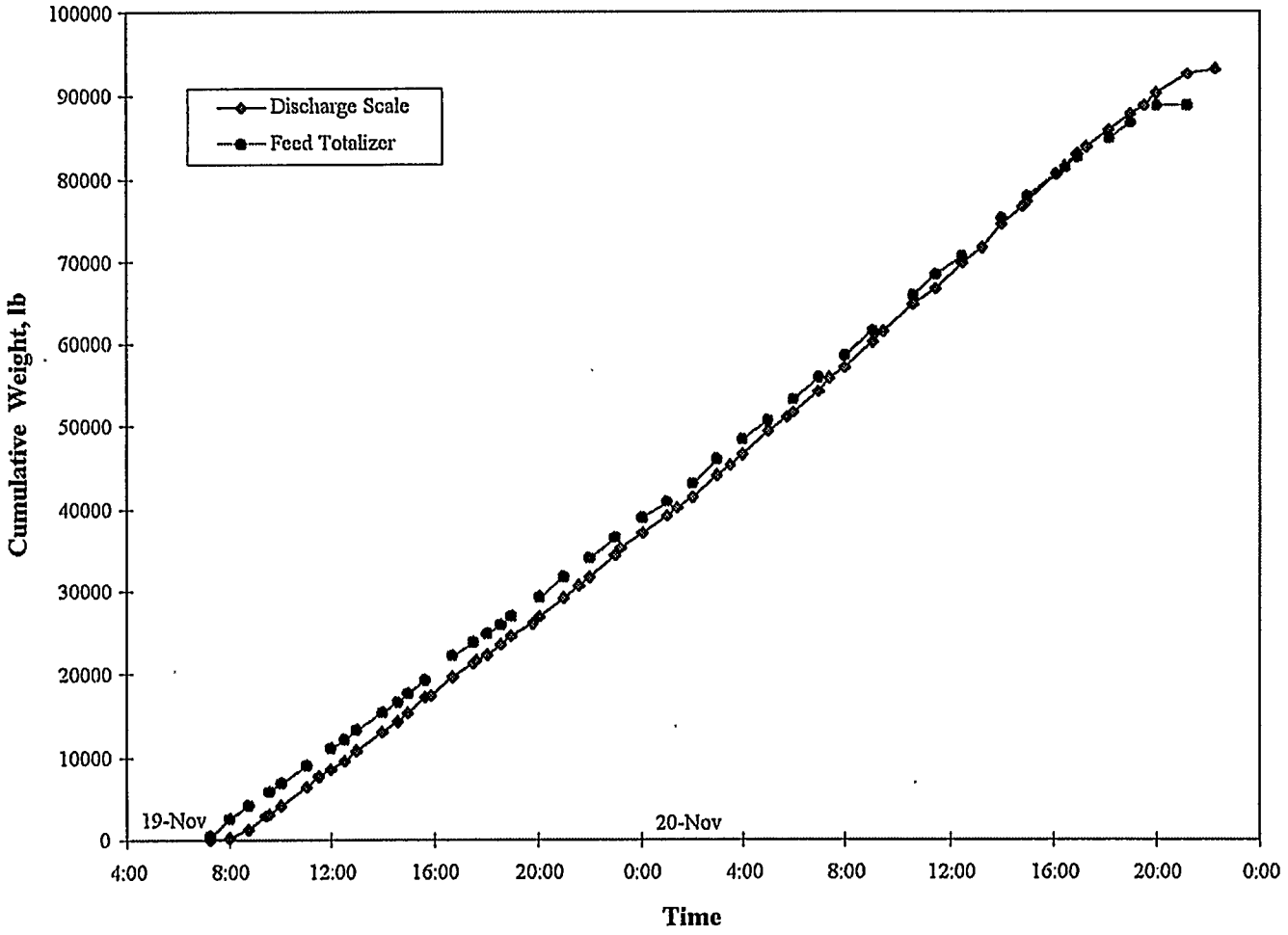


Figure 5.16. Cumulative Feed and Discharge Weights from November 1994 Hot Run

5.2.4.4. Analytical Data. Process samples, including soil, water, air, oil, and activated carbon samples, were analyzed for PCB, dioxins/dibenzofurans, moisture, and total petroleum hydrocarbon (TPH). A summary of PCB analytical results is presented in Table 5.9. Dioxin analyses are presented in Table 5.10. The remainder of the analyses are presented in Table 5.11.

PCB Analysis. PCB analyses were conducted initially at the onsite laboratory by a chemist, Tammie Stouter, under contract to PNNL. Selected samples were then sent off-island to SWRI for additional analyses. In some cases duplicate samples of those already analyzed onsite were sent to SWRI for confirmation. Problems with the GC-MS at the onsite laboratory resulted in poor agreement between the two labs.

Dioxin Analysis. During the February 1994 hot run, higher-than-expected concentrations of dioxins were discovered in the cyclone and baghouse dust. Therefore, a number of samples from the November hot run were submitted for analysis to determine if the source and distribution of the dioxins could be established. A comparison was made of the concentrations of the various PCB, dioxin, and furan homologs in the cyclone and baghouse with their respective concentrations in the process feed. This comparison indicates that much of the dioxin and furan in the cyclone and baghouse had been concentrated from the feed in a manner similar to that of PCB. However, sufficient data to complete a rigorous mass balance of dioxins, furans, and PCB was not obtained (i.e., only 9% to 17% of PCB in the feed was recovered in the process residuals). Without a rigorous mass balance, it is not possible to conclusively state whether the BCD process is creating or destroying some fraction of the dioxins and furans originally present in the feed soil.

Organic Carbon Analysis. A number of samples were submitted to the FENA Laboratory on Guam for various analyses, including oil and grease, total organic carbon (TOC), and alkalinity (carbonate, bicarbonate). An ash determination was performed by SWRI on a feed soil sample collected during the 5 February 1994 run. This sample contained 11.6% moisture, 2.8% bicarbonate and carbonate, and was 80.8% ash. Accounting for moisture and bicarbonate and carbonate, up to 4.8% of this sample may have been organic in nature. The relatively high organic content of the soil may have been a significant factor in the unsatisfactory performance of the offgas system. Another analysis performed by SWRI showed that the feed contained approximately 750 ppm total residual petroleum hydrocarbon (February 1994 sample).

TOC analyses were also performed on treated and untreated scrubwater samples, as well as treated water leaving the filter press (prior to final treatment in two 55-gal carbon polishing drums). Examination of the TOC in the scrubwater indicated that the TOC increased with time (Table 5.12).

The sample of water leaving the filter press had a TOC value of 690 mg/L, indicating that a significant portion of the organic carbon in the scrubwater was not removed after treatment with GAC. The same sample was also analyzed for PCB and found to contain 5 mg/L PCB. Much of the escaping

Table 5.9. PCB Analysis Results for November 1994 Hot Run

Sample Description	Sample Time	Onsite Lab	SWRI
Feed			
FC00001 Feed Composite	11/19/94 07:23 - 11:00	1,100 ppm	NA
FC00002 Feed Composite	11/19/94 12:45 - 16:15	NA	1,722 ppm
FC00007 Feed Composite	11/20/94 09:00 - 12:00	560 ppm	1,098 ppm
FC00009 Feed Composite	11/20/94 16:30 - 20:00	660 ppm	NA
No Sodium Bicarbonate			
FC00010 Overall Feed Composite	11/19/94 07:23 - 11/20/94 16:00	NA	1,252 ppm
Product			
PC00001 Product Composite	11/19/94 08:45 - 12:45	ND	NA
PC00002 Product Composite	11/19/94 12:45 - 16:15	ND	<0.09 ppm
PC00003 Product Composite	11/19/94 16:15 - 20:00	ND	NA
PC00004 Product Composite	11/19/94 20:00 - 00:00	ND	NA
PC00005 Product Composite	11/20/94 00:00 - 04:00	ND	NA
PC00009 Product Composite	11/20/94 16:00 - 21:00	NA	<0.32 ppm
PC00010 Overall Product Composite	11/19/94 08:45 - 11/20/94 21:00	NA	<0.19 ppm
Water			
W00002 Scrubber Water	Entire Run	12,000 ppb	NA
W00009 Treated Water	Entire Run	3 ppb	NA
W00010 Water from Filter Press	Entire Run	190 ppb	NA
W00011 Treated Water Tank 2	Entire Run	3 ppb	1.75 ppb
W00012 Water from Filter Press	Entire Run	5,000 ppb	NA
W00013 Treated Water Third Set	Entire Run	3 ppb	NA
Other			
S00001 Sludge from O/W Separator	Entire Run	160,000 ppm	368,000 ppm
CY00001 Cyclone Dust	Entire Run	NA	15,742 ppm
BH00001 Baghouse Dust	Entire Run	NA	109,331 ppm
AC00001 Activated Carbon from Scrubber Water Treatment	Entire Run	48,000 ppm	931 ppm

NA - Not Analyzed.
ND - Not Detected.

Table 5.10. Dioxin Analysis for November 1994 Hot Run

Sample	Units	Dioxin				Dibenzofurans			
		TCDD	PeCDD	HxCDD	HpCDD	TCDF	PeCDF	HxCDF	HpCDF
Activated Carbon	ppb	2,341.4	3,253	341.33	13.56	20,883	6,371.4	1,104	33.99
Baghouse Dust	ppb	3,623.1	11,535	3,348.78	504.92	39,590	41,001	15,310	1,151.71
Cyclone Dust	ppb	1,083.8	3,290.6	861.36	147.28	9,233	8,470	3,944	486.7
Feed Composite	ppb	9.64	159.17	10.00U	4.71	34.51	71.11	37.88	12.73
STR Slurry Feed	ppm	0.29J	0.61J	0.10J	0.01J	3.15	2.18	0.54J	0.06J
STR Slurry Product	ppm	0.04J	0.96U	2.40U	0.12U	0.08J	0.08J	0.03J	0.60U
Product Composite 9	ppb	0.20U	0.15U	0.50U	0.02J	0.25U	0.10U	0.06J	0.09J
Product Composite 10	ppb	0.20U	0.15U	0.50U	0.03U	0.25U	0.10U	0.65U	0.13U
O/W Separator Sludge	ppm	14.11	28.85	2.67J	0.54J	169.16	80.35	14.33J	1.41J
Treated Water	ng/L	1.40U	2.40U	2.80U	0.22U	0.60U	1.00U	5.00U	1.10U

U = Undetected analyte.
J = Below method detection limit.

Table 5.11. PCB Material Balance for November 1994 Hot Run

Mass Balances	Based on SWRI Data		Balance Using Onsite Data for Activated Carbon		
Stream	Weight lb	Total PCB lb	% Recovery	Total PCB lb	% Recovery
Feed (dry weight)	93,270	116.83	--	116.83	--
Cyclone Dust	20.5	0.32	0.28	0.32	0.28
Baghouse Dust	47	5.14	4.40	5.14	4.40
Activated Carbon	222	0.21	0.18	9.93	8.50
Oil from Oil/Water Separator	13	4.79	4.10	4.79	4.10
Water	12,450	0.06	0.05	0.06	0.05
Total Recovery			9.00		17.33

Table 5.12. Total Organic Carbon in Scrubwater

Hours into Run	Sample Location	TOC, mg/L
15	O/W Separator Inlet	1140
15	O/W Separator Outlet	1020
22	O/W Separator Outlet	1220
37	O/W Separator Outlet	1320

TOC was suspected to be from short-chained biomass pyrolysis products, including organic acids (e.g., formic and acidic acid), alcohols (e.g., methanol and ethanol), aldehydes (e.g., acetaldehyde), and ketones (e.g., acetone). These types of compounds tend to have a low affinity for carbon.

5.2.4.5. Material Balance. The PCB material balance was calculated based on measured weights of system streams and analytical results from Table 5.9. The results of these material balance calculations were shown in Table 5.11. A large portion of the PCB is not accounted for by these calculations. Possible reasons for this discrepancy are 1) a higher portion of the PCB was destroyed in the reactor; 2) large quantities of PCB were held up in the system inventory, including the reactor feed plenum, cyclone, baghouse, and condensed oil in the ID fan; 3) a combination of Reasons 1 and 2; or 4) difficulties encountered in sample extraction for PCB analyses. A combination of these factors most likely led to such a poor accountability of the PCB. Better material balances should be obtained by IT Corporation once the system has been run at steady state for a number of weeks.

5.2.4.6. Conclusions from November 1994 Testing. The BCD system can effectively treat PCB in soil onsite to meet EPA's TSCA permit standard of 2 ppm per congener under sustained operations.

The performance of the rotary reactor under sustained operation was excellent. The only problem encountered was that the wireless temperature monitoring system operated intermittently.

Soil preparation and conveying equipment performed adequately. Minor problems with soil bridging in hoppers occurred.

The originally unknown level of soil organics present (in addition to the PCB) proved to have a major effect on how the equipment may operate in the long term. Pyrolysis oils, aerosols, and smoke were generated from heating of significant amounts of roots and other vegetation as well as other naturally occurring organics. These oils showed significant deposition in the baghouse and were present on the walls of the ID fan despite changes to the scrubbing system.

5.2.4.7. Recommendations. High moisture content of the feed creates significant materials handling problems and reduces kiln throughput. Therefore, a covered feed preparation area should be available to allow efficient long-term operation.

Sodium bicarbonate feeding to the pugmill had difficulties with caking and bridging within the sodium bicarbonate hopper. Alternative sodium bicarbonate feeding methods or modifications to the existing system should be considered.

Control of the sodium bicarbonate feeder should be integrated with the pugmill to reduce labor requirements and to provide better accuracy of sodium bicarbonate metering. Good control systems using weight loss in the hopper are available from Flexicon (i.e., supplier of the sodium bicarbonate feeding system).

The cyclone and baghouse should be operated at the highest temperatures possible to minimize condensation of water, oils, and tars. Consideration should be given to replacing the Nomex bags with higher-temperature fiber glass bags.

To remove aerosols that penetrate through the wet scrubber, consideration should be given to the installation of a high efficiency mist eliminator (HEME) between the scrubber and the ID fan.

Consideration should be given to replacing the offgas carbon canisters with a thermal oxidizer because it will better remove small-chain organics (pyrolysis products) and eliminate problems with operating carbon canisters at positive pressure.

Permanent use of an oil/water separator especially those having a coalescing mechanism attached is recommended to remove as much oil and particulate as possible from the water and reduce the burdening on activated carbon.

Preliminary data and recently reported research (Tanaguchi et al. 1965) indicate that the sodium bicarbonate level can be reduced to ~5% by weight.

5.2.5. STR Testing

During the predeployment operations conducted in Stockton from September to November 1991, piping and wiring was completed for the STR skid. The individual components for the system were tested, and verified that the system was operational. The STR heating system was tested by partially filling the reactor with water, and boiling the water. Due to time and funding limitations, the STR system was not tested with oil in Stockton. Further testing was conducted at the Guam site. The text below describes the results of the Guam testing.

Although the following discussion on STR testing is lengthy, it is important to note that, by weight, the STR treats only a small fraction of the material processed through the rotary kiln. However, the relatively small mass of material may contain 30% to 100% of the PCB to be destroyed by the entire BCD operation. Additionally, Stage 2 (STR) of the BCD process is less developed than Stage 1; consequently significant detail has been provided in this subsection.

5.2.5.1. July 1993. Cold testing of the 400-gal STR system was initiated at PWC-Guam in July 1993. The objectives of the July testing were to obtain heatup and cooldown data and to process uncontaminated fines and activated carbon. LW-107 oil was loaded into the reactor, and the system was heated. Problems were encountered with the ability to heat the system to the desired reaction temperature and, consequently, further testing of the STR system in July was suspended. Further analysis determined that the temperature problems were an artifact of the thermowell, not the reactor heaters. Most likely the STR target operating temperature of 350°C (662°F) had been achieved, but because the reactor thermocouple had been placed in the thermowell, the temperature reading was as much as 167°C (300°F) below the actual temperature of the reactor contents.

Another potential problem was identified when monitoring the amperage to the three legs of the Inconel strip heaters. A significant imbalance was detected; i.e., the legs going to the heaters read 27 amps, 36 amps, and 55 amps. The imbalance was an indication of a problem associated with the wiring or the heating elements, or problems at the power plant in Guam.

During the July STR shakedown testing, it was also observed that the agitator shaft seal had been compromised. Condensable vapors were observed escaping from the STR agitator seal.

Examination of the limited reactor cooldown data showed that cooling the reactor contents from 343°C to 66°C (650°F to 150°F) would likely take several days. Unless cooling coils were added to the reactor, it would not be possible to meet the 2 batch/day throughput as specified in the BCD process flowsheet documents.

5.2.5.2 January/February 1994. For the testing during January and February 1994, a 2-L (2-liter capacity) batch STR system was procured to facilitate testing on a smaller, more controllable scale. Cold testing in July 1993 had revealed several significant problems in operating the full-scale STR. Correcting these problems was expected to require significant modifications and funding, but before major corrective actions on the STR were initiated, a strategy was adopted to test the treatment of the BCD process residuals with the 2-L batch STR system. Also, by using the 2-L reactor, the efficacy of the concept could be determined quickly, and numerous operating conditions and strategies could be tested safely and inexpensively. The 2-L STR system consisted of a 2-L stainless steel reactor, a three-port stainless steel reactor head, a mixing assembly, body and head heating mantels, and a rheostat for temperature control.

During the hot demonstration of the rotary kiln reactor system, residuals captured in the offgas treatment system were collected and used as feed for the 2-L system. These collected residuals (particulates and loaded GAC) amounted to slightly less than 1% of the mass of the contaminated soil processed through the rotary kiln reactor. A series of tests were conducted; however, none of the tests were completed. Significant problems with foaming and rapid boiling occurred, which caused material to leave the reactor. Consequently, Stage 2 of the BCD system was not successfully demonstrated in January/February 1994. Corrective modifications to the setup of the 2-L system were identified, and the use of antifoaming agents was recommended.

Activities associated with the full-scale STR system during the January/February hot demonstration of the BCD system were limited to troubleshooting and corrective actions for problems identified during the July 1993 cold testing. The contents of the STR (LW-107 oil) were transferred to 55-gal drums, and the reactor tank vessel was removed from the STR heating jacket via crane, which allowed access to the Inconel strip heaters. The heaters were in good condition; however, the fabricator of the heating jacket had insulated the heaters with standard fiber glass insulation, and the fiber glass insulation had melted around the strip heater in some places. This insulation was removed. Also, the heating jacket had partially filled with water from heavy tropical rains, which significantly reduced the heating rates (i.e., much of the energy from the heaters was consumed in boiling off the water inside the jacket). These problems were addressed when reassembling the kettle by drilling drainage holes in the bottom of the jacket and using a high-temperature kaowool instead of fiber glass. The reactor tank vessel was placed back into the jacket, and the heaters were reconnected to the power supply.

Modifications were also made during this time to the STR agitator seal. A nitrogen purge system was installed on the seal that would maintain the seal at a positive pressure and exclude the possibility of air inleakage. Due to time and budget constraints, further testing of the STR system was not conducted during this time frame.

5.2.5.3 October/November 1994. In October and November 1994, significant modifications were made to the full-scale STR based on observations and problems identified from the July 1993 and January/February 1994 testing. These modifications and the rationale behind the modifications are given in Table 5.13. During the November hot run, collected residuals (i.e., particulates, oil, and loaded GAC) amounted to approximately 0.3% of the mass of the contaminated soil processed through the rotary kiln reactor.

Cold Test. After the modifications were made, five 55-gal drums of LW-110 oil were pumped into the reactor for cold shakedown testing. On 24 November 1994, the STR was heated to 360°C (680°F) in approximately 9 hr (including a 35-min power outage) without any problems. The STR easily heated up to the target temperature, and all ancillary equipment functioned as designed. When the temperature of the oil reached 170°C (338°F), the valve to the reflux condenser tower was opened. The

Table 5.13. Modifications Made to STR in October/November 1994

Modification	Rationale
Rewiring/reconnection of heaters.	Heaters were disconnected and kettle disassembled to facilitate installation of new insulation.
Extension of agitator shaft and addition of rake.	Rate added to prevent solid settling and buildup on bottom of reactor.
Replaced 1750 RPM 3/4 hp agitator motor with 1200 RPM 1-1/2 hp motor.	Additional power and slower speed required for rake; also, BCD inventors suggested slower agitation speed would be beneficial to process.
Two 1000-watt immersion heaters installed.	Supply additional heat to system, if needed, to achieve target reaction conditions.
Repacked agitator seal packing.	Mitigate oil seepage through seal.
Installed reflux tower on offgas outlet.	Condense and reflux organic vapors that may contain PCB.
Installed nitrogen purge to reactor plenum.	Nitrogen purge on agitator seal plugged; installation of a nitrogen purge to plenum was necessary to provide inert blanket over hot oil.
Installed redundant thermocouples with tips exposed to oil.	Provide direct reading of oil temperature in reactor.
Added pressure and temperature indicators to reactor plenum and offgas line.	Better monitoring of conditions in and around reactor for troubleshooting.
Installed oil filled knockout pot on rupture disk vent line.	Quench oil and vapors if reactor pressure surges and rupture disk fails.
Provided for intermittent monitoring of offgas for oxygen level.	Ensure that offgas composition is not allowed to reach potentially flammable conditions.

offgas was routed through the condenser for the duration of the run. During the heating, the Inconel heaters around the kettle provided sufficient heat, and consequently the immersion heaters that had been added for supplemental heat were not needed. These heaters were removed. The nitrogen blanketing system operated as designed, and the oxygen content in the reactor plenum was routinely less than 0.5% O_2. A contributing factor to the absence of oxygen in the reactor plenum was the continuous generation of volatile organic vapor, which acted to sweep the headspace along with the nitrogen purge. As previously noted, the STR did not include provisions for cooling. Forty hours after the heaters had been turned off, the oil temperature was 120°C (248°F).

Concurrent with the STR cold test was the hot testing with the 2-L STR. A series of tests were initiated with feed containing oil, activated carbon, cyclone/baghouse dust, catalyst, and sodium hydroxide. In each of these tests, foaming and very rapid boiling (of the water introduced into the system from the activated carbon) were significant enough that the tests had to be halted. The foaming was similar to a soapy film that climbed the walls of the reactor vessel. In all of the tests, the foaming and boiling were sufficiently vigorous to force the mixture up and over into the condenser system. Previous EPA liquid-phase STR testing had used only hydrocarbon liquids. The high levels of biomass organics present in the process residuals (cyclone/baghouse dust and GAC) created a problem that was not foreseen. One option that appeared to minimize the foaming problems was rapid injection of purge gas directed at the oil surface.

Hot Test. In light of the unsuccessful 2-L STR tests, a sparge tube was added to the full-scale STR to facilitate blowing air onto the surface of the oil slurry near the STR outlet. With the air lance, it was speculated that the cap of bubbles may be broken up during the early water removal stage [at 95°C to 115°C (200°F to 240°F)], preventing foam from building up and potentially clogging the offgas outlet. When this modification was completed, the STR was loaded with the following:

420 L (360 kg) [110 gal (790 lb)] of LW-110
420 L (360 kg) [110 gal (790 lb)] of LW-107
150 kg (328 lb) GAC (33% moisture)
17 kg (38 lb) GAC (38% moisture)
110 kg (250 lb) of fines collected in the cyclone and baghouse.

Analytical data indicated these residuals contained approximately 16 kg (36 lb) of PCB. Therefore, the following reagents were added.

82 kg (180 lb) NaOH (50% solution) (NaOH:PCB = 2.5:1 w/w)
21 kg (47 lb) of catalyst (2% w of slurry)

1100 kg (2400 lb) total batch.

PCB concentration of this mixture was measured to be approximately 7000 ppm (about half of what was calculated based on analytical data from the residuals; this difference may have been caused by obtaining a nonhomogeneous sample of the slurry, and/or the result of nonhomogeneous samples of the GAC and/or baghouse/cyclone dusts).

The run was initiated on 28 November 1994, at about 09:35, with the air lance turned on. Figure 5.17 shows the relationship between oil temperature, condensate rate, and time. The oil was quickly heated to about 100°C (212°F), and then water (from activated carbon and sodium hydroxide solution) began to boil off. During the water removal [100°C to 150°C (212°F to 302°F)] the heating

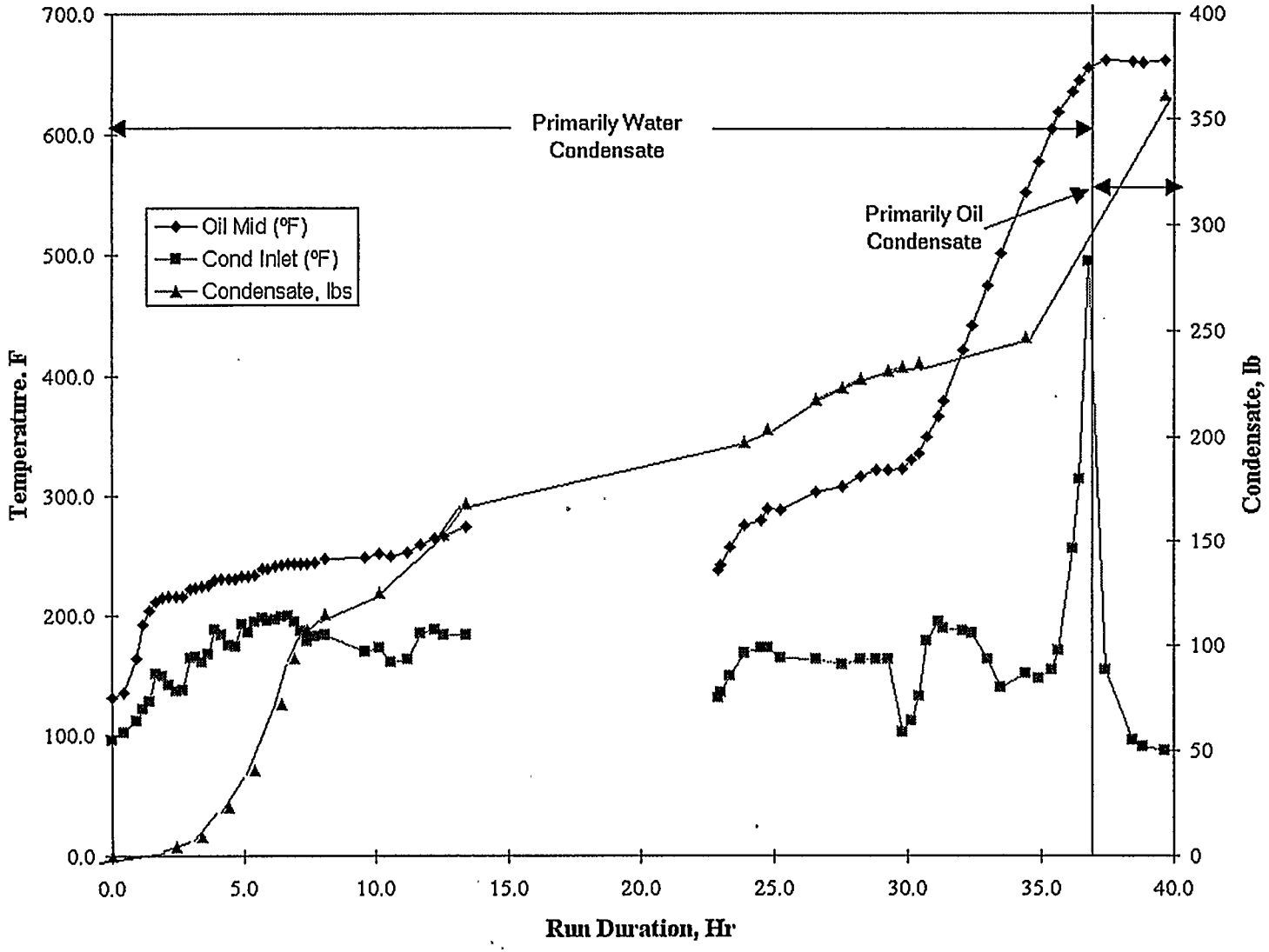


Figure 5.17. STR Temperatures and Condensate Generation for 28 November 1994

rate was slowed drastically to minimize boilovers and foaming events. Attempts to push the water boil-off rate much above 9.1 kg/hr (20 lb/hr) resulted in boilover/foaming events. These events were verified by observation of rapid pressure fluctuations [pressure increased from 0.37 to 7.5 mm Hg (0.2 to over 4 in. H_2O)] in the reactor plenum and by significant quantities of catalyst being found in the condensate receiver tank (i.e., foam contained catalyst which traveled through the offgas line, through the condenser, and into the condensate receiver tank). Conclusive evidence of boilover/foaming events was found twice during the run. After the bulk of the water was removed [oil temperature in reactor of about 120°C (248°F)], the air lance was turned off.

Heatup to the reaction temperature was not achieved on 28 November and, at approximately 23:00, power to the reactor heater was turned off. The next morning at 05:00, the heaters were re-energized and the heatup was continued. During the night, the oil temperature dropped from 135°C (275°F) to 107°C (225°F). By 16:00, nearly all the water had been removed from the oil [approximately 110 kg (250 lb) of water], and the heaters were engaged at their maximum setting. When the oil temperature reached 160°C (320°F) the nitrogen purge to the reactor plenum was turned on at a rate of about 38 L/hr (10 cfh). Within 1 hr, the oxygen content in the offgas was down to 1.3%, and within 2 hr it was at 0.1%. The reactor was heated from 170°C (340°F) to 343°C (650°F) in approximately 8 hr without much event. Between the temperatures of 338°C and 350°C (640°F and 662°F), significant oil vapors came off, and the pressure in the reactor plenum fluctuated rapidly between about 3.7 mm Hg (2 in. H_2O) to greater than 15 mm Hg (8 in. H_2O). These fluctuations were due in part to significant holdup of oil in the reflux tower. Large quantities of oil would drop back into the reactor and would flash back to vapor, creating pressure spikes. The reflux tower bypass was opened to bring stability back to the system, which sent the vapor directly to the condenser. The reactor was held at the target temperature [350°C (662°F)] for approximately 3 hr. After the hold time, the heaters were shut off, and the reactor was allowed to cool with the agitator running. The following day, the condensate receiver tank was emptied and the reactor was sampled. Approximately 52 kg (114 lb) of organic condensate were removed.

The final treated oil had a PCB concentration of about 1100 ppm PCB. Although the target of 2 ppm was not reached, a reduction of about 85% was achieved. The PCB homologs in the feed slurry were primarily hepta- (29%), hexa- (57%), and penta- (10%) chlorobiphenyls; while those in the treated oil were primarily hexa- (18%), penta- (38%), tetra- (26%), and tri- (9%) chlorobiphenyls. During the run, six condensate samples were taken and analyzed. The concentrations of these samples were 0.30 ppm, 0.83 ppm, 0.70 ppm, 0.48 ppm, 4.1 ppm, and 3400 ppm (sample obtained immediately after boilover into the condenser).

Conclusions from November 1994 Testing: The full-scale STR and 2-L STR runs did not successfully treat PCB to the target treatment levels. Further testing of the chemistry was needed to determine reagent loadings and operating strategies. The 2-L system, which would provide the most cost-effective method for this testing, needed to be modified to effectively handle pressure surges. Also, antifoaming agents needed to be examined and tested to minimize potential foaming events.

Mechanically, the STR system performed as designed. The agitation system (including agitator seal) performed flawlessly. The condenser had sufficient capacity to cool and condense the steam and organic vapors. The heating system adequately heated the oil slurry to the reaction temperature. Additional heating capacity is not warranted since the heating rate appears to be limited by the water removal rate. During the water removal, the heaters were operated at less than 50% of capacity.

The STR system performed safely despite several boilover/foaming events. After the run was completed, the offgas lines were disassembled and inspected. There was no buildup in the lines. It appears that the condensing oils in the offgas lines act as a solvent and effectively clean the lines.

Testing in November 1994 clearly showed that the system is self purging; that is, as the oil is heated, volatile components in the oil are offgases and serve to purge air from the system. Additionally, the system is equipped with nitrogen gas for removal of air from the reactor plenum space. Even though the reactor is operated at or near the auto-ignition temperature of the oil, air is necessary for a fire. While air is excluded from the system, there is no danger of fire. Additionally, in November, the system operated at a slight pressure, i.e., 3.7 to 9.4 mm Hg (2 to 5 in. H_2O), due to the continuous generation of organic vapors. This slight pressure served to prevent inleakage.

In the event oil does spill and then catches fire, it is important to note that it burns in a manner similar to kerosene. It does not violently deflagrate upon ignition.

Use of a 2-in. pipe as a reflux condenser was inadequate to handle the volume of oil vapors generated. Too much oil was held up, creating a significant pressure drop. The reflux tower was thus bypassed to provide for stable operation, and the heldup condensate was directed to the condenser. A larger capacity reflux tower would be more effective.

5.2.5.4 May 1995. Observations and results from the November 1994 400-gal STR and 2-L STR testing revealed some issues associated with the operation and efficacy of the liquid-phase BCD process as applied to the waste materials in Guam. In particular, foaming occurred during water removal, and the process failed to adequately treat PCB. Therefore, further proof-of-principle testing in Guam became imperative.

On 12 May 1995, three PNNL staff members arrived in Guam to conduct the STR testing. Staff from NFESC, IT Corporation, and BCD Group, Inc., also participated in/observed the testing. The main objectives of testing were to 1) successfully demonstrate the efficacy of the BCD process, 2) develop an operating strategy that could be adopted by the Navy's RAC, and 3) test enhancements to the BCD process developed by the process inventors. The selected run conditions were determined by NFESC and BCD Group, Inc., with input from PNNL. During a 2-1/2 week period in May, two tests were completed with the 400-gal STR, and five tests were completed with the 2-L STR. This testing successfully demonstrated the liquid-phase BCD process (Stage 2 process), with PCB concentrations in the oil phase being reduced from approximately 42,000 ppm to less than 2 ppm per congener.

400-gal STR Testing. During May 1995, two tests were completed with the 400-gal STR. The objective of the first test was to further demonstrate the BCD chemistry and to re-treat previously unsuccessfully treated material from the November 1994 STR run. Table 5.14 provides the test conditions and analytical results from the 400-gal STR testing on 28 November 1994 and the two May 1995 tests designated FSSTR1 (17 May) and FSSTR2 (25 May). The equipment configuration used in November 1994 was left essentially intact for the May 1995 testing. The unsuccessfully treated material from November 1994 was loaded into the STR along with base (sodium hydroxide) and hydrogen donor material. On 17 May 1995, the reactor contents were heated to and held at 352°C (665°F) for 3 hr. Analytical results from samples showed that the PCB content was reduced from about 1100 ppm to 340 ppm PCB. Results from the May 1995 testing with the 2-L STR (see next section) led to speculation that the lack of fresh catalyst may have been responsible for the failure of this run.

A second 400-gal STR run was conducted on 25 May 1995. To the unsuccessfully treated material, 93 kg (204.5 lb) of loaded GAC were added. Additional base, hydrogen donor, and fresh catalyst were added. The reactor was heated to 349°C to 357°C (660°F to 675°F) for 6 hr. Samples were taken from the reactor every 2 hr. Analytical results showed that all samples had no detectable PCB. Oil phase condensate collected during the run was also shown to be free of PCB.

Summary of 17 May 1995 Run (FSSTR1). The primary objective of this run was to re-treat the material from the unsuccessful STR run in November 1994. Additionally, based on recommendations of BCD Group, Inc., a superior hydrogen donor was used in the November run. From SWRI's analytical results, the estimated 910 kg (2000 lb) of material contained 1100 ppm PCB, for a total PCB mass of 1 kg (2.2 lb). The baseline dosage of sodium hydroxide and hydrogen doner was added to give mass ratios (relative to PCB) of 2.5:1 and 2:1, respectively [i.e., 2.3 kg (5 lb) of sodium hydroxide and 1.8 kg (4 lb) of hydrogen donor were added]. Sodium hydroxide was added as solid flakes, rather than as a 50% solution as was done November 1994. Based on the experience in November, it was determined that efforts had to be made to minimize the quantity of water in the reactor to provide more stable operation and to minimize heat time. This run was performed before the supposition that fresh catalyst was needed; therefore, no catalyst was added since the reactor contents already contained 23 kg (50 lb) of catalyst added in November 1994. Antifoaming agent was not added to the STR, as the contents of the reactor contained no water [it had been previously treated at 349°C (660°F)]. Condensate would not be pumped from the receiver tank until the run had been completed.

Table 5.14. Summary of 400-gal STR Tests, November 1994 and May 1995

Test ID No. Test Date	Feed Material wt, lb	Estimated Feed PCB, ppm (wt)	Measured Feed PCB, ppm (wt)	NaOH, lb (form)	Catalyst, lb	Hydrogen Donor, lb	Reactor Conditions, Time, Temp	Product PCB, ppm	Condensate Mass: Oil, PCB, ppm; (H_2O, PCB, ppm)
28Nov94	100 gal LW-110 100 gal LW-107 356 lb GAC (34% moisture) 250 lb particulate (2400 lb total)	15,000 (36 lb)	7000 (17 lb)	90 lb (180 lb 50% solution)	47	Present in LW-107	3 hr, 350°C	1100	114 lb oil, 0.3 to 3400 ppm; (247 lb water, 0.3 to 4.1 ppm)
FSSTR1 17May95	Product from 28Nov94 400-gal STR run (2000 lb total)	1100 (2.2 lb)	1100 (2.2 lb)	5 lb (solid flakes)	none	4	3 hr, 350°C	380	94 lb oil, NA; (no water collected)
FSSTR2 25May95	Product from 17May95 run + 205 lb GAC (40% moisture) (2200 lb total)	3200 (7 lb)	850 (2 lb)	51 lb (solid flakes)	20	20	heatup, 310°C 2 hr, 352°C 2 hr, 356°C 2 hr, 357°C	460 ND ND ND	170 lb oil, ND; (125 lb water, ND)

ND = Not detected.
NA = Not analyzed.

The system was sealed and heating was begun at approximately 06:30 on 17 May 1995. Initial heating was uneventful, although it seemed quite slow. Ambient oxygen concentration was measured with the O_2 meter at 21.4%. Nitrogen flow was initiated to the reactor at about 08:00 when the temperature reached about 111°C (200°F). This flow was minimal [57 to 140 L/hr (2 to 5 cfh)] just to begin bringing the O_2 down gradually. Typical pressure in the reactor was 1.4 mm Hg (3/4 in. H_2O) during early heatup. As water was driven off, the pressure increased to a high of approximately 11 mm Hg (6 in. H_2O). At this pressure, temperature at the condenser inlet rose to over 111°C (200°F) and the fan was turned on. During this increased pressure visible signs of leakage around the mixer shaft seal were observed. Condensed water and penetrating oil (left from efforts to free the sticking shaft) emulsion was visible about the shaft seal area. Leakage was minimal at this time.

Once the water was driven off [reactor temperature of 121°C (250°F)], the pressure drop returned to a lower value of 3.7 to 5.6 mm Hg (2 to 3 in. H_2O). This caused the shaft seal leakage to return to zero and also caused the heatup rate to increase to the typical 0.55 °C/min (1 °F/min) seen during the earlier testing in November 1994.

Increasing the rate of heating during the water removal phase does not appear to be feasible. Efforts to increase the heating rate resulted in heavy foaming/ boilovers during the November runs, also seen repeatedly during 2-L STR runs. Once the water is completely removed, heating can be done at a faster rate.

Heatup during the 121°C to 316°C (250°F to 600°F) range was uneventful. The oxygen content in the offgas dropped to below detection at 329°C (625°F), and the N_2 was decreased from 140 to 57 L/hr (5 to 2 cfh) to conserve nitrogen and to minimize stripping of organic mist. Above 316°C (600°F), limited amounts of light condensate were observed at the agitator seal. Slight increases in pressure were noted upon reaching the target operating temperature of 350°C (662°F). A corresponding increase in condenser inlet temperatures from 114°C (237°F) to about 265°C (509°F) indicated that the reactor was generating significant organic overheads. The reflux tower was not used on this run, and the vapors were removed and condensed.

An attempt was made to increase the reactor temperature to 354°C (670°F); however, at this temperature, additional volatile organics were generated, increasing the pressure in the reactor and causing the additional material to be ejected from the shaft seal. The temperature was lowered, and the operation was to finish at approximately 352°C (665°F). After 3 hr at about 350°C (662°F), the heaters were shut off, and the reactor was allowed to cool.

Condensate was pumped and sampled the next morning but not analyzed. The approximately 57 L (15 gal) of collected material weighed 42.5 kg (93.5 lb.). Most of the material was light distillate resembling a heavy diesel fuel. There was a slight yellow aqueous layer but not more than several liters.

Results from analyses of the treated product showed that PCB had been reduced from 1100 to 380 ppm. While the feed contained primarily hepta-, penta-, and tetra- PCB homologs, the treated sample contained only di- and mono- PCB homologs.

With the exception of the seal leak, the system operated without any significant problems. From the run, it was clear that the shaft seal on this unit had to be repacked prior to further runs. Following the run, some of the offgas piping was disassembled and examined. All lines examined, including the line to the rupture disk, were extremely clean, probably because of the reflux of the light ends.

Summary of 25 May 1995 Run (FSSTR2). The objectives of FSSTR2 were to treat a moisture-bearing feedstream at temperatures of 354°C to 360°C (670°F to 680°F) for 6 hr. Product samples were to be collected at 2 hr, 4 hr, and 6 hr. No antifoaming agents were added. For this run, approximately 760 L (200 gal) of the unsuccessfully treated material from FSSTR1 were used as the starting feed material. This material had an estimated PCB concentration of 380 ppm. Additionally, 93 kg (204.5 lb) of loaded GAC [approximately 40% water by weight, or about 37 kg (80 lb) of water] were charged to the reactor for the purpose of increasing the PCB feed concentration. Based on previously obtained analytical data, the GAC was estimated to contain approximately 5% PCB by weight (dry basis). With the residual PCB concentration in the feed and the GAC, it was estimated that the STR reactor contained approximately 3.2 kg (7 lb) of PCB. However, subsequent analysis of a feed sample indicated that the feed contained only about 850 ppm PCB, or about 0.82 kg (1.8 lb) PCB in the reactor.

Excess reagents were added over the amounts used in the two earlier 400-gal STR runs. Catalyst and hydrogen donor were added at the rate of 9.1 kg (20 lb) each. Approximately 23 kg (51 lb) of sodium hydroxide flakes (97%) were added. Prior to the sodium hydroxide addition, the temperature of the slurry inside the reactor was 42°C (108°F). After addition and mixing, the temperature of the slurry increased to approximately 57°C (135°F) as a result of the heat of dissociation. Before STR startup for this run, the agitator shaft seal was disassembled and the graffoil packing was removed and replaced to mitigate leaking problems that occurred during FSSTR1.

The reactor heaters were energized at 06:30 on 25 May 1995. The nitrogen purge was turned on and set at 57 L/hr (2 cfh). The purge rate was maintained at this level for the duration of the run (except where noted otherwise). When the reactor contents were heated to 113°C (236°F), significant condensate (water) began to come off. At the condenser inlet, the temperature jumped from 35°C (95°F) to 99°C (210°F). At this time, the reactor set point was adjusted to 112°C (233°F) to allow the plenum and slurry temperatures to equilibrate. Extreme caution was exercised with respect to pushing the reactor temperature, based on boilover experience during the November 1994 testing. Consequently, during the time period between 08:00 and 09:00, the reactor heaters were energized only about 50% of the time. During this time period, approximately 3.4 kg (7.5 lb) of condensate were removed. At this rate, water removal operations would exceed 10 hr, so after 09:00 a more aggressive operating strategy was pursued.

As discussed in the next section, in the 2-L runs, it was found that stable water removal (i.e., removal without foaming and boilovers) could be achieved by controlling the system based on the condenser temperature. For the 2-L STR system, 65°C (149°F) was selected as the control temperature, since it provided an acceptable water removal rate. A similar strategy was pursued with the 400-gal STR, with an attempt to maintain system stability by controlling the condenser inlet temperature. Due to differences in geometry, 65°C (149°F) for a condenser inlet temperature on the 400-gal STR was too low and resulted in inadequate water removal. Watching for offgas temperature and reactor plenum pressure fluctuations allowed the system to be operated stably by maintaining the condenser inlet temperature between 99°C (210°F) and 102°C (215°F). Under these conditions, the reactor heaters were energized about 90% of the time, and condensate removal rates of about 9.1 kg/hr (20 lb/hr) were obtained. This water removal rate is about the same as the maximum stable water removal rate achieved during the November 1994 STR run.

Water removal rates were measured by closing the valve to the condensate collection tank, and allowing water to build up in the condenser. Approximately once every 10 min, water was removed from the condenser into a 5-gal bucket via the condenser drain line. To maintain positive pressure in the reactor when the drain line was open, the nitrogen purge was turned up to 560 L/hr (20 cfh) during draining. With this strategy, a positive pressure in the reactor of approximately 1.9 mm Hg (1 in. H_2O) was maintained while draining the condenser.

While water was being removed during the run, the oil slurry temperature was increased from 113°C (236°F) to 181°C (358°F) and the condenser inlet temperature was maintained between 100°C (212°F) and 102°C (216°F). At a reactor temperature of 181°C (358°F), the condenser temperature began dropping, signaling that water removal was nearly complete. At this time, the set point was increased, and the reactor heaters remained energized at 100% until the target reactor temperature was achieved. Total condensate removed between 113°C (236°F) and 181°C (358°F) was 48 kg (106 lb). Between 182°C (359°F) and 339°C (642°F), about 8.6 kg (19 lb) of condensate, consisting primarily of water, were collected. Figure 5.18 shows the reactor and condenser inlet temperatures for the entire run. In addition, this figure also shows the condensate collection rate.

While the reactor contents were heated from 260°C (500°F) to about 316°C (600°F), the pressure in the reactor would intermittently oscillate between 1.9 and 5.6 mm Hg (1 and 3 in. H_2O). For a complete pressure oscillation, approximately 15 sec would elapse. There was no evidence that these pressure swings had any effect on the reactor operations. It is suspected that the oscillations were caused by semivolatile organic materials condensing on the inside of the reactor head and offgas outlet line, then dropping back into the reactor and flashing off.

The lower end of the target temperature range 349°C (660°F) was reached at approximately 20:30. The operating strategy adopted for this temperature range was to keep the temperature at about 352°C (665°F) for the first 2 hr, 356°C (672°F) for the next 2 hr, and 357°C (675°F) for the final 2 hr. As the reactor contents temperature reached 349°C (660°F), significant volatile material began coming over into the condenser. The condenser inlet temperature increased to over 260°C (500°F). During this period, the peak condensate flowrate obtained was about 6.4 kg/hr (14 lb/hr). After the reactor was held at a given temperature for about 15 to 30 min, the condenser inlet temperature would drop back in the 60°C (140°F) to 82°C (180°F) range. However, as the temperature of the reactor contents was boosted to the next operating plateau, additional volatile constituents would come off into the condenser.

At 21:00 [reactor temperature 351°C (664°F)], the reactor agitator began vibrating. The intensity of the vibration caused the entire STR skid to shake, and it was shut off to maintain the integrity of the agitator shaft seal. The agitator was engaged periodically (3- to 5-min intervals) for several seconds to maintain mixing. As the reactor temperature was increased to 356°C (672°F), the vibration stopped and the agitator was again operated continuously. However, even at this temperature, vibration recurred several times for brief intervals. After the vibration, the shaft seal was observed to be leaking oil at the rate of about several grams every couple of minutes. The packing was tightened and the leak stopped.

The vibration likely was caused by polymeric material (possibly agglomerated hydrogen donor) sticking to one or both blades of the lower rake agitator. After completion of the run and subsequent cooling of the reactor contents, the agitator was operated continuously for several days without any problems or vibration.

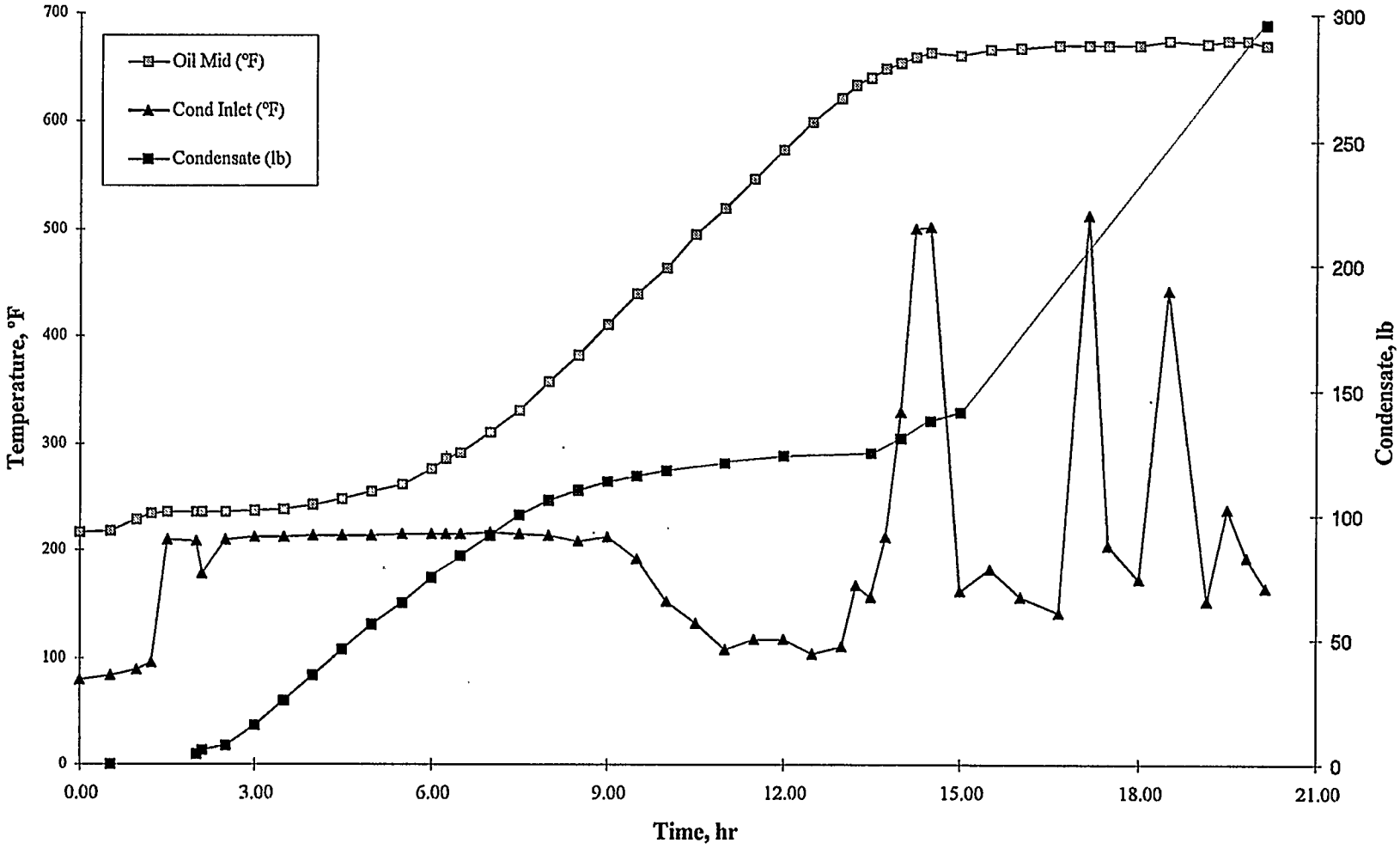


Figure 5.18. STR Temperatures and Condensate Rate 25 May 1995

While the reactor was held at the target temperatures (from 20:30 to 02:30), about 73 kg (160 lb) of organic condensate were collected. Thus, for the entire run, a total of 135 kg (296 lb) of condensate were collected [including about 4.5 kg (10 lb) collected after heat was turned off on the STR].

Four samples were taken from the STR during operations: a sample during heatup at 310°C (590°F) and product samples at 2 hr, 4 hr, and 6 hr at the target temperature range. Samples were collected by attaching a 4-ft tube to an evacuated bomb. The tube was inserted into the reactor, and a valve on the bomb was opened. Sample was pulled into the tube, the tube was withdrawn, and the reactor sampling port was closed. Pulling the sample and resealing the sample port required about 1 min.

Analyses of the samples showed that PCB in the oil was reduced to below detection limits (< 1 ppm per congener) in the 2 hr, 4 hr, and 6 hr samples. The sample pulled during heatup [at 310°C (590°F)] also had a significant PCB concentration reduction. This sample had a concentration of 460 ppm PCB, compared with 850 ppm PCB in the feed. Additionally, PCB in the condensate was also below detection limits.

- **2-L STR Testing.** All testing conducted with the 2-L STR in January/February 1994 and November 1994 was unsuccessful, as target reaction conditions [350°C to 360°C (662°F to 680°F)] were not achieved. As the temperature in the reactor reached 105°C to 130°C (221°F to 266°F), foaming and boiling became excessive, and the reactor contents would travel up the condenser. Cold testing of the 2-L STR system was performed at PNNL in Richland, Washington, with antifoaming agents to develop a safe and successful operating strategy. Ultimately, from this testing, the reactor setup was modified as described below.

The reactor head contained three ports. The center port housed the agitator shaft. One offset port was fitted with a thermocouple (to measure temperature of reactor contents) and a 1/4-in. pressure relief tube (bent 180 degrees) with one end submerged in 5.1 to 7.6 cm (2 to 3 in.) of oil in a knockout pot. The pressure relief tube provided relief in the event of sudden reactor pressurization in excess of 3.7 to 7.5 mm Hg (2 to 4 in. H_2O). In the final three runs, the pressure relief tube was replaced with a multifunctional 1/2-in. tube with two 1/4-in. nipples (one for nitrogen purge and the other connected to a water manometer) and one 1/2-in. tube submerged in the oil-filled knockout pot. The third port served as the offgas vent system, which included a straight connecting tube with a 4-mm downspout and vacuum hose fitting below the downspout (for introducing the nitrogen purge), a moisture test receiver (MTR), and a water-cooled condenser. The top of the MTR was fitted with a thermocouple to measure offgas temperature just before the condenser. The 2-L STR setup for the May 1995 tests in Guam is shown in Figure 5.19.

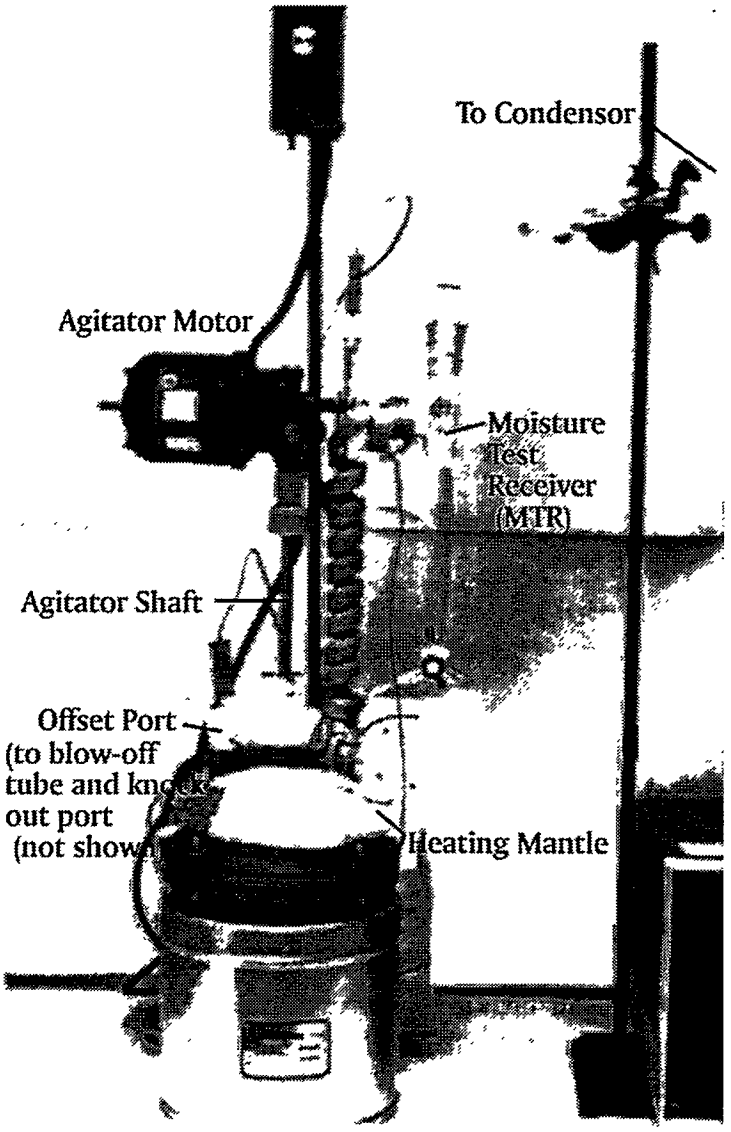


Figure 5.19. The 2-L STR Setup in Guam (Photo taken in May 1995)

The test conditions and analytical results from the 2-L STR testing are summarized in Table 5.15. The runs are designated at MSTR1 through 5 to distinguish them from the 400-gal STR tests. Table 5.15 provides information on the feed material, including mass, the source of PCB used for the test, concentration of PCB in the feed (estimated and measured), and reagent loading. For this testing, three sources of PCB were used to make the feed: unsuccessfully treated STR slurry from the 24 November 1994 full-scale STR run; oil collected from the bottom of the oil/water separator during the 50-ton run in November 1994 [this oil was determined to contain approximately 37 % (wt) PCB (370,000 ppm PCB)]; and loaded GAC containing 5% (dry wt) PCB and 40% moisture (obtained for water treatment operations during the November run).

Table 5.15. Summary of 2-L STR Tests, May 1995

Test ID No. Test Date	Feed - wt, g; (source of PCB)	Estimated Feed PCB, ppm (wt)	Measured Feed PCB, ppm	NaOH, g	Catalyst, g	Hydrogen Donor, g	Reactor Conditions, Time, Temp	Product PCB, ppm	Condensate: Oil, ppm - PCB; (Vol H_2O)
MSTR1 16May95	1071 g (STR residual 24Nov94)	1000 (1 g)	1000	5.1	none	4.0	2 hr, 350°C	880	4 ml - ND
MSTR2 17May95	1294 g (143 g of 37% PCB oil)	41,000 (53 g)	25,000	133	10	107	4 hr, 360°C	ND	Oil, 28 ml, 5340 ppm; (H_2O, 12 ml)
MSTR3 18May95	1050 g (140 g GAC, 40% H_2O)	4000 (4.2 g)	NA	10.6	none	8.4	1.5 hr, 350°C 1.5 hr, 350°C	1040 800	Oil, 78 ml, NA; (H_2O, 54 ml)
MSTR4 22May95	1641 g (283 g 37% PCB oil; 142 g GAC, 40% H_2O)	67,000 (109 g)	42,000	272	10	218	2 hr, 355°C 2 hr, 355°C	ND ND	Oil, 528 ml, 23,000 ppm; (H_2O, 71 ml)
MSTR5 25May95	1169 g (145 g of 37% PCB oil)	46,000 (53 g)	25,000	66	10	53	2 hr 355°C 2 hr 360°C	6040 870	Oil, 67 ml, 33,600 ppm; (H_2O, 8.8 ml)

ND = Not detected.
NA = Not analyzed.

In all 2-L STR tests, the reagent loadings were based on the estimated PCB concentration, since the measured values were not available until after the tests had been conducted. Estimates were based on previously measured PCB concentrations in the source material. The reagent additions were based on mass ratios of the reagent to quantity of PCB. Baseline reagent ratios were NaOH:PCB = 2.5:1 and hydrogen donor:PCB=2:1. When added, the catalyst comprised 0.5% to 1% (wt) of the mass of the reactor contents.

Table 5.15 also provides information on test temperatures and hold times (residence times) at those temperatures. In tests with several run conditions (e.g., MSTR3), the reactor was held at the first temperature for the indicated time, sampled, then held at the second temperature for the indicated time. In most cases, the reactor was allowed to cool prior to sampling. The analytical results from the product samples are also given in Table 5.15. The last column in Table 5.15 provides information on volume and concentration of PCB in condensed overheads from the 2-L STR. Analytical results are given only for the oil fraction of the condensate, since most PCB will partition into the oil.

Temperature profiles and condensate rates from an example run (MSTR2) are shown in Figure 5.20. The discontinuity in the oil temperature (reactor) is a result of shutting the reactor down at night. An important feature to note is that upon reaching the target reaction temperature, the organic condensate generation rate remains constant. Also, during this run, boilovers/foaming events were

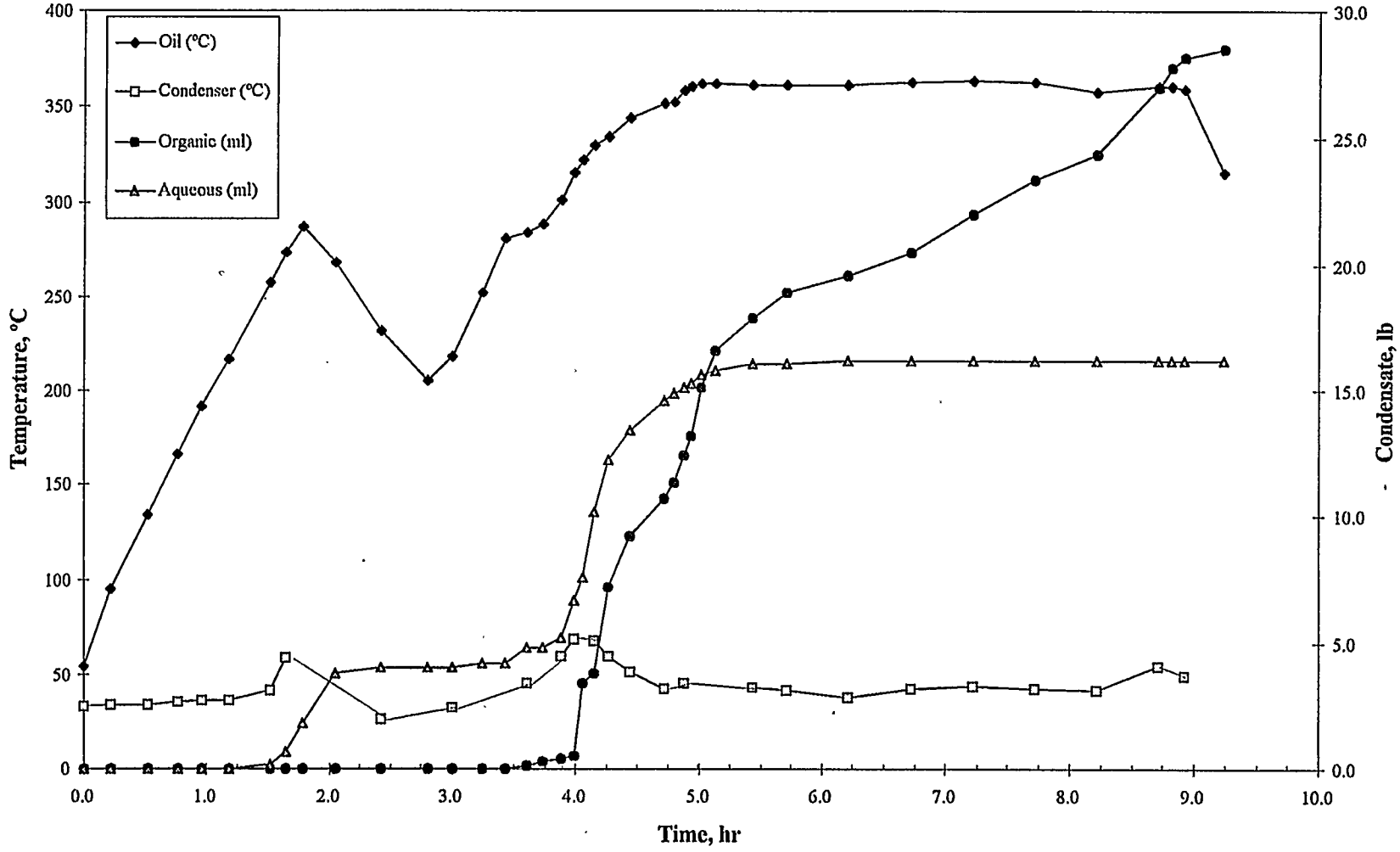


Figure 5.20. 2-L STR Temperature Profiles and Condensate Rates for MSTR2 (17 May 1995)

prevented by controlling the heat input (and water boiloff rate) to the reactor by keeping the condenser temperature below 65°C (149°F) during water removal (aqueous condensate). The importance of this operating strategy is discussed further in the text below.

MSTR1. The objective of this test was to demonstrate the BCD process on previously partially treated oil media and activated carbon from the unsuccessful full-scale STR run in November 1994. This test served as a shakedown for the new 2-L STR configuration and to model the expected operation of the full-scale STR loaded with the same material. Sodium hydroxide was added at a mass ratio to PCB of 5:1, and hydrogen donor was added at a mass ratio to PCB of 4:1 to help ensure success of this run (in comparison, baseline ratios are 2.5:1 and 2:1, respectively.) Target run conditions were 350°C (662°F) for a 2-hr hold time.

On 15 May 1995, after the reactor was loaded, the head of the reactor was cemented to the base with a high-temperature RTV gasket compound. Two hours into the run, during heatup, light smoke appeared from the reactor head. The system was shut down and cooled. Inspection of the reactor head revealed the presence of a 0.5-mm hole in the weld along a port. The reactor unit was disassembled and the reactor head was decontaminated using multiple washes of hexane and a citrus-based decontamination fluid. It was taken to a PWC shop where it was repaired with a stainless steel wire welder.

On 16 May 1995, the reactor was reassembled, and the run was continued. A light mist began to form in the MTR when the contents of the reactor reached 336°C (637°F). Target temperature [350°C (662°F)] was achieved and held for 2 hr. The reactor was shut down and a sample was collected after the reactor had cooled to 200°C (392°F). During the course of the run, approximately 4 mL of condensate were generated. Analysis of the product and condensate sample showed that the condensate was free of PCB; however, the concentration in product was 880 ppm, compared with a feed concentration of 1000 ppm.

Conclusions and Recommendations from MSTR1: MSTR1 was the first run with the 2-L STR in which target temperature had been achieved. From an operations perspective, the run was successful. While the total PCB content of the reactor was not reduced drastically, it was apparent that destruction occurred. The feed contained primarily hepta-, penta-, and tetra- PCB homologs; while the treated product contained only tri-, di- and mono- PCB homologs. [It was later surmised (after conducting MSTR3) that lack of completed destruction was partially due to not adding fresh catalyst to the reactor, although a significant quantity of catalyst was present in the material from the November 1994 run.] Chemists from BCD Group, Inc., speculated that the catalytic properties of the existing catalyst may have been poisoned. In addition, a reactor mechanical error, rather than an error with the chemistry, may have been another factor. Condensation being held up within dead spaces in the offgas glassware and pressure relief line dripped back into the reactor during reactor cooling. This was visually observed during cooldown around 200°C (392°F), and was accompanied by bumping and turnover of the reactor contents

at this temperature as the condensate dripped back in. The heldup condensate may have contained partially treated PCB. However, this problem was not identified and resolved until the configuration changes were made in MSTR3.

MSTR2. The objective of MSTR2 was to load the 2-L STR with a higher concentration of PCB oils and biomass oils with no activated carbon or fines. Also, PCB and biomass oils were introduced into the reactor by adding 143 g of a heavy oil (37% by weight, PCB) collected in the oil/water separator from extended hot run testing conducted in November 1994. Sodium hydroxide and hydrogen donor were added at a baseline ratio to PCB of 2.5:1 and 2:1, respectively. The system was also charged with fresh catalyst so that the final feed slurry contained about 0.75% by weight catalyst. Within this run, the effectiveness of an antifoaming agent (Dow-Corning Agent 544) was evaluated. Target residence time was 4 hr at 355°C (671°F).

On 17 May 1995, the reactor was sealed and heated to about 60°C (140°F) and stirred to homogenize the slurry prior to collecting a feed sample. As the reactor temperature climbed to about 285°C (545°F), foaming/vigorous boiling commenced, even though the slurry contained 50 ppm antifoaming agent. Heat was shut off to the system as boiling continued. The first 1.3 cm (0.5 in.) of the carbon bed (for offgas polishing) was observed to be wetted, and significant backpressure was being placed on the reactor. This led to sharp pressure fluctuations that caused slugs of condensate to drop back into the reactor and flash. The carbon bed was removed, the vent line was replaced with tubing, and the heat was turned back on to the reactor. To further combat foaming/boilover, additional antifoaming agent was added to boost its concentration to approximately 1400 ppm; however, the antifoaming agent had no noticeable effect on the boiling/foaming. The target temperature 355°C (671°F) was achieved and held for 4 hr. The reactor cooled normally and was sampled the next morning. During the course of the run, 28 mL of oil condensate and 12 mL of aqueous condensate were generated. Analysis of the treated slurry showed no detectable PCB; however, the oil condensate contained approximately 5300 ppm PCB.

Conclusions and Recommendations from MSTR2: MSTR2 was the first successful STR test conducted with PCB residuals from Guam. Comparison of MSTR2 with MSTR1 indicated that fresh catalyst may be necessary for the successful operation of the BCD process. This run also showed that the antifoaming agent tested was not effective against the specific foaming problems encountered.

MSTR3. The objective of MSTR3 was to simulate a proposed run in the full-scale STR in which about 91 kg (200 lb) of loaded GAC would be treated in 760 L (200 gal) of oil. Therefore, for MSTR3, 140 g of wet loaded GAC (40% H_2O, 5% PCB-dry basis) were added to the reactor. (Based on moisture measurement, the feed contained approximately 56 mL of water that would have to be removed during the run.) Baseline reagent dosages were used, except no catalyst was added. (The necessity of the catalyst had not yet been determined.) In addition, the antifoaming agent (Agent 544) was added at approximately 1.0% by weight of reactor contents to examine its effectiveness at very high concentrations. This run also explored BCD Group's recommended use of intermittent stirring as a tool to reduce foaming. Some changes to the equipment were made to eliminate dead spaces that could potentially hold

up incompletely treated material and recontaminate the reactor contents. Target conditions were to operate for 90 min at 350°C (662°F), sample, then operate for an additional 90 min at 350°C (662°F). A new source of hydrogen donor, acquired from a service station on Guam, was used for this test. After closer examination and initial testing, this hydrogen donor appeared to exhibit a higher melting point than the donor brought to Guam by BCD Group, Inc., and may not have adequately decomposed at 350°C (662°F).

On 18 May 1995, the reactor was loaded and operations commenced for heatup and water removal. Fogging and condensation inside the MTR were observed at a reactor temperature of 106°C (223°F). The stirrer was operated at a low speed for a few seconds every 5 or 10 min. The reactor still intermittently boiled over, and the run was ended for the night with about 16.4 mL of condensate collected over a 90-min period.

The next morning, the run was continued with 10.2 g of Agent 544 added to the reactor prior to restart, bringing the total antifoam addition to 11.4 g. Within 15 min of reaching 110°C (230°F), the reactor foamed/boiled over, indicating that the antifoam addition at 1.0% by weight did not eliminate the violent boiling problems. When the boilovers ceased, another method was explored that involved holding the reactor at a temperature below where boilover was expected, and moving the target temperature upwards as the carbon/water or water/NaOH desorption temperature increased. This method was attempted for several hours with moderate success. Later, examining the previous data showed that the majority of boilovers occurred when the MTR thermocouple (measuring offgas temperature immediately prior to condenser) exceeded 70°C (158°F). From this information, the heat input to the reactor was regulated to keep the MTR close to or below 65°C (149°F). This approach was overwhelmingly successful in maintaining a high water removal rate while minimizing boilovers and foaming during water removal.

During the entire hold time temperature of 350°C (662°F), oil condensate was generated at approximately 0.3 mL/min. After 90 min at temperature, the heat was turned off, and a sample was taken at 200°C (392°F). After sampling, the heat was turned back on and the reactor was reheated to 350°C (662°F) and held there for an additional 90 min. Analytical results showed that the PCB content had been reduced from 5000 ppm to 1040 ppm after the first 90 min and to 800 ppm after the final 90 min at temperature. While the feed contained primarily hexa-, hepta-, and penta- PCB homologs, the 90-min sample contained only tetra- through mono- PCB homologs. The final 180-min sample contained only mono-, di- and tri- PCB homologs. During the course of MSTR3, 78 mL of organic condensate and 54 mL of aqueous condensate were collected. However, no analytical results on the condensate are available.

Conclusions and Recommendations from MSTR3: The results of this experiment were very similar to MSTR1 for the PCB concentrations and homolog distribution in the unsuccessfully treated material. In both MSTR1 and MSTR3, no fresh catalyst was added to the reactor. From this run, ideas were developed for eliminating dead spaces conducive to condensation holdup. Also, based on a

comparison of the first three runs, fresh catalyst would be added in subsequent runs. Use of intermittent stirring was found to be ineffective for controlling foaming and boilovers. The strategy of minimizing boilovers by controlling energy input based on the offgas temperature was deployed for all subsequent runs (including the final full-scale run).

MSTR4. The objective of MSTR4 was to simulate the planned full-scale STR test, applying lessons learned from prior tests, including regulation of heat during water removal by monitoring offgas temperature. The feed contained 142 g of wet loaded GAC (40% H_2O, 5% PCB-dry basis) and 283 g of a heavy oil (37% by weight PCB) collected in the oil/water separator from extended hot run testing conducted in November 1994. Sodium hydroxide and hydrogen donor were added at a baseline ratio to PCB of 2.5:1 and 2:1, respectively. The system was also charged with fresh catalyst so that the final feed slurry contained about 0.65% by weight catalyst. Target operating conditions were 4 hr at 355°C (671°F), with samples taken after 2 and 4 hr. After the reactor was loaded, the donor acquired from the service station on Guam was determined to be suspect; therefore, an equal weight of softer donor material was added before achieving the target temperature.

On 22 May 1995, data reporting began after the mixed feed sample was taken at 80°C (176°F). At 148°C (298°F), a two-phase condensate began to form in the MTR. Up to this temperature, no condensate had been generated. At 180°C (356°F), liquid condensing in the entrance tube to the MTR began to bubble and foam in the 4-mm downspout on the connecting tube between the reactor and the MTR. At 184°C (363°F), the heat was turned off to allow the foaming to cease, although very little condensate had been collected, 1.0 mL oil and 2.5 mL aqueous. Antifoaming agent was added to the reactor, but had no effect on the light foaming. The foam did not appear to be a function of violent boiling but merely an artifact of the refluxing liquid in the very small (4 mm) downspout back to the reactor. Heatup was resumed and, as the condensate was mostly water, the strategy of keeping the condenser at 65°C (149°F) was successfully employed to keep violent boiling from occurring. When the reactor temperature reached 268°C (514°F), a total of 41 mL of water and 8.5 mL of oil were collected, and the rate of water condensation was tailing off significantly. The reactor was shut down for the night to continue operations the next morning.

By the next morning, the reactor contents had jelled, which was observed upon restart, and the stirrer was unable to move. At a temperature of 109°C (228°F), the reactor contents had warmed to the point where the medium was once again mixable, and the stirrer was re-engaged. At 273°C (523°F) the condensation rate was 0.22 mL/min for oil and 0.04 mL/min for water. This increased to 1.3 mL/min oil and 0.4 mL/min water at 303°C (577°F) and to 4.45 mL/min oil and 0.6 mL/min water at 320°C (608°F). By the start of the residence time [355°C (671°F)], the oil flowrate had increased to 4.88 mL/min and water dropped to 0.13 mL/min. The MTR and condenser both contained a white mist.

After 30 min at 355°C (671°F), water production had ceased entirely and oil condensation had eased to 2.2 mL/min. Oil condensation continued to slow during the run and was down to 0.5 mL/min at the end of the 4-hr residence time. At the conclusion of the run, a total of 528 mL of oil and 71 mL of

water had been collected. The reactor was allowed to cool overnight, and again the contents solidified to a slightly elastic, unstirrable gel. The volume of the reaction medium was also greatly diminished. The gel was not a pumpable fluid at room temperature, although it was easily removed from the small-scale system with a scoop.

Both the 2-hr and 4-hr product samples contained no detectable PCB. However, the condensate composite sample did contain 23,000 ppm PCB.

Conclusions and Recommendations from MSTR4: MSTR4 was successful in treating the bulk of the reactor slurry; however, there was a high concentration of PCB in the significant volume of condensed oil. In this 2-L STR run, the nitrogen flow was not held at as low a flowrate as it had been in previous tests. Reducing the flow of the nitrogen to the minimum amount necessary would result in less misting within the reactor and less oil condensation occurring in the MTR, condenser, and connecting tubing.

Further speculation on the large amount of oil in the condensate indicated that the base may have reacted with the LW-110 at high temperatures and high concentrations of base in the reactor. The weight of the oil collected in the MTR exceeded the weight of any single component by at least a factor of 2, except for LW-110, thereby leading to the conclusion that the light oils were, to a large degree, composed of LW-110 or its reaction products. Furthermore, the oils collected, when returned to the reactor through the MTR trap return, immediately flashed to vapor, thereby indicating that the oil was not just condensed LW-110, but shorter chain hydrocarbons with a higher volatility.

Finally, this run illustrated the problems associated with overloading the reactor with the new hydrogen donor. While the process reactor product was clean and free of PCB, the final status of the product, a slightly elastic gel, could present many materials handling problems in removal from a large-scale reactor and reprocessing, recovery, or disposal.

MSTR5. The objective of MSTR5 was to reproduce the feed conditions for the successful test MSTR2, and cut the reagent loadings by half, specifically the hydrogen donor and sodium hydroxide. Catalyst dosage remained the same as experiment MSTR2; however, the antifoaming agent was eliminated. Target conditions were to operate at 355°C (671°F) for 2 hr, then sample, operate at 360°C (680°F) for 2 hr, and take the final sample.

MSTR5 began on 25 May 1995 after a feed sample had been collected. Initial heatup was rapid, and condensate began to form at a reactor temperature of 179°C (354°F). By 288°C (550°F), 17.7 mL of oil and 1.6 mL of water condensate had been collected, and a heavier-than-air white vapor was visible inside the MTR. The nitrogen purge gas was suspended, based on lessons learned from the previous operations, since the reactor head had been purged. When the nitrogen purge was removed, the mist abated somewhat, but was not eliminated, and the oil collection rate dropped off considerably.

By 304°C (579°F), boiling and bumping of the reactor contents began to occur due to water and light oils condensing in the inlet of the MTR, dripping back into the bulk liquid, and flashing off. The nitrogen purge gas was reinstated at a very low flowrate to provide some sweeping effect for these vapors, and the MTR was insulated even further to prevent condensation at this point. Slight foaming occurred from the condensation flashing, and 1.2 g of Agent 544 was added to the reactor. Foaming abated after 10 min as the reactor temperature dropped to 280°C (536°F), and heatup was again initiated, although the white vapor was still present in the MTR. By 309°C (588°F), 10 mL more of oil and 2.0 mL more of water had collected.

Oil continued to collect at a rate of around 0.6 mL/min and water at a rate of about 0.1 mL/min. Thirty minutes after the target temperature [354°C (669°F)], was achieved, oil condensate generation slowed to 0.02 mL/min. The 2-hr sample was taken without dropping the temperature, and the temperature of the reactor was boosted to 360°C (680°F) for the remainder of the residence time. The reactor was also allowed to cool before the final sample was collected. During the course of the run, 67 mL of oil and 8.8 mL of aqueous phase condensate were collected. Analytical results showed that during the 2 hr at 355°C (671°F), the PCB concentration was reduced from 25,000 ppm to 6040 ppm. After the final 2 hr at 360°C (680°F), the PCB concentration was reduced to 870 ppm. Both product samples contained mono- through hex- PCB homologs. The condensate contained 33,000 ppm PCB.

Conclusions and Recommendations from MSTR5: Although this experiment did not achieve target destruction level, significant PCB reduction did occur with 50% of the dosage of MSTR2. However, some of the PCB was solvent stripped and captured in the condenser. Significantly less overheads were formed in this test, indicating that the carefully controlled nitrogen purge gas flow may play a large part in the overheads production rate, especially considering the relatively constant condensation rate during the hold temperatures of the various tests. Further testing was recommended for optimizing the reagent loading, as the residence time for destruction of the PCB appeared to be fairly sensitive to the reagent dosage.

Conclusions from May 1995 STR Testing Campaign. The 400-gal STR can reduce PCB levels to below detection limits. During the second run, the PCB in the reactor was dropped from 850 ppm to less than 2 ppm per congener. Also, for this run, the condensate was found to be free of PCB.

Results indicated that fresh catalyst may be necessary for the BCD process to successfully destroy PCB to target levels in the matrices tested. Several tests conducted without catalyst were unsuccessful. A catalyst loading of 0.75% by weight of the total batch (i.e., reagents, contaminants, and the reaction medium oil) appears to be effective.

The oil used in the successful run, FSSTR2, had been used in two previous runs. This demonstrated that the oil can be recycled for a minimum of three cycles.

The STR can handle a fairly high solids loading. During FSSTR2, the feed contained approximately 760 L (200 gal) of oil, 110 kg (250 lb) of fines, 260 kg (570 lb) of GAC (wet basis), 64 kg (140 lb) of sodium hydroxide, 32 kg (70 lb) of catalyst, and 11 kg (25 lb) of hydrogen donor.

Excess sodium hydroxide apparently facilitated partial breakdown of LW-110 oil into semivolatile fragments. The feed material for FSSTR2 was heated to 354°C (670°F) during FSSTR1 (i.e., all light hydrocarbons should have been driven off during FSSTR1). Additionally, this material had been heated to about 352°C (665°F) during the STR test in November 1994. During FSSTR2, approximately 73 kg (160 lb) of semivolatile organic constituents were generated during the hold time at the target temperature, which is presumed to be caused by the large excess of sodium hydroxide added to the feed [i.e., 23 kg (51 lb)]. Further evidence of this hypothesis is supported by testing conducted at PNNL (Richland, Washington) in early May 1995. In this testing, the hydrogen donor was added to LW-110 in the absence of sodium hydroxide. During this testing [conducted in the 2-L STR at temperatures up to 354°C (670°F)], no condensate was generated.

The hydrogen donor used for the testing has the potential to form a material that can stick to the agitator impellers. Overloading with hydrogen donor during a 2-L STR run resulted in a treated product that was not pumpable.

Antifoaming agents at concentrations of 50 ppm, 1000 ppm, and 10,000 ppm were not effective in preventing foaming events. It appears that foaming events are actually caused by the onset of vigorous boiling.

The STR system, when loaded with a high-moisture feed, can be operated without foaming and boilovers, as shown by controlling the system around the condenser inlet temperature during FSSTR2. It is feasible that logic could be incorporated into the reactor heater control that would regulate energy input to maintain a constant condenser inlet temperature, resulting in stable water removal.

Nominal reagent loadings were cut in half in the final 2-L STR test. For this test, PCB was reduced by 76% after 2 hr and by 97% after 4 hr; however, the target treatment level of 2 ppm per congener was not met. The results of this test indicate that nominal reagent loadings can be significantly reduced, but further testing will be necessary to determine the optimum levels. Until optimization of reagent is completed, the mass ratios of reagents to PCB are NaOH:PCB=2.5:1; hydrogen donor:PCB=2:1.

Options should be investigated and a decision made on how to dispose of treated residuals (oily sludge) from STR operations. One option is to turn over the residuals to the Defense Reutilization and Marketing Office (DRMO) for recycle or use as a fuel. Other options include burning it as a bunker fuel

additive on Guam; shipping it to the continental U.S. for recycle, fuel, an asphalt additive, or land disposal, or as a nonhazardous carbonaceous waste.

Recommendations from May 1995 STR Testing Campaign. An appropriate hydrogen donor must be selected that will decompose and react at or below the operating temperature of the STR.

If oil (LW-110) is to be reused for a number of cycles, solids will eventually build up. The solid-laden oil can be pumped to drums or tanks, and allowed to settle for several days. The clarified supernatant in the drums can then be recycled back to the reactor for additional runs.

While installing the larger loading port, the reactor head gasket should be replaced. During FSSTR1, small amounts of oil seeped out through one section of the head gasket. During FSSTR2, no leakage/seepage was observed. However, considering the amount of time the reactor has been in Guam, it would be prudent to replace this gasket.

To facilitate loading of the reactor, it is recommended that a 12-in. flange be added to the reactor. With the current 6-in. flange, it is difficult to load fines and reagents without some material being spilled. The existing 6-in. flanges should be used for installation of bayonet-style cooling coils. The space available in the 6-in. flange provides sufficient cooling surface area to cool the reactor contents in approximately 4 hr.

Run cycle time could be further reduced by providing supplemental heating for the reactor. In the current configuration, approximately 6 hr were required while the heaters were operating at 100% to heat the reactor contents (during FSSTR2) from 180°C to 350°C (360°F to 662°F).

For any changes/modification made to the STR, consideration should be given to the elimination/minimization of dead spaces that can potentially hold up PCB-containing condensates and recontaminate treated feed during cooldown.

Generation of volatile organic material in the reactor is excessive at target reaction temperatures, and efforts should be taken to reduce it. During testing at high PCB levels with the 2-L STR, the organic overheads collected in the condenser contained significant quantities of PCB. It has been proposed to reinject the organic condensate back into the STR at a level below the slurry surface. Based on experience with the 2-L STR, the organic condensate can account for up to one third of the mass of the initial feed material. With the current configuration of the 400-gal STR design, reinjection of this much material will be difficult. Tremendous energy will be expended in revaporizing the condensate. Additionally, if large quantities are reinjected, a large offgas flowrate will be created that could intensify the stripping of PCB from the slurry solution. A more prudent approach would be to adjust the sodium hydroxide addition rate to a minimum level, or operate the reactor at a lower temperature for a longer period of time [since most of the organic overheads come off at temperatures above 350°C (662°F)].

Also, during 2-L STR testing, minimizing the flow of the nitrogen purge gas was shown to be effective in reducing the organic condensate generation rate.

The condensate receiver tank pump can generate enough suction such that negative pressure can be pulled on the reactor, which could allow oxygen to be pulled into it. It is recommended that a vent be put in the condensate receiver tank to open during this pumping. This will minimize any pressure fluctuations when the unit is taken on/offline and would preclude any introduction of O_2 into a hot reactor.

As currently configured, the STR has only one offgas outlet that serves both as a transport line to the condenser and as the pathway to the system rupture disk. If this line were to become plugged, both the rupture disk and the offgas line would be blocked, and the reactor could become over pressurized. A separate line for pressure relief should be added to the system. This line should have a second safety relief device with a set pressure slightly higher than the rupture disk, perhaps a 3 psi rupture disk and 5 psi secondary. It is unknown what effect these oils have on the graphite rupture disks. It is conceivable that these oils could weaken the disks, causing premature failure and loss of product into the knockout drum. Metal disks should be considered. In addition, prior to each run, or on another suitable schedule, the condition of the relief devices and line conditions should be checked for buildup and blockage.

Additional testing of Stage 2 BCD should be conducted to optimize reagent requirements and refine operating strategies. Because Stage 2 is sensitive to the process matrix, this testing should be conducted with the actual process residuals generated from the Guam BCD treatment operation. To minimize costs, most of this testing can be conducted with a bench-scale test system.

6.0 Economic Assessment

The economics of the BCD process were evaluated in terms of capital and operating costs for a system operating at a throughput of 1.25 ton/hr with soil contaminated with 500 ppm PCB and containing 10% moisture. The objective of the assessment was to determine the treatment cost per ton of contaminated soil at a site in the continental U.S. with a system equivalent to that used for the Guam BCD demonstration. It was assumed that the system would run 24 hr/day with an operating availability of 70%.

Equipment costs for this evaluation were based on actual equipment costs for the system procured for the Guam demonstration. These costs, which are presented in Table 6.1, were escalated to 1995 dollars. The plant equipment was depreciated over 10 years to obtain a final total annual operating cost and the unit cost ($/ton) for the treated soil.

6.1. Capital Costs

From Table 6.1, the total purchased cost for the major components in the BCD system were $858K at the time of purchase. In June 1995 dollars, using the Chemical Engineering Plant Cost Index (Chemical Engineering 1995), the total equipment cost is $1.06 million. The 1995 equipment costs include a front end loader and a cooling system for the STR. These two items were not included in the actual purchased cost of the BCD system demonstrated in Guam.

In addition to the purchased equipment costs, the fixed capital investment (FCI) includes other direct and indirect costs, as shown in Table 6.2. The direct costs include installation, instrumentation and controls, piping, electrical, site preparation, and service/support facilities. Indirect costs include engineering and construction.

The ratios for the cost elements comprising the total FCI in Table 6.2 are based on standard estimates for major additions to chemical processing operations at partially developed sites (Peters and Timmerhaus 1991). As testing and demonstration of the BCD process in Guam was developmental in nature, and the remote location of Guam added additional costs to the project, projected ratios were used to provide an estimate of the FCI for an equivalent BCD operation in the continental U.S. Table 6.2 provides information on the ranges of typical ratios for major plant additions to an existing site. The ratios used for the BCD system fall into the low end of these typical ratio ranges. The lower ratios were used since most of the larger pieces of equipment for the BCD process (e.g., rotary kiln reactor, crushing plant, pugmill, feed conveyer, front end loader) are mobile and are delivered to the site in a condition that requires minimal setup and installation. Use of the ratios in Table 6.2 results in a total FCI of $3.01 million to purchase and deploy a 1.25 ton/hr BCD system.

Table 6.1. BCD Equipment Purchase Costs (dollars)

Equipment	Year Acquired	Purchase Price, $	June 1995 Cost, $
Rotary Kiln Reactor	1990	381,000	407,000
Knife Gate Valves	1991	2,390	2,500
Portable Crushing Plant	1991	104,000	110,000
Portable Mixing Plant (Pugmill)	1991	89,600	94,700
Feed Hopper/Conveyer Weighbelt	1991	49,800	52,600
Flexible Screw Conveyer	1991	11,100	11,700
Reactor Outlet Conveyer	1991	10,900	11,500
Portable Conveyer	1991	2,730	2,890
Bin Vibrators	1993	2,580	2,740
Platform Weigh Scales	1991	8,200	8,700
Fuel Tanks	1991	5,700	6,030
Baghouse	1991	14,900	15,800
Cyclone	1991	5,780	6,110
Wet Scrubbers	1991	12,000	12,700
Forced Air Heat Exchangers	1991	19,700	20,800
Induce Draft Fan	1990	9,280	9,910
Compressor and Dryer	1991	10,200	10,800
Stainless and Carbon Steel Tanks	1991	13,400	14,200
Agitators for Tanks	1990	6,610	7,060
Butterfly Valve	1990	3,100	3,300
Filter Press	1991	14,700	15,500
Pumps	1990	18,100	19,300
Carbon Adsorption Units	1991	15,200	16,100
Skids for Process Equipment	1991	14,000	14,800
Feed Shelter (20' x 30')	1994	2,400	2,500
Stirred Tank Reactor (STR)	1991	31,000	33,000
Cooling System for STR	(a)	(a)	47,300
Front End Loader	(b)	(b)	100,000
Total Equipment Cost		**858,000**	**1,060,000**

(a) Not purchased for Guam BCD Demonstration, but recommended.

(b) Supplied by the Navy for Guam BCD Demonstration.

Table 6.2. Ratio Factors Used in Estimated Fixed Capital Investment Costs for 1.25 ton/hr BCD Process

Item	Percent of Purchased Equipment Cost (Typical Ranges [a])	Percent of Purchased Equipment Cost BCD Operation
Direct Costs		
Purchased equipment (delivered)	100%	100%
Installation	25 to 55%	30%
Instrumentation and Controls	6 to 30%	13%
Piping (installed)	16 to 66%	16%
Electrical (installed)	10 to 15%	10%
Site Preparation	10 to 20%	10%
Service/Support Facilities	30 to 80%	30%
Total Direct Costs (TDC)	**197 to 366%**	**209%**
Indirect Costs		
Engineering - 8% of TDC	16 to 30%	17%
Construction expenses - 10% of TDC	20 to 37%	21%
Total Indirect Cost (TIC)	**36 to 67%**	**38%**
Contractors Fee at 5% TDC and TIC	12 to 22%	12%
Contingency at 10% TDC and TIC	23 to 43%	25%
Fixed Capital Investment	**268 to 498%**	**284%**

(a) Peters and Timmerhaus (1991).

The costs associated with service and support facilities can be very significant and highly variable, depending on the site and the availability of existing facilities. While a ratio of 30% was used for this economic evaluation, if the BCD system were to be deployed at a site containing no existing facilities or utilities, a ratio of 55% may be more appropriate.

6.2. Operating Costs

Annual operating cost estimates for processing 1.25 ton/hr (7700 ton/year) are shown in Table 6.3. An operating schedule of 24 hr/day with an operating availability of 70% is assumed. The FCI is depreciated over 10 years of operation with maintenance and repairs estimated at 5% of the FCI/year (Peters and Timmerhaus 1991).

Table 6.3. Estimated Costs for BCD Treatment of Contaminated Soil (7700 ton/yr) in Continental U.S.

Item	Unit	Unit Cost, $	Number of Units Per Year	Annual Cost, $/yr
Chemicals				
$NaHCO_3$	lb	0.21	1,390,000	290,000
Granular activated carbon (GAC)	lb	1.50	39,000	59,000
LW-110	gal	2.00	5,300	11,000
NaOH (solid)	lb	0.50	9,600	4,800
Hydrogen donor	lb	0.40	7,700	3,100
Catalyst	lb	0.39	2,600	1,000
Disposal/Recycle Fee	gal	3.00	14,000	42,000
Subtotal				**410,000**
Utilities				
Fuel Oil	gal	1.20	55,000	66,000
Electricity	kWh	0.10	290,000	29,000
Subtotal				**95,000**
Labor				
Supervisors	hr	30	7,200	220,000
Operators	hr	25	29,000	730,000
Subtotal				**950,000**
Supervision (20% of labor)				190,000
Offsite Analyses	PCB Analysis	500	100	50,000
Maintenance Supplies 5% of FCI[(a)]/yr				151,000
Operating Supplies 1% of FCI[(a)]/yr				30,000
Plant Overhead Costs, 60% of labor				570,000
Depreciation, 10% of FCI[(a)]/yr				301,000
Total Treatment Cost per year				**2,750,000**

(a) FCI, Fixed Capital Investment (i.e., capital necessary for equipment, installation, and all auxiliaries for complete process operation) for 1.25 ton/hr BCD system is $3,010,000.

Chemical costs are based on the annual consumption of the BCD reagents in both Stage 1 and Stage 2 for processing 7700 ton/yr of contaminated soil (500 ppm PCB). Based on operations in Guam, sodium bicarbonate will be added to soil at 10% by weight of soil (soil dry weight). Granular activated carbon is specified for treatment of scrubber water at a ratio of 5 lb GAC for each lb of PCB in the feed soil.

The 400-gal STR reactor will be operated once for every 60 tons of soil processed (based on operating experience in Guam). Each batch processed in the STR will be assumed to contain 14 kg (30 lb) of PCB for determining reagent requirements (i.e., based on an assumption that 50% of PCB in the feed is thermally desorbed and captured in process residuals; with the other 50% of PCB assumed to be destroyed in Stage 1). Reagents will be added to the STR at the following mass ratios: NaOH:PCB = 2.5:1; hydrogen donor:PCB = 2:1. The catalyst will be added at 9.1 kg (20 lb) per batch. For each batch processed in the STR, it is assumed that 760 L (200 gal) of LW-110 oil will be added. After each batch, 80% of the LW-110 will be recovered and reused in subsequent batches. Each batch will generate 416 L (110 gal) of residual (nonhazardous) for industrial recycle or disposal. Based on motor oil disposal pathways, a recycle/disposal cost of $0.79/L ($3/gal) has been assumed for oily residuals.

The estimates for utility costs for fuel and electrical consumption provided in Table 6.3 are based on BCD operating experience in Guam. Labor costs were estimated based on the following assumptions:

- Operating schedule: 3 shift/day; 300 days/yr
- Operating staff: 1 supervisor and 4 operators per shift.

6.3. Total Treatment Costs

The total annual treatment cost shown in Table 6.3 includes both Fixed Capital Investment depreciation and operating costs. Based on the assumptions outlined, the total annual treatment cost is projected to be $2.75 million/year for the 1.25 ton/hr BCD system with a 10-year life. The unit cost for treating 7700 ton/year is estimated at $360/ton. This estimate does not take into account the costs of obtaining any regulatory permits which may be required for treatment operations.

Approximately 62% of the total treatment costs are from labor costs (labor, supervision, and overheads). Therefore, efforts to reduce treatment costs should be focused on reducing labor requirements (e.g., incorporation of more automated systems for materials handling).

The total treatment cost is fairly insensitive to PCB concentration in the soil. In Guam, the PCB concentration varied from approximately 200 to 2000 ppm PCB. This variation had little effect on the operations or chemical reagent requirements for Stage 1. Particulate generation rates were more affected by soil moisture and rotary kiln operating conditions than PCB content of the soil. Consequently,

doubling the PCB concentration in the feed would primarily affect reagent consumption in the Stage 2 operations. Even if the number of batches to be processed through Stage 2 doubled (i.e., doubling GAC usage, STR reagents and utilities, and STR residual disposal costs), total treatment costs would only increase by approximately $16/ton.

7.0 Conclusions and Recommendations

A continuous, 1 to 2 ton/hr Based Catalyzed Decomposition system was designed, constructed, and successfully demonstrated in Guam by Pacific Northwest National Laboratory (PNNL) and Battelle-Columbus Laboratory (BCL) for the treatment of PCB-contaminated soil and process residuals. The BCD process development and system operation was a result of the U.S. Navy's efforts to deploy a new PCB treatment technology at Navy facilities.

With the system tested and demonstrated in Guam, PCB concentrations in the soil were reduced from 290 - 1900 ppm to below the TSCA treatment standard of less than 2 ppm per resolvable PCB congener. Upon completion of the demonstration, the system was transferred to the Navy and its Remedial Action Contractor (RAC) for clean up of the contaminated site at the Navy's Public Works Center in Guam.

This demonstration is the culmination of more than 10 years of laboratory testing and development of dehalogenation processes that ultimately evolved into the BCD process. Much of the success of the demonstration can be attributed to the participation and cooperative relationships among the Navy, U.S. EPA, U.S. Department of Energy, PNNL, BCL, and the Navy's RAC. During the course of this project, the BCD technology also received recognition with awards from *Research and Development Magazine* (R&D 100 Award, 1992) and *Popular Science* (Best of What's New - 100, 1993).

With the successful demonstration, the state of development of the BCD technology has been significantly advanced for potential treatment of the more than 1 billion tons of U.S. soils contaminated by PCB. Furthermore, as shown in Guam, the process can also effectively treat other toxic chlorinated compounds, such as dioxins and furans.

Specific conclusions and recommendations resulting from the BCD Demonstration Project are summarized below.

7.1. Conclusions

7.1.1. Process Chemistry

Small-scale laboratory data were used to provide design and operational bases for the 1 to 2 ton/hr BCD system. For Stage 1 soil processing, laboratory data adequately predicted the efficacy of the 1 to 2 ton/hr rotary kiln operation.

Preliminary data and recently reported research indicates that it may be possible to reduce the sodium bicarbonate level from 10% by weight to ~5% by weight. Approximately 6 tons of soil were successfully treated with sodium bicarbonate added at 5% by weight. Additionally, approximately 4 tons of soil were successfully treated with no sodium bicarbonate. However, residual sodium bicarbonate in the system and back-mixing may have contributed to these results.

For Stage 2 STR operations, though successful, , significant discrepancies existed between the results of the laboratory design basis testing and the full-scale demonstration results. These discrepancies were primarily the result of performing Stage 2 laboratory testing with feed material that was not representative of the actual feed. As a result, additional small-scale STR testing was necessary to determine suitable reagent loadings and to refine operating strategies. The STR operations conducted in November 1994 and May 1995 showed that further process improvements and optimization of Stage 2 are desirable to make it more cost effective and could be achieved through additional testing.

7.1.2. Equipment

The rotary kiln reactor used for Stage 1 BCD treatment was an effective and robust piece of equipment. The performance of the rotary reactor under sustained operations was excellent. The most notable exception encountered was that the wireless temperature monitoring system, retrofitted to existing equipment, operated only intermittently.

Soil preparation and conveying equipment performed adequately. Because of the frequent heavy rains and inherent high moisture and agglomeration of the high clay content soil in Guam, problems with soil bridging in hoppers were encountered.

Offgas cleaning equipment successfully removed PCB and other contaminants from the process offgas stream during the BCD demonstration. However, the originally unknown high level of naturally occurring organics present in the soil (in addition to the PCBs) had a significant effect on offgas cleaning equipment operations. Pyrolysis oils, aerosols, and smoke were generated from the heating of roots, vegetation and other naturally occurring organics. These oils showed significant deposition on the filter bags in the baghouse and were present on the walls of the ID fan.

Use of granular activated carbon to treat process scrubber water was effective in reducing the PCB concentration to less than 1 ppb.

7.1.3. Demonstration Testing Campaigns

Cold integration and shakedown testing performed in Guam during July 1993 demonstrated the operability of the BCD system and provided operational training to a full complement of staff from PNNL and the Navy's RAC. Testing with contaminated soil was postponed until early 1994 as a result of a major earthquake in Guam on 8 August 1993.

Testing in February 1994 showed that Stage 1 of the process worked as designed, treating 16 tons of PCB-contaminated soil to less than 2 ppm per congener for soil heated to a temperature range of 325°C to 350°C (620°F to 662°F).

In November 1994, continuous processing of approximately 50 tons of soil reconfirmed that the BCD process can consistently meet the target treatment standard for PCB.

7.1.4. Stirred-Tank Reactor Operations

Although the STR treats only a comparatively small fraction of the material processed through the rotary kiln reactor, that material may contain 30% to 100% of the PCB to be destroyed. Initial STR testing in November 1994 showed that while the STR system performed operationally as designed, it did not successfully treat PCB to target levels. However, dioxin and furan levels were reduced to below detection limits.

Further STR testing in May 1995 involved two runs with the 400-gal system and five runs with the 2-L system. In the 400-gal STR, PCB was reduced from 850 ppm to less than 2 ppm per congener. In the 2-L STR, PCB was reduced from approximately 42,000 ppm to less than 2 ppm per congener.

7.1.5. Health and Safety

An impressive safety record was achieved by PNNL and BCL staff throughout the 6 years of the BCD demonstration project. During the course of the project, which included system operations, setup, and integration of the process equipment (approximately 200 tons of equipment) in Stockton, California, and in Guam, no reportable accidents or lost time injuries occurred.

The results from limited stack sampling and ambient air monitoring showed that process emissions were well below the OSHA permissible exposure limits for particulates and PCB.

7.1.6. Economics

An economic evaluation was performed to estimate the treatment cost for the deployment of a BCD system (equivalent to the BCD system in Guam) in the continental U.S. Based on this analysis, it was estimated that the total treatment cost (soils and residues) would be approximately $360/ton. This evaluation confirmed earlier projections that predicted the BCD process displays favorable economics, even at the relatively small scale of 1 to 2 ton/hr.

7.2. Recommendations

7.2.1. Chemistry

Based on limited, but successful, Stage 1 testing with reduced sodium bicarbonate concentrations (i.e., less than the 10% by weight design basis), future process testing should be conducted with 5% by weight sodium bicarbonate addition. If this proves to be effective, further sodium bicarbonate reductions may be warranted.

Additional testing of Stage 2 BCD should be conducted to optimize reagent requirements and to refine operating strategies. Because Stage 2 is sensitive to the process matrix, this testing should be conducted with the actual process residuals generated from the Guam BCD treatment operation. To minimize costs, most of this testing can be conducted with a bench-scale test system.

7.2.2. Equipment

High feed moisture content creates materials handling problems requiring frequent operator intervention and can reduce kiln throughput. Therefore, a covered feed preparation and storage area should be available to ensure efficient process operation.

Prolonged storage of sodium bicarbonate in the humid climate of Guam should be avoided to prevent caking and bridging within the hopper as the sodium bicarbonate absorbs moisture. Also, control of the sodium bicarbonate feeder should be integrated with the pugmill to reduce labor requirements and to provide better accuracy of sodium bicarbonate metering.

Modifications to the offgas treatment system, including insulation of the cyclone and baghouse, permanent use of an oil/water separator, and installation of a HEME and a thermal oxidizer, would likely provide enhanced performance and operability.

The cyclone and baghouse should also be operated at the highest temperatures possible to minimize condensation and deposition of water, oils, and tars inside these offgas cleaning components.

Consideration should be given to installing the HEME between the wet scrubber and the ID fan to remove aerosols that penetrate through the scrubber.

Replacing the offgas carbon canisters with a thermal oxidizer (as a final offgas polishing device) would better remove small chain organics (pyrolysis products) and eliminate difficulties associated with operating carbon canisters at positive pressures.

Permanent use of the oil/water separator is recommended to remove as much oil and particulate as possible from the scrubber water and reduce burden on granular activated carbon used to treat the scrubber water.

7.2.3. Process Demonstration

Further demonstration and deployment of advanced BCD systems for PCB and other halogenated contaminant remediation should be pursued. The BCD demonstration in Guam showed that the process is a viable and effective alternative to incineration for remediation of PCB contamination in soil. Advancement of the BCD process will expand its applicability and decrease total treatment costs.

8.0 References

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Appendices

Appendix A

Equipment List

Appendix A

Equipment List

Tag No.	Equipment	Specifications
CR100	Crushing Plant	20 ton/hr soil throughput; 5 ft x 10 ft hopper with stationary grizzly; vibrating grizzly feeder; impact crusher; discharge conveyor with 7-ft discharge elevation
BH100	Portable Baghouse	132 sq ft filter area; 1000 acfm and 90 F inlet air; 3-hp fan; 480 volt/3 phase input
PU200	Mixing Plant	20 ton/hr soil plus 2.4 ton/hr sodium bicarbonate throughput; 5 cu yd hopper, variable speed feeder; pugmill, discharge conveyor with 15-ft discharge height
FS200	Catalyst Feeding System	2.4 ton/hr sodium bicarbonate throughput; 1-ton bulk bag unloading frame; 20 cu ft stainless steel hopper; 20-ft long flexible conveyor, 5-hp DC motor with SCR speed control; 240 volt/1 phase input
RR400	Rotary Reactor	2000 lb/hr soil (dry basis), 353 lb/hr soil moisture, and 240 lb/hr sodium bicarbonate feed; indirectly heated; operating temperature at 644 F, 1-hr residence time at 644°F, 1 hr residence time at 644°F, carbon steel construction
FS400	Reactor Feeding System	2000 lb/hr soil (dry basis), 353 lb/hr sodium bicarbonate feed; 3 cu yd hopper, variable speed feeder, belt scale with set-point automatic feeder control and totalizer; discharge conveyor with 15-ft discharge height
CV400	Treated Soil Conveyor	Approx. 1.2 ton/hr soil; 30-ft length; high-temperature (700°F) belt; 480 volt/3 phase input
CY500	Cyclone	1127 acfm and 250°F at inlet; 4.7 gr/cu ft dust loading; 5" w.c. pressure drop; carbon steel
BH500	Baghouse	533 sq ft filter area; 1127 acfm and 250°F inlet; 4.7 gr/cu ft dust loading; 10" w.c. pressure drop; carbon steel

Tag No.	Equipment	Specifications
FA500	Dilution Air Fan	486 scfm air and 90°F inlet air; 10" w.c. differential pressure; 480 volt/3 phase input
V571, V572	Rotary Valves	8" x 8" size; cast iron construction; 3/4-hp motor
VS500	Scrubber	Venturi/impinging jet scrubber with demister; 1120 acfm inlet gas at 250°F, consisting of 2820 lb/hr air, 559 lb/hr water vapor and 63 lb/hr carbon dioxide; 2.1 gr/cu ft dust loading at inlet; 110°F inlet water; 140°F outlet gas saturated with water; 20" w.c. pressure drop; stainless steel
T501	Settling Tank	500 gal; stainless steel
T502, T503	Mixing Tanks	500 gal; stainless steel
MI02, MI503	Tank Mixers	12" dia. impeller; 3/4" x 36" shaft; 1/3 hp; 240/480 volt/3 phase input; stainless steel
HX500	Air-Cooled Heat Exchanger	38 gpm water flow rate; 122°F inlet water; 110°F outlet water; 90°F inlet air for cooling; aluminum fins on stainless steel tubes; 480 volt/3 phase input
CF561, CF562	Carbon Filters	903 acfm inlet gas saturated with water vapor at 140°F; 2" w.c. pressure drop per unit
FA501	Induced-Draft Fan	795 scfm and 140°F inlet gas, consisting of 2844 lb/hr air, 438 lb/hr water and 63 lb/hr carbon dioxide; 60: w.c. differential pressure; 480 volt/3 phase input
P500, P501	Scrubber Pumps	50 gpm x 50 psi; air-powered diaphragm type; stainless steel
P502, P503	Filter Press Pumps	20 gpm x 80 psi, air-powered diaphragm type; stainless steel
P504	Sludge Pump	20 gpm x 50 psi, air-powered diaphragm type; stainless steel
EP600	Filter Press	4 cu ft; 100 psi; air over oil/hydraulic closing; carbon steel
T601	Cake Dumpster	10 cu ft; carbon steel
CF602, CF603	Carbon Filters	15 gpm; 2.5 psi pressure drop per unit

Tag No.	Equipment	Specifications
T602	Treated Water Tank	700 ga; stainless steel
T603	Cake Dumpster	10 cu ft; carbon steel
MI603	Reactor Mixer	14" dia. impeller; 3/4" x 48" shaft; 3/4 hp; 240/480 volt/3 phase input; carbon steel construction
T605	Waste Oil Tank	500 gal; stainless steel construction
MI604	Tank Mixer	12" dia. impeller; 3/4" x 36" shaft; 1/3 hp; 240/480 volt/3 phase input; stainless steel
HX600	Air-Cooled Condenser	200 lb/hr inlet steam at 212°F; 90°F inlet air for cooling, aluminum fins on stainless steel tubes;
T604	Condensate Receiver	40 gal; stainless steel
CF600, CF601	Carbon Filters	< 1 acfm inlet gas at 150°F
P600	Filtrate Pump	20 gpm x 80 psi; air-powered diaphragm type; stainless steel construction
P620	Condensate Pump	5 gpm x 50 psi, air powered diaphragm type; stainless steel
P621	STR Discharge Pump	50 gpm x 50 psi, air-powered diaphragm type; stainless steel
P622	Waste Oil Pump	50 gpm x 50 psi, air-powered diaphragm type; stainless steel
HR600	STR Heater	55 kw; 480 volt/3 phase input; heat to be transferred to 47-3/4" O.D. x 53" H reactor outer wall at 750°F
CO600	Air Compressor	10 acfm at 100 psig; 480 volt/3 phase; NEMA 4
AD600	Compressed Air Dryer	100 acfm at 100 psig; refrigerator type; 240 volt/1 phase; NEMA 4

Appendix B

Instrument List

Appendix B

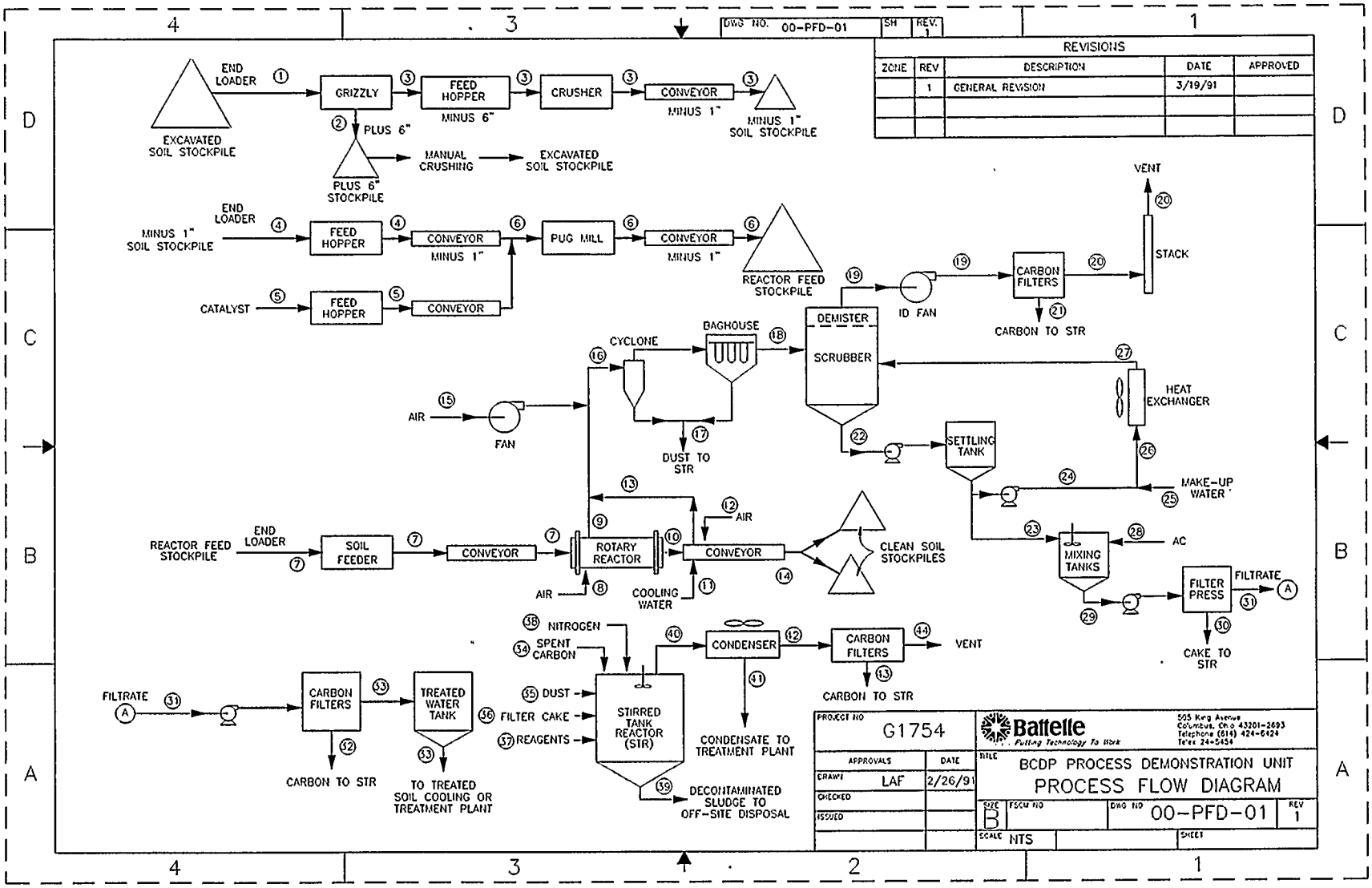
Instrument List

Tag No.	Description	Range	Parameter/Location
FI-500	Magnetic flowmeter	0-80 gpm	Scrubber water circulation
FI-501	Rotameter	2-20 gpm	Water to venturi
FI-502	Rotameter	0.5-5 gpm	Scrubber make-up water
FI-503	Orifice	0-1000 cfm	Stack inlet gas
LI-500	Level transmitter	0-150" w.c.	Scrubber level
LI-501	Level transmitter	0-150" w.c.	Settling tank level
LI-502	Level transmitter	0-150" w.c.	Mixing tank level
LI-503	Level transmitter	0-150" w.c.	Mixing tank level
LI-602	Level transmitter	0-150" w.c.	Treated water tank level
PI-500	Pressure gage	0-minus 30" w.c.	Scrubber inlet gas
PI-501	Pressure gage	0-minus 50" w.c.	Scrubber outlet gas
PI-502	Pressure gage	0-20" w.c.	ID fan discharge
PI-503	Pressure gage	0-20" w.c.	Stack inlet gas
PI-504	Pressure gage	0-50 psig	Water cooler inlet
PI-505	Pressure gage	0-50 psig	Water cooler outlet
PI-510	Pressure gage	0-minus 10" w.c.	Cyclone inlet
PI-512	Pressure gage	0-minus 20" w.c.	Baghouse inlet
PI-600	Pressure gage	0-100 psig	Filter press inlet
PI-601	Pressure gage	0-15 psig	Inlet of first carbon filter (CF602)
PI-602	Pressure gage	0-15 psig	Outlet of first carbon filter (CF602)
PI-603	Pressure gage	0-15 psig	Outlet of second carbon filter (CF603)
PI-620	Pressure gage	30" Hg vac-15 psig	Stirred-tank reactor
PIC-400	Pressure controller	0-minus 0.5" w.c.	Rotary reactor
TI-500	Thermocouple	0-1000 F	Scrubber inlet gas
TI-501	Thermocouple	0-250 F	Scrubber outlet gas
TI-502	Thermocouple	0-250 F	Stack inlet gas
TI-503	Thermocouple	0-250 F	Scrubber outlet water
TI-504	Thermocouple	0-250 F	Water cooler inlet
TI-505	Thermocouple	0-250 F	Water cooler outlet

Tag No.	Description	Range	Parameter/Location
TI-506	Thermocouple	0-250 F	Scrubber inlet water
TI-510	Thermocouple	0-1000 F	Rotary reactor outlet gas
TI-511	Thermocouple	0-1000 F	Cyclone inlet
TI-512	Thermocouple	0-1000 F	Baghouse inlet
TI-600	Thermocouple	0-1000 F	Stirred-tank reactor
TI-601	Thermocouple	0-1000 F	Condenser inlet gas
TI-602	Thermocouple	0-500 F	Condenser outlet gas
TIC-511	Temperature controller	0-1000 F	Cyclone inlet
TIC-600	Temperature controller	0-1000 F	Stirred-tank reactor

Appendix C

Equipment Drawings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CHECKED
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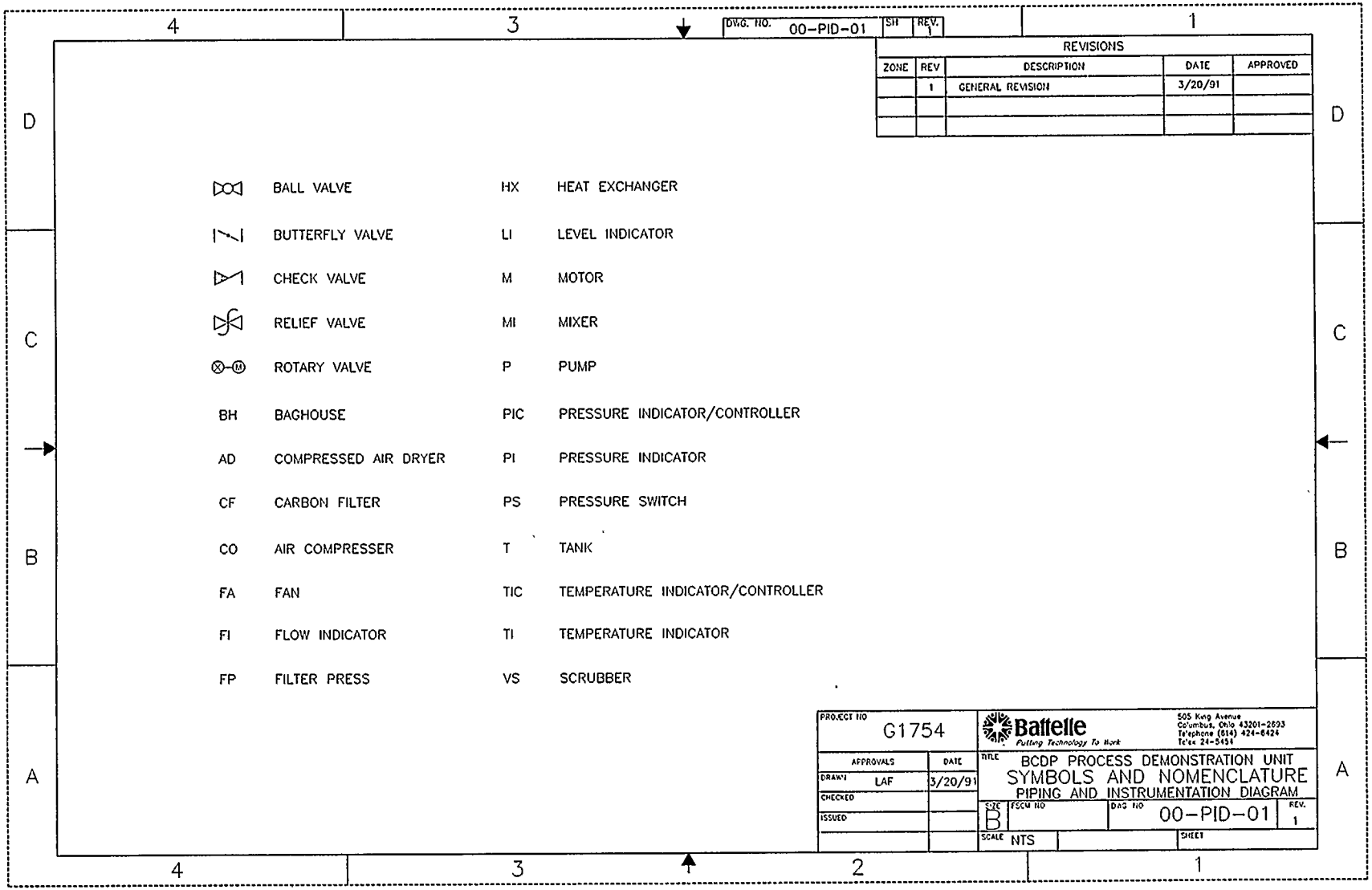
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CO AIR COMPRESSER
FA FAN
FI FLOW INDICATOR
FP FILTER PRESS
HX HEAT EXCHANGER
LI LEVEL INDICATOR
M MOTOR
MI MIXER
P PUMP
PIC PRESSURE INDICATOR/CONTROLLER
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Putting Technology To Work
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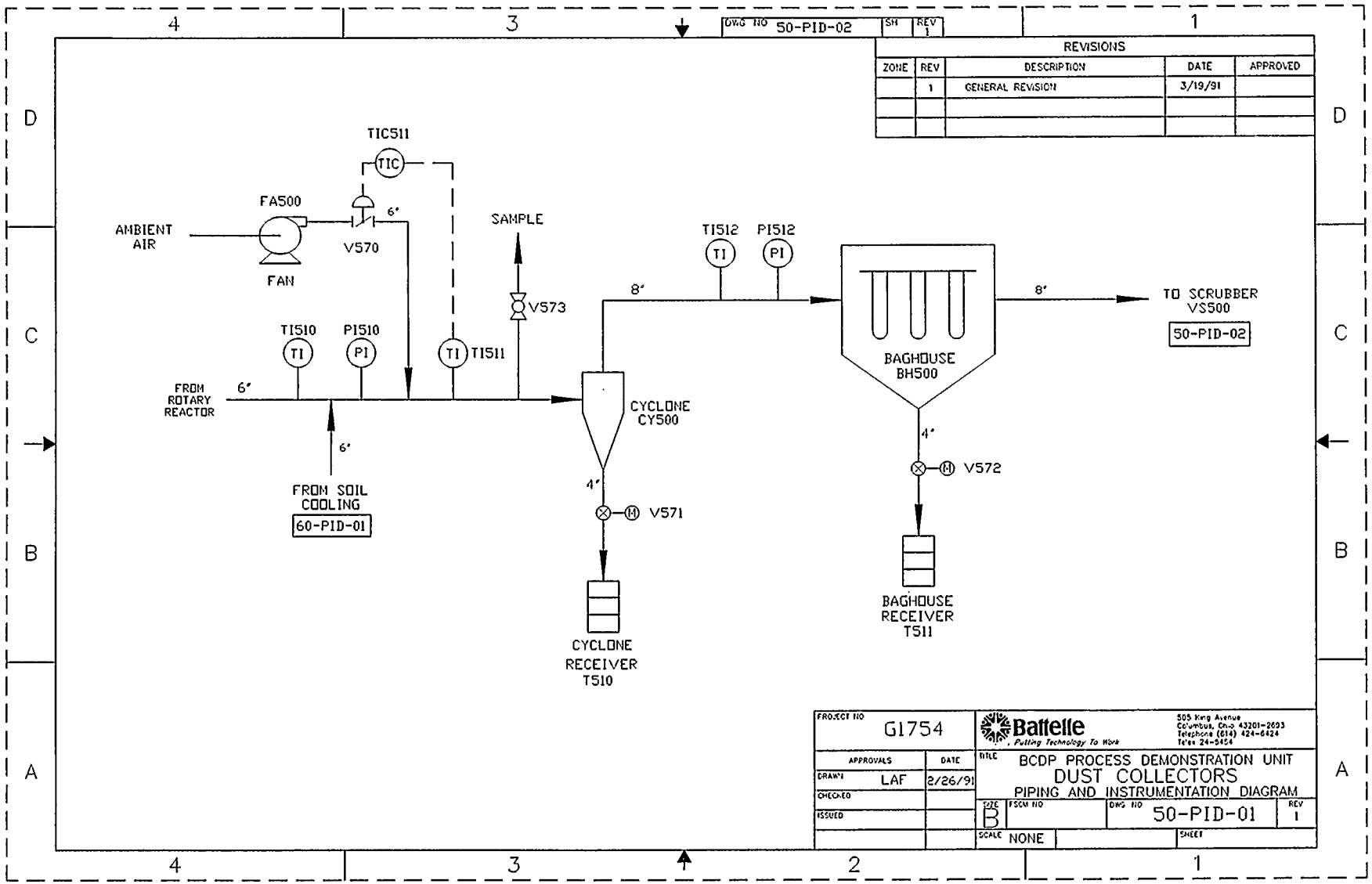
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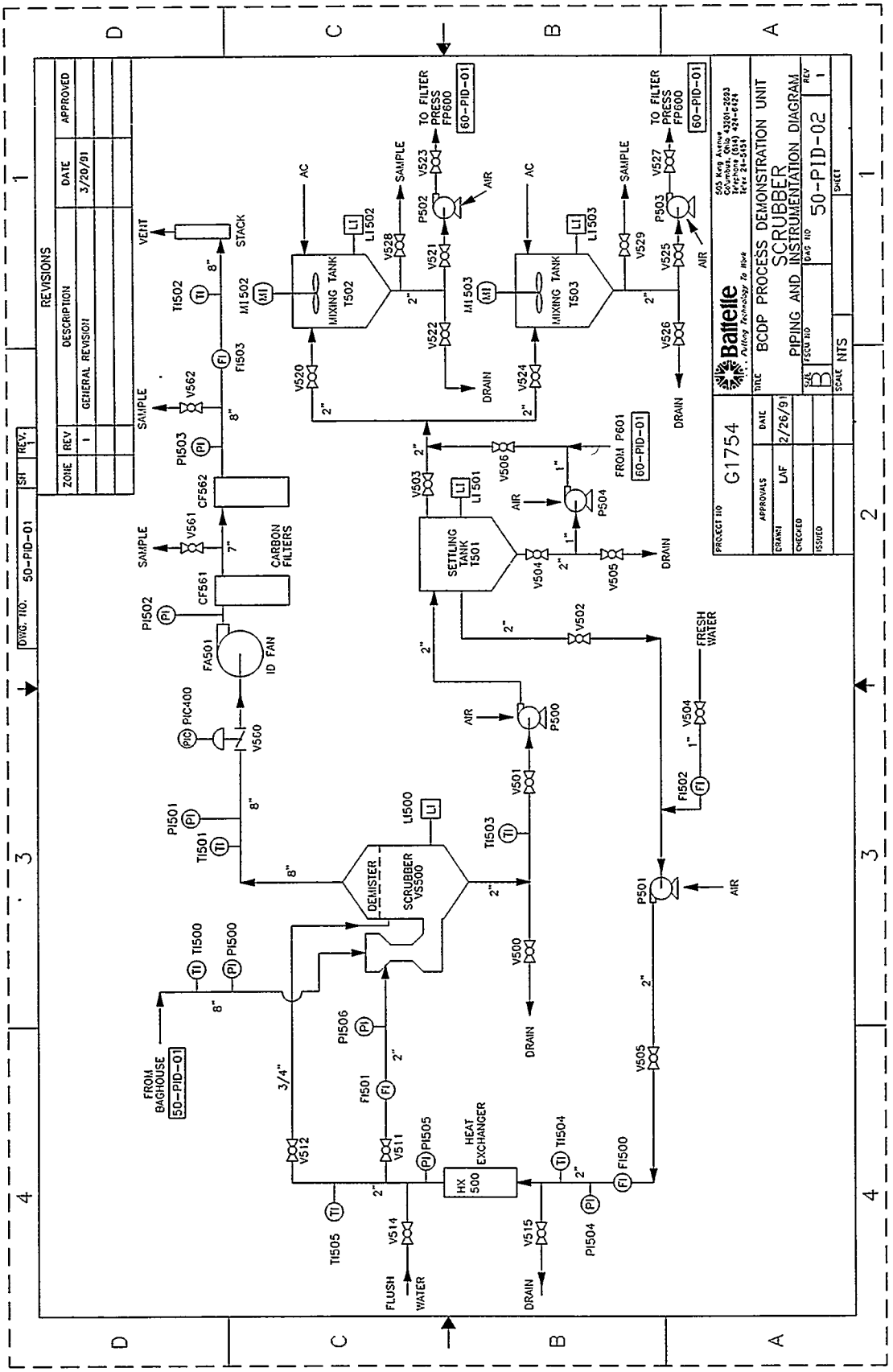
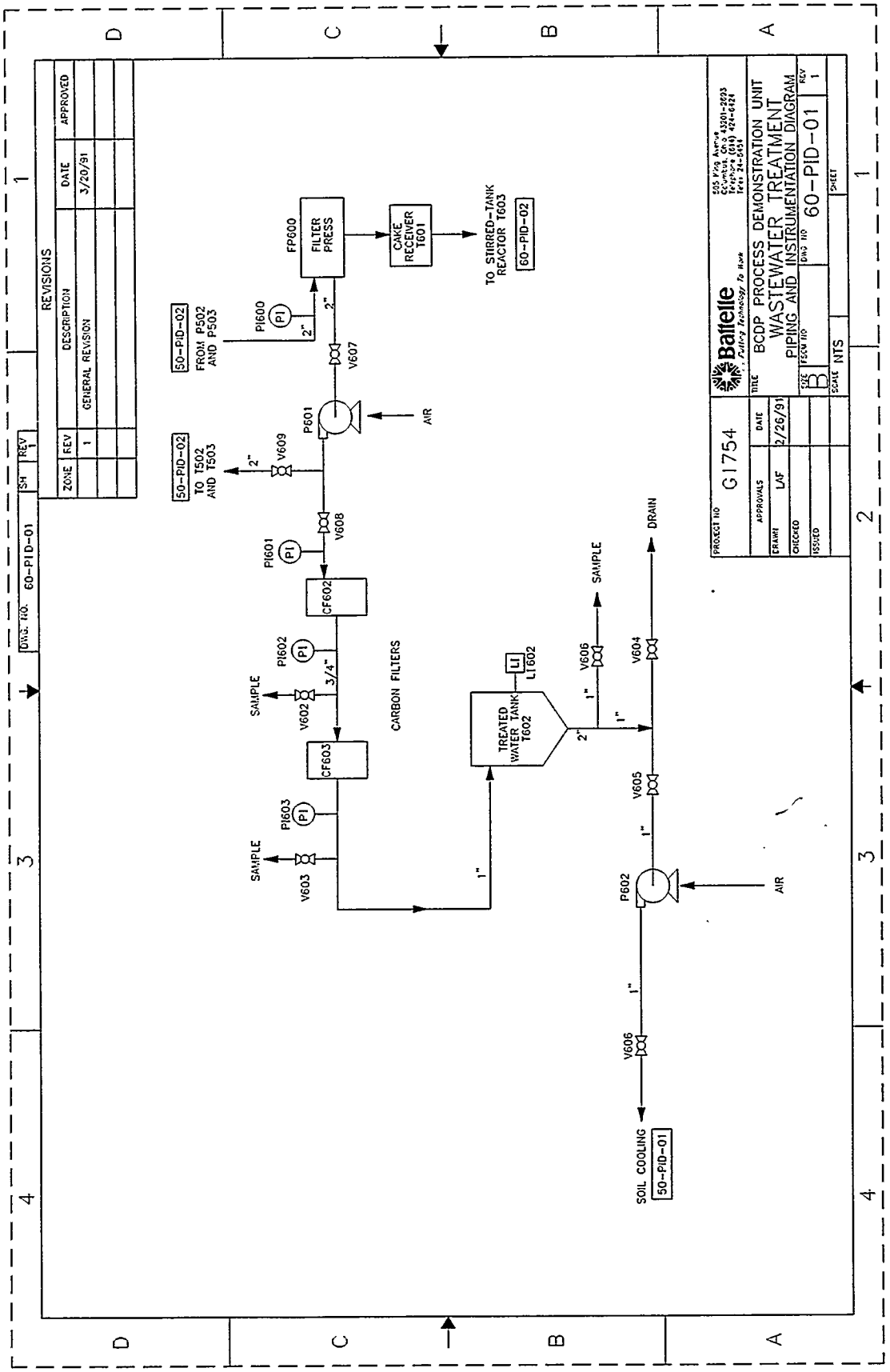
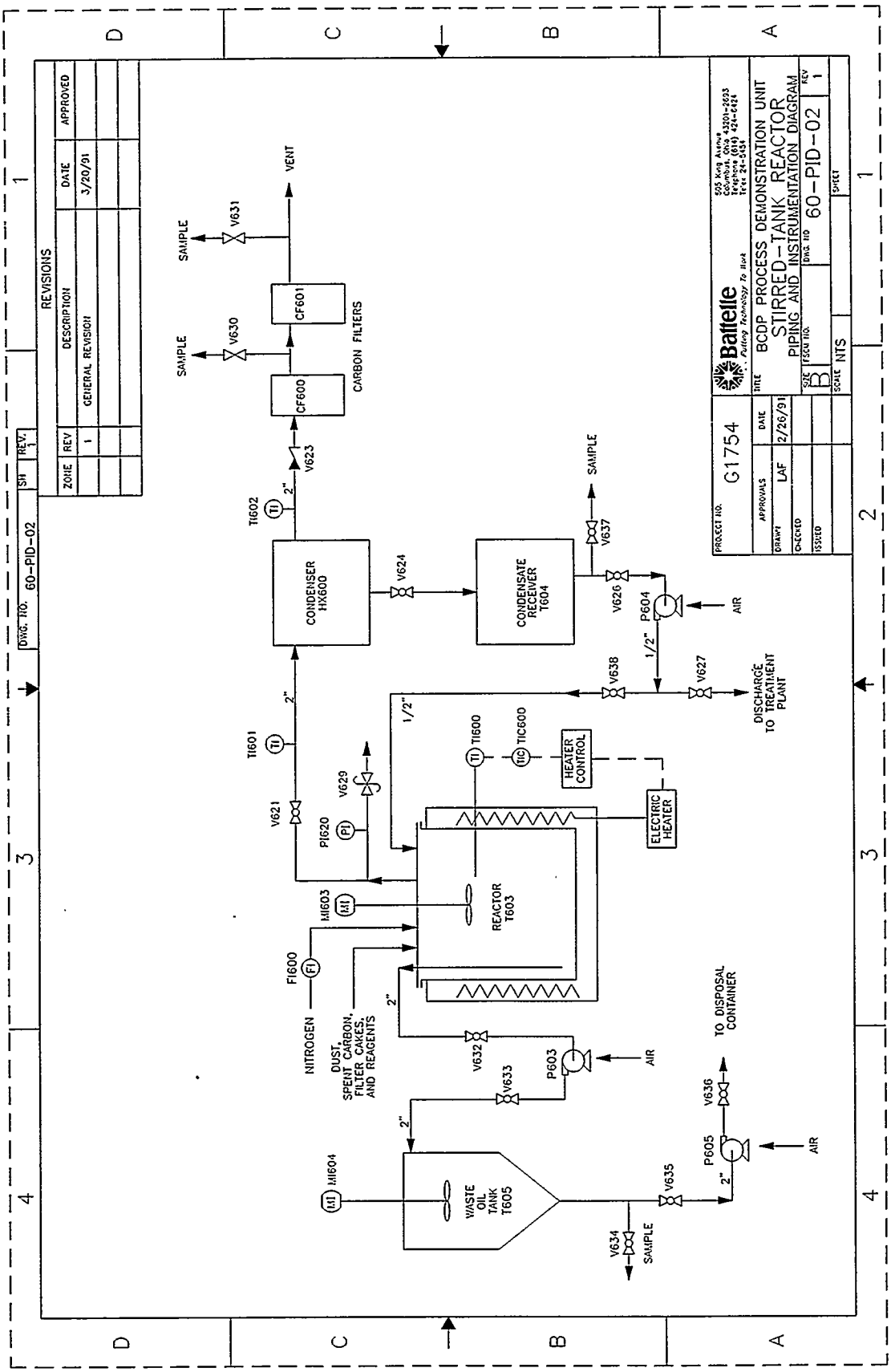
PI510
TI
PI
TI
TI511
FROM ROTARY REACTOR
6"
CYCLONE CY500
4"
V572
6"
FROM SOIL COOLING
60-PID-01
4"
V571
CYCLONE RECEIVER T510
BAGHOUSE RECEIVER T511
PROJECT NO
G1754
APPROVALS
DATE
DRAWN
LAF
2/26/91
CHECKED
ISSUED
Battelle
Putting Technology To Work
505 King Avenue
Columbus, Ohio 43201-2693
Telephone (614) 424-6424
Telex 24-5454
TITLE
BCDP PROCESS DEMONSTRATION UNIT
DUST COLLECTORS
PIPING AND INSTRUMENTATION DIAGRAM
SIZE
B
FSCM NO
DWG NO
50-PID-01
REV
1
SCALE
NONE
SHEET


REVISIONS
ZONE REV DESCRIPTION DATE APPROVED
1 GENERAL REVISION 3/20/91
DWG. NO. 50-PID-01 SH 1 REV. 1
Battelle
Putting Technology to Work
505 King Avenue
Columbus, Ohio 43201-2693
Telephone (614) 424-6424
Fax 24-5454
PROJECT NO G1754
TITLE BCDP PROCESS DEMONSTRATION UNIT
SCRUBBER
PIPING AND INSTRUMENTATION DIAGRAM
APPROVALS DATE
DRAWN LAF 2/26/91
CHECKED
ISSUED
SIZE B FSCM NO
DWG NO 50-PID-02 REV 1
SCALE NTS SHEET
FROM BAGHOUSE 50-PID-01
TO FILTER PRESS FP600 60-PID-01
FROM P601 60-PID-01
VENT
STACK
SAMPLE
CARBON FILTERS
ID FAN
MIXING TANK T502
MIXING TANK T503
SETTLING TANK T501
SCRUBBER VS500
DEMISTER
HEAT EXCHANGER HX 500
FRESH WATER
FLUSH WATER
DRAIN
AIR
AC


REVISIONS
ZONE
REV
DESCRIPTION
DATE
APPROVED
1
GENERAL REVISION
3/20/91
DWG NO. 60-PID-01
REV 1
PROJECT NO G1754
APPROVALS
DRAWN LAF 2/26/91
CHECKED
ISSUED
Battelle
Putting Technology To Work
505 King Avenue
Columbus, Ohio 43201-2693
Telephone (614) 424-6424
Telex 24-6454
TITLE
BCDP PROCESS DEMONSTRATION UNIT
WASTEWATER TREATMENT
PIPING AND INSTRUMENTATION DIAGRAM
SIZE B
FSCM NO
DWG NO 60-PID-01
REV 1
SCALE NTS
SHEET
FP600
FILTER PRESS
CAKE RECEIVER T601
TO STIRRED-TANK REACTOR T603
60-PID-02
50-PID-02
FROM P502 AND P503
PI600
V607
P601
AIR
50-PID-02
TO T502 AND T503
V609
V608
PI601
CF602
PI602
V602
SAMPLE
3/4"
CARBON FILTERS
CF603
PI603
V603
SAMPLE
TREATED WATER TANK T602
LI LT602
1"
2"
V606
SAMPLE
V604
DRAIN
V605
P602
AIR
V606
SOIL COOLING
50-PID-01


REVISIONS
ZONE
REV
DESCRIPTION
DATE
APPROVED
1
GENERAL REVISION
3/20/91
DWG. NO. 60-PID-02
SH
REV. 1
PROJECT NO. G1754
APPROVALS
DATE
DRAWN LAF
2/26/91
CHECKED
ISSUED
Battelle
Putting Technology To Work
505 King Avenue
Columbus, Ohio 43201-2693
Telephone (614) 424-6424
Telex 24-5454
TITLE BCDP PROCESS DEMONSTRATION UNIT
STIRRED-TANK REACTOR
PIPING AND INSTRUMENTATION DIAGRAM
SIZE B
FSCM NO.
DWG NO 60-PID-02
REV 1
SCALE NTS
SHEET
VENT
SAMPLE
V631
V630
CF601
CF600
CARBON FILTERS
TI602
2"
V623
CONDENSER HX600
V624
CONDENSATE RECEIVER T604
SAMPLE
V637
V626
P604
AIR
1/2"
V638
V627
DISCHARGE TO TREATMENT PLANT
TI601
2"
V621
PI620
V629
TI600
TIC600
HEATER CONTROL
ELECTRIC HEATER
1/2"
MI603
REACTOR T603
FI600
NITROGEN
DUST, SPENT CARBON, FILTER CAKES, AND REAGENTS
2"
V632
V633
P603
AIR
2"
MI604
WASTE OIL TANK T605
V635
V634
SAMPLE
P605
2"
V636
TO DISPOSAL CONTAINER
AIR

C.6

DWG NO 50-GA-01 | SH | REV 1

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
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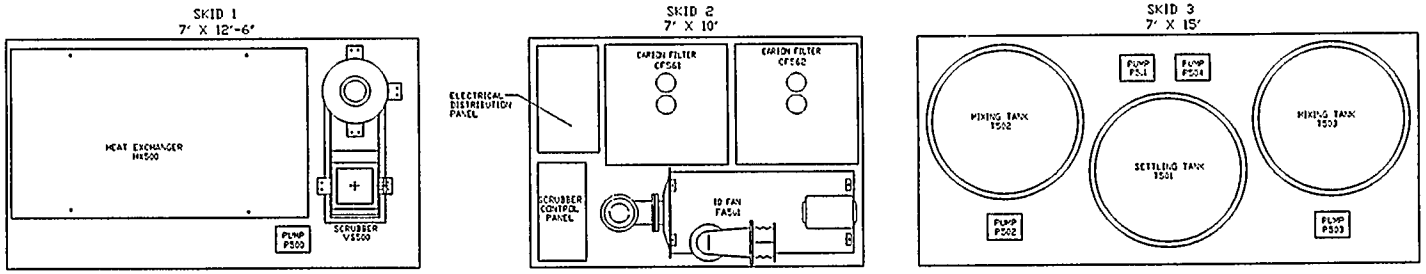


CONTRACT NO	
G1754	

APPROVALS	DATE
DRAWN LAF	3/19/91
CHECKED	
ISSUED	

Battelle
Putting Technology To Work
505 King Avenue
Columbus, Ohio 43201-2693
Telephone (614) 424-6424
Telex 24-5454

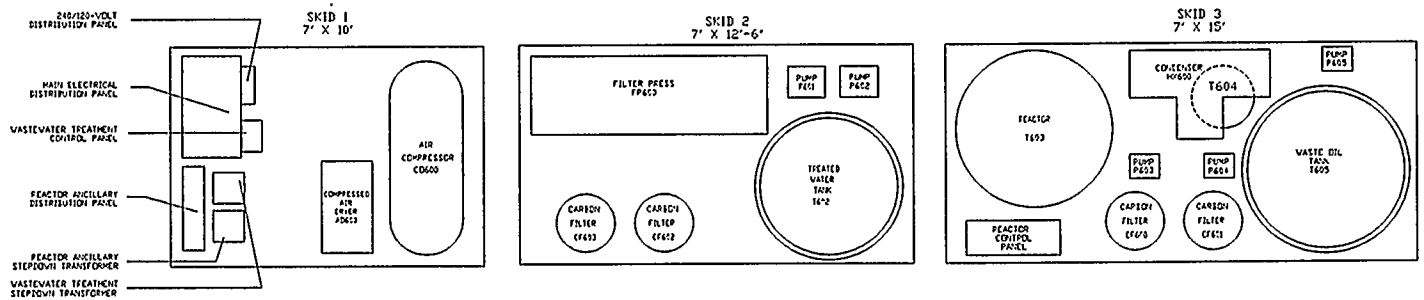
TITLE: BCDP PROCESS DEMONSTRATION UNIT
SCRUBBER
EQUIPMENT LAYOUT

SIZE	FSCM NO	DWG NO	REV
B		50-GA-01	1

SCALE | SHEET

DWG. NO. 60-GA-01 | SH | REV 1

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	1	GENERAL REVISION	3/25/91	



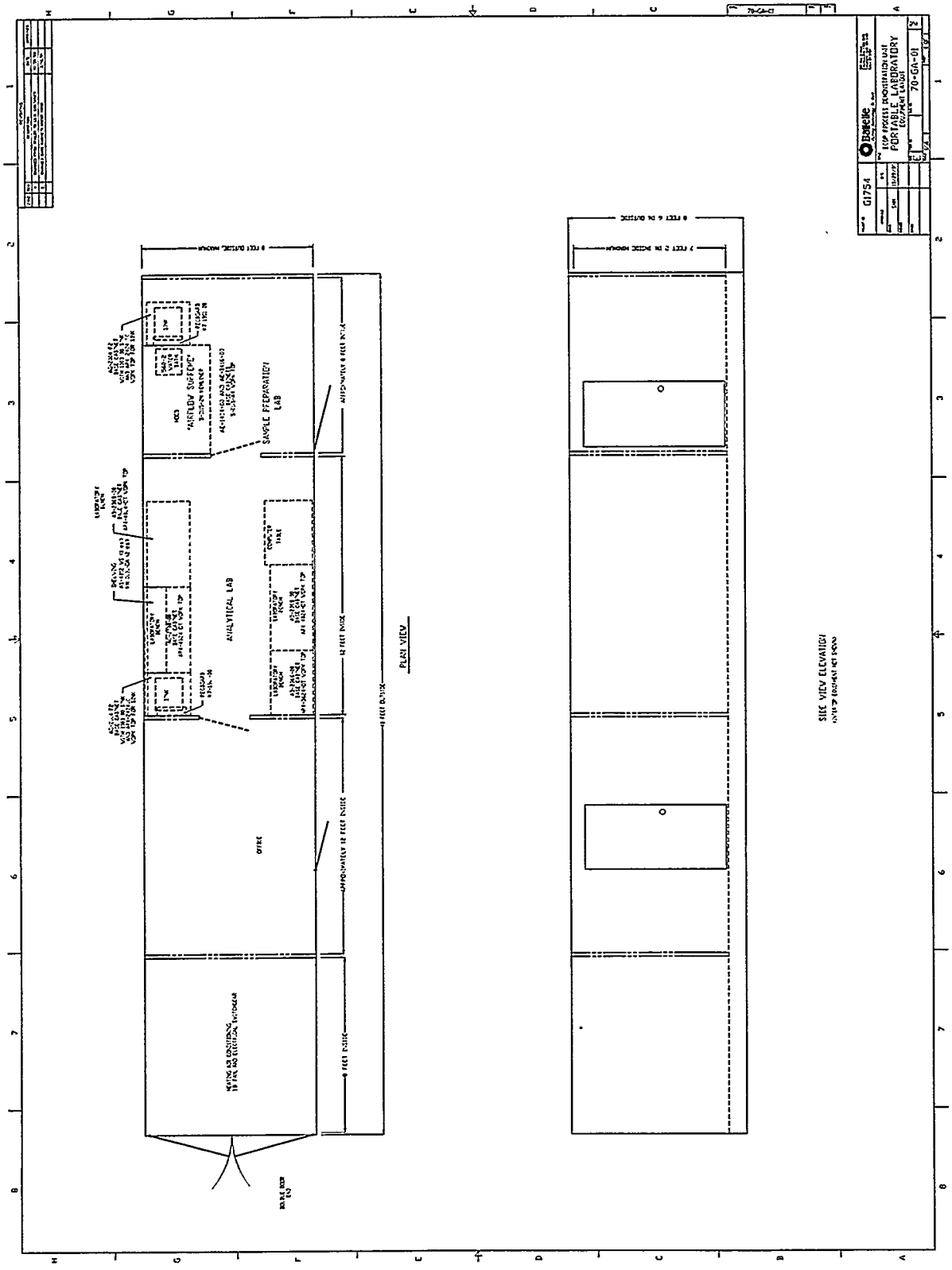
CONTRACT NO	
G1754	
APPROVALS	DATE
DRAWN LAF	3/25/91
CHECKED	
ISSUED	

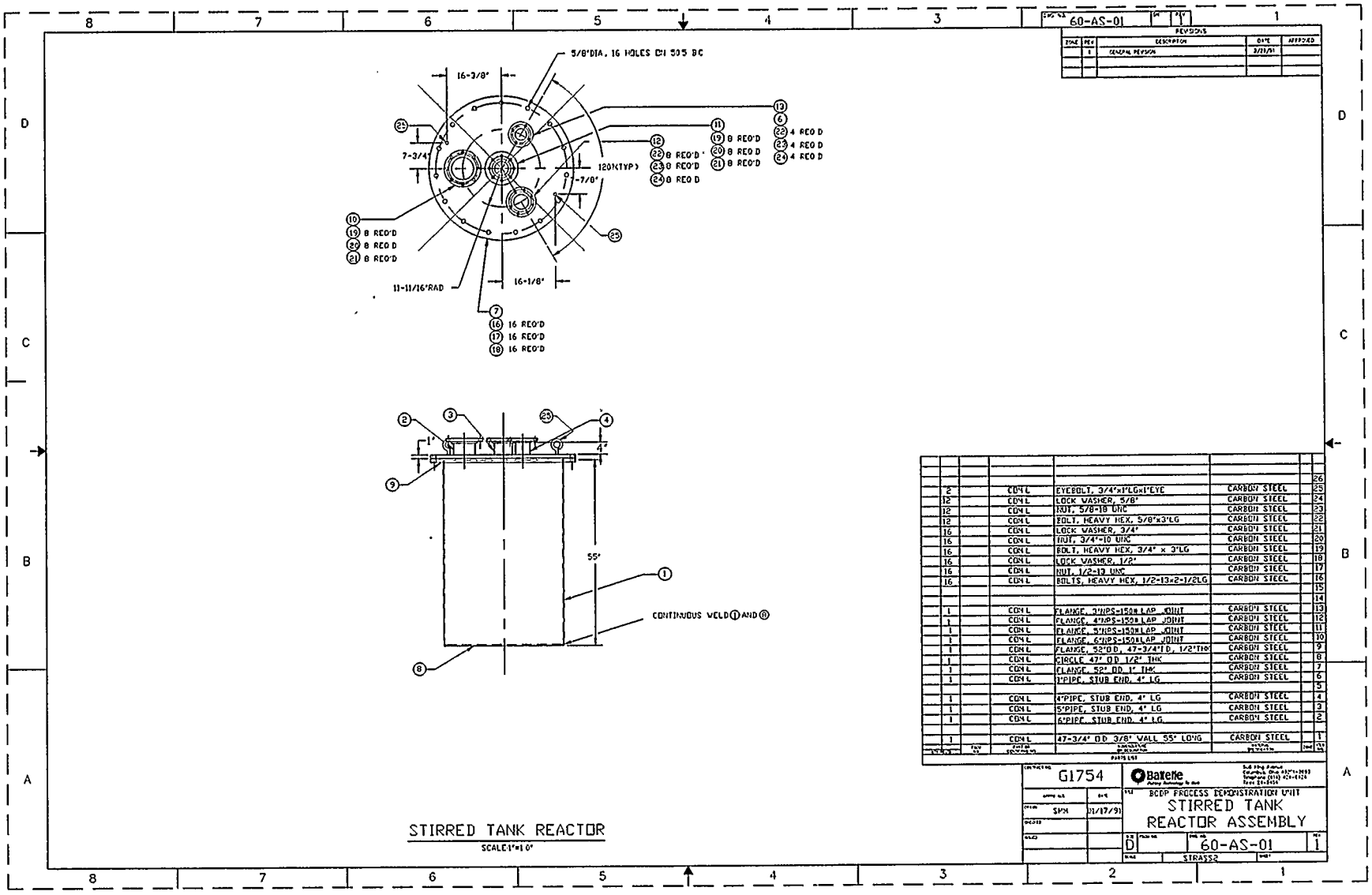
Battelle
Putting Technology To Work
505 King Avenue
Columbus, Ohio 43201-2693
Telephone (614) 424-6424
Telex 24-5454

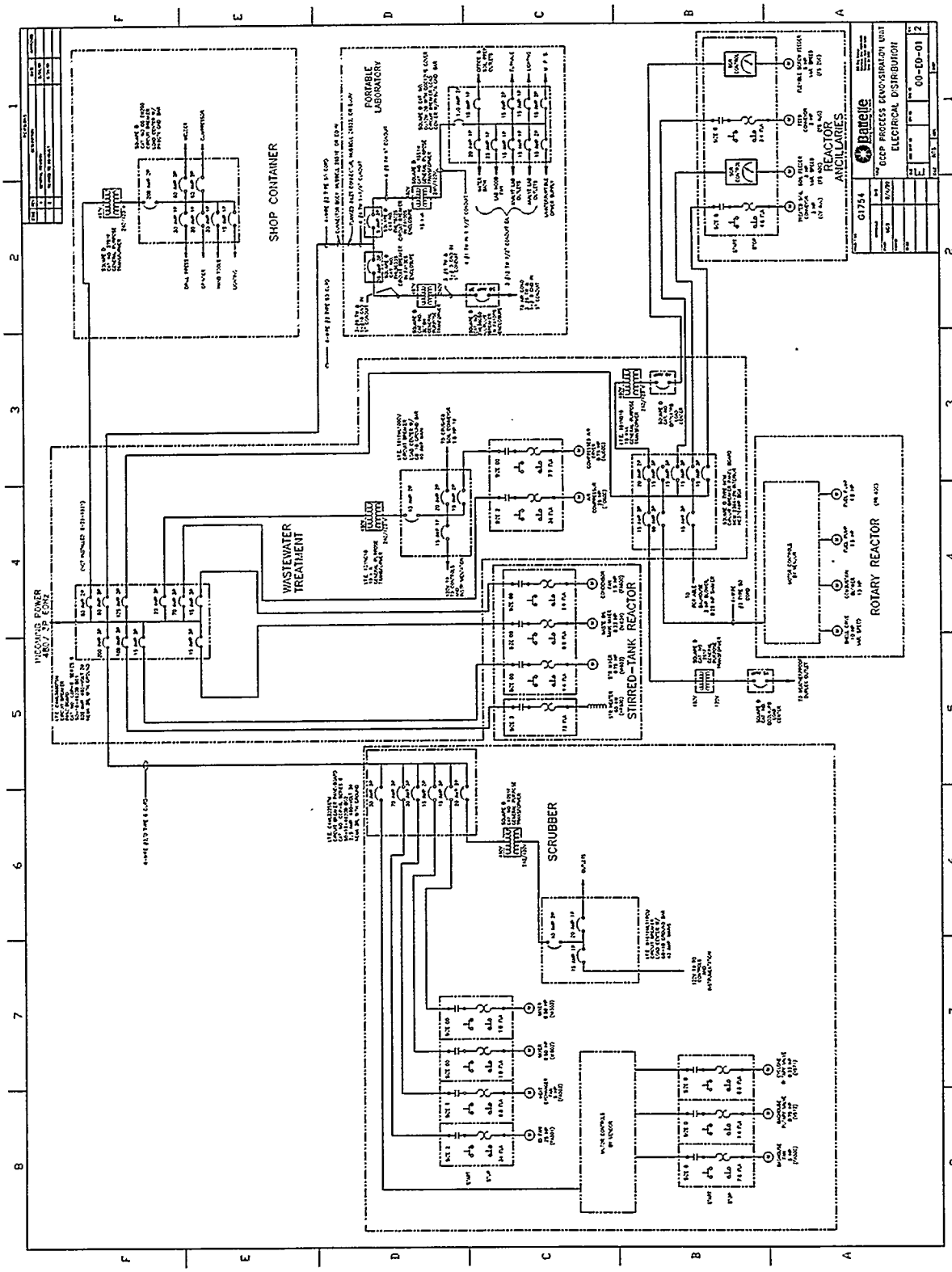
TITLE BCDP PROCESS DEMONSTRATION UNIT
WASTEWATER TREATMENT
EQUIPMENT LAYOUT

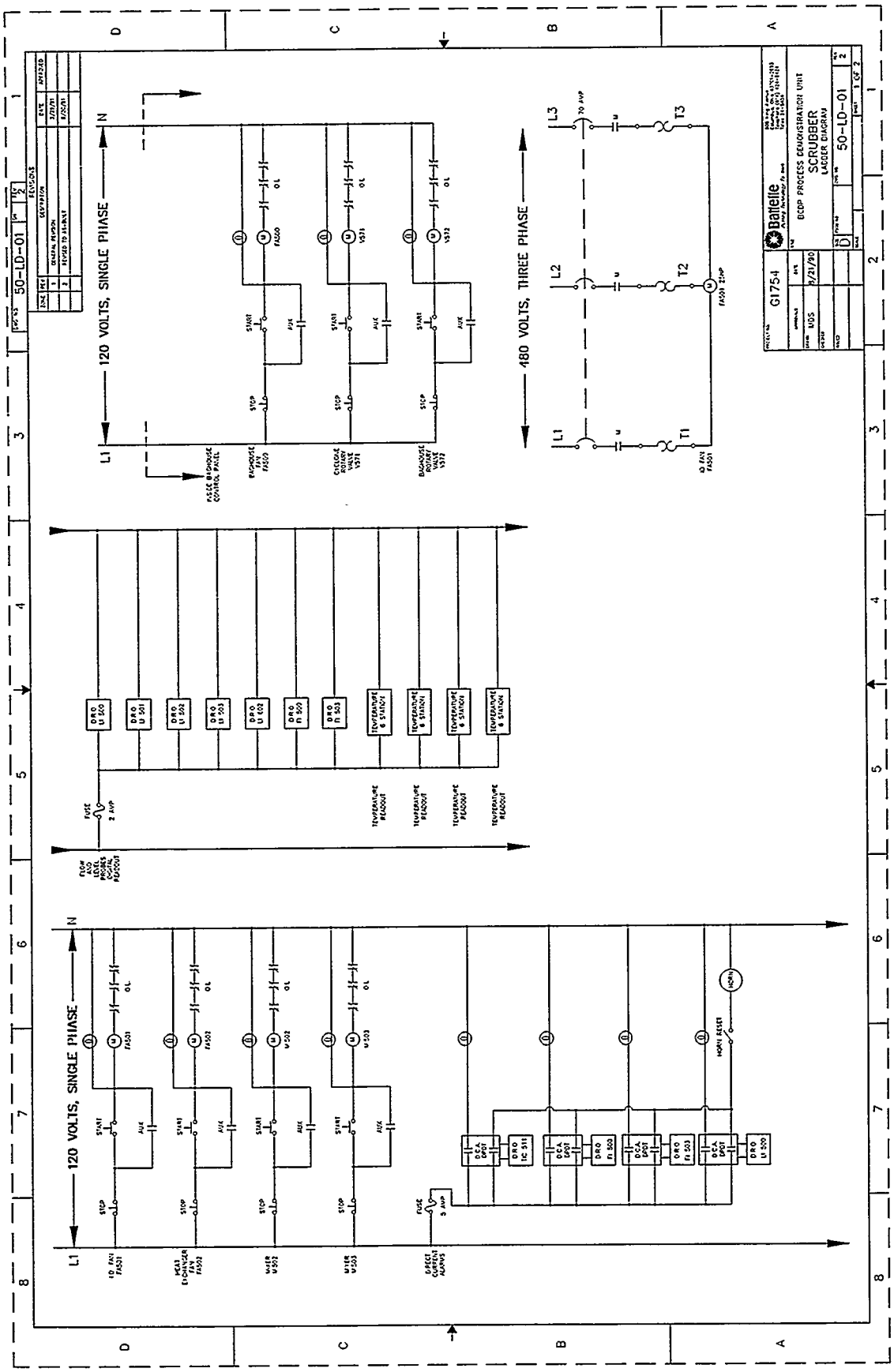
SIZE	FSCM NO.	DWG NO	REV
B		60-GA-01	1

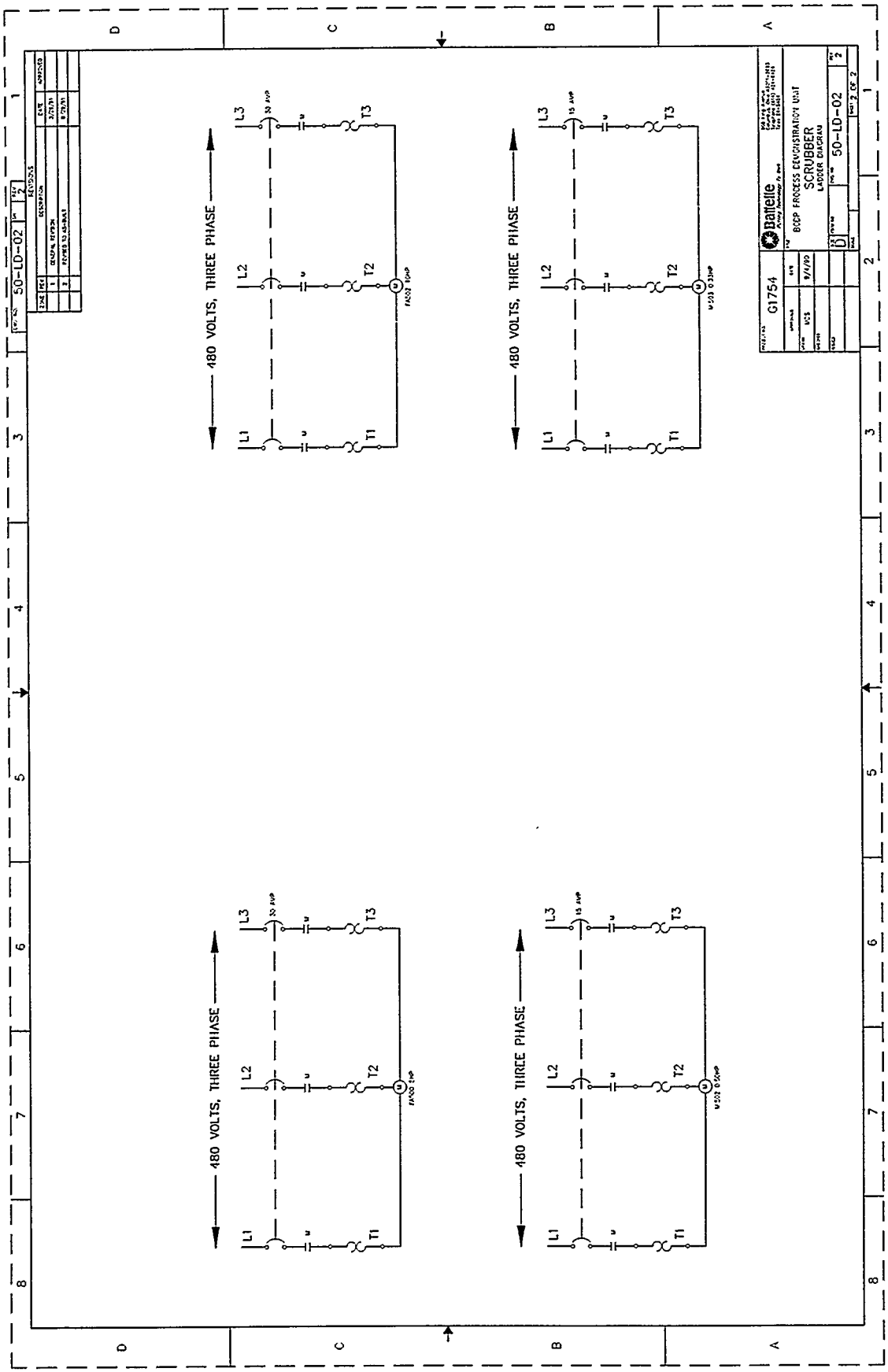
SCALE | SHEET

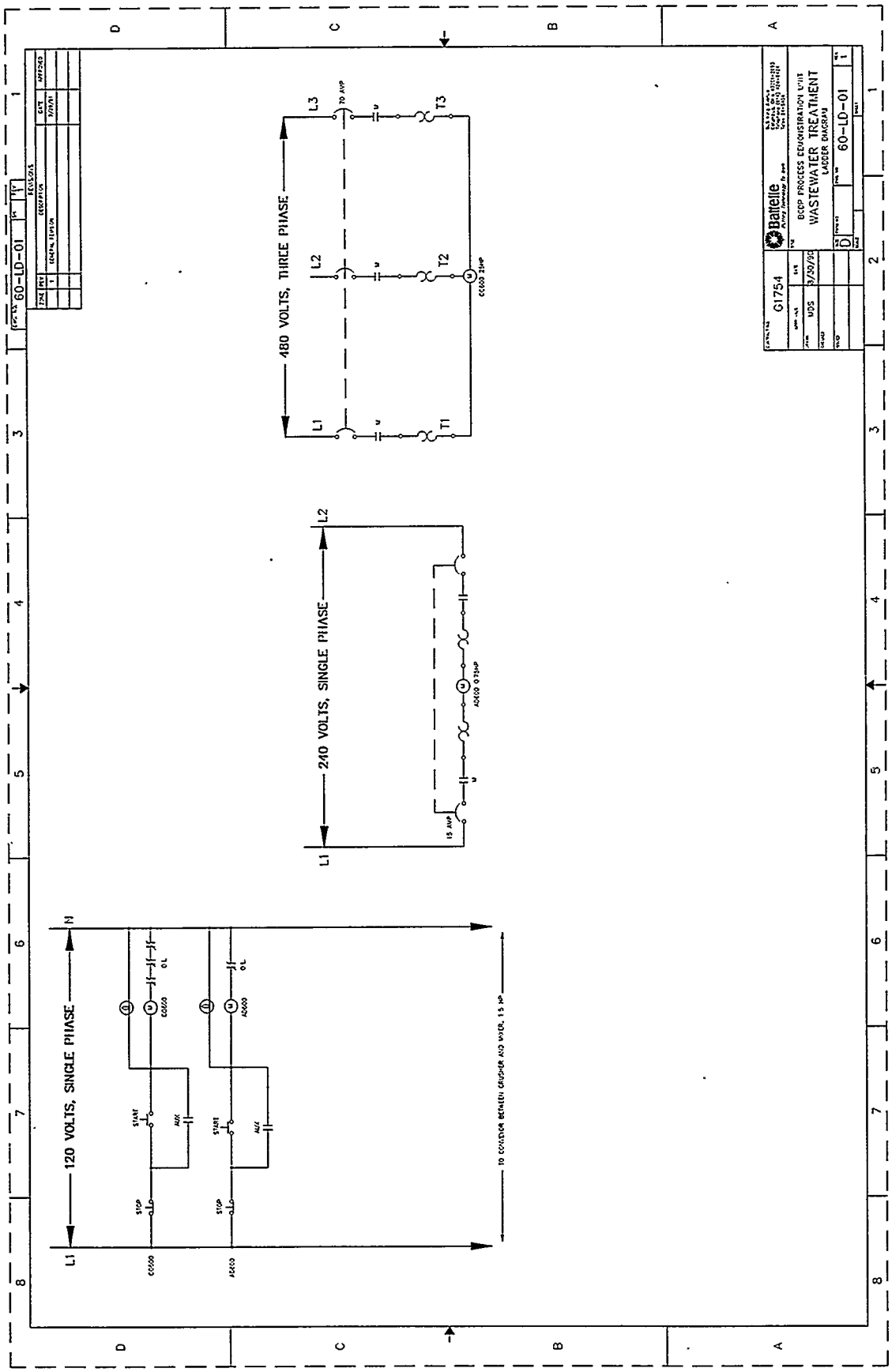

PLAN VIEW
SIDE VIEW ELEVATION
ANALYTICAL LAB
SAMPLE PREPARATION LAB
OFFICE
G1754
PORTABLE LABORATORY
70-GA-01


60-AS-01
REVISIONS
ZONE REV DESCRIPTION DATE APPROVED
1 GENERAL REVISION 3/21/91
5/8"DIA. 16 HOLES ON 505 BC
16-3/8"
7-3/4"
120°(TYP.)
7-7/8"
11-11/16"RAD
16-1/8"
12
6
22 4 REQ'D
23 4 REQ'D
24 4 REQ'D
11
19 8 REQ'D
20 8 REQ'D
21 8 REQ'D
12
22 8 REQ'D
23 8 REQ'D
24 8 REQ'D
10
19 8 REQ'D
20 8 REQ'D
21 8 REQ'D
25
7
16 16 REQ'D
17 16 REQ'D
18 16 REQ'D
2
3
25
4
1"
4"
9
55"
1
CONTINUOUS WELD ① AND ⑧
8
STIRRED TANK REACTOR
SCALE 1"=1'0"
26 2 CON'L EYEBOLT, 3/4"x1"LGx1"EYE CARBON STEEL
25 12 CON'L LOCK WASHER, 5/8" CARBON STEEL
24 12 CON'L NUT, 5/8-18 UNC CARBON STEEL
23 12 CON'L BOLT, HEAVY HEX, 5/8"x3"LG CARBON STEEL
22 16 CON'L LOCK WASHER, 3/4" CARBON STEEL
21 16 CON'L NUT, 3/4"-10 UNC CARBON STEEL
20 16 CON'L BOLT, HEAVY HEX, 3/4" x 3"LG CARBON STEEL
19 16 CON'L LOCK WASHER, 1/2" CARBON STEEL
18 16 CON'L NUT, 1/2-13 UNC CARBON STEEL
17 16 CON'L BOLTS, HEAVY HEX, 1/2-13x2-1/2LG CARBON STEEL
16
15
14
13 1 CON'L FLANGE, 3"NPS-150# LAP JOINT CARBON STEEL
12 1 CON'L FLANGE, 4"NPS-150# LAP JOINT CARBON STEEL
11 1 CON'L FLANGE, 5"NPS-150# LAP JOINT CARBON STEEL
10 1 CON'L FLANGE, 6"NPS-150# LAP JOINT CARBON STEEL
9 1 CON'L FLANGE, 52"OD, 47-3/4"ID, 1/2"THK CARBON STEEL
8 1 CON'L CIRCLE 47" OD 1/2" THK CARBON STEEL
7 1 CON'L FLANGE, 52" OD, 1" THK CARBON STEEL
6 1 CON'L 3"PIPE, STUB END, 4" LG CARBON STEEL
5
4 1 CON'L 4"PIPE, STUB END, 4" LG CARBON STEEL
3 1 CON'L 5"PIPE, STUB END, 4" LG CARBON STEEL
2 1 CON'L 6"PIPE, STUB END, 4" LG CARBON STEEL
1 1 CON'L 47-3/4" OD 3/8" WALL 55" LONG CARBON STEEL
PARTS LIST
G1754
Battelle
BCDP PROCESS DEMONSTRATION UNIT
STIRRED TANK REACTOR ASSEMBLY
SPM 01/17/91
D 60-AS-01 1
STRASS2

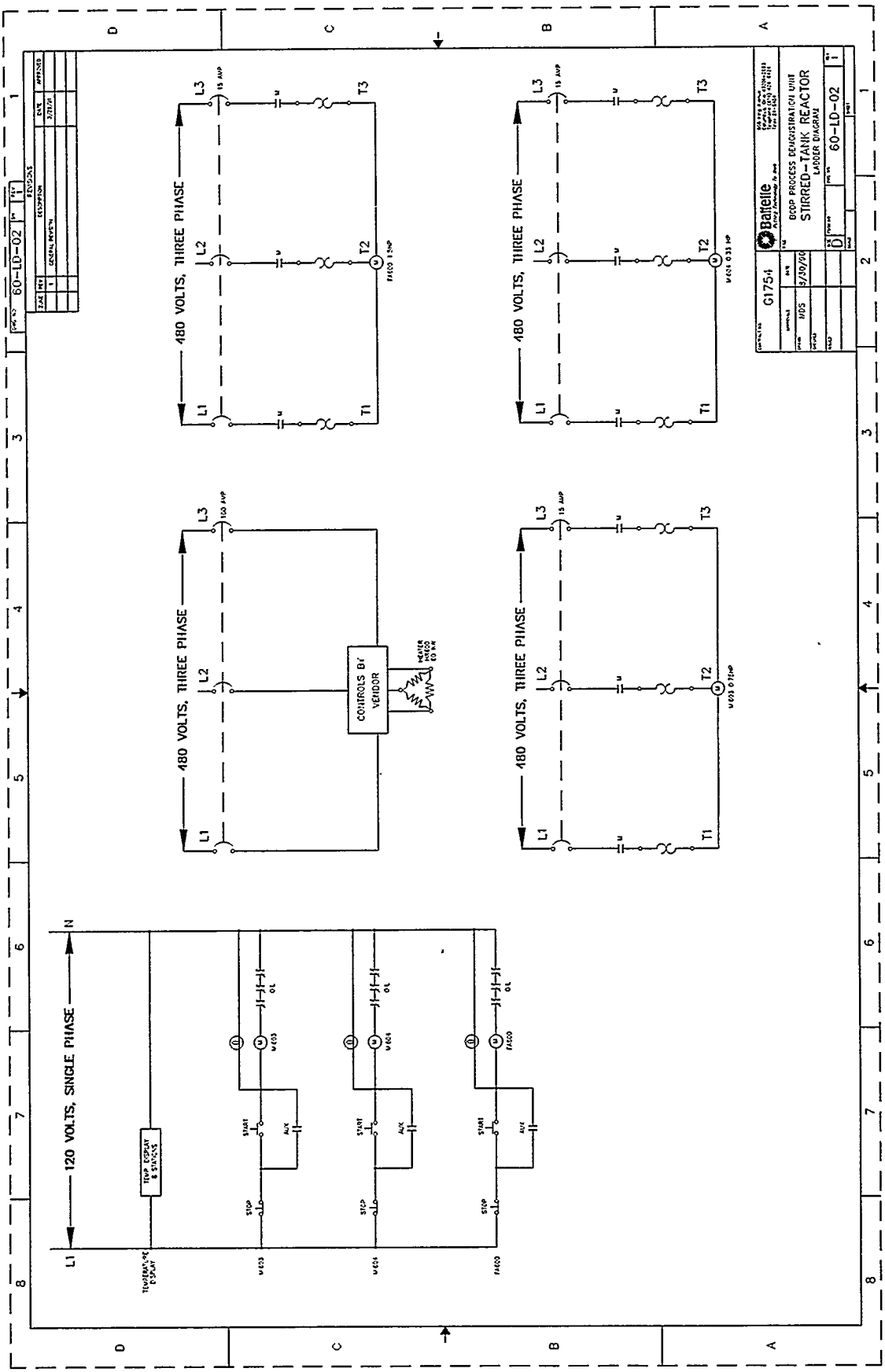

SHOP CONTAINER
PORTABLE LABORATORY
REACTOR ANCILLARIES
WASTEWATER TREATMENT
STIRRED-TANK REACTOR
ROTARY REACTOR
SCRUBBER
Battelle
DCCP PROCESS DEMONSTRATION UNIT
ELECTRICAL DISTRIBUTION
00-ED-01
G1754


120 VOLTS, SINGLE PHASE
480 VOLTS, THREE PHASE
Battelle
BCDP PROCESS DEMONSTRATION UNIT
SCRUBBER
LADDER DIAGRAM
50-LD-01
G1754

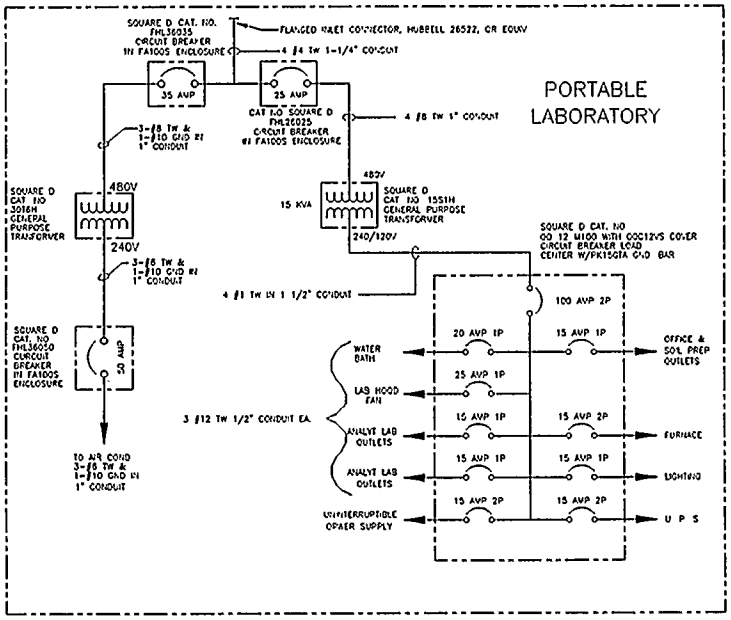

480 VOLTS, THREE PHASE
L1
L2
L3
T1
T2
T3
480 VOLTS, THREE PHASE
L1
L2
L3
T1
T2
T3
480 VOLTS, THREE PHASE
L1
L2
L3
T1
T2
T3
480 VOLTS, THREE PHASE
L1
L2
L3
T1
T2
T3
Battelle
BCDP PROCESS DEMONSTRATION UNIT
SCRUBBER
LADDER DIAGRAM
50-LD-02
G1754



480 VOLTS, THREE PHASE
240 VOLTS, SINGLE PHASE
120 VOLTS, SINGLE PHASE
L1
L2
L3
T1
T2
T3
N
START
STOP
AUX
OL
TO CONVEYOR BETWEEN CRUSHER AND MIXER, 1.5 HP
Battelle
BCDP PROCESS DEMONSTRATION UNIT
WASTEWATER TREATMENT
LADDER DIAGRAM
60-LD-01
G1754
MDS
3/30/90

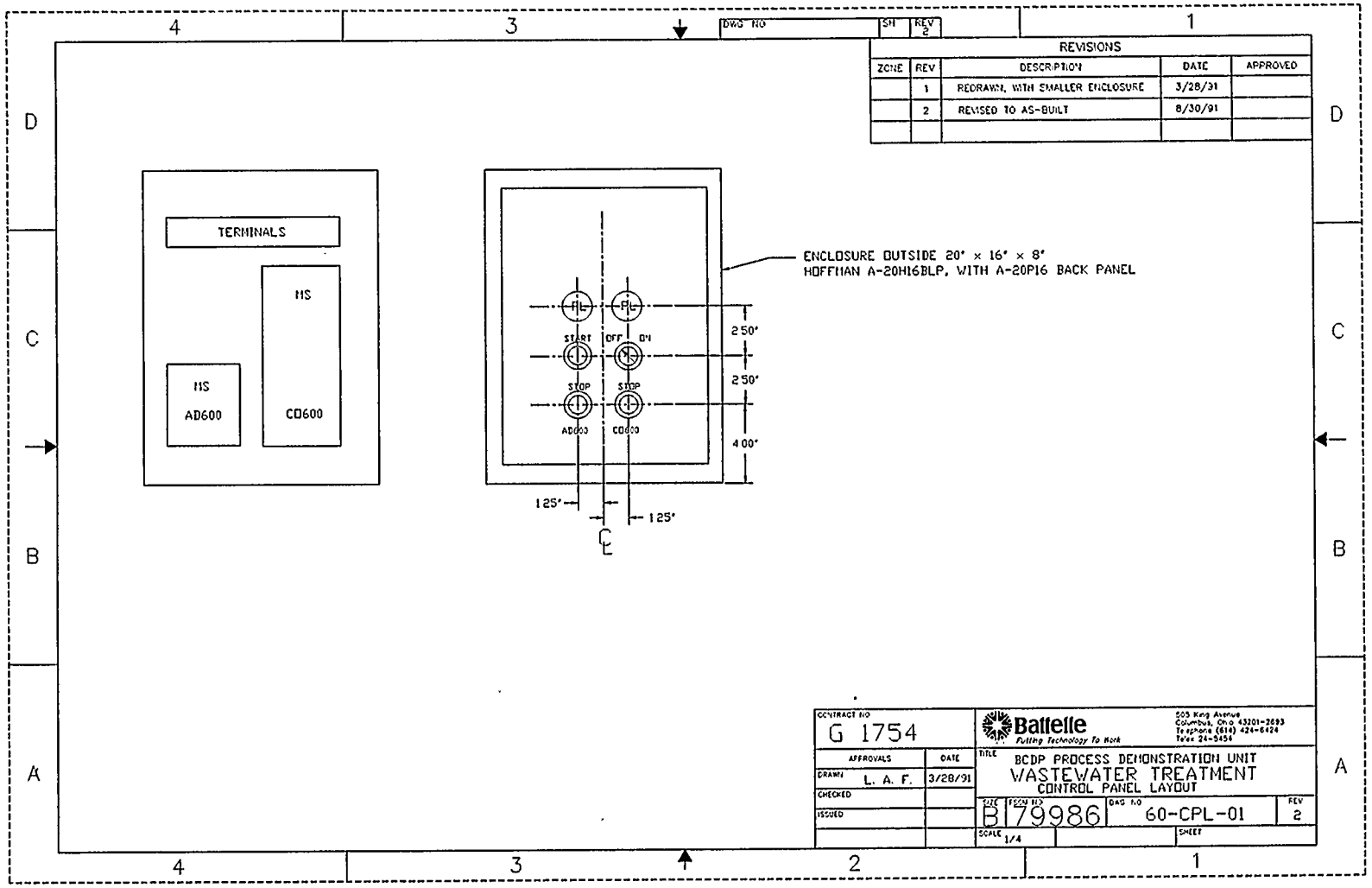

180 VOLTS, THREE PHASE
120 VOLTS, SINGLE PHASE
CONTROLS BY VENDOR
STIRRED-TANK REACTOR
LADDER DIAGRAM
60-LD-02
Battelle

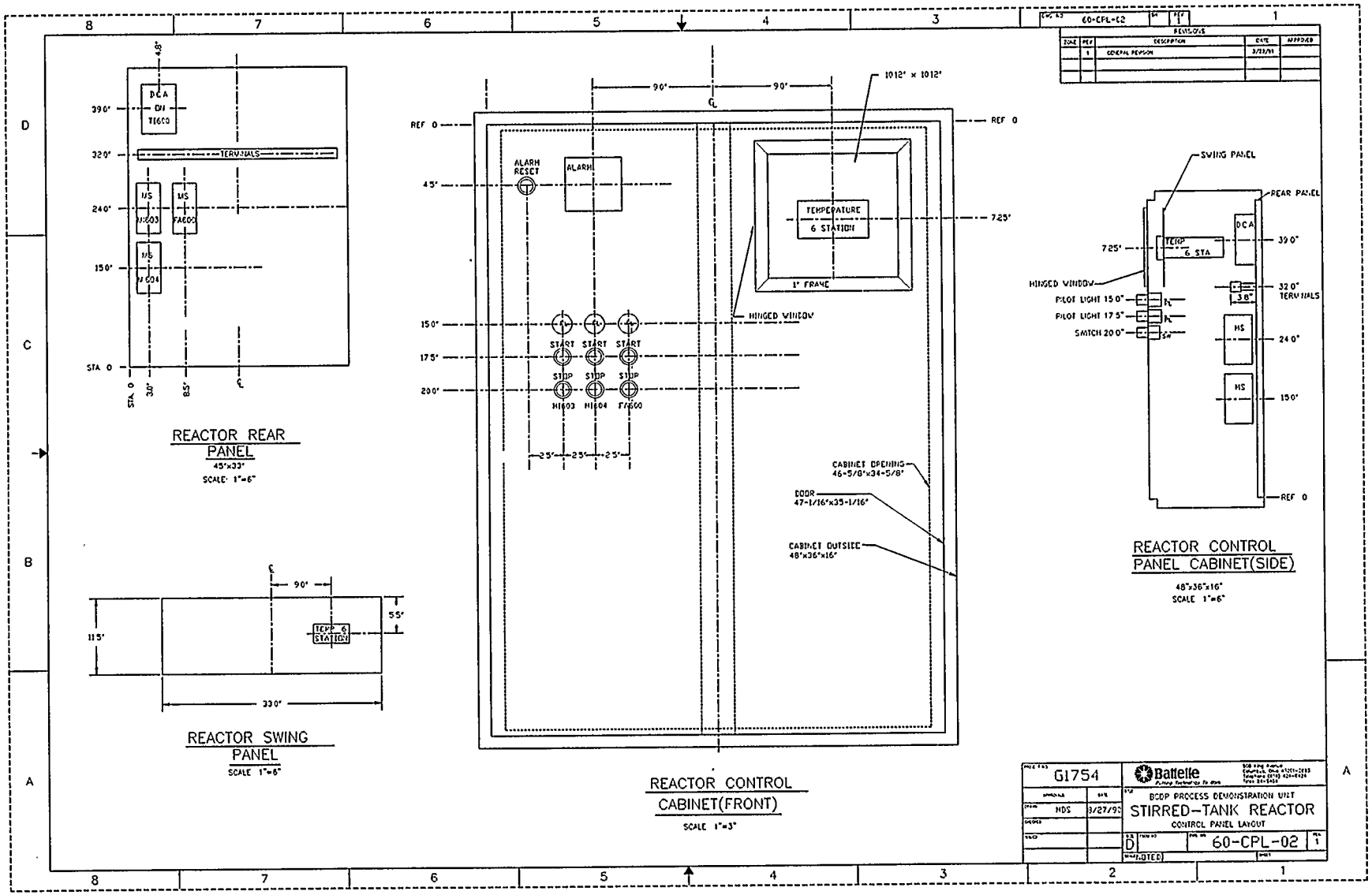
REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	1	GENERAL REVISION, TO PORTABLE LAB	10/30/90	
	2	ADDED CKT BKRS FOR U P S	2/05/91	



PROJECT NO. G1754	Battelle		
APPROVALS	DATE	TITLE	BCDP PROCESS DEMONSTRATION UNIT PORTABLE LABORATORY ELECTRICAL DISTRIBUTION
DRAWN S.M.M.	10/30/90		
CHECKED		SIZE C	DWG NO. 70-EL-01
ISSUED		REV 2	
		SCALE NTS	SHEET

DWG NO 70-EL-01 SH REV 2


DWG NO
SH
REV 2
REVISIONS
ZONE | REV | DESCRIPTION | DATE | APPROVED
1 | REDRAWN, WITH SMALLER ENCLOSURE | 3/28/91
2 | REVISED TO AS-BUILT | 8/30/91
TERMINALS
MS
AD600
MS
CD600
ENCLOSURE OUTSIDE 20" x 16" x 8"
HOFFMAN A-20H16BLP, WITH A-20P16 BACK PANEL
PL
START
OFF
ON
STOP
STOP
AD600
CD600
2.50"
2.50"
4.00"
1.25"
1.25"
CONTRACT NO
G 1754
APPROVALS
DATE
DRAWN L. A. F.
3/28/91
CHECKED
ISSUED
Battelle
Putting Technology To Work
505 King Avenue
Columbus, Ohio 43201-2693
Telephone (614) 424-6424
Telex 24-5454
TITLE
BCDP PROCESS DEMONSTRATION UNIT
WASTEWATER TREATMENT
CONTROL PANEL LAYOUT
SIZE B
FSCM NO 79986
DWG NO 60-CPL-01
REV 2
SCALE 1/4
SHEET


REACTOR REAR PANEL
45"x33"
SCALE 1"=6"
REACTOR SWING PANEL
SCALE 1"=6"
REACTOR CONTROL CABINET(FRONT)
SCALE 1"=3"
REACTOR CONTROL PANEL CABINET(SIDE)
48"x36"x16"
SCALE 1"=6"
TEMPERATURE 6 STATION
ALARM RESET
ALARM
START
STOP
SWING PANEL
REAR PANEL
HINGED WINDOW
CABINET OPENING 46-5/8"x34-5/8"
DOOR 47-1/16"x35-1/16"
CABINET OUTSIDE 48"x36"x16"
G1754
Battelle
BCDP PROCESS DEMONSTRATION UNIT
STIRRED-TANK REACTOR
CONTROL PANEL LAYOUT
60-CPL-02
NDS
3/27/95

Appendix D

Run Data

Table of Contents

July, 1993

Table 1. July 17, 1993 ..... D.1
Table 2. July 19, 1993 ..... D.4
Table 3. July 23, 1993 ..... D.6

February 1994

Table 4. February 2, 1994 ..... D.10
Table 5. February 5, 1994 ..... D.11

November 1994

Table 6. November 19 - 20, 1994 ..... D.12
Table 7. November 28 - 30, 1994 ..... D.21

May 1995

Table 8. May 15 - 16, 1995 ..... D.23
Table 9. May 17, 1995 ..... D.24
Table 10. May 18 - 19, 1995 ..... D.25
Table 11. May 22 - 23, 1995 ..... D.27
Table 12. May 25 - 26, 1995 ..... D.29
Table 13. May 25, 1995 ..... D.30

Table 1 - July 17, 1993 (Page 1 of 3)

		Reactor Kiln Soil Temperatures, C									Reactor Furnace Control Zone Temperatures, C				Process Temperatures, C									
Date	Time	5 ft	9.5 ft	13.5 ft	18 ft	22.5 ft	27 ft	31.5 ft	35.5 ft	Discharge	Zone 1	Zone 2	Zone 3	Zone 4	Scrubber Inlet	Scrubber Outlet	Stack Inlet	Scrubber Water	HX Inlet	HX Outlet	Stack Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet
7/17/93	12:55	247	204	226	250	340	381	380	336	134	566	572	533	581	76	32	48	52	35	34	42	174	72	118
7/17/93	13:00	251	210	234	253	340	387	382	347	225	567	575	530	580	75	32	48	51	36	34	41	172	71	119
7/17/93	13:06	257	211	248	259	340	384	382	349	168	570	577	527	579	74	33	48	51	36	34	42	169	72	118
7/17/93	13:11	265	214	270	267	333	384	382	350	179	565	573	526	580	74	33	48	51	36	34	42	169	71	117
7/17/93	13:16	270	215	289	273	347	386	381	353	211	562	572	533	583	74	33	48	50	36	34	42	175	72	119
7/17/93	13:21	285	222	306	288	355	392	385	358	251	564	576	538	583	73	33	48	49	36	34	42	168	70	118
7/17/93	13:26	297	235	327	300	370	399	390	365	274	566	580	538	591	72	33	49	47	36	34	42	165	70	118
7/17/93	13:31	306	236	344	309	384	406	396	368	257	569	595	537	585	71	32	48	46	36	34	42	163	71	118
7/17/93	13:36	314	238	361	317	394	417	402	374	278	569	600	539	586	71	32	48	46	35	34	42	161	70	117
7/17/93	13:41	321	239	366	323	404	423	408	372	275	566	532	540	583	70	32	48	46	35	33	42	165	71	118
7/17/93	13:46	325	239	351	327	413	431	412	373	265	560	546	538	541	70	32	48	46	35	33	41	163	69	118
7/17/93	13:51	320	232	328	323	414	428	414	365	210	566	550	519	505	71	32	48	47	35	33	42	162	72	120
7/17/93	13:57	316	228	313	319	415	428	414	358	158	563	557	566	503	71	32	51	43	35	34	44	194	75	129
7/17/93	14:02	308	225	285	311	414	424	407	355	181	568	579	543	517	76	32	52	40	36	34	45	191	77	128
7/17/93	14:07	305	225	284	308	413	422	400	356	190	570	579	544	517	79	33	52	44	36	34	46	195	79	129
7/17/93	14:12	302	229	307	304	409	422	401	359	248	569	575	542	520	80	32	53	44	36	34	47	200	79	129
7/17/93	14:17	303	232	328	306	404	421	408	359	230	565	571	541	514	80	32	53	43	36	34	47	214	78	128
7/17/93	14:22	310	235	346	312	402	418	412	362	177	565	577	539	511	82	32	53	43	36	34	47	216	79	127
7/17/93	14:27	314	236	358	316	399	417	411	360	142	565	577	538	513	82	32	53	42	36	34	47	210	79	128
7/17/93	14:32	317	230	358	319	400	412	415	360	137	567	591	537	510	83	32	53	42	36	34	47	205	78	128
7/17/93	14:37	325	234	352	327	408	416	403	363	150	565	594	537	508	85	32	53	45	36	34	47	217	88	160
7/17/93	14:43	322	228	321	325	412	411	396	362	194	565	585	541	513	90	33	54	45	36	35	47	204	85	140
7/17/93	14:48	313	229	292	316	412	405	404	358	277	564	575	539	528	82	33	54	43	36	34	48	182	77	88
7/17/93	14:53	310	230	287	313	416	409	395	362	291	562	569	540	532	69	33	54	42	36	34	48	180	67	77
7/17/93	14:58	307	227	289	310	413	412	401	364	233	565	568	542	531	62	32	54	42	36	34	48	194	72	94
7/17/93	15:03	302	229	283	304	406	410	402	364	215	569	564	544	541	65	32	55	42	36	34	48	180	70	80
7/17/93	15:08	304	229	291	306	401	414	399	368	189	567	561	547	537	63	32	55	46	36	34	48	191	70	100
7/17/93	15:13	306	230	297	309	402	417	396	373	169	564	552	548	533	77	32	56	44	36	35	49	196	73	127
7/17/93	15:18	308	232	311	311	402	416	398	374	207	559	477	548	530	80	32	56	43	36	35	49	192	74	125
7/17/93	15:23	313	235	328	316	404	422	403	378	193	555	422	555	511	83	32	57	42	36	35	49	207	81	149
7/17/93	15:28	315	236	331	319	406	423	415	378	232	565	479	553	509	89	32	57	44	36	35	50	217	91	177
7/17/93	15:34	322	238	343	326	413	425	403	382	259	569	478	557	504	93	32	57	44	37	35	50	230	96	173
7/17/93	15:39	323	238	348	326	416	422	401	378	219	567	480	562	493	92	32	57	44	37	35	50	212	78	136
7/17/93	15:44	325	238	340	328	420	422	399	377	190	573	584	552	509	89	33	58	44	37	35	51	208	77	129
7/17/93	15:49	326	238	327	329	420	424	399	376	194	562	553	552	495	86	33	59	45	37	35	51	202	71	125
7/17/93	15:54	322	234	302	325	419	423	398	375	210	563	541	551	497	84	33	59	44	37	35	51	195	70	123
7/17/93	15:59	316	231	284	319	415	422	397	372	217	561	537	550	495	84	33	60	44	37	35	52	184	66	122
7/17/93	16:04	306	229	271	308	410	419	395	370	228	559	538	548	492	83	33	60	45	37	35	52	184	66	122
7/17/93	16:09	297	228	278	299	405	421	396	370	248	566	533	543	485	82	33	60	45	37	35	52	192	66	125
7/17/93	16:14	285	227	272	288	394	416	393	369	234	565	539	539	489	81	33	61	44	37	35	52	194	68	121
7/17/93	16:19	280	225	270	283	381	408	389	366	229	567	533	532	482	80	33	61	44	37	35	52	192	68	119
7/17/93	16:25	277	223	269	280	371	401	389	364	246	564	526	521	463	80	33	61	43	37	35	52	186	68	119
7/17/93	16:30	277	223	269	279	367	396	385	365	258	569	521	533	550	79	33	60	43	37	35	52	177	66	117
7/17/93	16:35	270	222	268	273	360	390	386	362	212	566	574	542	544	80	33	61	42	36	35	52	171	64	118
7/17/93	16:40	275	220	270	277	358	388	380	362	246	565	575	537	536	81	33	61	43	36	35	53	171	63	118

Table 1 - July 17, 1993 (Page 2 of 3)

		Reactor Kiln Soil Temperatures, C									Reactor Furnace Control Zone Temperatures, C				Process Temperatures, C									
Date	Time	5 ft	9.5 ft	13.5 ft	18 ft	22.5 ft	27 ft	31.5 ft	35.5 ft	Discharge	Zone 1	Zone 2	Zone 3	Zone 4	Scrubber Inlet	Scrubber Outlet	Stack Inlet	Scrubber Water	HX Inlet	HX Outlet	Stack Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet
7/17/93	16:45	278	220	273	281	358	387	377	361	273	565	575	536	540	80	33	61	43	36	34	53	178	64	120
7/17/93	16:50	277	217	265	280	359	383	375	358	261	568	582	536	532	81	33	61	43	36	35	53	190	69	123
7/17/93	16:55	276	221	255	279	355	377	369	353	305	570	568	537	533	84	33	61	41	36	35	53	147	68	118
7/17/93	17:00	277	218	266	280	361	380	371	354	258	549	491	538	543	80	33	61	42	36	35	53	183	68	119
7/17/93	17:05	278	221	269	281	365	382	373	354	243	540	436	538	542	81	33	61	42	36	35	53	179	68	119
7/17/93	17:10	280	227	279	284	368	387	375	351	219	544	542	538	534	80	33	61	41	36	34	52	171	66	118
7/17/93	17:16	293	252	301	295	374	392	380	357	251	506	522	538	546	80	33	61	40	36	34	52	170	65	119
7/17/93	17:21	303	279	323	305	382	396	386	358	280	537	507	539	527	80	32	60	39	35	34	52	177	66	121
7/17/93	17:26	313	322	341	315	386	399	377	357	243	541	546	539	533	80	32	60	38	35	33	52	183	66	122
7/17/93	17:31	327	352	360	328	396	398	382	356	276	501	473	538	540	80	32	60	37	35	33	51	191	69	124
7/17/93	17:36	344	375	377	345	408	404	372	354	237	521	453	542	548	80	32	59	36	34	33	51	197	72	125
7/17/93	17:41	360	387	390	360	406	410	376	353	239	430	378	447	452	79	31	59	35	33	32	50	199	68	125
7/17/93	17:46	362	384	385	363	417	406	362	343	197	353	361	385	393	81	31	59	34	33	32	51	197	71	125
7/17/93	17:51	357	372	377	359	400	392	353	331	192	317	323	344	340	80	31	58	33	32	32	50	193	71	123
7/17/93	17:56	348	358	364	348	372	379	329	312	166	280	323	339	333	80	31	58	33	32	31	50	187	74	126
7/17/93	18:01	332	342	349	332	350	357	314	297	169	236	332	340	336	80	31	58	33	32	31	50	181	71	119
7/17/93	18:07	307	327	332	303	330	337	296	276	149	251	323	330	324	80	31	58	32	30	29	50	180	71	118
7/17/93	18:12	297	315	320	297	309	322	283	262	169	249	313	320	311	79	31	58	34	30	29	50	175	69	115
7/17/93	18:17	278	294	299	277	291	294	261	241	146	262	304	310	300	76	31	60	35	30	29	51	170	71	125
7/17/93	18:22	264	279	287	264	274	271	250	232	120	259	281	292	276	82	30	58	32	30	29	50	168	74	135
7/17/93	18:27	256	269	274	256	260	265	238	221	107	246	261	268	253	85	30	58	32	30	30	50	163	75	131
7/17/93	18:32	244	256	261	242	250	246	229	208	108	236	248	253	238	84	30	58	32	31	30	50	157	74	124
7/17/93	18:37	231	243	249	230	236	232	218	199	108	227	236	239	225	83	30	58	32	31	30	50	150	72	121
7/17/93	18:42	220	231	235	220	224	221	207	188	102	218	226	227	213	82	30	58	32	31	30	50	145	71	118
7/17/93	18:47	212	221	225	211	216	208	199	183	97	211	216	216	203	80	30	58	32	31	30	50	140	68	114
7/17/93	18:53	201	211	211	200	203	196	187	170	102	203	207	206	193	78	30	57	32	30	30	50	136	66	108
7/17/93	18:58	191	200	199	191	192	181	176	160	85	195	198	196	183	68	28	56	31	30	29	48	129	61	98
7/17/93	19:03	180	190	187	179	181	174	167	150	73	187	189	186	174	67	27	55	31	30	29	47	126	58	98
7/17/93	19:08	170	180	177	170	171	161	158	143	76	181	181	178	166	65	27	55	31	30	29	47	121	55	96
7/17/93	19:13	160	170	166	160	159	154	149	135	66	175	174	170	159	67	27	56	31	30	29	48	118	56	95
7/17/93	19:18	151	161	156	151	149	143	140	127	72	169	168	163	152	67	27	56	31	29	29	49	116	56	95
7/17/93	19:24	143	150	147	143	139	140	134	120	66	163	162	156	146	69	28	56	31	29	29	50	106	57	94
7/17/93	19:29	135	141	139	135	131	132	127	113	63	158	156	150	141	69	28	57	31	29	29	50	104	59	92
7/17/93	19:34	135	145	137	134	132	126	123	111	70	154	152	146	137	65	28	53	32	29	29	48	101	59	87
7/17/93	19:39	145	145	146	145	148	140	133	122	82	149	165	161	158	51	28	45	31	29	29	42	80	53	73
7/17/93	19:44	142	145	144	142	145	133	130	117	77	139	163	160	156	35	26	39	29	29	28	32	64	39	56
7/17/93	19:49	136	138	139	136	139	132	123	112	71	140	162	160	157	26	25	36	27	29	27	28	51	29	38
7/17/93	19:54	132	136	135	132	137	129	120	109	66	139	159	157	156	25	25	34	27	28	26	27	49	28	33
7/17/93	19:59	129	133	133	129	135	125	118	107	64	137	156	154	155	25	25	32	26	28	26	26	49	27	32
7/17/93	20:04	127	129	131	126	133	122	117	106	62	139	154	151	152	26	25	31	26	28	26	26	49	28	31
7/17/93	20:09	125	125	129	125	132	122	116	105	60	137	151	148	150	26	25	31	26	28	25	26	50	28	30
7/17/93	20:15	122	123	127	123	129	118	114	104	59	135	149	145	147	26	25	32	26	28	25	26	51	28	29
7/17/93	20:20	121	119	125	120	126	114	112	102	58	128	145	143	144	26	25	32	26	27	25	27	52	29	28
7/17/93	20:25	118	123	122	118	125	113	111	100	56	127	144	141	143	26	25	31	26	27	25	26	48	28	28
7/17/93	20:30	117	116	121	117	123	111	110	100	55	127	141	139	141	26	25	31	26	27	25	26	49	29	28

Table 1 - July 17, 1993 (Page 3 of 3)

		Reactor Kiln Soil Temperatures, C									Reactor Furnace Control Zone Temperatures, C				Process Temperatures, C									
Date	Time	5 ft	9.5 ft	13.5 ft	18 ft	22.5 ft	27 ft	31.5 ft	35.5 ft	Discharge	Zone 1	Zone 2	Zone 3	Zone 4	Scrubber Inlet	Scrubber Outlet	Stack Inlet	Scrubber Water	HX Inlet	HX Outlet	Stack Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet
7/17/93	20:35	116	114	119	115	121	112	109	98	54	127	139	137	138	26	25	31	25	27	25	26	50	29	27
7/17/93	20:40	114	112	118	113	119	111	108	97	53	126	136	134	136	26	25	31	24	27	25	26	51	29	27
7/17/93	20:45	111	114	116	112	117	110	106	95	52	125	135	133	134	26	25	31	25	27	25	26	50	29	27
7/17/93	20:50	109	115	113	109	115	107	104	93	51	122	132	131	132	26	25	31	24	27	25	26	50	29	27
7/17/93	20:55	108	113	111	108	113	107	103	92	51	120	130	129	130	26	26	31	24	26	25	25	50	29	27
7/17/93	21:01	105	111	110	104	111	105	101	91	50	119	129	127	128	26	26	30	24	27	25	25	47	29	26
7/17/93	21:06	105	108	108	104	110	104	100	90	49	118	127	126	127	26	26	30	24	26	25	25	48	29	26

Table 2 - July 19, 1993 (Page 1 of 2)

		Soil									Furnace Zones				Process Temperatures, C									
Date	Time	5 ft	9.5 ft	13.5 ft	18 ft	22.5 ft	27 ft	31.5 ft	35.5 ft	Soil Discharge	Zone1	Zone2	Zone3	Zone4	Scrubber Inlet gas	Scrubber Outlet Gas	ID Fan Outlet	Scrubber Water Outle	Heat Exch Inlet	Heat Exch Outlet	Stack Outlet	Reactor Exhaust	Cyclone Inlet	Baghouse Inlet
7/21/93	9:20	161	197	157	162	195	187	177	154	89	608	447	581	566	98	95	91	97	82	89	92	108	92	95
7/21/93	9:25	171	212	167	171	219	201	190	164	90	621	458	595	580	98	95	92	97	82	90	93	110	92	95
7/21/93	9:30	183	238	179	183	228	217	204	177	91	607	463	616	591	95	93	91	96	83	89	91	111	92	93
7/21/93	9:35	193	249	190	193	244	233	219	189	91	665	531	649	712	92	91	90	94	83	88	89	113	92	92
7/21/93	9:40	213	278	210	213	268	260	246	207	91	778	748	730	758	94	93	91	94	83	89	90	118	93	93
7/21/93	9:45	238	307	233	237	301	290	278	229	91	867	835	751	769	96	95	94	96	83	90	91	125	94	94
7/21/93	9:50	262	350	279	261	345	331	322	262	91	891	856	808	897	97	95	95	96	83	91	92	132	96	95
7/21/93	9:55	265	401	328	262	406	389	378	310	91	929	826	811	906	98	95	94	97	84	91	92	139	97	96
7/21/93	10:00	308	451	368	306	446	420	418	342	91	983	841	824	904	99	97	96	98	84	92	93	146	99	97
7/21/93	10:05	344	482	418	342	474	445	451	364	91	984	865	823	922	100	97	97	98	85	92	93	152	101	98
7/21/93	10:10	380	505	457	379	494	458	462	377	92	993	857	862	915	101	98	97	99	85	93	93	160	103	99
7/21/93	10:16	420	531	491	417	512	465	468	380	92	1002	882	889	906	101	97	98	99	85	93	94	165	105	99
7/21/93	10:21	464	554	526	460	543	485	491	396	92	1030	945	940	987	99	97	98	99	85	93	93	170	106	99
7/21/93	10:26	506	588	577	505	582	518	514	412	92	1051	984	988	1013	100	98	100	99	86	94	93	177	108	100
7/21/93	10:31	554	613	617	558	618	544	535	429	92	1067	1003	1003	1010	100	98	101	100	86	94	94	183	110	101
7/21/93	10:36	593	638	645	592	651	585	558	443	92	1067	1010	1009	1032	100	99	102	100	87	95	94	185	111	101
7/21/93	10:41	615	663	670	614	683	594	579	457	93	1080	1030	1028	1039	99	98	102	100	87	94	94	189	111	101
7/21/93	10:46	645	683	692	643	717	646	599	471	93	1091	1046	1051	1063	99	98	103	99	87	95	93	191	111	101
7/21/93	10:51	679	709	720	675	756	650	622	488	93	1104	1066	1156	1086	99	98	103	88	88	88	94	187	111	100
7/21/93	10:56	693	729	738	692	740	676	613	480	94	1060	1063	1182	1121	118	95	104	96	86	86	99	385	160	250
7/21/93	11:01	713	755	757	714	770	679	617	503	132	1088	1088	1122	1074	138	95	119	93	87	86	108	383	140	236
7/21/93	11:06	692	746	748	692	754	646	601	484	131	1107	1110	1008	1036	150	94	123	100	88	87	112	363	144	236
7/21/93	11:11	582	651	713	576	717	603	578	460	131	1093	1125	989	1027	158	95	126	109	89	88	115	322	147	233
7/21/93	11:16	513	590	709	516	700	586	561	447	144	1063	1133	1061	1028	161	96	130	114	90	89	117	336	139	236
7/21/93	11:21	516	549	690	519	707	586	567	450	144	1041	1126	1152	1044	164	97	132	116	92	91	119	346	136	237
7/21/93	11:26	516	400	651	522	704	585	556	434	146	1012	1113	1184	1043	164	96	133	117	93	91	121	345	149	241
7/21/93	11:31	539	390	629	533	715	609	562	438	133	1013	1094	1079	1041	164	96	135	117	95	92	121	329	150	236
7/21/93	11:36	511	392	609	521	723	647	594	455	135	995	1080	1039	1057	168	97	137	119	95	93	122	311	154	236
7/21/93	11:41	505	386	554	511	711	681	601	463	244	1024	1058	1017	1055	164	97	137	120	96	94	123	325	157	243
7/21/93	11:46	533	381	586	538	714	711	606	488	240	1007	1037	1011	1049	166	99	138	119	98	95	124	326	153	244
7/21/93	11:51	499	394	576	511	709	730	617	504	210	991	1040	989	1064	172	100	140	120	98	95	126	313	153	247
7/21/93	11:56	511	393	559	515	705	731	618	518	239	1013	1016	1077	1060	169	99	139	120	98	95	125	318	159	244
7/21/93	12:01	496	404	563	500	700	709	622	531	230	999	1019	973	1065	168	98	139	119	98	95	125	324	158	246
7/21/93	12:06	504	399	554	507	694	692	633	541	247	1024	1003	964	1060	168	98	139	119	99	95	125	329	159	246
7/21/93	12:11	506	408	544	510	692	730	637	555	247	1019	1045	843	1098	168	98	139	118	99	95	125	317	158	243
7/21/93	12:16	486	395	535	488	685	727	641	560	263	998	1043	881	1073	168	98	139	118	99	95	125	308	156	238
7/21/93	12:21	532	393	522	537	691	729	645	574	282	997	1041	1072	1101	169	98	139	118	99	96	126	317	156	242
7/21/93	12:26	532	376	484	535	686	720	650	572	294	977	1028	1043	1093	170	98	139	120	99	96	126	316	157	242
7/21/93	12:31	471	377	453	473	685	716	649	579	302	1008	1008	1051	1084	170	98	140	122	100	96	127	310	157	239
7/21/93	12:36	468	371	443	468	673	690	650	583	315	1001	1005	1051	1090	169	97	140	124	100	96	125	301	155	234
7/21/93	12:41	413	371	436	417	658	694	656	608	344	1013	985	1049	1082	167	96	139	127	100	96	123	313	158	238

Table 2 - July 19, 1993 (Page 2 of 2)

		Soil									Furnace Zones				Process Temperatures, C								
Date	Time	5 ft	9.5 ft	13.5 ft	18 ft	22.5 ft	27 ft	31.5 ft	35.5 ft	Soil Discharge	Zone1	Zone2	Zone3	Zone4	Scrubber Inlet gas	Scrubber Outlet Gas	ID Fan Outlet	Scrubber Water Outle	Heat Exch Inlet	Heat Exch Outlet	Stach Outlet	Reactor Exhaust	Cyclone Inlet	Baghouse Inlet
7/21/93	12:46	397	365	419	401	631	645	659	598	367	984	1021	1046	1082	166	95	140	128	101	96	124	310	157	237
7/21/93	12:51	474	364	383	478	604	602	649	606	383	1001	1047	1045	1079	170	97	143	131	102	98	127	299	157	238
7/21/93	12:56	484	363	378	480	588	552	626	597	422	997	1049	1047	1056	167	97	144	131	102	98	126	299	154	232
7/21/93	13:01	470	344	342	476	541	505	587	566	431	985	1048	1034	1045	166	97	144	131	103	98	128	295	154	229
7/21/93	13:06	428	329	358	436	513	466	553	532	422	993	1045	1059	1030	167	98	147	131	104	99	130	283	152	229
7/21/93	13:11	426	325	352	435	500	456	535	511	388	975	1036	1084	1017	161	94	143	130	103	97	121	290	154	223
7/21/93	13:16	414	302	339	417	471	468	524	499	385	981	1035	1089	1037	162	93	145	131	103	98	124	292	152	233
7/21/93	13:21	425	305	334	428	453	473	516	491	382	1017	1051	1094	1021	166	96	148	132	104	99	130	287	153	237
7/21/93	13:26	411	304	342	413	466	460	517	492	364	1042	1062	1120	1046	153	98	149	133	104	99	132	297	157	240
7/21/93	13:31	398	301	338	400	434	458	502	482	341	1062	1045	1128	1058	157	100	151	134	105	100	133	302	161	246
7/21/93	13:36	404	294	328	408	428	450	500	476	344	1064	1048	1136	1056	170	101	151	134	105	100	134	297	162	246
7/21/93	13:41	414	289	330	419	438	459	501	480	318	1063	1036	1142	1064	172	101	152	134	106	101	134	305	165	248
7/21/93	13:46	399	291	329	401	418	443	497	474	352	1070	1054	1150	1052	173	102	153	135	107	102	135	304	164	248
7/21/93	13:51	401	294	330	405	433	434	503	483	306	1069	1044	1153	1066	173	102	152	134	106	101	135	296	162	248
7/21/93	13:56	400	294	333	403	436	432	510	482	352	1006	1056	1158	1070	174	102	153	134	106	101	136	302	164	246
7/21/93	14:01	399	288	331	398	399	449	506	477	362	1017	1069	1164	1065	173	101	152	134	107	101	135	307	166	245
7/21/93	14:06	335	294	340	351	425	460	524	488	340	984	1064	1078	1066	172	102	153	132	107	101	135	289	163	242
7/21/93	14:11	439	305	345	443	446	486	541	504	355	900	1043	1049	1079	169	101	152	130	107	101	134	283	160	235
7/21/93	14:16	365	308	344	379	457	516	549	514	389	967	1036	1033	1094	169	102	151	130	107	102	135	282	161	235
7/21/93	14:21	390	312	350	393	446	529	560	523	371	951	1049	1044	1092	166	101	151	127	106	100	133	274	158	229
7/21/93	14:26	444	312	343	447	468	532	569	528	290	955	1050	1057	1099	166	101	151	128	105	100	134	272	157	229
7/21/93	14:31	364	318	351	362	476	540	576	531	295	973	1059	1053	1103	166	101	151	128	105	100	135	275	158	231
7/21/93	14:36	438	317	368	440	443	547	569	530	274	1011	1049	1051	1108	170	102	154	123	106	101	138	276	158	236
7/21/93	14:41	422	314	369	424	443	531	573	531	325	1016	1039	1047	1099	169	101	154	122	105	100	139	275	159	232
7/21/93	14:50	434	312	353	437	420	530	563	530	285	1004	1040	1049	1110	174	102	155	125	106	101	140	283	160	239
7/21/93	14:55	440	318	369	444	401	533	571	534	289	1017	1034	1047	1104	174	102	156	125	106	101	140	276	159	237
7/21/93	15:00	452	324	378	455	384	529	574	535	415	1029	1054	1054	1100	173	102	157	123	106	101	140	274	159	235
7/21/93	15:05	456	326	381	459	420	531	579	538	407	1014	1045	1058	1105	172	102	156	122	106	101	140	275	159	233

Table 3 - July 23, 1993 (Page 1 of 4)

		Reactor Kiln Soil Temperatures, C									Reactor Furnace Control Zone Temperatures, C				Process Temperatures, C									
Date	Time	5 ft	9.5 ft	13.5 ft	18 ft	22.5 ft	27 ft	31.5 ft	35.5 ft	Discharge	Zone 1	Zone 2	Zone 3	Zone 4	Scrubber Inlet	Scrubber Outlet	Stack Inlet	Scrubber Water	HX Inlet	HX Outlet	Stack Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet
7/23/93	7:20	179	181	187	179	177	184	176	153	535	570	429	441	84	83	82	82	79	81	83	97	84	82	198
7/23/93	7:25	168	200	212	168	196	202	194	168	492	590	421	431	84	84	82	82	79	81	84	101	85	83	199
7/23/93	7:30	216	213	231	216	210	213	207	177	488	546	498	442	85	84	83	83	80	81	84	105	85	83	198
7/23/93	7:35	229	227	250	229	225	229	220	189	486	520	463	452	85	84	83	83	80	82	84	109	85	83	198
7/23/93	7:40	241	239	264	241	238	243	232	196	493	520	428	467	86	85	84	84	80	82	85	112	86	84	198
7/23/93	7:45	246	251	278	245	251	258	245	206	499	525	460	473	86	85	85	84	80	82	85	115	87	84	198
7/23/93	7:50	255	265	291	257	264	269	253	216	505	536	539	481	87	85	85	85	80	82	85	117	87	85	198
7/23/93	7:55	271	275	303	265	280	277	263	225	508	543	549	490	87	86	85	85	80	83	86	119	88	86	198
7/23/93	8:00	278	285	317	277	295	289	275	233	513	552	561	500	88	86	87	86	81	83	86	122	89	87	198
7/23/93	8:05	289	299	331	289	314	303	292	245	517	559	572	551	87	87	87	81	81	81	87	125	90	87	199
7/23/93	8:10	283	317	339	282	331	298	292	263	534	625	583	566	98	85	87	85	82	82	113	197	109	150	199
7/23/93	8:15	296	339	353	295	346	313	302	265	632	632	597	573	109	85	88	86	82	82	125	212	120	171	198
7/23/93	8:20	311	358	369	311	361	319	312	272	650	629	607	578	118	84	88	86	82	82	130	223	128	182	198
7/23/93	8:25	331	375	386	331	378	333	326	283	601	633	621	597	124	84	88	87	83	83	133	233	134	191	198
7/23/93	8:30	351	393	405	351	398	353	342	302	578	651	639	651	131	85	89	88	83	83	136	241	140	202	199
7/23/93	8:35	388	435	437	388	420	386	369	325	763	679	660	716	136	86	90	90	84	83	136	260	148	216	198
7/23/93	8:40	396	460	459	395	443	400	383	332	704	694	667	697	143	86	91	90	84	84	136	269	154	226	198
7/23/93	8:45	422	491	482	422	466	423	402	352	846	735	770	754	147	87	92	92	85	84	137	283	161	236	198
7/23/93	8:50	470	541	523	473	505	463	438	380	791	791	830	808	154	88	93	93	85	85	139	306	164	254	198
7/23/93	8:55	501	567	553	500	539	491	458	389	788	797	805	798	163	88	94	93	85	85	139	322	169	255	198
7/23/93	9:00	517	580	575	516	567	506	471	395	837	793	797	804	167	88	95	94	86	85	139	331	172	254	198
7/23/93	9:05	553	623	608	553	606	540	502	422	980	905	947	902	168	89	95	95	86	86	140	349	177	267	199
7/23/93	9:10	590	633	640	591	639	567	520	436	1006	913	960	941	173	89	95	99	86	85	141	356	174	260	199
7/23/93	9:15	572	560	647	574	664	570	547	450	1036	998	1035	1006	175	90	96	109	88	86	141	359	168	256	198
7/23/93	9:20	536	451	616	538	667	566	538	416	1075	1031	1045	1019	185	91	96	117	89	88	143	390	175	282	198
7/23/93	9:25	525	403	606	528	678	576	534	421	1067	1022	1051	1027	192	92	96	118	91	89	144	386	171	262	198
7/23/93	9:30	534	395	610	540	703	624	558	446	1072	1020	1105	1054	185	92	96	120	92	90	144	380	167	239	198
7/23/93	9:35	502	417	589	505	724	661	595	461	1044	1019	1099	1071	181	93	97	121	94	91	145	383	167	239	198
7/23/93	9:40	494	417	567	498	735	699	614	483	1044	1028	1034	1080	179	93	97	122	95	91	146	379	170	238	198
7/23/93	9:45	472	413	515	477	736	715	626	513	1029	1060	1016	1098	179	94	98	123	96	93	146	374	166	238	198
7/23/93	9:50	472	416	472	476	732	716	637	540	1062	1053	1013	1111	180	96	99	124	97	93	148	375	165	240	198
7/23/93	9:55	448	420	454	463	737	717	660	574	1049	1042	1039	1124	181	96	100	125	98	94	149	377	167	239	198
7/23/93	10:00	458	433	471	425	759	729	689	618	1074	1047	1052	1136	181	96	100	126	98	94	149	380	170	240	198
7/23/93	10:05	339	452	485	266	775	755	700	654	1055	1043	1041	1036	181	96	101	127	100	95	150	379	169	241	199
7/23/93	10:10	351	465	482	386	765	747	697	661	1049	1044	1054	1023	182	96	101	127	100	95	150	379	170	244	201
7/23/93	10:15	356	444	484	247	776	735	709	669	1052	1047	1063	1051	183	97	102	128	100	96	150	379	170	244	204
7/23/93	10:20	173	447	478	176	772	709	710	675	1051	1051	1059	1052	184	97	102	128	101	96	151	378	167	245	207
7/23/93	10:25	175	462	473	286	755	706	701	667	1044	1043	996	1050	184	97	102	129	101	97	151	380	165	245	210

Table 3 - July 23, 1993 (Page 2 of 4)

		Reactor Kiln Soil Temperatures, C									Reactor Furnace Control Zone Temperatures, C				Process Temperatures, C									
Date	Time	5 ft	9.5 ft	13.5 ft	18 ft	22.5 ft	27 ft	31.5 ft	35.5 ft	Discharge	Zone 1	Zone 2	Zone 3	Zone 4	Scrubber Inlet	Scrubber Outlet	Stack Inlet	Scrubber Water	HX Inlet	HX Outlet	Stack Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet
7/23/93	10:30	386	431	460	390	744	703	700	659	1054	1050	1008	1052	186	98	102	129	102	97	151	382	166	247	212
7/23/93	10:35	366	416	447	380	721	676	680	649	1052	1048	1007	1056	186	98	102	129	103	98	151	381	163	246	216
7/23/93	10:40	372	417	439	380	712	672	676	644	1053	1046	998	1048	187	99	102	128	102	97	152	381	160	246	219
7/23/93	10:45	434	412	442	359	713	665	677	643	1054	1051	1001	1050	188	98	102	128	102	97	153	382	166	245	221
7/23/93	10:50	409	423	434	425	704	642	674	639	1051	1047	1008	1057	188	98	102	129	102	97	153	379	167	246	224
7/23/93	10:55	389	420	448	224	703	627	674	638	1036	1050	998	1046	184	97	102	129	103	97	152	378	167	242	228
7/23/93	11:00	458	403	426	462	694	618	663	629	1045	1051	1001	1054	184	97	102	130	103	97	152	377	165	246	231
7/23/93	11:05	424	399	421	357	693	630	660	648	1047	1051	1021	1051	187	98	101	131	103	98	152	374	162	248	234
7/23/93	11:10	293	419	423	313	699	630	664	633	1047	1046	1017	1051	188	98	101	132	103	98	153	375	164	248	238
7/23/93	11:15	318	406	425	295	700	608	667	633	1060	1057	1053	1049	187	98	101	132	104	98	153	377	166	249	241
7/23/93	11:20	179	428	444	268	720	650	656	626	1060	1054	1051	1051	190	102	102	138	116	115	155	375	169	250	244
7/23/93	11:25	337	396	415	334	696	594	647	623	1059	1048	1047	1047	189	105	102	139	119	119	157	372	163	247	248
7/23/93	11:30	363	386	407	371	683	598	635	608	1064	1044	1058	1056	190	107	102	141	122	122	159	371	166	248	249
7/23/93	11:35	367	387	408	368	686	568	634	615	1070	1044	1058	1049	190	109	103	142	125	125	161	376	168	248	252
7/23/93	11:40	334	399	415	259	702	598	633	610	1071	1048	1046	1049	189	110	104	142	128	127	162	377	172	248	255
7/23/93	11:45	363	386	405	367	681	590	632	607	1077	1045	1056	1048	188	111	104	141	130	130	164	371	169	244	257
7/23/93	11:50	345	389	410	358	682	561	636	606	1082	1043	1058	1046	186	111	105	141	132	131	163	366	168	240	259
7/23/93	11:55	366	389	410	371	683	572	628	608	1090	1048	1052	1050	184	112	106	141	133	133	165	362	165	239	260
7/23/93	12:00	325	395	414	330	685	594	633	607	1088	1043	1063	1054	182	111	107	142	135	134	165	355	166	235	263
7/23/93	12:05	366	389	410	370	680	608	624	601	1086	1051	1093	1053	182	112	108	143	135	135	165	357	169	238	264
7/23/93	12:10	366	394	415	370	680	613	633	605	1082	1046	1043	1060	182	113	108	144	136	136	166	353	169	238	261
7/23/93	12:15	367	388	414	371	679	604	639	603	1081	1048	1056	1104	184	116	109	144	137	137	168	351	167	240	264
7/23/93	12:20	370	394	415	374	681	629	641	607	1063	1049	1060	1074	184	116	110	144	138	138	168	355	163	241	264
7/23/93	12:25	369	392	414	374	682	626	637	602	1058	1050	1062	1084	185	117	111	145	139	138	168	358	167	244	265
7/23/93	12:30	372	393	414	376	686	600	644	603	1058	1050	1067	1087	188	118	112	146	140	139	170	363	163	248	266
7/23/93	12:35	372	394	414	377	688	615	645	603	1058	1052	1078	1092	188	117	112	146	140	140	169	370	161	249	267
7/23/93	12:40	377	396	418	382	692	600	648	612	1059	1052	1081	1096	190	118	112	147	141	140	170	369	164	251	267
7/23/93	12:45	379	397	421	384	693	602	654	620	1041	1043	1071	1095	191	119	111	147	142	141	170	367	159	251	268
7/23/93	12:50	377	400	417	383	687	580	646	620	1041	1049	1066	1090	192	120	112	146	142	141	171	367	154	252	269
7/23/93	12:55	374	394	413	378	680	576	636	617	1041	1052	1064	1088	191	120	111	146	142	142	171	368	155	251	269
7/23/93	13:00	368	395	410	372	675	572	627	612	1036	1042	1059	1088	190	120	112	146	142	142	171	368	159	250	270
7/23/93	13:05	368	391	408	374	670	578	622	607	1037	1048	1061	1086	191	120	111	146	142	142	171	363	155	250	270
7/23/93	13:10	368	385	406	372	670	579	624	607	1031	1049	1070	1085	192	120	111	146	142	142	172	361	155	249	270
7/23/93	13:15	371	385	410	374	671	570	629	607	1053	1048	1061	1085	192	120	111	146	142	142	171	362	157	248	270
7/23/93	13:20	370	387	406	375	673	566	635	606	1047	1048	1063	1085	191	119	110	146	142	141	169	359	151	247	270
7/23/93	13:25	372	385	406	377	677	574	631	611	1046	1050	1062	1086	190	119	109	146	143	142	170	361	152	247	271
7/23/93	13:30	373	389	406	377	680	585	644	611	1046	1046	1059	1086	188	118	110	146	142	142	169	362	154	246	270
07/23/9	13:38	377	392	405	381	680	588	641	617	1048	1046	1059	1088	187	117	109	147	142	142	168	363	154	246	271
07/23/9	13:43	378	391	404	383	684	592	646	618	1044	1046	1064	1090	186	117	109	146	142	142	168	365	155	245	270

Table 3 - July 23, 1993 (Page 3 of 4)

		Reactor Kiln Soil Temperatures, C									Reactor Furnace Control Zone Temperatures, C				Process Temperatures, C									
Date	Time	5 ft	9.5 ft	13.5 ft	18 ft	22.5 ft	27 ft	31.5 ft	35.5 ft	Discharge	Zone 1	Zone 2	Zone 3	Zone 4	Scrubber Inlet	Scrubber Outlet	Stack Inlet	Scrubber Water	HX Inlet	HX Outlet	Stack Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet
07/23/9	13:48	380	391	407	383	683	587	652	617	1051	1051	1066	1092	185	116	107	146	142	142	167	366	156	245	273
07/23/9	13:53	380	396	412	385	681	597	656	621	1058	1054	1065	1096	182	115	106	146	142	141	165	373	152	242	273
07/23/9	13:58	389	407	425	395	691	602	664	630	1041	1054	1062	1100	177	111	102	145	141	141	160	375	146	238	273
07/23/9	14:00	387	405	421	394	693	601	661	631	1059	1058	1061	1101	175	110	101	144	141	141	159	375	142	236	272
07/23/9	14:05	389	400	425	396	688	597	662	630	1054	1065	1064	1104	172	108	98	143	141	140	155	377	137	236	273
07/23/9	14:10	387	399	432	393	691	604	664	629	1051	1070	1062	1105	172	106	95	143	140	140	152	381	129	246	273
07/23/9	14:15	385	401	428	391	691	605	664	628	1062	1061	1057	1105	174	105	93	143	141	140	155	381	135	250	273
07/23/9	14:20	383	401	430	389	691	607	667	629	1054	1062	1064	1106	175	106	93	143	140	139	155	381	135	253	273
07/23/9	14:25	387	401	429	390	692	611	670	629	1039	1064	1063	1107	177	106	93	142	140	139	155	381	136	253	274
07/23/9	14:30	386	404	431	390	696	618	669	633	1030	1054	1061	1107	178	106	92	143	140	139	154	379	141	256	274
07/23/9	14:35	385	403	428	389	696	612	670	628	1055	1067	1062	1110	176	104	91	143	139	139	151	378	136	249	273
07/23/9	14:40	386	402	428	392	699	612	674	630	1045	1066	1062	1109	173	102	89	143	139	138	143	376	133	244	273
07/23/9	14:45	387	403	428	392	699	608	674	636	1070	1100	1064	1108	170	102	87	142	138	137	138	373	131	240	273
07/23/9	14:50	378	393	420	382	690	585	660	624	1044	1096	1064	1109	166	99	86	143	138	137	139	369	122	234	273
07/23/9	14:55	383	400	424	388	694	606	663	627	1063	1062	1062	1113	166	99	85	144	138	137	139	366	126	234	273
07/23/9	15:00	383	400	425	387	693	599	660	625	1063	1063	1063	1112	165	100	85	144	139	138	140	362	126	233	274
07/23/9	15:05	376	390	417	381	687	576	654	622	1037	1015	1063	1113	166	100	84	144	139	138	140	358	126	234	274
07/23/9	15:10	382	394	420	386	691	598	656	629	1074	1038	1019	1130	147	98	84	136	134	131	127	339	116	212	276
07/23/9	15:15	382	391	419	386	694	584	653	628	1076	1026	1071	1131	146	97	82	138	133	131	128	328	104	203	278
07/23/9	15:20	383	397	422	390	703	609	660	633	1064	1071	1118	1110	148	97	82	139	133	130	129	320	108	203	279
07/23/9	15:25	391	402	425	395	710	619	673	636	1036	1071	1137	1102	151	97	82	141	133	132	134	329	110	216	280
07/23/9	15:30	390	402	431	394	717	625	678	642	1041	1060	1127	1098	152	97	82	141	134	133	135	328	114	220	282
07/23/9	15:35	387	405	436	391	717	613	684	645	1051	1078	991	1095	155	98	82	143	135	134	136	331	114	222	283
07/23/9	15:40	390	409	436	394	715	636	689	647	1062	1086	1059	1088	158	100	82	143	135	135	138	341	120	229	285
07/23/9	15:45	391	404	431	396	710	611	687	644	1073	1112	1059	1085	160	102	81	145	136	135	138	354	126	239	285
07/23/9	15:50	390	399	426	394	708	607	678	641	1026	1104	1059	1082	163	102	81	147	137	136	139	355	123	237	286
07/23/9	15:55	387	404	424	392	699	603	670	636	1042	1102	1055	1081	163	103	82	148	138	137	141	356	125	238	288
07/23/9	16:00	382	390	423	387	694	599	666	634	1026	1081	1049	1082	153	104	82	142	139	138	145	372	130	250	290
07/23/9	16:05	382	401	425	387	685	607	666	633	1053	1097	1049	1080	168	105	83	138	139	138	142	378	135	246	293
07/23/9	16:10	380	391	424	385	678	579	658	630	1033	1086	1043	1079	172	105	84	137	138	137	143	381	137	249	293
07/23/9	16:15	377	390	425	382	674	610	649	624	1058	1103	1044	1072	173	104	84	135	136	135	149	383	137	246	293
07/23/9	16:20	392	389	426	437	673	635	645	619	1056	1099	1098	1073	155	99	83	133	134	132	135	381	131	231	294
07/23/9	16:25	443	396	434	448	686	612	646	621	1042	1100	1167	1073	135	96	82	128	129	126	127	372	116	203	295
07/23/9	16:30	377	389	423	381	682	651	651	614	1049	1085	1131	1071	143	96	83	130	128	125	130	378	118	212	296
07/23/9	16:35	469	400	431	471	693	637	656	624	1042	1078	1153	1069	150	97	83	130	127	125	131	382	126	225	297
07/23/9	16:40	387	391	431	384	692	619	652	620	1058	1087	1109	1066	156	97	84	131	126	124	131	385	139	237	297
07/23/9	16:45	358	392	440	362	695	645	653	621	1065	1097	1103	1064	171	98	84	132	127	126	134	386	142	257	299
07/23/9	16:50	360	397	455	362	698	623	654	622	1057	1100	1102	1064	177	97	83	132	128	126	136	379	147	262	299
07/23/9	16:55	433	408	454	443	702	626	655	625	1057	1103	1104	1064	183	97	82	132	128	127	147	376	149	267	299

Table 3 - July 23, 1993 (Page 4 of 4)

		Reactor Kiln Soil Temperatures, C									Reactor Furnace Control Zone Temperatures, C				Process Temperatures, C									
Date	Time	5 ft	9.5 ft	13.5 ft	18 ft	22.5 ft	27 ft	31.5 ft	35.5 ft	Discharge	Zone 1	Zone 2	Zone 3	Zone 4	Scrubber Inlet	Scrubber Outlet	Stack Inlet	Scrubber Water	HX Inlet	HX Outlet	Stack Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet
07/23/9	17:00	365	398	438	369	703	630	653	626	1049	1101	1105	1066	188	98	82	134	129	128	151	368	149	269	300
07/23/9	17:05	376	413	445	382	717	663	661	635	1055	1103	1105	1069	191	99	82	135	130	129	152	375	152	273	302
07/23/9	17:10	434	406	438	438	714	678	675	640	1059	1094	1100	1072	196	100	82	136	131	130	156	361	150	271	302
07/23/9	17:15	388	422	441	392	721	685	686	652	1032	1081	1080	1077	198	102	83	138	132	131	158	364	151	274	302
07/23/9	17:20	388	411	437	393	712	628	686	653	1049	1086	997	1031	203	103	84	138	133	133	161	367	158	279	303
07/23/9	17:25	391	408	444	395	702	633	678	656	897	990	1005	1009	208	105	85	135	134	133	162	369	158	280	304
07/23/9	17:30	453	407	471	461	688	600	653	649	681	942	953	962	209	105	86	131	133	133	162	381	160	280	304
07/23/9	17:35	401	413	509	405	679	620	636	632	620	780	973	951	210	105	86	127	132	131	162	400	169	286	305
07/23/9	17:40	473	427	555	473	691	652	634	625	598	732	971	938	211	104	87	124	130	130	161	406	171	286	305
07/23/9	17:45	526	466	599	529	708	677	633	633	569	703	977	928	210	104	86	122	128	127	159	408	170	283	305
07/23/9	17:50	545	497	618	547	717	680	634	629	555	692	936	919	208	103	86	120	126	126	157	410	165	283	305
07/23/9	17:55	550	534	623	552	717	668	633	611	546	682	907	911	206	101	86	118	124	123	156	408	160	281	305
07/23/9	18:00	463	602	647	464	738	703	643	613	541	669	835	903	205	101	86	115	122	121	155	406	157	270	305
07/23/9	18:05	544	591	633	545	713	702	624	583	539	662	818	915	202	100	86	113	120	120	155	395	154	266	306
07/23/9	18:10	540	592	628	541	703	695	606	560	553	658	807	861	202	99	86	111	118	117	155	394	153	266	307
07/23/9	18:15	467	611	641	468	712	684	611	575	557	654	798	847	202	97	86	110	116	116	155	391	154	266	304
07/23/9	18:20	473	602	634	473	700	686	586	539	497	537	668	698	202	96	86	108	114	114	154	391	154	265	304
07/23/9	18:25	519	587	618	519	671	628	571	529	471	511	631	655	198	96	86	106	112	112	152	392	153	256	304
07/23/9	18:30	494	571	603	494	645	603	549	503	455	493	604	623	195	95	86	105	111	110	151	383	152	253	305
07/23/9	18:35	467	553	573	464	617	563	522	466	441	475	579	594	195	96	86	129	110	108	149	360	141	252	304
07/23/9	18:40	455	533	551	454	595	538	504	461	429	459	555	567	193	106	85	184	109	106	156	354	139	246	304
07/23/9	18:45	445	508	537	445	568	505	480	432	419	443	534	542	191	112	85	187	108	104	168	350	140	249	304
07/23/9	18:50	435	487	509	435	543	479	458	416	408	428	514	519	191	115	85	188	107	102	178	345	140	247	302
07/23/9	18:55	423	468	484	423	520	453	434	394	397	414	495	498	190	118	86	187	106	101	183	332	144	248	305
07/23/9	19:00	412	445	467	412	496	431	413	371	386	400	476	477	190	121	87	188	105	99	188	317	143	245	305
07/23/9	19:05	400	424	441	400	470	409	388	352	377	387	459	459	192	123	88	190	104	98	191	308	150	248	305
07/23/9	19:10	389	406	424	389	453	394	374	339	366	374	442	441	189	123	89	187	102	96	190	304	152	242	305
07/23/9	19:16	378	385	407	378	436	374	360	319	357	362	426	423	186	123	90	186	101	95	192	294	151	237	305
07/23/9	19:20	370	376	396	370	415	367	346	312	348	351	411	407	176	122	90	182	101	94	191	263	152	238	305
07/23/9	19:26	355	347	365	355	394	338	325	290	338	341	398	394	184	123	91	184	100	93	192	267	156	241	305
07/23/9	19:31	341	328	337	340	368	321	311	276	329	330	385	380	186	123	91	185	99	92	193	264	157	238	305
07/23/9	19:36	329	324	337	329	375	316	307	273	321	320	372	367	182	122	91	182	98	91	192	255	156	231	305
07/23/9	19:44	312	303	317	312	339	301	293	260	307	304	353	346	175	120	91	177	97	90	191	240	149	219	305
07/23/9	19:49	303	293	302	303	325	290	282	252	300	296	342	335	172	118	90	173	96	90	189	221	143	210	305

Table 4 - February 2, 1994 (Page 1 of 1)

		Furnace Zones				Soil								Process Temperatures, C									
Date	Time	Zone 1	Zone2	Zone3	Zone4	Bed1	Bed2	Bed3	Bed4	Bed5	Bed6	Bed7	Bed8	Scrubber Inlet	ID Fan Inlet	Scrubber Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet	HX Inlet	HX Outlet	Stach Outlet	ID Fan Outlet
2/2/94	10:30	852	852	848	844	485	563	567	486	521	518	461	404	129	93	90	313	154	151	90	90	124	159
2/2/94	11:30	944	945	948	951	618	726	730	618	684	665	617	514	142	96	93	377	185	174	95	94	140	162
2/2/94	11:55	999	1120	986	1011	218	457	694	223	682	656	621	502	142									
2/2/94	12:00					339	362	680	340	676	651			199	104	109	405	248	252	96	93	145	167
2/2/94	12:15					405	343	652	404	698	667	630	494										
2/2/94	12:55					408	362	532	409	695	678	713	530										
2/2/94	13:02	1057	1025	1010	1096	404	381	558	407	692	685	721	534	205	106	110	406	289	244	101	97	150	171
2/2/94	13:17	1033	1009	1021	1124	406	353	555	406	703	725	737	544										
2/2/94	13:30	964	1003	1028	1128	397	363	572	398	702	739	750	554										
2/2/94	13:50	999	993	1034	1137	370	415	589	378	700	744	755	560	196	107	110	429	302	248	102	98	148	168
2/2/94	14:08					407	380	585	396	706	746	755	574										
2/2/94	14:20					436	375	572	439	712	789	756	577	194	106	110	421	300	248	102	98	148	168
2/2/94	14:56	998	968	1040	1149	428	643	600	430	722	771	766											
2/2/94	15:11	1047	1006	1044	1076	439	633	667	439	728	770	772	599	193	106	111	414	283	247	104	100	150	171
2/2/94	15:35	982	1001	1039	1052	427	622	664	430	707	746	762	592										
2/2/94	15:52	1004	1002	1033	1040	433	629	648	448	690	736	752	591										
2/2/94	16:03	1017	1005	1032	1035	424	570	644	426	686	723	740	582										
2/2/94	16:17	1024	1004	1032	1024	440	614	656	441	699	730	744	591	197	107	111	421	298	249	103	99	148	169

Table 5 - February 5, 1994 (Page 1 of 1)

		Furnace Zones				Soil								Process Temperatures, C									
Date	Time	Zone 1	Zone2	Zone3	Zone4	Bed1	Bed2	Bed3	Bed4	Bed5	Bed6	Bed7	Bed8	Scrubber Inlet	ID Fan Inlet	Scrubber Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet	HX Inlet	HX Outlet	Stack Outlet	ID Fan Outlet
2/5/94	8:00	586	520	549	508	185	235	229	187	212	187	190	157										
2/5/94	8:30	675	601	635	599	347	377	362	350	340	298	301	236										
2/5/94	9:00	772	697	714	694	486	500	496	486	465	407	422	326										
2/5/94	9:30	820	800	783	798	failed TC	576	578	failed TC	500	472	477	383	136	93	90	351	275	194	85	86	117	166
2/5/94	10:00	892	899	900	886	failed TC	667	677	failed TC	615	568	581	464										
2/5/94	10:30	1009	999	991	992	failed TC	807	813	failed TC	801	725	742	592	171	99	99	480	378	247	94	94	131	174
2/5/94	11:10	1065	996	1038	1005	failed TC	651	746	failed TC	794	727	744	567	180	104	117	429	347	248	98	94	145	128
2/5/94	11:30	1011	1005	1018	1026	failed TC	592	655	failed TC	750	759	768	580	180	106	117	403	339	246	102	98	150	181
2/5/94	12:00	997	995	1015	1022	failed TC	555	604	failed TC	705	699	761	607	178	110	121	385	335	242	103	99	150	184
2/5/94	12:30	988	1000	1036	1027	failed TC	433	600	failed TC	679	694	758	599	180	109	123	369	319	240	102	98	151	183
2/5/94	13:00	1055	1067	989	1099	failed TC	916	613	failed TC	601	695	719	583	178	111	126	402	354	252	106	100	153	186
2/5/94	14:00	1059	1093	1079	1120	failed TC	465	644	failed TC	677	720	706	588	186	111	126	411	357	257	106	100	150	182
2/5/94	14:30	1069	1080	1053	1126	failed TC	466	637	failed TC	639	732	723	600	186	109	121	397	339	254	107	100	149	181
2/5/94	15:00	1059	1080	1049	1123	failed TC	437	600	failed TC	677	700	691	571	192	110	122	416	342	259	107	102	152	180
2/5/94	15:30	1057	1106	1047	1120	failed TC	444	629	failed TC	693	717	706	591	185	111	125	386	331	254	107	102	150	183
2/5/94	16:00	1066	1089	1064	1142	failed TC	451	626	failed TC	716	727	703	589	183	110	125	384	329	254	106	103	149	182
2/5/94	16:30	1050	1079	1072	1143	failed TC	413	624	failed TC	699	709	706	582	192	110	121	395	334	262	106	101	146	175
2/5/94	17:00	1031	1077	1073	1144	failed TC	446	623	failed TC	702	718	711	585	188	109	123	395	338	260	105	100	147	177
2/5/94	17:30	1038	1072	1081	1145	failed TC	454	636	failed TC	723	728	720	591	188	109	124	390	341	262	106	100	145	177
2/5/94	18:00	1042	1075	1083	1144	failed TC	462	637	failed TC	704	736	738	599	189	109	123	380	329	259	105	99	146	177
2/5/94	18:30	1048	1070	1101	1142	failed TC	451	637	failed TC	704	751	747	578	190	107	120	386	334	252	104	99	144	174
2/5/94	19:00	1047	1059	1106	1142	failed TC	444	637	failed TC	704	751	747	578	190	107	123	383	325	258	102	97	146	177
2/5/94	20:00	1067	1049	1051	1009	failed TC	644	608	failed TC	657	657	684	544	188	106	120	368	324	259	102	97	145	177
2/5/94	20:30	1079	1062	1047	1046	failed TC	708	623	failed TC	705	684	722	561	190	106	120	363	309	260	102	97	141	173
2/5/94	21:00	1005	1079	1055	1052	failed TC	564	414	failed TC	643	669	671	537	194	108	122	384	263	102	97	148	177	

Table 6 - November 19 - 20, 1994 (Page 1 of 9)

		Temperature																													
Date	Time	BED 1	BED 2	BED 3	BED 4	BED 5	BED 6	ZONE 1	ZONE 2	ZONE 3	ZONE 4	Scrubber Inlet	Scrubber Outlet	ID Fan Inlet	ID Fan Outlet	HX Inlet	HX Outlet	Carbon Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet	Soil Discharge	DP (volts)	Flow DP (in H20)	Reactor DP (in H20)	Scrubber Level (in)	Tank 502 Level (%)	TanK 503 Level (%)	Tank 602 Level (%)	Wind Speed (mph)	Wind Direction
11/19/94	07:35:00	NF	NF	NF	NF	NF	NF	1040	1065	1005	990	201	111	109	172	87	84	149	462	391	272	149	2.18	3.87	0.72	1.04	0.50	0.32	-0.07	3.507	59.75
11/19/94	07:40.00	NF	NF	NF	NF	NF	NF	1004	1037	1006	994	202	112	110	173	87	84	150	452	380	275	157	2.45	4.35	0.78	0.89	0.48	0.33	-0.04	3.444	73
11/19/94	07:45:00	NF	NF	NF	NF	NF	NF	1003	1008	1004	1000	204	113	111	174	88	85	151	441	371	275	159	2.40	4.25	0.75	0.86	0.49	0.33	-0.05	2.812	62
11/19/94	07:50:00	NF	NF	NF	NF	NF	NF	999	1020	1003	996	205	113	111	176	88	85	152	432	361	275	226	2.25	3.99	0.75	0.91	0.48	0.32	-0.05	3.227	79.4
11/19/94	07:55:00	NF	NF	NF	NF	NF	NF	997	972	1001	1000	202	115	112	176	88	85	151	426	353	275	305	2.07	3.68	0.76	0.99	0.50	0.33	-0.04	3.235	74.3
11/19/94	08:00.00	NF	NF	NF	NF	NF	NF	996	975	993	1009	201	116	111	176	89	85	150	421	356	275	355	2.09	3.71	0.81	0.96	0.52	0.33	-0.05	3.488	77.1
11/19/94	08.05.00	NF	NF	NF	NF	NF	NF	1034	991	1007	1018	205	118	113	178	90	86	151	420	354	275	400	2.01	3.57	0.77	0.99	0.62	0.31	-0.05	3.39	67.07
11/19/94	08:10.00	NF	NF	NF	NF	NF	NF	1001	1003	1002	1027	206	118	114	180	91	87	153	419	348	275	440	1.90	3.38	0.77	1.00	0.62	0.28	-0.03	3.604	73.4
11/19/94	08:15:00	NF	NF	NF	NF	NF	NF	1001	1037	1007	1034	207	119	115	181	91	87	153	416	354	275	483	1.87	3.32	0.73	1.01	0.61	0.27	-0.03	3.045	60.84
11/19/94	08:20.00	NF	NF	NF	NF	NF	NF	997	1052	1009	1034	207	120	116	182	92	88	153	413	358	274	508	1.78	3.16	0.74	1.07	0.60	0.26	-0.04	3.406	68.65
11/19/94	08:25.00	NF	NF	NF	NF	NF	NF	999	1051	1002	1036	208	121	117	183	92	88	154	412	358	275	516	1.90	3.37	0.75	0.97	0.59	0.27	-0.05	2.302	66.72
11/19/94	08:30.00	NF	NF	NF	NF	NF	NF	1000	1055	1001	1035	208	121	117	183	93	88	154	412	359	275	524	1.88	3.33	0.75	0.99	0.59	0.25	-0.06	2.615	77.8
11/19/94	08:35.00	NF	NF	NF	NF	NF	NF	1054	1077	1020	1031	209	123	119	184	93	89	155	413	363	275	533	1.83	3.24	0.75	0.96	0.60	0.24	-0 06	2.605	52.75
11/19/94	08:40.00	NF	NF	NF	NF	NF	NF	1009	1056	1044	1066	210	124	121	185	94	89	156	420	366	275	539	1.94	3.45	0.74	0.91	0.58	0.24	-0.06	2.367	63.08
11/19/94	08:45:00	NF	NF	NF	NF	NF	NF	1017	1050	1055	1092	210	125	121	185	94	89	157	423	366	275	552	2.08	3.70	0.79	0.84	0.56	0.21	-0.05	2.068	77.3
11/19/94	08:50.00	NF	NF	NF	NF	NF	NF	1022	1047	1063	1091	210	124	121	185	95	90	157	426	369	275	545	2.05	3.64	0.74	0.87	0.54	0.21	-0.05	2.229	71.6
11/19/94	08:55:00	NF	NF	NF	NF	NF	NF	976	1039	1068	1095	210	123	120	185	95	90	156	424	371	275	544	1.93	3.43	0.70	0.91	0.57	0.20	-0.05	2.126	74.7
11/19/94	09.00.00	NF	NF	NF	NF	NF	NF	963	1038	1071	1098	208	121	120	185	95	90	156	422	370	274	552	1.87	3.33	0.78	0.95	0.58	0.19	-0.07	3.103	92.5
11/19/94	09.05.00	NF	NF	NF	NF	NF	NF	981	1045	1073	1083	206	120	116	185	96	90	155	421	355	274	549	1.71	3.04	0.78	1.07	0.60	0.16	-0.05	3.471	106.6
11/19/94	09:10.00	NF	NF	NF	NF	NF	NF	1024	1055	1075	1061	204	121	114	183	96	91	151	420	366	275	546	1.51	2.69	0.74	1.10	0.56	0.12	-0.06	3.547	90
11/19/94	09:15.00	NF	NF	NF	NF	NF	NF	1019	1060	1080	1059	204	122	116	183	96	91	151	421	365	275	579	1.50	2.66	0.71	1.11	0.57	0.11	-0.06	3.697	98.7
11/19/94	09:20.00	NF	NF	NF	NF	NF	NF	1019	1066	1084	1055	204	122	117	184	96	91	152	421	368	275	578	1.56	2.77	0.76	1.09	0.59	0.12	-0.07	4.188	96.4
11/19/94	09:25.00	NF	NF	NF	NF	NF	NF	1019	1071	1090	1075	203	124	118	184	96	91	153	419	365	275	579	1.47	2 60	0.75	1.12	0.59	0.11	-0.05	4.03	83.3
11/19/94	09:30.00	NF	NF	NF	NF	NF	NF	1015	1076	1092	1097	201	125	119	184	96	91	152	417	357	274	585	1.37	2.43	0.75	1.20	0 60	0.10	-0.06	5.518	81.8
11/19/94	09:35.00	NF	NF	NF	NF	NF	NF	1019	1081	1093	1105	200	125	120	184	96	91	152	416	361	275	576	1.31	2.32	0.71	1.21	0.60	0.10	-0.08	5.074	87.3
11/19/94	09:40.00	NF	NF	NF	NF	NF	NF	1022	1083	1096	1114	201	125	120	184	96	91	153	420	360	275	570	1.46	2.59	0.77	1.11	0.58	0.09	-0.05	4.509	109.8
11/19/94	09:45:00	NF	NF	NF	NF	NF	NF	1023	1084	1100	1122	202	125	120	185	97	92	155	425	367	275	572	1.51	2.69	0.75	1.12	0.59	0.08	-0.06	4.378	109.7
11/19/94	09:50:00	NF	NF	NF	NF	NF	NF	1025	1086	1102	1130	203	126	121	185	97	92	155	425	372	275	570	1.49	2.64	0.73	1.11	0.60	0.06	-0.05	4.507	91.8
11/19/94	09:55:00	NF	NF	NF	NF	NF	NF	1029	1089	1105	1136	203	126	121	185	97	92	156	427	368	275	567	1.56	2.76	0.74	1.05	0.60	0.14	-0.04	4.829	105.6
11/19/94	10.00.00	NF	NF	NF	NF	NF	NF	1036	1096	1107	1141	204	127	122	186	98	92	157	430	369	275	589	1.57	2.79	0.76	1.05	0.60	0.10	0.02	4.438	99
11/19/94	10.05:00	NF	NF	NF	NF	NF	NF	1025	1094	1109	1146	205	127	122	187	98	93	158	432	375	275	594	1.64	2.90	0.77	1.00	0.64	0.08	0.01	4.959	95.6
11/19/94	10:10.00	NF	NF	NF	NF	NF	NF	1030	1098	1110	1150	206	127	122	187	98	93	158	432	375	274	602	1.61	2 86	0.76	0.99	0.65	0.05	-0.01	5.068	94.9
11/19/94	10:15:00	NF	NF	NF	NF	NF	NF	1038	1097	1114	1155	205	127	122	187	98	93	158	429	362	275	608	1.62	2 88	0.75	1.02	0.63	0.05	-0.02	3.345	92.6
11/19/94	10.20:00	NF	NF	NF	NF	NF	NF	1025	1097	1115	1158	206	128	123	188	99	93	158	431	366	275	613	1.61	2.85	0.76	1.02	0.63	0.06	0.00	4.306	111.4
11/19/94	10:25:00	NF	NF	NF	NF	NF	NF	1030	1102	1117	1161	207	128	123	188	99	94	159	432	379	274	639	1.59	2.83	0.75	1.01	0.63	0.04	0.00	4.971	109.8
11/19/94	10:30.00	NF	NF	NF	NF	NF	NF	1028	1105	1118	1126	203	127	122	188	98	92	157	430	372	274	637	1.58	2.80	0.76	1.06	0.60	0 05	-0.01	6.324	114.3
11/19/94	10:35.00	NF	NF	NF	NF	NF	NF	1026	1114	1116	1112	199	126	120	186	97	91	154	431	360	274	635	1.49	2.64	0.75	1.12	0.57	0 06	-0.03	6.687	109.4
11/19/94	10:40:00	NF	NF	NF	NF	NF	NF	1033	1116	1117	1104	194	126	119	182	96	90	149	433	344	275	642	1.48	2.63	0.79	1.17	0.53	0.11	-0.05	5.039	105.5
11/19/94	10:45:00	NF	NF	NF	NF	NF	NF	1033	1115	1118	1099	195	127	120	181	96	90	149	431	324	276	632	1.32	2.34	0.72	1.25	0.52	0.13	-0.06	3.888	124.4
11/19/94	10:50.00	NF	NF	NF	NF	NF	NF	1035	1115	1119	1106	200	126	121	182	97	90	153	434	344	276	641	1.51	2.67	0.74	1.23	0.51	0.17	-0.07	3.675	118.1
11/19/94	10:55:00	NF	NF	NF	NF	NF	NF	1029	1115	1120	1107	203	126	121	184	97	91	155	436	356	275	624	1.52	2.70	0.75	1.23	0.53	0.15	-0.03	3.429	110.3
11/19/94	11:00.00	NF	NF	NF	NF	NF	NF	1028	1116	1123	1109	205	124	119	185	98	92	155	436	365	275	621	1.54	2.74	0.74	1.17	0.54	0.19	-0.02	3.262	111.8
11/19/94	11:05.00	NF	NF	NF	NF	NF	NF	1029	1121	1125	1112	206	124	119	186	98	93	155	437	366	275	629	1.50	2.66	0.75	1.15	0.56	0.13	-0.02	5.118	105.6
11/19/94	11:10.00	NF	NF	NF	NF	NF	NF	1027	1124	1129	1116	206	124	120	187	99	93	155	438	359	275	627	1.50	2.66	0.75	1.14	0.58	0.10	-0.04	4.804	105.4
11/19/94	11:15.00	NF	NF	NF	NF	NF	NF	1032	1129	1134	1121	206	125	120	187	98	93	155	440	375	274	628	1.49	2.64	0.76	1.13	0.58	0.08	-0.04	3.989	112.7
11/19/94	11:20 00	NF	NF	NF	NF	NF	NF	1029	1127	1139	1124	206	125	120	188	99	94	156	441	386	274	635	1.49	2.65	0.75	1.11	0.58	0.05	-0.05	4.317	91.5
11/19/94	11:25:00	NF	NF	NF	NF	NF	NF	1029	1126	1142	1128	206	125	121	188	99	94	156	440	383	275	636	1.48	2.63	0.73	1.10	0.60	0 05	-0.03	4.566	86.1
11/19/94	11:30.00	NF	NF	NF	NF	NF	NF	1030	1126	1147	1132	207	126	121	188	100	94	157	442	367	275	643	1.60	2.84	0.75	1.02	0.63	0.05	0.00	4.582	107.2
11/19/94	11:35:00	NF	NF	NF	NF	NF	NF	1032	1130	1149	1138	207	126	122	188	100	94	157	442	349	274	645	1.58	2.81	0.77	0.99	0.67	0.03	0.02	3.656	116
11/19/94	11:40:00	NF	NF	NF	NF	NF	NF	1041	1130	1152	1144	207	126	121	189	100	95	157	444	350	275	668	1.56	2.76	0.75	1.01	0.66	0.02	0.02	3.492	125.1
11/19/94	11:45:00	NF	NF	NF	NF	NF	NF	1042	1132	1154	1149	207	126	122	188	100	95	157	448	354	275	661	1.57	2.78	0.75	1.01	0.59	0.02	0.01	4.573	118.6
11/19/94	11:50.00	NF	NF	NF	NF	NF	NF	1040	1133	1156	1153	207	126	122	189	100	95	158	449	353	275	674	1.62	2.88	0.74	0.97	0.64	0.03	0.01	2.756	129.1
11/19/94	11:55.00	NF	NF	NF	NF	NF	NF	1039	1138	1157	1156	208	126	121	189	101	95	158	451	349	274	671	1.63	2 89	0.75	0.91	0.64	0.02	0.02	3.885	112.8
11/19/94	12:00.00	NF	NF	NF	NF	NF	NF	1041	1124	1144	1144	209	125	121	189	101	96	158	453	362	275	672	1.68	2.97	0.76	0.86	0.65	-0.02	0.02	4.743	128.2
11/19/94	12:05.00	NF	NF	NF	NF	NF	NF	1045	1121	1141	1141	209	124	120	188	101	96	158	453	362	274	675	1.66	2.95	0.74	0.85	0.64	-0.06	0.03	3.711	104.9
11/19/94	12:10.00	NF	NF	NF	NF	NF	NF	1048	1121	1140	1140	208	125	121	188	101	96	158	453	363	274	678	1.63	2.89	0.74	0.86	0.67	-0.10	0.03	4.399	96.4
11/19/94	12:15.00	NF	NF	NF	NF	NF	NF	1049	1122	1139	1140	208	124	120	188	101	96	159	453	357	274	675	1.62	2.87	0.75	0.86	0 65	-0.13	0.03	4.44	127.1
11/19/94	12:20.00	NF	NF	NF	NF	NF	NF	1052	1121	1140	1141	207	125	121	188	101	96	159	456	362	275	673	1.63	2.89	0.75	0 89	0.63	-0.13	-0.00	4.439	108.3

Table 6 - November 19 - 20, 1994 (Page 2 of 9)

		Temperature																													
Date	Time	BED 1	BED 2	BED 3	BED 4	BED 5	BED 6	ZONE 1	ZONE 2	ZONE 3	ZONE 4	Scrubber Inlet	Scrubber Outlet	ID Fan Inlet	ID Fan Outlet	HX Inlet	HX Outlet	Carbon Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet	Soil Discharge	DP (volts)	Flow DP (in H20)	Reactor DP (in H20)	Scrubber Level (in)	Tank 502 Level (%)	TanK 503 Level (%)	Tank 602 Level (%)	Wind Speed (mph)	Wind Direction
11/19/94	12:25:00	NF	NF	NF	NF	NF	NF	1042	1124	1139	1142	207	125	121	188	101	96	160	455	327	274	676	1.66	2.95	0.75	0 85	0.62	-0.16	0.01	3.414	120
11/19/94	12:30:00	NF	NF	NF	NF	NF	NF	1055	1126	1140	1143	208	125	121	188	101	96	160	455	315	274	676	1.72	3.05	0.75	0.83	0.62	-0.16	0.01	4.222	130.7
11/19/94	12:35:00	NF	NF	NF	NF	NF	NF	1052	1124	1139	1143	208	126	122	188	102	96	161	455	327	275	686	1.77	3.14	0.75	0.81	0.63	-0.17	0.02	4.713	111.7
11/19/94	12:40 00	NF	NF	NF	NF	NF	NF	1047	1123	1137	1144	208	126	122	188	102	96	161	455	317	274	680	1.82	3.22	0.76	0.79	0.63	-0.19	-0.01	3.989	112.2
11/19/94	12:45.00	NF	NF	NF	NF	NF	NF	1048	1125	1137	1143	209	127	123	188	102	96	162	456	317	275		1.87	3.31	0.74	0.77	0.62	-0.19	-0.01	4.343	120.6
11/19/94	12:50.00	NF	NF	NF	NF	NF	NF	1051	1136	1135	1143	209	127	123	188	102	96	163	457	317	274	682	1.91	3.38	0.74	0.76	0.61	-0.19	0.00	4.746	123.9
11/19/94	12:55.00	NF	NF	NF	NF	NF	NF	1053	1137	1134	1142	209	128	124	188	102	96	163	459	317	275		1.95	3.46	0.75	0.72	0.62	-0.19	0.01	3 23	106.3
11/19/94	13:00.00	NF	NF	NF	NF	NF	NF	1016	1145	1131	1140	210	128	124	188	103	97	164	460	319	274	672	1.98	3.52	0 75	0.70	0 65	-0.18	0.02	4.193	105
11/19/94	13.05.00	NF	NF	NF	NF	NF	NF	995	1123	1130	1137	211	128	124	188	103	97	164	458	328	274	683	1.98	3.51	0.75	0.64	0.64	-0.16	0.02	4.318	108
11/19/94	13:10.00	NF	NF	NF	NF	NF	NF	1054	1146	1127	1136	211	127	123	188	103	97	163	458	323	274		1.87	3.32	0.75	0.70	0 63	-0.19	0.01	3.498	114.3
11/19/94	13:15:00	NF	NF	NF	NF	NF	NF	1047	1151	1124	1135	210	127	123	188	103	97	162	458	315	274		1.86	3.29	0.75	0.72	0.63	-0 21	-0.00	4.041	136.5
11/19/94	13:20.00	NF	NF	NF	NF	NF	NF	1051	1156	1123	1133	209	127	123	188	103	97	162	459	321	274	690	1.84	3.27	0.76	0.74	0.65	-0.20	0 00	3.988	116.4
11/19/94	13:25:00	NF	NF	NF	NF	NF	NF	1051	1161	1121	1132	208	127	123	188	103	97	161	459	345	274	677	1.84	3.26	0.74	0.79	0.63	-0.19	-0.00	3.382	133.9
11/19/94	13:30 00	NF	NF	NF	NF	NF	NF	1050	1161	1122	1130	209	127	123	188	103	97	161	461	349	274	664	1.87	3.32	0.75	0.76	0.60	-0.20	-0.01	3.612	116.1
11/19/94	13:35.00	NF	NF	NF	NF	NF	NF	1051	1166	1123	1129	208	125	121	188	103	97	160	461	334	274	675	1.81	3.20	0.76	0.77	0.72	-0.24	-0.03	3.366	120.5
11/19/94	13:40.00	NF	NF	NF	NF	NF	NF	1046	1168	1125	1128	208	125	121	188	103	97	159	462	332	274	675	1.77	3.14	0.75	0.77	0.71	-0.24	-0.01	3.93	146.9
11/19/94	13:45.00	NF	NF	NF	NF	NF	NF	1058	1170	1125	1129	208	124	121	187	103	97	159	464	337	274	666	1.84	3.26	0.77	0.75	0 69	-0.22	-0.01	3 669	136.7
11/19/94	13:50.00	NF	NF	NF	NF	NF	NF	1050	1150	1128	1128	211	124	120	187	103	97	160	467	338	274	666	1.93	3.42	0.74	0 69	0.56	-0.24	-0.00	2.695	153.7
11/19/94	13:55.00	NF	NF	NF	NF	NF	NF	1050	1146	1131	1129	211	124	120	187	103	97	159	466	335	274	663	1.89	3.36	0.75	0 69	0.51	-0.24	-0.03	2.955	118 3
11/19/94	14.00 00	NF	NF	NF	NF	NF	NF	1049	1132	1135	1129	212	123	120	187	103	98	159	468	338	274	666	1.86	3.30	0.76	0.67	0.54	-0.27	-0.03	3.582	122.7
11/19/94	14:05:00	NF	NF	NF	NF	NF	NF	1050	1129	1139	1131	211	122	119	187	103	97	159	468	344	274	661	1.70	3.01	0.76	0.76	0.55	-0.31	-0 05	2.226	139.6
11/19/94	14:10 00	NF	NF	NF	NF	NF	NF	1047	1131	1139	1134	208	123	119	187	102	97	158	467	340	274	655	1.64	2.91	0.74	0.84	0.51	-0.31	-0.05	3.493	127.7
11/19/94	14:15:00	NF	NF	NF	NF	NF	NF	1046	1132	1141	1137	207	123	119	187	102	96	158	466	335	274	642	1.72	3.05	0.74	0 82	0.52	-0.32	-0.06	2.308	108.4
11/19/94	14:20:00	NF	NF	NF	NF	NF	NF	1052	1131	1142	1140	207	123	119	187	102	96	159	466	344	274	650	1.72	3.06	0.75	0.83	0.53	-0.33	-0.11	2.079	127.1
11/19/94	14:25:00	NF	NF	NF	NF	NF	NF	1051	1126	1140	1143	209	122	118	185	101	96	159	471	357	275	650	2.43	4.32	0.93	0.44	0.55	-0.33	-0.10	2.541	139.7
11/19/94	14:30.00	NF	NF	NF	NF	NF	NF	1049	1124	1140	1144	212	121	117	182	102	96	159	473	353	274	655	2.90	5.15	1.02	0 27	0 53	-0.27	-0.10	3.478	103.3
11/19/94	14:35:00	NF	NF	NF	NF	NF	NF	1046	1122	1136	1143	213	121	117	181	101	96	159	474	357	275	667	3.07	5.45	1.01	0.23	0.52	-0.23	-0.08	2.491	99.4
11/19/94	14:40:00	NF	NF	NF	NF	NF	NF	1048	1124	1127	1140	214	121	117	180	101	95	160	473	384	274	664	3.17	5.63	1.03	0.20	0.57	-0.21	-0.09	2.152	117.7
11/19/94	14:45:00	NF	NF	NF	NF	NF	NF	1056	1128	1122	1138	214	122	117	180	101	95	160	471	381	274	656	3.19	5.66	1.05	0.19	0.57	-0.16	-0.10	3.049	132.9
11/19/94	14:50.00	NF	NF	NF	NF	NF	NF	1047	1117	1117	1136	215	122	118	180	101	95	161	471	381	274	648	3.20	5.67	1.04	0.22	0 64	-0.15	-0.08	1.828	152
11/19/94	14:55:00	NF	NF	NF	NF	NF	NF	1044	1111	1116	1134	217	123	118	181	101	95	161	470	381	274	644	3.23	5.74	1.06	0.20	0.59	-0.14	-0.07	1.841	116.1
11/19/94	15:00 00	NF	NF	NF	NF	NF	NF	1048	1110	1112	1131	216	123	119	181	101	95	161	466	379	274	650	3.21	5.70	1.06	0.26	0.64	-0.10	-0.05	1.907	105.7
11/19/94	15:05:00	NF	NF	NF	NF	NF	NF	1051	1102	1107	1128	219	122	118	181	101	95	161	466	378	275	652	3.23	5.73	1.06	0 23	0 65	-0.12	-0 07	0.937	100.6
11/19/94	15:10.00	NF	NF	NF	NF	NF	NF	1054	1097	1102	1124	220	123	118	181	100	94	160	464	377	274	651	3.16	5 61	1.07	0.32	0.68	-0.12	-0.09	0.978	161.6
11/19/94	15:15.00	NF	NF	NF	NF	NF	NF	1055	1096	1100	1121	221	123	119	182	100	94	160	460	374	274	643	3.09	5.49	1.07	0.49	0.66	-0.10	-0.08	1.686	217
11/19/94	15:20.00	NF	NF	NF	NF	NF	NF	1047	1093	1094	1116	222	123	119	182	100	94	160	457	372	274	639	3.03	5.37	1.06	0 54	0.66	-0.08	-0.08	1.994	259.4
11/19/94	15:25.00	NF	NF	NF	NF	NF	NF	1045	1091	1089	1112	220	123	118	182	99	93	159	455	375	274	648	2.93	5.21	1.06	0.65	0.64	-0.08	-0.08	2.196	195.9
11/19/94	15:30.00	NF	NF	NF	NF	NF	NF	1047	1093	1086	1108	220	123	118	182	100	94	159	452	369	274	653	2.90	5.15	1.07	0.65	0.71	-0.05	-0.09	2.696	268.1
11/19/94	15:35 00	NF	NF	NF	NF	NF	NF	1049	1094	1085	1103	221	123	119	182	100	94	159	452	373	274	644	2.91	5.17	1.04	0.69	0.70	-0.05	-0.06	1.461	230.1
11/19/94	15:40.00	NF	NF	NF	NF	NF	NF	1052	1093	1083	1100	222	123	119	182	99	93	159	452	372	274	645	2.93	5.21	1.04	0.69	0.69	-0.06	-0.03	1.4	177.9
11/19/94	15:45:00	NF	NF	NF	NF	NF	NF	1052	1093	1081	1097	222	123	119	182	99	93	160	451	373	274	637	3.02	5.35	1.05	0.57	0.73	-0.05	-0.02	1.651	187.1
11/19/94	15:50.00	NF	NF	NF	NF	NF	NF	1056	1092	1082	1094	222	123	119	182	100	93	160	451	373	274	640	3.01	5.34	1.05	0.56	0.73	-0.05	-0.04	1.39	162.9
11/19/94	15:55:00	NF	NF	NF	NF	NF	NF	1059	1092	1082	1091	220	124	119	182	99	93	160	449	373	274	630	2.94	5.22	1.06	0.58	0.72	-0.04	-0.03	2.459	146.8
11/19/94	16.00.00	NF	NF	NF	NF	NF	NF	1060	1093	1081	1089	219	123	119	182	97	90	159	447	376	274	621	2.89	5.12	1.08	0.66	0.75	-0.04	-0.03	2.52	174.9
11/19/94	16.05.00	NF	NF	NF	NF	NF	NF	1071	1096	1103	1089	218	124	119	182	95	89	159	450	380	275	617	2.91	5.17	1.04	0 66	0.73	-0.02	-0.06	1.102	169
11/19/94	16:10.00	NF	NF	NF	NF	NF	NF	1069	1097	1109	1090	216	124	119	182	94	87	159	454	381	275	606	3.00	5.32	1.03	0.43	0.69	-0.01	-0.07	2 645	143.3
11/19/94	16:15.00	NF	NF	NF	NF	NF	NF	1070	1098	1105	1089	216	123	118	181	95	88	159	459	366	275	613	3.08	5.47	1.06	0.37	0.73	-0.02	-0.06	3 657	128.3
11/19/94	16:20.00	NF	NF	NF	NF	NF	NF	1070	1101	1089	1087	214	119	115	179	95	88	157	456	378	274	619	3.13	5.56	1.06	0.31	0.84	-0.02	-0.03	3.664	142.9
11/19/94	16:25:00	NF	NF	NF	NF	NF	NF	1067	1103	1110	1088	212	115	111	178	97	89	153	467	386	275	609	2.88	5.11	1.10	0.49	0.93	-0.03	-0 04	3 891	124.8
11/19/94	16:30.00	NF	NF	NF	NF	NF	NF	1074	1113	1109	1088	211	114	110	177	98	92	152	473	391	275	613	2.81	4.99	1.03	0 56	0.89	-0.01	-0.05	3.125	125.4
11/19/94	16:35:00	NF	NF	NF	NF	NF	NF	1076	1125	1097	1088	211	115	111	176	98	92	151	475	393	275	609	2.87	5.10	1.04	0.59	0.90	-0.02	-0.04	3.195	136.4
11/19/94	16:40.00	NF	NF	NF	NF	NF	NF	1063	1128	1102	1090	211	116	112	176	98	93	152	476	395	275	603	3.00	5.33	1.01	0 59	0.92	-0.08	-0.05	4.213	91.3
11/19/94	16:45.00	NF	NF	NF	NF	NF	NF	1066	1132	1108	1092	211	117	112	176	98	93	153	476	396	275	592	3.10	5.51	1.03	0.47	0 94	-0.08	-0.05	3.957	74.7
11/19/94	16:50.00	NF	NF	NF	NF	NF	NF	1071	1135	1115	1094	212	117	113	176	98	93	153	476	395	275	595	3.19	5.66	1.03	0.44	0.92	-0.04	-0.04	4.142	89.9
11/19/94	16:55.00	NF	NF	NF	NF	NF	NF	1071	1138	1134	1098	212	118	114	176	98	92	154	474	397	274	613	3.26	5.78	1.05	0.40	0.94	-0.02	-0.04	4.181	90.5
11/19/94	17:00.00	NF	NF	NF	NF	NF	NF	1068	1134	1141	1104	212	120	115	176	98	92	155	475	397	275	613	3.27	5.80	1.04	0.40	0.97	0.02	-0.05	5.053	94.3
11/19/94	17:05 00	NF	NF	NF	NF	NF	NF	1072	1130	1144	1110	212	120	116	177	97	92	155	476	402	275	627	3.33	5.91	1.04	0.35	1.00	0.04	-0.06	4.212	92.9
11/19/94	17:10:00	NF	NF	NF	NF	NF	NF	1065	1123	1143	1116	212	121	116	177	97	91	155	474	401	274	632	3.34	5.93	1.05	0.32	1.09	0.08	-0.11	4 231	103.6

Table 6 - November 19 - 20, 1994 (Page 3 of 9)

		Temperature																												
Date	Time	BED 1	BED 2	BED 3	BED 4	BED 5	BED 6	ZONE 1	ZONE 2	ZONE 3	ZONE 4	Scrubber Inlet	Scrubber Outlet	ID Fan Inlet	ID Fan Outlet	HX Inlet	HX Outlet	Carbon Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet	Soil Discharge	DP (volts)	Flow DP (in H20)	Reactor DP (in H20)	Scrubber Level (in)	Tank 502 Level (%)	TanK 503 Level (%)	Tank 602 Level (%)	Wind Speed (mph)	Wind Direction
11/19/94	17:15:00	NF	NF	NF	NF	NF	NF	1071	1119	1139	1121	213	121	116	177	97	91	155	475	401	275	628	3.39	6.02	1.04	0.30	1.17	0.13	-0.08	3.189	94.1
11/19/94	17:20.00	NF	NF	NF	NF	NF	NF	1069	1115	1137	1122	214	121	116	177	97	91	155	475	398	275	650	3.44	6.10	1.01	0.26	1.26	0.12	-0.06	2.697	91.1
11/19/94	17:25:00	NF	NF	NF	NF	NF	NF	1069	1112	1133	1122	214	121	117	178	97	91	156	474	397	274		3.50	6.21	1.04	0.19	1.38	0.07	-0 08	2.302	92.8
11/19/94	17:30:00	NF	NF	NF	NF	NF	NF	1070	1112	1128	1122	214	121	117	177	98	91	155	473	399	275	661	3.50	6.21	1.05	0.20	1.53	0.12	-0.08	3.232	91.1
11/19/94	17:35:00	NF	NF	NF	NF	NF	NF	1075	1111	1124	1119	215	122	117	178	98	91	155	473	396	275	651	3.51	6.24	1.03	0.18	1.61	0.11	-0.07	2.508	100.9
11/19/94	17:40:00	NF	NF	NF	NF	NF	NF	1067	1107	1121	1117	214	121	116	178	97	91	155	471	395	274	644	3.50	6.22	1.05	0.36	1.79	0.13	-0.05	2.852	94.8
11/19/94	17:45:00	NF	NF	NF	NF	NF	NF	1069	1107	1118	1114	214	121	116	178	97	91	155	471	396	275	653	3.49	6.19	1.07	0.35	1.91	0.12	-0.08	2.459	110.1
11/19/94	17:50.00	NF	NF	NF	NF	NF	NF	1069	1105	1114	1111	215	121	117	178	97	91	155	472	395	275	650	3.44	6.10	1.04	0.27	2.06	0.11	-0.11	2.626	96
11/19/94	17:55:00	NF	NF	NF	NF	NF	NF	1070	1102	1112	1108	216	121	116	178	98	91	155	471	392	275	657	3.50	6.21	1.04	0.30	2.26	0.13	-0.08	2.139	81.7
11/19/94	18.00.00	NF	NF	NF	NF	NF	NF	1070	1099	1109	1106	217	121	116	178	97	91	155	470	393	275	661	3.49	6.19	1.05	0.22	2.47	0.13	-0.10	1.957	71.3
11/19/94	18.05 00	NF	NF	NF	NF	NF	NF	1069	1098	1107	1104	217	121	116	178	97	91	155	470	392	274	650	3.50	6.21	1.04	0.19	2.73	0.15	-0.08	1.998	77.2
11/19/94	18:10.00	NF	NF	NF	NF	NF	NF	1067	1098	1105	1102	217	121	116	178	97	91	154	470	394	275	634	3.48	6.17	1.05	0.22	2.93	0.15	-0.09	1.82	86.6
11/19/94	18:15:00	NF	NF	NF	NF	NF	NF	1075	1098	1105	1100	217	120	116	178	97	91	155	468	396	275	645	3.51	6.23	1.06	0.23	3.15	0.14	-0.08	1.458	100.1
11/19/94	18:20.00	NF	NF	NF	NF	NF	NF	1076	1098	1105	1099	219	121	116	178	97	90	155	469	395	275	659	3.52	6.25	1.05	0.23	3.34	0.15	-0.09	1.26	97
11/19/94	18:25:00	NF	NF	NF	NF	NF	NF	1061	1092	1104	1098	218	121	116	178	97	90	155	468	397	274	651	3.50	6.22	1.07	0.26	3.54	0.16	-0.06	1.89	104.6
11/19/94	18:30.00	NF	NF	NF	NF	NF	NF	1072	1094	1103	1097	218	121	116	178	97	90	155	466	396	275	650	3.45	6.12	1.07	0.33	3.75	0.16	-0.07	1.583	87.4
11/19/94	18:35.00	NF	NF	NF	NF	NF	NF	1069	1092	1103	1096	218	121	116	178	97	91	155	468	396	275	651	3.43	6.09	1.05	0.30	3.94	0.18	-0.05	1.593	82.6
11/19/94	18:40.00	NF	NF	NF	NF	NF	NF	1068	1091	1102	1095	217	121	116	178	97	91	155	469	396	275	638	3.46	6.15	1.05	0.28	4.16	0.18	-0 06	1.777	90.4
11/19/94	18:45.00	NF	NF	NF	NF	NF	NF	1067	1088	1101	1093	215	121	116	178	97	91	155	468	397	275	644	3.49	6.20	1.05	0.29	4.40	0.19	-0.07	1.929	82.5
11/19/94	18:50.00	NF	NF	NF	NF	NF	NF	1077	1090	1100	1091	215	121	116	177	97	91	155	468	396	275	642	3.47	6.16	1.06	0.33	4.65	0.20	-0.06	2.28	81.8
11/19/94	18:55:00	NF	NF	NF	NF	NF	NF	1071	1087	1098	1090	214	120	116	177	97	90	154	467	397	275	647	3.48	6.18	1.04	0.37	4.88	0.20	-0.07	2.381	87
11/19/94	19.00.00	NF	NF	NF	NF	NF	NF	1068	1086	1096	1087	215	120	115	177	97	90	154	464	393	274	646	3.51	6.24	1.03	0.28	5.14	0.19	-0.08	1.991	86.6
11/19/94	19.05:00	NF	NF	NF	NF	NF	NF	1069	1086	1095	1085	215	120	115	177	97	90	155	457	389	274	647	3.54	6.28	1.06	0.23	5.40	0.20	-0.07	2.009	89.3
11/19/94	19:10.00	NF	NF	NF	NF	NF	NF	1069	1089	1094	1083	215	120	115	177	97	90	154	461	389	275	639	3.52	6.25	1.10	0.21	5.75	0.20	-0.08	2.65	75.9
11/19/94	19:15:00	NF	NF	NF	NF	NF	NF	1069	1088	1091	1081	215	119	114	176	99	92	153	460	387	275	645	3.44	6.11	1.06	0.35	5.88	0.22	-0.06	2.25	87.4
11/19/94	19:20.00	NF	NF	NF	NF	NF	NF	1067	1086	1089	1080	215	119	113	176	98	92	153	459	387	275	640	3.47	6.16	1.05	0.33	5.92	0.21	-0.06	2.108	75.9
11/19/94	19:25:00	NF	NF	NF	NF	NF	NF	1071	1085	1087	1076	216	119	113	176	98	92	152	458	388	275	633	3.50	6.22	1.04	0.34	6.06	0.21	-0.06	2.694	67.45
11/19/94	19:30.00	NF	NF	NF	NF	NF	NF	1066	1079	1085	1074	215	119	113	175	98	92	153	455	384	275	633	3.55	6.30	1.04	0.29	6.26	0.21	-0.05	2.698	72.8
11/19/94	19:35.00	NF	NF	NF	NF	NF	NF	1072	1081	1082	1071	216	119	113	175	99	92	152	454	384	274	623	3.51	6.24	1.07	0.33	6.55	0.21	-0.04	3.51	64.4
11/19/94	19:40.00	NF	NF	NF	NF	NF	NF	1073	1079	1077	1068	215	119	113	175	98	92	152	452	382	274	620	3.45	6.13	1.07	0.39	6.76	0.22	-0.05	3.341	77.1
11/19/94	19:45:00	NF	NF	NF	NF	NF	NF	1072	1078	1074	1065	215	118	112	175	98	92	152	449	380	275	612	3.40	6.04	1.08	0.48	7.01	0.23	-0.04	3.477	76.8
11/19/94	19:50.00	NF	NF	NF	NF	NF	NF	1067	1076	1070	1061	214	118	112	175	98	92	151	445	378	275	614	3.37	5.97	1.04	0.57	7.24	0.25	-0.04	2.832	73.7
11/19/94	19:55.00	NF	NF	NF	NF	NF	NF	1064	1074	1068	1058	214	119	112	175	98	92	152	442	375	275	618	3.31	5.88	1.08	0.70	7.48	0.22	-0.04	2.104	73.5
11/19/94	20.00.00	NF	NF	NF	NF	NF	NF	1070	1075	1065	1055	214	119	113	175	98	92	152	440	375	275	619	3 26	5.78	1.07	0.78	7.74	0.21	-0.05	2.988	67.64
11/19/94	20.05:00	NF	NF	NF	NF	NF	NF	1070	1076	1064	1060	214	119	113	176	98	92	152	437	371	275	617	3.20	5 67	1.08	0.90	8.02	0.22	-0.05	3.189	72.4
11/19/94	20:10.00	NF	NF	NF	NF	NF	NF	1077	1101	1096	1097	214	120	114	176	98	92	152	439	373	275	605	3.16	5.60	1.04	0.64	8.22	0.20	-0.05	2.824	67.75
11/19/94	20:15.00	NF	NF	NF	NF	NF	NF	1069	1102	1107	1110	215	121	115	177	98	92	153	442	375	275	603	3.22	5.72	1.05	0.57	8 60	0.21	-0.05	3.332	64.9
11/19/94	20:20.00	NF	NF	NF	NF	NF	NF	1068	1102	1111	1101	216	121	115	177	98	92	153	445	378	275	600	3.30	5.85	1.03	0.52	9.03	0.22	-0 06	2.509	60.46
11/19/94	20:25.00	NF	NF	NF	NF	NF	NF	1069	1100	1096	1101	216	122	115	177	99	92	154	447	378	275	599	3.35	5.94	1.04	0.48	9.43	0.20	-0.07	3.355	65.16
11/19/94	20:30.00	NF	NF	NF	NF	NF	NF	1067	1103	1095	1101	216	121	115	177	99	92	153	446	380	275	604	3.04	5.39	0.97	0.71	9.74	0.22	-0 06	3.371	65.03
11/19/94	20:35.00	NF	NF	NF	NF	NF	NF	1072	1102	1115	1103	215	122	116	178	99	92	153	448	382	275	625	2.74	4 86	0 88	0.82	9.89	0.20	-0.05	2.588	57.77
11/19/94	20:40.00	NF	NF	NF	NF	NF	NF	1071	1100	1101	1086	215	122	116	179	99	92	153	446	379	275	614	2.73	4.84	0.85	0.83	10.08	0.20	-0.04	2.271	67.02
11/19/94	20:45.00	NF	NF	NF	NF	NF	NF	1072	1098	1093	1103	215	122	116	179	99	92	153	449	382	275	620	2.71	4.80	0.85	0.82	10.36	0.20	-0.05	2.607	68.64
11/19/94	20:50.00	NF	NF	NF	NF	NF	NF	1073	1098	1110	1103	215	122	116	179	99	92	153	450	380	275	623	2.75	4.88	0.85	0 83	10.65	0.20	-0.05	2.261	56.14
11/19/94	20:55.00	NF	NF	NF	NF	NF	NF	1060	1102	1107	1102	215	122	116	179	99	92	153	452	384	274	627	2.71	4 80	0.86	0.79	10.91	0.21	-0.05	3.664	41.92
11/19/94	21:00.00	NF	NF	NF	NF	NF	NF	1067	1102	1099	1101	215	122	116	179	99	92	153	452	386	275	629	2.67	4.73	0.86	0.82	11.35	0.20	-0.05	3.421	53.18
11/19/94	21:05:00	NF	NF	NF	NF	NF	NF	1071	1101	1099	1096	214	121	115	179	99	92	153	450	384	275	629	2.65	4.70	0.86	0.85	11.78	0.22	-0.06	2.473	65.13
11/19/94	21:10.00	NF	NF	NF	NF	NF	NF	1070	1102	1099	1090	214	121	115	179	99	92	153	450	384	275	625	2.66	4.71	0.85	0.85	12.17	0.21	-0.07	2.896	62.13
11/19/94	21:15.00	NF	NF	NF	NF	NF	NF	1069	1102	1100	1103	213	121	115	179	99	92	152	449	385	275	628	2.59	4.60	0.86	0.89	12.53	0.21	-0.06	3.661	63.58
11/19/94	21:20.00	NF	NF	NF	NF	NF	NF	1067	1102	1115	1101	212	121	115	179	99	92	152	449	385	275	625	2.57	4.56	0.85	0.91	12.87	0.22	-0.08	3.316	62.45
11/19/94	21:25.00	NF	NF	NF	NF	NF	NF	1070	1106	1108	1102	213	121	115	179	99	92	152	449	385	275	627	2.60	4.62	0.84	0 89	13.22	0.22	-0.07	3.078	65.23
11/19/94	21:30.00	NF	NF	NF	NF	NF	NF	1071	1102	1098	1101	214	122	115	178	99	92	153	452	384	275	615	2.67	4.74	0.83	0.88	13.60	0.21	-0.08	3.115	57.93
11/19/94	21:35:00	NF	NF	NF	NF	NF	NF	1070	1102	1097	1101	209	122	115	178	99	91	152	450	360	274	628	2.60	4.61	0.88	0.93	13.96	0.22	-0.08	4.485	72.8
11/19/94	21:40.00	NF	NF	NF	NF	NF	NF	1070	1100	1095	1101	207	122	115	177	98	91	151	450	384	276	624	2.55	4.53	0.83	0.91	14.31	0.24	-0.08	3.466	62.28
11/19/94	21:45:00	NF	NF	NF	NF	NF	NF	1069	1097	1112	1067	211	121	115	177	98	91	152	450	387	276	622	2.75	4.89	0.83	0.89	14.74	0.26	-0.08	2.557	55.6
11/19/94	21:50.00	NF	NF	NF	NF	NF	NF	1069	1100	1109	1117	213	121	115	177	98	91	153	451	388	275	621	2.78	4.93	0.85	0.88	15.16	0.28	-0.07	2.823	59.89
11/19/94	21:55.00	NF	NF	NF	NF	NF	NF	1070	1102	1101	1106	214	121	115	177	98	91	153	445	383	275	625	2.91	5.16	0.87	0.86	15.51	0.32	-8.27	2.056	74.1

Table 6 - November 19 - 20, 1994 (Page 4 of 9)

		Temperature																												
Date	Time	BED 1	BED 2	BED 3	BED 4	BED 5	BED 6	ZONE 1	ZONE 2	ZONE 3	ZONE 4	Scrubber Inlet	Scrubber Outlet	ID Fan Inlet	ID Fan Outlet	HX Inlet	HX Outlet	Carbon Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet	Soil Discharge	DP (volts)	Flow DP (in H20)	Reactor DP (in H20)	Scrubber Level (in)	Tank 502 Level (%)	TanK 503 Level (%)	Tank 602 Level (%)	Wind Speed (mph)	Wind Direction
11/19/94	22:00 00	NF	NF	NF	NF	NF	NF	1070	1102	1100	1104	215	121	115	177	99	91	153	451	387	275	619	2.88	5.11	0.85	0.84	15.86	0.32	-0.07	1.629	71.4
11/19/94	22:05.00	NF	NF	NF	NF	NF	NF	1070	1107	1095	1096	216	120	114	178	98	91	152	450	386	275	630	2.88	5.11	0.85	0.84	16.29	0.31	-0.08	1.523	71.7
11/19/94	22:10.00	NF	NF	NF	NF	NF	NF	1070	1100	1101	1095	216	120	114	178	98	91	152	450	385	275	634	2.80	4.97	0.87	0.83	16.62	0.31	-0 09	1.774	59.51
11/19/94	22:15.00	NF	NF	NF	NF	NF	NF	1072	1102	1115	1101	214	120	114	178	98	91	152	447	385	275	635	2.70	4.79	0 86	0.88	16 92	0.30	-22.57	2.677	68 69
11/19/94	22:20 00	NF	NF	NF	NF	NF	NF	1068	1104	1096	1100	213	120	114	178	98	91	151	447	385	275	632	2.57	4.55	0 86	0.92	17.22	0.30	-23 64	2.988	72.8
11/19/94	22:25.00	NF	NF	NF	NF	NF	NF	1067	1100	1092	1100	212	120	114	178	98	91	151	444	383	275	625	2.54	4.51	0 87	0.93	17 54	0.31	-23 64	2.356	90.6
11/19/94	22:30.00	NF	NF	NF	NF	NF	NF	1073	1101	1113	1103	211	121	114	178	98	91	151	445	383	275	628	2.55	4.52	0.86	0.94	17.92	0.31	-23.76	2.994	100 8
11/19/94	22:35:00	NF	NF	NF	NF	NF	NF	1076	1101	1103	1104	210	121	115	178	98	91	152	445	383	275	619	2.57	4.56	0.86	0.96	18.18	0.29	-23.67	2.808	90.9
11/19/94	22:40.00	NF	NF	NF	NF	NF	NF	1061	1101	1092	1085	210	122	115	178	98	91	153	444	383	275	624	2.56	4.55	0.86	0.96	18.43	0.31	-23.64	2.516	77
11/19/94	22:45:00	NF	NF	NF	NF	NF	NF	1069	1102	1113	1104	211	122	116	179	98	91	153	446	384	275	624	2 60	4.62	0.85	0.93	18.74	0.30	-23.63	2.398	73.3
11/19/94	22:50.00	NF	NF	NF	NF	NF	NF	1069	1102	1107	1103	211	123	116	179	98	91	154	446	385	275	623	2.65	4.71	0.85	0.92	19.15	0.30	-23.63	2.513	72.1
11/19/94	22:55:00	NF	NF	NF	NF	NF	NF	1072	1101	1096	1103	210	123	116	179	98	91	153	446	383	275	629	2.66	4.72	0.86	0.91	19.56	0.29	-23.63	2.906	88.8
11/19/94	23:00.00	NF	NF	NF	NF	NF	NF	1075	1102	1094	1093	210	123	116	178	99	91	153	444	382	275	627	2.64	4.68	0.86	0.92	19.95	0.30	-23.65	2.991	82.1
11/19/94	23:05:00	NF	NF	NF	NF	NF	NF	1064	1101	1111	1097	210	123	114	178	99	91	152	445	383	275	629	2.59	4.59	0.85	0.93	20.32	0.28	-23.72	2.646	80.4
11/19/94	23:10.00	NF	NF	NF	NF	NF	NF	1067	1102	1106	1103	210	122	114	178	99	91	151	442	383	275	627	2.53	4.49	0.85	0.94	20.71	0.28	-7.16	3.641	60.7
11/19/94	23:15.00	NF	NF	NF	NF	NF	NF	1073	1101	1091	1100	209	123	115	178	99	92	151	440	382	275	635	2.45	4.35	0.85	0.95	21.12	0.25	-0.05	4.301	61.96
11/19/94	23.20.00	NF	NF	NF	NF	NF	NF	1072	1101	1103	1101	210	123	115	178	99	92	151	435	376	275	633	2.45	4.36	0.87	0.95	21.53	0.26	-0.05	2.973	66.56
11/19/94	23:25.00	NF	NF	NF	NF	NF	NF	1065	1101	1110	1101	210	122	114	178	99	92	151	432	375	275	629	2.45	4.34	0.87	0.96	21.95	0.25	-0.06	2.454	61.22
11/19/94	23:30 00	NF	NF	NF	NF	NF	NF	1068	1104	1106	1101	211	122	114	178	99	92	151	433	377	275	625	2.42	4.30	0 84	0.96	22.34	0.25	-0.05	2.763	61.78
11/19/94	23:35.00	NF	NF	NF	NF	NF	NF	1075	1099	1089	1099	211	122	114	179	99	92	151	433	377	275	625	2 43	4.31	0.87	0.97	22.75	0.24	-0.03	3.029	59.04
11/19/94	23:40.00	NF	NF	NF	NF	NF	NF	1068	1097	1103	1100	211	123	115	179	99	92	152	434	377	275	623	2.45	4.35	0.84	0.97	23.16	0.24	-0.04	3.545	63.12
11/19/94	23:45:00	NF	NF	NF	NF	NF	NF	1066	1101	1107	1100	211	123	115	178	99	92	152	436	379	275	620	2.48	4.40	0.84	0.96	23.58	0.25	-0.05	3.792	59.27
11/19/94	23:50.00	NF	NF	NF	NF	NF	NF	1076	1103	1110	1101	211	124	116	179	99	92	152	437	380	275	618	2.53	4.50	0.85	0.96	24.03	0.23	-0.05	3.752	63.12
11/19/94	23:55.00	NF	NF	NF	NF	NF	NF	1067	1105	1101	1099	211	124	116	179	100	92	153	436	382	275	627	2.57	4.56	0 85	0.94	24.50	0.24	-0.05	4.165	55.97
11/20/94	00.00.00	NF	NF	NF	NF	NF	NF	1062	1102	1090	1098	210	124	116	179	100	92	153	435	380	275	622	2.50	4.44	0.85	0.94	24.93	0.23	-0.06	4.832	49.98
11/20/94	00:05:00	NF	NF	NF	NF	NF	NF	1070	1100	1105	1099	209	124	116	179	100	92	152	434	380	275	613	2.40	4.26	0.86	0.97	25.36	0.23	-0.05	5.298	49.18
11/20/94	00:10.00	NF	NF	NF	NF	NF	NF	1070	1102	1103	1099	209	123	115	179	100	92	152	433	377	275	617	2 44	4.33	0.86	0.92	25.77	0.23	-0.05	4.318	54.81
11/20/94	00:15.00	NF	NF	NF	NF	NF	NF	1073	1102	1102	1099	210	122	115	179	100	92	152	435	381	275	612	2.49	4.41	0.85	0.92	26.20	0.24	-0.04	2.466	54.63
11/20/94	00:20.00	NF	NF	NF	NF	NF	NF	1072	1099	1102	1098	211	122	114	178	100	92	152	435	381	275	616	2.56	4.55	0.84	0.91	26.65	0.24	-0.05	2.653	57.88
11/20/94	00:25.00	NF	NF	NF	NF	NF	NF	1073	1103	1106	1098	212	122	114	178	100	92	152	432	379	275	609	2.60	4.61	0.84	0.91	27.06	0.25	-0.05	2.287	60.56
11/20/94	00:30:00	NF	NF	NF	NF	NF	NF	1066	1100	1106	1098	213	123	115	178	100	92	152	437	381	275	615	2.63	4.66	0.84	0.93	27.45	0.27	-0.06	1.579	66.4
11/20/94	00:35.00	NF	NF	NF	NF	NF	NF	1065	1101	1107	1099	213	123	115	178	100	92	152	438	382	275	605	2.65	4.71	0.85	0.90	27.87	0.24	-0.05	2.503	57.62
11/20/94	00:40.00	NF	NF	NF	NF	NF	NF	1071	1102	1090	1098	213	124	116	179	100	92	153	441	385	275	608	2.70	4.79	0.84	0.94	28.30	0.24	-0.05	2.712	59.47
11/20/94	00:45.00	NF	NF	NF	NF	NF	NF	1070	1102	1101	1098	213	123	116	179	99	91	153	443	385	275	604	2.73	4.84	0.86	0.90	28.76	0.26	-0.04	3.618	51.31
11/20/94	00,50.00	NF	NF	NF	NF	NF	NF	1070	1101	1106	1100	213	121	114	178	97	89	152	446	389	275	613	2 65	4.71	0.85	0.88	29.16	0.25	-0.05	3.276	51.86
11/20/94	00.55.00	NF	NF	NF	NF	NF	NF	1072	1102	1106	1102	213	120	112	178	97	88	151	445	386	275	613	2.70	4.79	0 84	0.83	29.56	0.24	-0.06	3.255	50.74
11/20/94	01:00.00	NF	NF	NF	NF	NF	NF	1075	1102	1107	1103	214	119	111	177	96	88	151	446	386	275	611	2.75	4.88	0.84	0 84	29.95	0.23	-0.07	2.579	49.19
11/20/94	01:05:00	NF	NF	NF	NF	NF	NF	1059	1101	1100	1086	214	118	111	176	96	88	150	450	389	275	613	2.70	4.80	0.87	0 84	30.35	0.26	-0.07	2.999	36.35
11/20/94	01:10:00	NF	NF	NF	NF	NF	NF	1070	1104	1092	1103	213	119	111	176	96	88	150	452	392	275	615	2.58	4.58	0.84	0.88	30.71	0.24	-0.07	2.948	36.2
11/20/94	01:15:00	NF	NF	NF	NF	NF	NF	1076	1105	1107	1104	213	119	111	176	96	88	150	452	393	275	612	2.59	4.59	0.85	0.89	31.06	0.25	-0.07	2.218	32.95
11/20/94	01:20:00	NF	NF	NF	NF	NF	NF	1066	1102	1111	1094	214	118	111	176	96	88	150	454	393	275	596	2.62	4.65	0.85	0.87	31.43	0.24	-0.07	2.256	35.86
11/20/94	01:25:00	NF	NF	NF	NF	NF	NF	1066	1094	1097	1098	213	118	110	176	96	87	150	452	394	275	617	2.54	4.50	0.86	0.90	31.81	0.23	-0.05	3.562	39.24
11/20/94	01:30.00	NF	NF	NF	NF	NF	NF	1077	1106	1095	1106	211	118	110	176	95	87	150	452	395	275	619	2.44	4.34	0 84	0.94	32.14	0.22	-0.06	3.24	60.8
11/20/94	01:35:00	NF	NF	NF	NF	NF	NF	1063	1102	1112	1098	210	119	110	176	95	87	150	452	394	275	627	2.51	4.46	0.84	0.91	32.51	0.23	-0.06	2.811	75.3
11/20/94	01:40.00	NF	NF	NF	NF	NF	NF	1072	1105	1104	1094	208	119	110	175	95	87	150	451	389	275	635	2.50	4.44	0.83	0.93	32.89	0.24	-0.05	4.079	94.2
11/20/94	01:45:00	NF	NF	NF	NF	NF	NF	1071	1092	1090	1107	207	118	110	174	95	87	149	451	390	275	637	2.53	4.49	0.84	0.92	33.30	0.27	-0 06	3.707	86.4
11/20/94	01:50.00	NF	NF	NF	NF	NF	NF	1075	1102	1113	1093	205	118	110	174	95	87	148	451	388	275	636	2.49	4.41	0.84	0.92	33.71	0.27	-0.05	3.458	85.4
11/20/94	01:55:00	NF	NF	NF	NF	NF	NF	1060	1104	1108	1105	201	118	109	172	94	87	147	449	384	274	638	2.49	4.41	0.89	0.89	34.11	0.29	-0.18	5.164	80.8
11/20/94	02.00.00	NF	NF	NF	NF	NF	NF	1072	1101	1093	1095	189	118	108	169	93	85	141	443	375	275	628	1.89	3.35	0.91	1.12	34.53	0.35	-23.31	4.383	83.1
11/20/94	02:05.00	NF	NF	NF	NF	NF	NF	1072	1101	1097	1098	198	119	109	171	94	86	143	447	384	276	642	2.00	3.55	0.85	1.11	34.95	0.38	-24.99	3.645	61.97
11/20/94	02:10.00	NF	NF	NF	NF	NF	NF	1074	1099	1109	1104	201	119	110	173	94	86	145	451	389	276	637	2.04	3.61	0.84	1.10	35.41	0.38	-25.00	3.613	58.94
11/20/94	02:15:00	NF	NF	NF	NF	NF	NF	1059	1101	1109	1089	202	120	111	174	94	86	146	447	387	275	632	2.03	3 61	0.84	1.12	35.88	0.37	-25.00	3.649	49.48
11/20/94	02:20.00	NF	NF	NF	NF	NF	NF	1072	1102	1094	1110	203	120	111	175	94	86	146	446	388	275	639	2.02	3.59	0.85	1.11	36.34	0.38	-25.00	4.488	40.21
11/20/94	02:25.00	NF	NF	NF	NF	NF	NF	1068	1101	1098	1090	203	119	110	176	94	86	146	438	382	275	637	1.95	3.46	0.85	1.10	36.81	0.39	-25.00	3.924	44.43
11/20/94	02:30.00	NF	NF	NF	NF	NF	NF	1069	1103	1108	1104	203	120	111	176	94	86	145	436	382	275	644	1.86	3.29	0.85	1.17	37.18	0.40	-25.00	4.146	41.98
11/20/94	02:35:00	NF	NF	NF	NF	NF	NF	1070	1102	1106	1102	203	121	111	177	94	86	145	433	383	275	637	1.86	3.30	0.86	1.23	37.31	0.38	-25.00	5.498	35.67
11/20/94	02:40.00	NF	NF	NF	NF	NF	NF	1070	1099	1103	1091	203	121	112	177	94	86	145	433	380	276	635	1.90	3.38	0.82	1.19	37.69	0.39	-25.00	4.434	46.42
11/20/94	02:45:00	NF	NF	NF	NF	NF	NF	1070	1102	1103	1107	204	121	112	177	94	86	146	432	376	275	627	2.07	3.67	0 84	1.06	38.41	0.37	-25.00	3.675	50.15

Table 6 - November 19 - 20, 1994 (Page 5 of 9)

		Temperature																													
Date	Time	BED 1	BED 2	BED 3	BED 4	BED 5	BED 6	ZONE 1	ZONE 2	ZONE 3	ZONE 4	Scrubber Inlet	Scrubber Outlet	ID Fan Inlet	ID Fan Outlet	HX Inlet	HX Outlet	Carbon Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet	Soil Discharge	DP (volts)	Flow DP (In H20)	Reactor DP (In H20)	Scrubber Level (in)	Tank 502 Level (%)	TanK 503 Level (%)	Tank 602 Level (%)	Wind Speed (mph)	Wind Direction
11/20/94	02:50.00	NF	NF	NF	NF	NF	NF	1069	1101	1091	1100	206	122	113	177	94	87	147	431	377	276	623	2.20	3.91	0.84	1.01	39.17	0.41	-25.00	2.918	47.04
11/20/94	02:55:00	NF	NF	NF	NF	NF	NF	1068	1101	1108	1089	206	123	113	177	95	87	147	427	373	275	617	1.63	2.90	0.63	1.28	39.64	0.39	-25.00	3.479	40.67
11/20/94	03:00.00	NF	NF	NF	NF	NF	NF	1072	1100	1105	1104	204	125	115	180	94	86	147	425	373	275	618	1.28	2.27	0.52	1.35	39.83	0.38	-25.00	3.3	180.3
11/20/94	03:05.00	NF	NF	NF	NF	NF	NF	1067	1102	1108	1104	202	125	115	181	95	86	147	424	372	275	607	1.33	2.37	0.55	1.32	40.17	0.36	-24.99	4.214	105.8
11/20/94	03:10.00	NF	NF	NF	NF	NF	NF	1071	1102	1092	1104	200	126	115	181	95	87	147	424	371	275	611	1.32	2.33	0.54	1.32	40.64	0.35	-24.59	4.843	43.25
11/20/94	03:15.00	NF	NF	NF	NF	NF	NF	1070	1102	1099	1088	199	125	115	180	95	87	147	422	371	276	620	1.30	2.31	0.51	1.30	41.20	0.36	-24.22	4.372	47.64
11/20/94	03:20.00	NF	NF	NF	NF	NF	NF	1069	1101	1105	1097	198	126	115	180	95	87	146	422	371	275	617	1.39	2.46	0.59	1.29	41.80	0.40	-24.08	5.265	41.71
11/20/94	03:25:00	NF	NF	NF	NF	NF	NF	1069	1102	1102	1099	198	126	115	180	95	87	147	423	372	276	623	1.40	2.49	0.56	1.31	42.35	0.39	-23.56	4.695	44.05
11/20/94	03:30.00	NF	NF	NF	NF	NF	NF	1073	1101	1103	1100	199	126	115	180	96	87	147	421	367	276	613	1.45	2.57	0.56	1.29	42.94	0.36	-25.00	4.014	53.62
11/20/94	03:35.00	NF	NF	NF	NF	NF	NF	1069	1102	1103	1100	201	125	115	180	96	87	148	421	366	276	610	1.52	2 69	0.56	1.24	43.52	0.40	-25.00	2.357	61.13
11/20/94	03:40.00	NF	NF	NF	NF	NF	NF	1070	1101	1101	1099	202	124	114	179	96	87	148	422	371	276	593	1.55	2.75	0.57	1.24	44.07	0.39	-25.00	2.551	56.63
11/20/94	03:45:00	NF	NF	NF	NF	NF	NF	1070	1102	1102	1098	203	123	113	180	96	87	147	419	370	275	596	1.51	2.67	0.58	1.24	44 64	0.40	-25.00	2.996	48.35
11/20/94	03:50.00	NF	NF	NF	NF	NF	NF	1066	1103	1104	1099	202	123	113	180	96	87	146	418	370	275	589	1.35	-1.52	0.56	1.27	45.25	0.37	-25.00	4.11	38.84
11/20/94	03:55.00	NF	NF	NF	NF	NF	NF	1041	1109	1100	1099	199	123	113	180	96	87	145	417	369	275	583	1.20	-1.51	0.51	1.31	45.85	0.37	-25 00	4.021	38.67
11/20/94	04:00:00	NF	NF	NF	NF	NF	NF	1043	1126	1104	1099	199	124	114	181	96	87	146	420	371	276	580	1.28	-1.78	0.54	1.31	46.39	0.36	-25.00	4.464	38.5
11/20/94	04.05:00	NF	NF	NF	NF	NF	NF	1053	1158	1102	1099	198	126	115	181	96	87	146	425	376	276	593	1.30	-2 07	0.52	1.32	46.91	0.38	-25.00	5.234	36.38
11/20/94	04:10.00	NF	NF	NF	NF	NF	NF	1063	1130	1103	1102	199	127	116	181	96	87	148	429	380	276	586	1.43	-1.68	0.54	1.25	47.46	0.35	-25.00	4.151	44.68
11/20/94	04:15:00	NF	NF	NF	NF	NF	NF	1065	1112	1102	1102	201	128	117	180	96	87	149	432	380	276	586	1.66	-1.13	0.59	1.15	48.08	0.36	-25.00	4.212	43.59
11/20/94	04:20.00	NF	NF	NF	NF	NF	NF	1071	1108	1103	1103	202	128	117	180	97	88	150	439	386	276	589	1.60	-1.45	0.55	1.19	48.71	0.33	-25.00	4.849	42.86
11/20/94	04:25.00	NF	NF	NF	NF	NF	NF	1079	1104	1102	1104	201	127	117	180	97	88	149	441	389	276	594	1.57	-1.75	0.54	1.17	49.32	0.35	-25.00	5.492	33.72
11/20/94	04:30.00	NF	NF	NF	NF	NF	NF	1079	1098	1102	1091	201	126	116	180	97	88	149	443	389	276	592	1.59	-1.07	0.55	1.12	50.00	0.37	-25.00	5.568	28.14
11/20/94	04:35:00	NF	NF	NF	NF	NF	NF	1077	1094	1106	1097	200	125	115	180	97	88	148	443	388	276	602	1.57	-0.83	0.56	1.12	50.59	0.32	-25.00	6.073	31.52
11/20/94	04:40 00	NF	NF	NF	NF	NF	NF	1075	1090	1098	1102	199	124	114	179	97	88	147	443	389	276	612	1.54	-0.77	0.57	1.15	51.17	0.31	-25.00	5.652	38.04
11/20/94	04:45:00	NF	NF	NF	NF	NF	NF	1075	1090	1106	1103	199	123	113	179	97	88	146	442	389	276	606	1.48	-0.95	0.58	1.20	51.75	0.30	-25.00	5.321	46.11
11/20/94	04:50.00	NF	NF	NF	NF	NF	NF	1074	1084	1101	1103	199	122	112	179	97	88	146	444	390	276	606	1.47	-1.37	0.56	1.20	52.31	0.31	-25.00	4.199	52.14
11/20/94	04:55.00	NF	NF	NF	NF	NF	NF	1072	1082	1106	1091	201	120	111	179	97	88	145	445	391	276	599	1.46	-0.74	0.56	1.20	52.82	0.33	-25.00	3.836	47.13
11/20/94	05.00.00	NF	NF	NF	NF	NF	NF	1054	1082	1098	1097	200	120	112	178	96	88	145	440	388	276	608	1.50	-1.14	0.58	1.20	53.30	0.32	-25.00	4.931	45.51
11/20/94	05:05:00	NF	NF	NF	NF	NF	NF	1061	1095	1108	1105	201	122	113	179	96	88	145	444	392	277	613	1.46	-0.80	0.57	1.24	53.77	0.32	-25.00	4.31	42.36
11/20/94	05:10.00	NF	NF	NF	NF	NF	NF	1071	1102	1102	1106	201	123	113	179	96	87	146	448	395	276	603	1.47	-1.26	0.57	1.23	54.25	0.33	-25.00	4.887	44.43
11/20/94	05:15:00	NF	NF	NF	NF	NF	NF	1054	1058	1102	1084	201	121	112	179	96	88	146	446	393	276	612	1.49	-0.98	0.56	1.20	54.74	0.31	-25 00	4.068	45.63
11/20/94	05:20.00	NF	NF	NF	NF	NF	NF	1025	1105	1105	1105	201	120	111	178	96	87	146	444	391	276	611	1.43	-1.58	0.54	1.21	55.27	0.35	-25.00	3.826	42.18
11/20/94	05:25.00	NF	NF	NF	NF	NF	NF	1042	1126	1105	1106	201	121	111	178	96	87	146	446	394	277	623	1.43	-1.61	0.57	1.20	55.75	0.33	-25.00	3.33	38.95
11/20/94	05:30.00	NF	NF	NF	NF	NF	NF	1045	1132	1103	1104	203	121	112	178	96	87	146	449	396	276	622	1.50	-1.56	0.56	1.20	56.17	0.33	-25.00	4.069	32.18
11/20/94	05:35.00	NF	NF	NF	NF	NF	NF	1068	1138	1102	1103	203	123	113	179	96	87	147	451	395	277	631	1.51	-1.51	0.53	1.20	56.62	0.31	-25.00	3.947	38.32
11/20/94	05;40.00	NF	NF	NF	NF	NF	NF	1075	1141	1102	1101	205	124	114	179	96	87	148	455	397	277	613	1.65	-1.64	0.54	1.13	57.13	0.32	-25.00	3.224	42.03
11/20/94	05:45.00	NF	NF	NF	NF	NF	NF	1080	1136	1099	1102	206	124	114	179	96	87	149	451	394	276	613	1.60	-1.49	0.57	1.14	57.64	0.29	-25.00	4.012	44.24
11/20/94	05:50.00	NF	NF	NF	NF	NF	NF	1080	1130	1098	1103	205	124	114	179	96	88	149	446	392	276	630	1.50	-1.64	0.55	1.19	58.21	0.32	-25.00	4.534	44.75
11/20/94	05:55:00	NF	NF	NF	NF	NF	NF	1072	1124	1105	1105	204	124	114	180	96	88	149	442	388	276	649	1.42	-1.72	0.57	1.24	58.83	0.33	-25.00	3.909	50.12
11/20/94	06.00.00	NF	NF	NF	NF	NF	NF	1065	1123	1099	1095	203	125	115	180	96	88	148	433	379	276	645	1.31	-1.68	0.52	1.29	59.42	0.31	-25.00	3.855	62.32
11/20/94	06.05.00	NF	NF	NF	NF	NF	NF	1061	1123	1100	1087	204	125	115	180	96	88	149	431	375	277	646	1.44	-1.66	0.52	1.23	59.95	0.34	-25.00	4.353	53.08
11/20/94	06:10.00	NF	NF	NF	NF	NF	NF	1054	1129	1080	1100	204	126	115	180	97	88	149	429	369	276	639	1.56	-1.55	0.57	1.16	60.45	0.32	-25.00	3.462	63.26
11/20/94	06:15:00	NF	NF	NF	NF	NF	NF	1049	1141	1090	1101	205	126	116	180	97	88	150	429	370	277	643	1.54	-1.66	0.55	1.17	61.01	0.35	-25 00	4.041	60.05
11/20/94	06:20:00	NF	NF	NF	NF	NF	NF	1049	1145	1107	1102	206	126	116	180	97	88	150	429	369	277	635	1.55	-1.60	0 55	1.16	61.58	0.31	-25.00	3.2	61.3
11/20/94	06:25:00	NF	NF	NF	NF	NF	NF	1052	1146	1111	1102	205	126	116	180	97	88	150	430	366	277	638	1.59	-1.87	0.56	1.11	62.21	0.34	-25.00	4.19	66.83
11/20/94	06:30.00	NF	NF	NF	NF	NF	NF	1057	1148	1098	1086	206	126	116	180	97	89	150	433	371	277	632	1.64	-1.16	0.55	1.09	62.77	0.32	-25.00	4.121	64.69
11/20/94	06:35.00	NF	NF	NF	NF	NF	NF	1065	1155	1097	1023	207	126	116	180	98	89	150	433	372	277	623	1.69	0.91	0.55	1.05	63.36	0.32	-25.00	3.897	59.24
11/20/94	06:40.00	NF	NF	NF	NF	NF	NF	1054	1155	1085	1037	207	126	116	180	98	89	150	432	376	277	621	1.64	0.99	0.55	1.09	63.93	0.32	-25.00	4.459	56.95
11/20/94	06:45:00	NF	NF	NF	NF	NF	NF	1053	1155	1081	1045	207	126	116	180	98	89	150	431	378	277	623	1.58	1.06	0.57	1.11	64.54	0.31	-25.00	4.998	48.49
11/20/94	06:50.00	NF	NF	NF	NF	NF	NF	1056	1113	1079	1038	204	127	117	182	98	89	149	426	361	277	623	1.08	0.59	0.45	1.37	65.24	0.30	-25.00	5.693	49.63
11/20/94	06:55.00	NF	NF	NF	NF	NF	NF	1059	1107	1075	1037	200	128	117	183	98	89	148	423	357	277	607	1.00	0.42	0.41	1.34	66.13	0.32	-25.00	3.802	57.81
11/20/94	07.00.00	NF	NF	NF	NF	NF	NF	1063	1109	1060	1029	198	126	116	183	98	89	147	420	361	277	591	1.00	0.32	0.39	1.29	66.82	0.34	-25.00	3.273	70.6
11/20/94	07.05.00	NF	NF	NF	NF	NF	NF	1064	1115	1051	1021	196	125	115	183	98	89	147	419	364	277	584	0.99	0.39	0.42	1.32	67.41	0.35	-25 00	3.768	64.89
11/20/94	07:10.00	NF	NF	NF	NF	NF	NF	1063	1115	1063	1013	196	125	115	182	98	89	146	417	366	277	572	0.98	0.45	0.42	1.32	67.91	0.33	-25.00	3.442	63.96
11/20/94	07:15:00	NF	NF	NF	NF	NF	NF	1065	1110	1063	1007	196	126	115	183	98	89	146	417	364	277	558	0 97	0.39	0.44	1.32	68.48	0.34	-25.00	3.58	57.24
11/20/94	07:20.00	NF	NF	NF	NF	NF	NF	989	1041	1064	1004	196	125	115	183	98	89	147	413	358	276	549	0.95	0.31	0.48	1 28	69.00	0.30	-25.00	4.468	58.42
11/20/94	07:25.00	533	549	554	608	668	677	1058	1088	1063	995	196	125	115	183	98	89	146	409	356	277	540	0.95	0.31	0.53	1.28	69.62	0.29	-25.00	5.552	45.95
11/20/94	07:30.00	545	547	560	615	663	668	1069	1092	1064	991	196	126	115	183	98	89	146	408	352	277	535	0.93	0.36	0.50	1.31	70.20	0.29	-25 00	5.248	49.06
11/20/94	07:35.00	554	538	548	616	660	663	1075	1093	1067	990	197	127	116	183	98	89	146	410	353	278	539	0.93	0.41	0.47	1.35	70.60	0.27	-25.00	4.141	57.22

Table 6 - November 19 - 20, 1994 (Page 6 of 9)

		Temperature																													
Date	Time	BED 1	BED 2	BED 3	BED 4	BED 5	BED 6	ZONE 1	ZONE 2	ZONE 3	ZONE 4	Scrubber Inlet	Scrubber Outlet	ID Fan Inlet	ID Fan Outlet	HX Inlet	HX Outlet	Carbon Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet	Soil Discharge	DP (volts)	Flow DP (in H20)	Reactor DP (in H20)	Scrubber Level (in)	Tank 502 Level (%)	TanK 503 Level (%)	Tank 602 Level (%)	Wind Speed (mph)	Wind Direction
11/20/94	07:40.00	557	547	551	627	660	659	1072	1093	1065	1067	197	127	117	183	98	89	147	411	353	277	540	0.94	0.36	0.46	1.33	71.20	0.25	-25 00	4.231	56.71
11/20/94	07:45.00	547	543	555	623	680	669	1076	1095	1059	1092	199	129	118	184	98	89	148	413	360	278	519	0.93	0.40	0.47	1.29	71.80	0.28	-22.66	3.528	51.94
11/20/94	07:50.00	547	544	559	618	690	681	1070	1097	1053	1079	201	129	118	185	98	90	149	414	361	278	517	0.93	0.41	0.48	1.32	72 40	0.26	-0.03	3.734	52.11
11/20/94	07:55:00	549	554	553	617	696	690	1073	1098	1065	1080	202	128	118	185	98	90	150	412	358	277	536	0.91	0.45	0.50	1.29	73.00	0.21	-0.03	4.105	51.45
11/20/94	08.00:00	550	551	559	630	696	693	1076	1099	1068	1079	202	129	118	185	98	90	149	414	360	278	554	0.93	0.43	0.53	1.31	73.50	0.22	-0.03	4.708	51.92
11/20/94	08.05.00	537	550	567	610	697	694	1078	1097	1069	1070	204	130	119	186	99	90	150	413	355	277	553	0 92	0.39	0.53	1.33	74.10	0.19	-0 02	4 817	55.23
11/20/94	08:10.00	539	551	567	614	698	700	1076	1097	1057	1090	204	130	120	186	99	90	150	414	359	277	553	0.93	0.44	0 53	1.35	74.70	0.22	-0.03	4.683	48.27
11/20/94	08·15.00	516	541	550	619	700	708	1073	1096	1063	1078	205	131	121	187	99	90	150	414	365	278	548	0.94	0.44	0 53	1.36	75.30	0.18	-0 03	4.949	55.32
11/20/94	08:20.00	524	537	544	613	705	705	1082	1093	1059	1073	206	132	122	187	99	91	152	413	361	277	557	0.94	0.44	0.51	1.35	76.00	0.21	-0.01	4.586	60.41
11/20/94	08:25:00	532	531	533	623	707	703	1082	1091	1063	1084	206	132	122	188	100	91	152	411	353	278	556	0.94	0.46	0.54	1.30	76.70	0.20	-0.03	4.96	59.6
11/20/94	08:30.00	565	535	537	617	710	708	1073	1090	1065	1081	205	132	121	187	100	92	152	408	354	277	552	0.94	0.54	0.53	1 28	77.40	0.17	0.01	4.535	62.13
11/20/94	08:35.00	578	539	536	610	707	711	1075	1091	1058	1080	202	130	120	186	100	91	150	408	352	278	553	0 95	0.40	0.55	1.28	78 00	0.15	0.01	4 893	69.2
11/20/94	08:40.00	582	528	532	593	708	714	1083	1091	1067	1079	203	129	119	186	100	91	149	410	356	278	556	0.97	0.36	0.55	1.27	78 50	0.19	0.00	4.73	63.02
11/20/94	08:45.00	598	534	534	611	701	711	1089	1093	1057	1080	203	128	119	185	100	91	148	411	355	277	563	0 99	0 44	0.57	1.29	79.10	0 18	-0.00	5 943	57.82
11/20/94	08·50.00	604	545	538	606	699	703	1096	1096	1065	1079	197	127	117	182	99	91	145	411	355	277	562	1.03	0.46	0.68	1.22	79.70	0.19	-0.01	7.1	69.35
11/20/94	08·55:00	600	551	544	611	696	698	1092	1097	1064	1079	192	127	115	178	99	90	139	411	356	278	556	1.05	0.66	0.81	1.22	80.30	0.35	-12.85	6.78	63.71
11/20/94	09.00.00	597	560	551	606	704	689	1093	1095	1061	1080	197	128	117	179	99	90	143	415	354	279	557	1.05	0.84	0.79	1.32	80.90	0.29	-25.00	5.654	70
11/20/94	09:05:00	592	560	553	614	702	699	1091	1091	1064	1074	200	128	118	180	99	90	145	417	359	279	548	1.05	0.55	0.71	1.32	81.50	0.31	-25.00	4.452	60.88
11/20/94	09:10.00	583	563	562	622	702	680	1092	1086	1062	1076	202	128	118	180	99	90	146	418	368	278	549	1.04	0.51	0.72	1.31	82.10	0 29	-25.00	6.637	35.31
11/20/94	09:15.00	584	566	559	626	707	640	1091	1078	1064	1079	202	127	118	181	99	90	146	420	366	279	549	1.05	0.48	0.73	1.28	82.70	0.34	-25.00	4.639	45.19
11/20/94	09:20.00	568	555	571	622	707	689	1092	1068	1061	1080	203	126	117	181	99	90	146	418	366	277	543	1.05	0.56	0.73	1.27	83.30	0 29	-25.00	5.365	49.79
11/20/94	09.25.00	575	555	560	628	708	697	1092	1056	1059	1083	203	126	117	182	99	91	146	415	363	278	550	1.05	0.54	0.77	1.27	83.80	0 28	-24.99	6.1	44 39
11/20/94	09:30.00	574	548	562	628	710	698	1071	1039	1068	1087	204	126	117	182	99	91	146	410	359	278	553	1.04	0.60	0.76	1.26	84.30	0.26	-19.74	5.044	44.53
11/20/94	09:35:00	585	553	567	630	712	690	1053	1068	1084	1075	206	127	117	183	99	91	147	405	353	278	554	1.00	0.58	0.78	1.28	84.90	0.25	0.00	5.721	47.93
11/20/94	09:40.00	572	577	588	633	713	703	1045	1104	1110	1080	206	127	117	184	99	91	147	405	351	278	557	1.00	0.52	0.77	1.27	85.40	0.22	-0.01	5.437	55.74
11/20/94	09:45.00	532	598	613	633	708	708	1043	1106	1107	1079	205	128	118	184	99	91	146	404	312	278	561	1.00	0.57	0.76	1.28	85.90	0.24	-0.01	5.765	60.4
11/20/94	09:50.00	523	599	607	634	712	707	1049	1107	1098	1080	203	128	118	184	100	92	146	400	307	277	555	1.00	0.57	0.77	1.29	86.40	0.18	-0.01	7.18	54.22
11/20/94	09.55:00	525	594	612	634	713	706	1065	1105	1086	1080	202	130	119	185	100	92	146	399	341	278	560	1.00	0.49	0.80	1.27	86.90	0.20	-0 02	8.77	57.75
11/20/94	10.00.00	526	588	615	631	716	706	1069	1098	1076	1079	205	130	121	186	100	93	148	396	293	278	554	0.96	0.53	0.73	1.26	87.50	0.19	0.01	7.1	59.04
11/20/94	10.05.00	509	576	614	627	716	707	1071	1100	1088	1080	206	132	123	187	101	93	150	395	294	277	543	0.95	0.40	0.72	1.22	88.10	0.14	-0 02	8.37	51.61
11/20/94	10:10.00	543	578	602	628	717	711	1068	1098	1089	1079	207	133	124	188	101	94	152	394	299	277	551	0.96	0.56	0.74	1.23	88.70	0.11	0 01	7.37	52.29
11/20/94	10.15:00	539	571	591	628	716	711	1067	1101	1098	1079	206	133	124	188	101	94	152	392	309	278	549	0.96	0.52	0.66	1.16	89.20	0.13	0.03	7.07	71.6
11/20/94	10:20 00	535	561	594	619	715	711	1071	1099	1094	1079	205	134	124	188	102	94	151	399	311	278	551	0.96	0.40	0 64	1.14	89.90	0.13	0.01	7.49	67.63
11/20/94	10:25.00	553	576	592	617	715	712	1072	1105	1098	1072	205	132	123	188	102	95	151	404	320	278	549	0.97	0.41	0.66	1.07	90.50	0.08	0.00	8.2	56.75
11/20/94	10:30.00	558	584	595	612	710	713	1074	1106	1090	1086	205	130	122	188	102	95	151	410	332	277	567	0.99	0.65	0.68	1.04	91.10	0.08	0.01	7.41	60.37
11/20/94	10:35:00	555	593	603	614	712	717	1081	1100	1073	1080	206	129	121	188	103	95	150	411	330	278	561	0.99	0.55	0.69	1.04	91.70	0 07	0.03	7.77	65.28
11/20/94	10:40.00	571	588	605	614	709	711	1083	1101	1079	1072	204	128	120	187	102	94	149	413	328	278	567	1.02	0.47	0.70	1.04	92.20	0.05	0.04	8.96	61.97
11/20/94	10:45;00	574	586	606	619	706	711	994	1011	1082	1089	203	127	119	186	102	94	146	409	331	277	562	1.07	0.41	0.68	1.05	92.70	0.07	0.03	7.85	57.71
11/20/94	10:50.00	568	595	615	626	716	710	994	1064	1078	1077	203	128	119	186	102	94	145	413	318	277	564	1.08	0.54	0.71	1.08	93.20	0.04	-0.01	9.74	51.99
11/20/94	10:55.00	576	611	619	633	717	715	1070	1100	1082	1078	203	127	118	185	102	94	147	414	308	278	559	1.08	0.46	0.72	1.07	93.70	0.07	0.00	9.19	71.9
11/20/94	11:00.00	587	596	616	639	724	712	1063	1102	1084	1073	204	127	118	185	102	94	147	413	330	278	560	1.08	0.62	0.71	1.08	94.20	0.05	-0.01	9.67	52.55
11/20/94	11:05:00	546	598	620	640	730	709	1055	1111	1078	1086	204	127	119	185	102	94	148	409	331	277	561	1.08	0.48	0.78	1.08	94.70	0.05	0.03	10.24	54.16
11/20/94	11:10.00	545	618	617	646	735	724	1055	1111	1050	1081	204	128	119	185	101	94	148	411	316	278	559	1.10	0.53	0.75	1.13	95.20	0.06	0.01	9.59	52.95
11/20/94	11:15:00	525	601	606	640	734	727	1058	1104	1034	1080	206	129	120	185	101	94	149	410	330	278	563	1.09	0.46	0.70	1.15	95.70	0 04	0.03	7.73	51.15
11/20/94	11:20.00	518	578	616	640	736	726	1059	1100	1024	1079	207	130	121	185	102	94	149	409	335	277	557	1.10	0.52	0.64	1.16	96.30	0.09	0.02	8.35	52.82
11/20/94	11:25.00	526	573	591	644	728	713	1050	1102	1020	1078	205	130	122	185	102	94	150	406	335	277	556	1.10	0.59	0.71	1.15	96.80	0.04	-0.01	10.22	70.7
11/20/94	11:30.00	515	560	575	640	733	723	1052	1092	1014	1079	207	131	122	186	102	94	150	407	338	278	560	1.11	0.53	0.65	1.14	97.40	0.06	-0.00	8.03	49.73
11/20/94	11:35.00	523	540	550	628	735	727	1053	1092	1019	1078	208	131	122	186	102	94	151	409	352	277	568	1.12	0.60	0.61	1.13	98.00	0.04	-0.01	7.54	63.34
11/20/94	11:40.00	516	546	532	606	729	722	1056	1097	1027	1079	207	131	122	186	102	94	151	409	361	277	558	1.10	0.66	0.64	1.14	98.50	0.04	-0.01	8.59	70.4
11/20/94	11:45.00	507	534	539	594	721	721	1057	1099	1041	1079	208	131	122	186	102	95	151	411	365	279	540	1.10	0.53	0.61	1.15	99.10	0.02	0.00	6.876	67.3
11/20/94	11:50.00	523	533	555	590	712	725	1060	1101	1069	1075	208	131	123	186	103	95	151	412	365	277	567	1.11	0.62	0.59	1.15	99.70	0.08	0.04	7.7	71
11/20/94	11:55:00	537	532	545	601	706	719	1064	1105	1068	1076	207	130	122	186	102	95	150	412	365	277	573	1.12	0.78	0.63	1.15	99.80	0.12	0.02	8.98	71.2
11/20/94	12:00.00	555	527	533	608	695	716	1059	1102	1046	1086	206	129	121	185	102	95	149	411	364	277	568	1.13	0.70	0.62	1.15	99.70	0.07	-0.00	7.88	66.21
11/20/94	12:05.00	572	543	542	595	705	709	1051	1106	1062	1079	205	128	120	184	102	95	148	410	364	277	559	1.14	0.38	0.69	1.16	99.70	0 05	0.01	8.76	54.44
11/20/94	12:10.00	562	553	548	593	708	712	1048	1107	1056	1079	207	129	121	185	103	95	149	410	364	278	555	1.13	0.29	0.68	1.16	99.80	0.10	0.07	8.45	55.5
11/20/94	12:15:00	574	567	558	606	705	715	1046	1111	1062	1079	208	129	121	185	102	95	150	409	364	277	560	1.14	0.66	0.76	1.19	99.70	0.08	0.06	10.51	50.15
11/20/94	12:20.00	568	568	557	616	703	713	1055	1107	1059	1078	208	129	121	185	102	95	150	408	360	278	565	1.15	0.72	0.72	1.21	99.80	0.05	0.05	8.65	74.5
11/20/94	12:25.00	554	561	570	618	700	712	1058	1108	1062	1070	208	130	121	185	102	95	149	407	360	277	561	1.15	1.05	0.72	1.21	99.80	0.03	0.06	10.41	60.8

Table 6 - November 19 - 20, 1994 (Page 7 of 9)

		Temperature																													
Date	Time	BED 1	BED 2	BED 3	BED 4	BED 5	BED 6	ZONE 1	ZONE 2	ZONE 3	ZONE 4	Scrubber Inlet	Scrubber Outlet	ID Fan Inlet	ID Fan Outlet	HX Inlet	HX Outlet	Carbon Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet	Soil Discharge	DP (volts)	Flow DP (in H20)	Reactor DP (in H20)	Scrubber Level (in)	Tank 502 Level (%)	TanK 503 Level (%)	Tank 602 Level (%)	Wind Speed (mph)	Wind Direction
11/20/94	12:30.00	553	561	582	629	714	690	1063	1104	1064	1091	207	130	121	184	102	95	148	406	355	278	563	1.14	0.55	0.68	1.20	99.70	-0.02	0.02	9	65.63
11/20/94	12:35:00	577	562	569	632	713	640	1067	1106	1063	1072	206	130	121	184	102	95	148	409	358	277	557	1.14	0.81	0.69	1.18	99.80	0.03	0.00	8.67	60.86
11/20/94	12:40.00	524	542	559	626	700	685	1059	1107	1063	1076	208	130	122	184	103	95	150	410	362	277	557	1.15	0.59	0.71	1.17	99.80	0 06	0.07	9.42	50.48
11/20/94	12:45.00	533	546	557	635	716	701	1048	1109	1060	1086	207	130	122	185	103	95	150	410	363	277	563	1.15	0.64	0.76	1.15	99.70	-0.01	0.07	10.28	48.85
11/20/94	12:50.00	548	574	568	641	728	702	1051	1105	1066	1081	207	130	121	185	102	95	150	410	362	278	555	1.14	1.01	0.72	1.15	99.70	-0.01	0.04	8.98	60.14
11/20/94	12:55.00	546	551	564	637	726	692	1055	1100	1057	1079	207	131	122	185	102	94	149	411	361	278	550	1.13	0.73	0.66	1.17	99.70	0.02	0.03	7.75	57.44
11/20/94	13:00.00	558	553	565	643	724	684	1057	1098	1065	1080	208	130	122	185	102	95	150	415	367	278	562	1.13	0.72	0.65	1.16	99.70	0.01	0.03	7.3	64.03
11/20/94	13:05:00	563	560	569	643	721	715	1062	1096	1062	1080	207	131	122	185	103	95	149	415	367	278	573	1.14	0.53	0.62	1.12	99.70	0.02	0.02	7.37	77
11/20/94	13:10.00	524	546	566	641	722	721	1065	1098	1060	1077	207	130	122	184	102	95	149	414	367	277	579	1.13	0.77	0.62	1.14	99.70	0.03	0.02	8.73	64.3
11/20/94	13:15:00	540	547	560	641	721	723	1068	1100	1066	1079	206	130	121	184	102	94	148	414	366	277	565	1.15	0.55	0.64	1.16	99.70	0.02	-0.03	9.31	76.3
11/20/94	13:20.00	528	556	562	636	720	722	1071	1100	1058	1082	205	128	120	182	102	94	147	415	364	278	566	1.16	0.79	0.65	1.21	99.70	0.09	-0.00	9.22	85.7
11/20/94	13:25.00	516	540	560	630	715	723	1068	1099	1066	1078	205	129	120	182	102	94	146	416	367	278	567	1.16	0.39	0.65	1.24	99.70	0.18	0.03	7.29	83.4
11/20/94	13:30.00	517	554	556	639	721	717	1066	1103	1058	1078	204	129	120	182	102	94	147	417	372	277	571	1.17	0.61	0.68	1.25	99.70	0.08	0.05	9.11	56.19
11/20/94	13:35.00	532	553	556	636	723	719	1065	1098	1062	1079	196	126	117	179	101	92	143	419	368	277	571	1.18	0.61	0.78	1.20	99.70	0.17	-0.02	8.15	60.28
11/20/94	13:40.00	494	537	549	612	717	702	1068	1096	1066	1079	190	124	114	174	99	90	131	410	365	277	565	1.18	0.74	0.83	1.24	99.80	0.36	-0.08	7	60.87
11/20/94	13:45.00	538	544	551	621	710	668	1074	1095	1059	1076	197	127	116	175	99	91	138	414	358	279	558	1.16	0.58	0.78	1.36	99.80	0.59	-0.07	6.56	48.81
11/20/94	13:50.00	565	561	558	637	715	607	1076	1095	1061	1074	202	128	118	177	100	91	142	417	359	279	554	1.18	0.67	0.75	1.40	99.90	0.51	-0.04	6.271	63.98
11/20/94	13:55.00	572	568	554	645	720	609	1078	1094	1063	1081	205	129	119	179	100	92	145	422	366	279	570	1.20	0.78	0.74	1.37	99.90	0.53	0.00	6.767	71.8
11/20/94	14:00.00	574	571	566	636	729	622	1085	1101	1066	1087	202	127	118	179	100	93	144	424	366	278	564	1.20	0.77	0.80	1.29	99.80	0.48	-0.01	9.77	87.4
11/20/94	14:20.00	582	568	601	649	728	639	1085	1105	1068	1080	204	130	121	183	102	95	145	423	374	278	547	1.04	0.93	0.75	1.31	99.70	1.77	0.10	11.91	71.8
11/20/94	14:25.00	562	566	594	645	721	642	1085	1105	1066	1079	204	131	122	183	102	95	146	422	374	277	564	1.05	0.47	0.71	1.32	99.70	2 01	0.09	8	68.01
11/20/94	14:30.00	558	574	580	653	722	661	1082	1113	1058	1068	194	127	117	180	100	92	142	419	373	275	580	1.09	0.43	0.89	1.23	99.70	2 62	0.01	12.32	65.15
11/20/94	14:35.00	547	580	568	649	727	629	1086	1103	1065	1088	195	127	117	176	100	91	135	424	373	281	571	1.15	0.55	0.77	1.31	99.70	3.27	-0.08	8 03	80.9
11/20/94	14:40.00	581	578	579	650	729	632	1088	1099	1062	1078	197	126	118	176	100	92	139	426	376	278	577	1.18	0.32	0.71	1.33	99.80	3.79	-0.03	8.57	72.7
11/20/94	14:45:00	594	573	584	641	727	673	1089	1095	1062	1072	199	126	117	177	100	93	141	426	378	279	570	1.19	0.46	0.73	1.34	99.80	4.28	0.03	7.71	67.99
11/20/94	14:50.00	595	580	580	646	725	695	1089	1094	1063	1078	201	127	118	179	101	93	141	425	379	278	575	1.05	0.45	0.69	1.38	99.80	4.70	0.06	7.78	73.4
11/20/94	14:55.00	580	580	566	642	726	705	1089	1095	1062	1091	202	126	118	180	101	93	142	425	377	278	580	1.04	0.54	0.73	1.35	99.80	5.11	0.05	8.98	77.7
11/20/94	15.00.00	570	593	586	654	728	717	1088	1096	1058	1077	202	126	118	180	101	94	141	425	376	278	574	1.04	0.42	0.75	1.29	99 80	5.61	0.02	10.19	73.8
11/20/94	15.05:00	568	596	591	656	723	717	1087	1094	1090	1089	200	126	117	180	101	93	141	425	376	278	572	1.13	0.59	0.82	1.26	99.80	5.95	-0.00	10.82	72.6
11/20/94	15:10.00	553	603	607	663	733	726	1082	1088	1107	1104	201	125	117	179	100	93	141	426	378	279	569	1.17	0.55	0.80	1.23	99.80	6.36	-0.01	8.31	71.5
11/20/94	15:15:00	573	594	608	674	742	729	1081	1087	1110	1099	202	125	116	179	100	93	141	426	379	278	583	1.17	0.65	0.78	1.22	99.80	6.83	-0.03	9.75	72.8
11/20/94	15:20.00	604	582	621	677	748	718	1081	1095	1110	1097	201	124	116	179	100	93	140	426	374	278	585	1.17	0.52	0.77	1.24	99.80	7.29	-0.04	9.99	74.3
11/20/94	15:25.00	589	591	619	688	750	726	1084	1102	1106	1099	200	125	116	179	100	93	139	427	377	278	576	1.16	0.56	0.75	1.28	99.80	7.75	-0.01	10.28	80
11/20/94	15:30 00	580	618	629	686	757	741	1082	1101	1095	1108	200	126	117	178	100	93	140	428	378	279	583	1.20	0.70	0.75	1.28	99.80	8.25	0.01	10.28	82
11/20/94	15:35.00	580	630	628	681	763	749	1074	1101	1098	1096	201	127	118	178	100	93	141	430	380	278	574	1.21	0.71	0.74	1.25	99.80	8 63	0.02	8.43	79
11/20/94	15:40.00	556	621	646	681	763	750	1069	1102	1108	1094	203	127	118	179	100	93	142	430	385	277	586	1.19	0.64	0.71	1.30	99.80	9.05	0.02	8.31	66.54
11/20/94	15:45:00	560	617	643	683	763	748	1075	1100	1107	1098	203	127	119	180	100	93	142	431	384	279	581	1.19	0.62	0.67	1.27	99.80	9.48	0.02	9.04	72.3
11/20/94	15:50.00	554	618	642	687	762	753	1075	1101	1104	1108	204	128	119	180	100	93	142	432	388	277	586	1.19	0.52	0.69	1.29	99.80	10.01	0.00	9.04	61.44
11/20/94	15:55.00	565	613	632	685	757	748	1075	1098	1104	1098	203	127	118	181	100	92	142	432	390	278	553	1.20	0.57	0.74	1.33	99.80	10 58	-0.04	9.03	63.4
11/20/94	16.00.00	569	596	641	680	767	750	1076	1094	1108	1101	204	126	118	180	100	93	142	433	387	279	574	1.20	0.57	0.67	1.22	99.80	11.13	-0.02	7.2	68.72
11/20/94	16:05.00	560	614	638	679	760	750	1081	1104	1112	1098	206	126	118	181	100	93	142	433	387	278	580	1.20	0.60	0.65	1.26	99.80	11.64	0.00	7.56	65.03
11/20/94	16:10.00	564	619	627	678	759	750	1088	1105	1100	1095	204	126	117	180	100	93	141	431	372	278	591	1.21	0.58	0.67	1.30	99.80	12.10	0.02	9.23	83.7
11/20/94	16:15.00	537	623	640	669	762	725	1084	1103	1085	1097	204	128	119	180	100	93	141	433	380	278	604	1.20	0.58	0.64	1.30	99.80	12.55	0.03	6.607	75
11/20/94	16:20.00	547	631	638	668	755	724	1081	1100	1099	1098	207	128	119	180	100	93	143	437	384	278	613	1.22	0.87	0.63	1.31	99.80	13.02	0 01	6.868	71.6
11/20/94	16:25:00	532	632	636	675	761	753	1082	1109	1108	1099	206	124	116	179	100	93	142	442	383	278	609	1.26	0.18	0.70	1.21	99.80	13.55	-0 05	8 57	75
11/20/94	16:30.00	570	627	650	681	762	751	1081	1108	1097	1112	206	122	114	178	100	93	140	443	381	278	614	1.29	0.62	0.73	1.18	99.80	13.99	-0.06	7.61	73.3
11/20/94	16:35.00	596	635	658	690	764	759	1085	1105	1094	1102	206	121	113	178	100	93	139	442	384	279	609	1.30	0.54	0.70	1.19	99.80	14.36	-0.05	7.09	76.3
11/20/94	16:40.00	588	640	659	699	775	759	1082	1112	1103	1096	206	122	114	178	99	92	139	439	385	277	592	1.30	0.51	0.73	1.22	99.80	14.75	-0.04	10.06	69.92
11/20/94	16:45:00	562	654	661	701	779	763	1084	1119	1099	1096	204	123	114	178	99	92	139	437	383	278	600	1.29	0.64	0.74	1.26	99.80	15.13	-0.05	9.53	82.3
11/20/94	16:50.00	556	654	667	715	781	764	1085	1119	1111	1101	205	124	115	178	99	92	139	435	383	278	601	1.31	0.62	0.72	1.30	99.80	15.51	-0.04	8.89	75
11/20/94	16:55:00	546	652	678	725	787	771	1087	1122	1109	1103	205	125	116	177	99	92	140	434	381	278	601	1.30	0.70	0.70	1.35	99.80	15.93	-0.25	8.83	80.3
11/20/94	17:00.00	558	647	677	726	791	770	1080	1123	1099	1108	205	125	116	177	99	92	140	433	382	278	595	1.32	0.69	0.70	1.32	99.80	16.41	-0.42	7.1	76.8
11/20/94	17.05.00	563	643	668	728	799	771	1081	1116	1104	1110	207	125	116	177	99	92	141	434	382	278	615	1.33	0.67	0.71	1.31	99.80	16.88	-0.23	8.62	68.54
11/20/94	17:10.00	552	635	661	732	807	789	1085	1113	1101	1114	207	125	116	178	99	92	141	434	379	278	612	1.32	0.70	0.71	1.24	99.80	17.10	-0.40	7.86	79.6
11/20/94	17:15.00	556	636	657	729	810	778	1082	1109	1102	1119	207	125	116	178	99	92	141	433	381	278	619	1.33	0.73	0.71	1.25	99.80	17.46	-0.56	6.553	72
11/20/94	17:20.00	540	641	655	730	813	791	1085	1113	1102	1121	207	124	115	178	99	91	141	434	382	278	628	1.33	0.75	0.74	1.26	99.80	17.80	-0.74	8.31	70.9
11/20/94	17:25:00	559	638	657	727	812	799	1088	1119	1101	1122	207	124	115	177	98	91	140	434	382	278	628	1.32	0.76	0.74	1.28	99.80	18 07	-1.99	7.98	74.7
11/20/94	17:30.00	546	646	646	723	812	799	1084	1134	1097	1124	207	125	115	177	98	91	140	436	385	278	633	1.31	0.72	0.70	1.31	99.80	18.37	-4.95	6.941	76.4

Table 6 - November 19 - 20, 1994 (Page 8 of 9)

		Temperature																													
Date	Time	BED 1	BED 2	BED 3	BED 4	BED 5	BED 6	ZONE 1	ZONE 2	ZONE 3	ZONE 4	Scrubber Inlet	Scrubber Outlet	ID Fan Inlet	ID Fan Outlet	HX Inlet	HX Outlet	Carbon Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet	Soil Discharge	DP (volts)	Flow DP (in H20)	Reactor DP (in H20)	Scrubber Level (in)	Tank 502 Level (%)	TanK 503 Level (%)	Tank 602 Level (%)	Wind Speed (mph)	Wind Direction
11/20/94	17:35:00	536	641	653	719	805	800	1084	1034	1096	1127	208	125	116	177	98	91	141	437	384	278	636	1.29	0.74	0.68	1.33	99 80	18.76	-3.12	6.689	82.7
11/20/94	17:40.00	524	638	655	714	803	800	1065	937	1110	1124	208	125	116	177	98	91	141	433	381	277	640	1.24	0.70	0.68	1.34	99.80	19.21	-3.35	7.11	76.9
11/20/94	17.45.00	510	629	664	718	801	794	1044	1044	1180	1108	208	125	115	177	98	91	140	434	381	279	647	1.21	0 58	0.71	1.33	99.80	19.74	-11.34	6.187	76
11/20/94	17:50.00	487	627	711	723	799	768	1044	1063	1174	1101	208	126	116	177	98	91	140	433	383	278	609	1.20	0 68	0 65	1.37	99.80	20.17	-23.46	6.493	80.9
11/20/94	17:55:00	463	631	721	722	799	779	1045	1061	1179	1084	208	125	116	178	98	91	141	435	386	278	638	1.19	0 58	0 67	1.34	99.80	20 63	-24.87	6 689	71.9
11/20/94	18.00.00	469	644	720	725	795	788	1046	1057	1023	1049	208	123	114	178	98	91	141	439	389	278	630	1.19	0 62	0.69	1.30	99.80	21 06	-24.83	6.738	67.77
11/20/94	18.05.00	458	645	683	722	788	786	1045	1058	1075	1032	207	123	114	177	98	90	139	440	388	279	633	1.18	0.56	0.68	1.33	99 80	21.53	-24 86	7.35	75.7
11/20/94	18:10.00	473	651	655	716	784	781	1047	1046	1080	1029	206	123	114	177	97	90	139	444	391	278	620	1.18	0.64	0 66	1.33	99.80	21.93	-24.79	6 821	70.4
11/20/94	18:15.00	471	649	638	708	787	781	1061	991	1088	1095	207	120	111	177	97	90	139	448	396	278	613	1.20	0.65	0.67	1.25	99.90	22.32	-24.83	5.601	68.44
11/20/94	18:20.00	506	647	642	706	791	786	1068	1017	1090	1098	205	116	108	176	98	91	137	453	397	278	622	1.20	0.57	0.76	1.19	99.80	22.69	-24 85	7.67	67.17
11/20/94	18:25:00	535	648	645	706	791	791	1025	1081	1082	1097	203	114	107	175	99	92	134	454	397	278	621	1.20	0 56	0.73	1.19	99.80	23.05	-24.91	6.723	67.87
11/20/94	18:30.00	553	660	656	700	790	790	1008	1088	1079	1074	205	115	107	175	99	92	135	453	396	278	612	1.19	0.57	0.70	1.24	99.80	23.29	-24.93	5.652	68.11
11/20/94	18:35.00	549	675	660	699	790	780	1008	1070	1054	1072	207	116	108	175	98	92	135	451	392	279	605	1.19	0 55	0.67	1.28	99.80	23.51	-24.95	5.548	70.2
11/20/94	18:40.00	554	683	666	698	788	777	1003	1082	1048	1089	207	117	109	175	98	92	136	447	394	278	602	1.17	0.54	0.67	1.31	99.80	23.76	-24.95	6 219	67.62
11/20/94	18:45.00	540	687	676	700	788	777	1000	1069	1058	1076	206	118	109	176	98	92	137	445	394	279	595	1.17	0 57	0.63	1.33	99.80	23.99	-24.95	5.549	68.34
11/20/94	18:50.00	524	682	687	706	790	777	995	1042	1051	1070	206	119	110	176	98	92	137	441	392	278	583	1.16	0.59	0.63	1.34	99 80	24.28	-24.94	5.583	66.23
11/20/94	18:55:00	520	677	691	715	790	778	987	1060	1051	1093	206	119	111	176	98	92	138	437	383	278	592	1.16	0.56	0 64	1.32	99.80	24.54	-24.93	5.855	71.8
11/20/94	19.00.00	520	677	691	715	790	778	994	1043	1052	1074	205	120	111	176	98	92	138	432	377	278	589	1.15	0.55	0.63	1.29	99.80	24.90	-24.90	4 657	79.4
11/20/94	19.05.00	508	673	685	712	792	778	1029	1060	1054	1072	205	120	111	176	98	92	138	430	365	278	588	1.15	0.55	0.65	1.30	99.80	25.29	-24.85	5.287	80.5
11/20/94	19:10.00	434	632	649	693	789	775	1052	1043	1050	1084	207	121	112	177	98	92	139	430	376	278	586	1.15	0.50	0.62	1.32	99.80	25.60	-24.87	4.082	76.2
11/20/94	19:15.00	429	629	648	690	788	774	1022	1052	1049	1083	198	121	111	175	97	91	137	426	372	277	588	1.17	0.48	0.73	1.24	99.80	25.95	-24.92	7.49	86.6
11/20/94	19:20.00	400	613	632	665	776	763	1013	1051	1045	1068	193	121	110	170	97	90	132	417	363	278	581	1.14	0.43	0.85	1.39	99.80	26.53	-24.99	6.599	66.54
11/20/94	19:25.00	395	612	630	663	775	763	1032	1050	1057	1092	203	123	113	172	97	91	136	421	364	280	590	1.17	0.51	0.81	1.46	99.90	26.95	-25.00	5.837	69.63
11/20/94	19:30.00	395	611	630	663	775	763	1065	1051	1054	1065	205	124	114	174	98	91	139	422	361	279	582	1.18	0.54	0.80	1.50	99.90	27.36	-25.00	6.259	70.5
11/20/94	19.35.00	395	612	630	663	775	763	1076	1052	1050	1091	206	124	114	175	98	92	140	426	368	279	589	1.17	0.62	0.78	1.47	99.90	27.78	-25.00	6.287	65.74
11/20/94	19:40.00	395	611	630	662	775	763	1080	1052	1052	1067	206	124	115	176	98	92	140	425	363	278	589	1.16	0.63	0.79	1.45	99.90	28.23	-25.00	6.119	65 82
11/20/94	19.45.00	395	611	630	663	775	763	1084	1050	1052	1089	207	125	115	177	99	92	141	425	367	278	583	1.09	0.57	0.75	1.46	99.90	28.71	-25.00	6.049	63.09
11/20/94	19:50.00	395	611	630	662	775	763	1050	1050	1052	1068	207	125	116	178	99	92	141	424	362	279	581	1.13	0.60	0.77	1.43	99.90	29.08	-25.00	6.336	67.06
11/20/94	19:55:00	395	611	630	662	775	763	1046	1045	1052	1086	206	126	116	178	99	93	141	420	358	278	593	1.13	0.61	0.75	1.42	99.90	29.47	-25.00	7.54	71.4
11/20/94	20:00.00	395	611	630	662	775	763	1050	1053	1052	1083	206	125	115	178	99	93	141	419	356	278	587	1.13	0.57	0.72	1.37	99.90	29.93	-25.00	5.53	70.5
11/20/94	20.05.00	395	611	630	662	775	763	1054	1051	1054	1068	206	123	114	178	99	93	140	418	355	278	575	1.14	0.58	0.74	1.32	99.90	30.41	-24.99	5.168	65.53
11/20/94	20:10.00	395	611	630	663	775	763	1051	1052	1050	1083	207	122	112	178	99	93	139	417	355	278	585	1.06	0.49	0.72	1.35	99.90	30.81	-24.98	5.392	65.41
11/20/94	20:15.00	395	611	630	662	775	763	1053	1052	1053	1084	208	122	113	178	99	93	139	420	355	279	576	1.12	0 54	0.72	1.35	99.90	31.15	-24.88	4.547	63.58
11/20/94	20.20.00	395	611	630	662	775	763	1050	1051	1052	1083	210	123	113	178	99	93	139	425	357	278	574	1.12	0.53	0.71	1.38	99.90	31.54	-24.70	6.146	61.65
11/20/94	20.25.00	395	611	630	662	775	763	1048	1052	1053	1067	209	121	112	178	99	93	138	431	358	279	571	1.13	0.53	0.67	1.33	99.80	31.87	-24 31	5.386	63.48
11/20/94	20:30.00	395	611	630	662	775	763	1051	1051	1050	1083	210	116	109	177	99	92	137	440	370	278	562	1.15	0.56	0.69	1.26	99.90	32 20	-9.64	4.729	63.97
11/20/94	20:35:00	395	611	630	662	775	763	1054	1051	1054	1086	211	113	106	176	98	92	136	449	380	278	565	1.09	0.60	0.66	1.25	99.90	32.39	-1.94	4.906	61.1
11/20/94	20:40 00	395	611	630	662	775	763	1052	1052	1049	1070	211	111	104	176	98	92	134	455	388	279	560	1.05	0.48	0.64	1.24	99.90	32.68	-5.52	5.158	56.95
11/20/94	20:45.00	395	611	630	663	775	763	1050	1058	1053	1083	210	108	102	175	97	91	132	465	396	279	563	1.05	0.47	0.62	1.24	99.90	32.94	-7.80	5.102	61.93
11/20/94	20:50:00	395	611	630	662	775	763	1041	1051	1051	1084	209	106	101	174	96	91	131	474	398	279	543	1.05	0.44	0.61	1.24	99.80	33.03	-7.71	4.876	71.7
11/20/94	20:55:00	395	612	630	663	775	763	1048	1053	1053	1074	207	105	100	173	96	91	130	482	403	279	552	1.05	0.45	0.58	1.25	99.80	33.08	-15.42	4.789	79.3
11/20/94	21:00.00	395	611	630	663	775	763	1051	1056	1052	1084	205	104	98	172	95	90	130	492	415	279	544	1.06	0.52	0.56	1.23	99.80	33.14	-23.79	3.895	90 8
11/20/94	21:05.00	395	611	630	662	775	763	1032	1052	1058	1072	202	102	96	170	94	89	128	504	415	279	541	1.16	0.71	0.63	1.21	99.80	33 21	-24.69	5.313	100
11/20/94	21:10.00	395	612	630	663	775	763	997	1052	1054	1078	202	100	95	168	93	88	127	517	416	279	551	1.22	0.62	0.66	1.21	99.80	33.21	-25.00	6.458	92.4
11/20/94	21:15.00	395	611	630	662	775	763	991	1051	1058	1078	203	99	94	167	93	88	128	527	418	280	556	1.24	0.47	0.71	1 22	99.80	33.21	-25.00	6 714	87.4
11/20/94	21:20 00	395	611	630	662	775	763	962	1003	1048	1078	203	99	94	166	92	88	128	533	418	279	535	1 25	0 63	0 68	1 23	99.80	33 21	-25.00	6.345	81.5
11/20/94	21:25.00	395	611	630	662	775	763	948	1002	1048	1068	200	98	93	165	91	87	128	538	417	279	539	1.26	0 65	0.67	1.23	99.90	33.24	-25.00	6.412	89.1
11/20/94	21:30.00	395	611	630	662	775	763	957	1004	1064	1074	197	98	92	164	90	87	127	541	416	279	531	1.27	0 65	0 64	1.24	99.80	33.27	-25.00	5.795	81.5
11/20/94	21:35.00	395	611	630	662	775	763	949	1001	1057	1076	203	97	92	164	90	87	128	547	428	279	519	1.26	0 64	0.60	1.26	99.90	33.28	-25.00	4.723	65.21
11/20/94	21:40.00	NF	NF	NF	NF	NF	NF	942	996	1052	1059	192	97	91	162	89	85	126	538	414	276	507	1.13	0.59	0.67	1.25	99.90	33.32	-25.00	8 26	80.3
11/20/94	21:45.00	NF	NF	NF	NF	NF	NF	949	998	1043	1068	178	95	89	158	88	84	122	535	393	280	491	1.26	0.69	0.77	1.18	99.90	33.41	-25.00	6.805	85.9
11/20/94	21:50.00	NF	NF	NF	NF	NF	NF	896	955	1014	1051	188	95	89	159	88	85	122	542	410	280	479	1.26	0.70	0.66	1.26	100.00	33.43	-25 00	4.761	78.7
11/20/94	21:55:00	NF	NF	NF	NF	NF	NF	846	893	931	959	197	95	90	161	88	85	124	541	419	279	469	1.27	0.70	0.66	1.29	99.90	33.43	-25.00	5.537	79.7
11/20/94	22:00.00	NF	NF	NF	NF	NF	NF	748	776	788	812	200	94	89	161	87	85	124	527	400	279	452	1.27	0.64	0.67	1.20	100.00	33.43	-25.00	5.943	76.7
11/20/94	22:05.00	NF	NF	NF	NF	NF	NF	693.2	720	729	757	201	94	89	162	87	85	125	513	397	278	439	1.27	0.69	0.67	1.20	100.00	33.44	-25.00	5.291	68.59
11/20/94	22:10.00	NF	NF	NF	NF	NF	NF	656	677.9	686.8	714	202	93	89	162	87	84	124	497	384	278	426	1.26	0.73	0.69	1.20	100.00	33.41	-25.00	5.354	91.4
11/20/94	22:15:00	NF	NF	NF	NF	NF	NF	624.6	640.4	649.9	673.9	194	93	88	160	86	84	122	476	399	277	403	1.26	0 66	0.73	1.19	100.00	33.40	-25.00	6.068	85.5
11/20/94	22:20.00	NF	NF	NF	NF	NF	NF	596.7	607.1	616.5	639.2	198	93	88	161	86	84	123	459	395	278	376	1.26	0.67	0.78	1.20	100.00	33.39	-25.00	4.978	92.5

Table 6 - November 19 - 20, 1994 (Page 9 of 9)

		Temperature																												
Date	Time	BED 1	BED 2	BED 3	BED 4	BED 5	BED 6	ZONE 1	ZONE 2	ZONE 3	ZONE 4	Scrubber Inlet	Scrubber Outlet	ID Fan Inlet	ID Fan Outlet	HX Inlet	HX Outlet	Carbon Outlet	Reactor Outlet	Cyclone Inlet	Baghouse Inlet	Soil Discharge	DP (volts)	Flow DP (in H20)	Reactor DP (in H20)	Scrubber Level (in)	Tank 502 Level (%)	TanK 503 Level (%)	Tank 602 Level (%)	Wind Speed (mph)	Wind Direction
11/20/94	22:25.00	NF	NF	NF	NF	NF	NF	570 8	576 8	585.9	607.4	201	93	88	162	86	84	124	444	382	278	358	1.25	0.66	0.82	1.20	100 00	33.41	-25.00	4.676	83.5
11/20/94	22:30.00	NF	NF	NF	NF	NF	NF	547.8	549.1	557.9	577.2	202	93	89	162	86	84	124	429	364	277	347	1.23	0.66	0.86	1.19	100.00	33.39	-25.00	5.012	76.8
11/20/94	22:35.00	NF	NF	NF	NF	NF	NF	525.9	524.2	532	550.3	203	93	89	163	86	84	125	414	355	278	306	1.15	0.68	0 86	1.20	100.00	33.38	-25.00	4.499	65.37
11/20/94	22:40.00	NF	NF	NF	NF	NF	NF	505 6	501	507.9	524.5	204	93	89	163	86	84	126	401	343	278	275	1.20	0.72	0.88	1.19	100.00	33.37	-25.00	4.383	68.93
11/20/94	22:45.00	NF	NF	NF	NF	NF	NF	486.2	479.2	485.6	500.3	205	93	89	163	86	84	126	387	339	277	265	1.19	0.68	0.94	1.18	100.00	33.38	-25.00	4.098	63.91
11/20/94	22:50:00	NF	NF	NF	NF	NF	NF	468.5	458.7	465.1	477.5	206	93	89	164	86	84	127	373	336	277	252	1.19	0.66	0.99	1.18	100.00	33.38	-25.00	3.591	66.3
11/20/94	22:55:00	NF	NF	NF	NF	NF	NF	451.6	439.4	446.3	456.4	206	94	89	164	86	84	127	359	334	276	239	1.10	0.60	1.01	1.20	100.00	33.37	-25.00	3.933	56.99
11/20/94	23.00:00	NF	NF	NF	NF	NF	NF	436.2	422.1	428.4	436.7	205	93	89	165	86	84	128	345	329	275	231	1.09	0.60	1.05	1.19	100.00	33.38	-25.00	5.103	61.81
11/20/94	23:05:00	NF	NF	NF	NF	NF	NF	421.3	405.4	411.6	418.5	203	93	89	165	85	84	128	332	319	269	221	1.10	0.59	1.03	1.19	100.00	33.34	-25.00	5.563	64.09
11/20/94	23:10.00	NF	NF	NF	NF	NF	NF	406.3	390.2	395.8	402.2	200	93	88	165	85	84	128	320	309	261	211	1.10	0.62	0.95	1.18	100.00	33.34	-25.00	4.793	69.56
11/20/94	23:15:00	NF	NF	NF	NF	NF	NF	391.7	376.6	381.3	387.4	197	93	88	165	85	84	129	310	300	255	203	1.11	0.61	0 87	1.18	100.00	33.33	-25.00	4.499	66.56
11/20/94	23:20.00	NF	NF	NF	NF	NF	NF	380	363.4	367.8	373.2	191	92	88	165	85	84	128	299	290	246	196	1.11	0.62	0 81	1.17	100.00	33.31	-25.00	6 61	68.35
11/20/94	23:25.00	NF	NF	NF	NF	NF	NF	366.6	351.4	354.9	360.5	186	92	88	164	85	84	128	289	280	239	189	1.11	0.60	0.72	1.17	99.90	33.32	-25.00	5.882	74.1
11/20/94	23:30.00	NF	NF	NF	NF	NF	NF	354.3	340.2	343.3	349.1	183	91	87	164	85	84	128	280	271	232	182	1.12	0.60	0.64	1.14	100.00	33.31	-25.00	4.16	72.9
11/20/94	23:35:00	NF	NF	NF	NF	NF	NF	343.1	329.6	332.6	338.5	180	91	87	164	85	84	129	272	263	227	176	1.12	0.63	0.57	1.23	99.90	33.31	-25.00	4.035	65.71
11/20/94	23:40.00	NF	NF	NF	NF	NF	NF	332 8	320.1	322.5	328.2	177	91	87	164	85	84	129	264	256	221	170	1.13	0.60	0.51	1.21	99.90	33.30	-25.00	4.541	69.35
11/20/94	23:45:00	NF	NF	NF	NF	NF	NF	322.8	310.5	312.8	318.5	171	90	87	163	85	83	129	255	248	214	165	1.13	0.59	0.46	1.19	99.90	33.33	-25.00	4.994	71.9
11/20/94	23:50:00	NF	NF	NF	NF	NF	NF	313.2	301.6	303.9	309.6	169	90	86	163	85	83	129	248	241	209	160	1.14	0 60	0.41	1.20	99.90	33.32	-25.00	3.653	69.18
11/20/94	23:55.00	NF	NF	NF	NF	NF	NF	304.5	293.6	295.8	301.4	167	89	86	164	84	83	130	242	235	204	156	1.14	0 63	0.37	1.19	99.90	33.32	-25.00	3.274	69.47

NF=Temperature Monitor Not Functioning Correctly

Table 7 - November 28 - 30, 1994 (Page 1 of 2)

Real Time	Reference Time (hrs)	Temperature Oil Mid (°F)	Temperature Head Space (°F)	Temperature STR Offgas (°F)	Temperature Cond Inlet (°F)
11/28/94 9:35	0.00	131.0	119.0	107.0	96.0
10:00	0.42	136.0	143.0	121.0	103.0
10:30	0.92	165.0	179.0	145.0	112.0
10:46	1.18	192.0	189.0	157.0	122.0
11:00	1.42	204.0	196.0	163.0	128.0
11:15	1.67	212.0	204.0	176.0	152.0
11:30	1.92	215.0	204.0	175.0	150.0
11:45	2.17	216.0	203.0	169.0	142.0
12:00	2.42	216.0	202.0	167.0	137.0
12:17	2.70	216.0	204.0	167.0	138.0
12:34	2.98	222.0	214.0	187.0	165.0
12:45	3.17	223.0	216.0	187.0	166.0
13:00	3.42	224.0	216.0	183.0	161.0
13:15	3.67	226.0	215.0	186.0	168.0
13:30	3.92	230.0	221.0	205.0	188.0
13:45	4.17	231.0	220.0	202.0	184.0
14:02	4.45	231.0	220.0	196.0	175.0
14:15	4.67	231.0	220.0	196.0	174.0
14:30	4.92	233.0	231.0	204.0	192.0
14:45	5.17	233.0	234.0	201.0	186.0
15:00	5.42	234.0	237.0	203.0	194.0
15:17	5.70	239.0	238.0	205.0	198.0
15:30	5.92	239.0	240.0	206.0	196.0
15:46	6.18	241.0	240.0	205.0	197.0
16:00	6.42	243.0	243.0	209.0	199.0
16:16	6.68	244.0	243.0	220.0	200.0
16:30	6.92	244.0	244.0	215.0	194.0
16:45	7.17	244.0	230.0	212.0	187.0
17:00	7.42	244.0	227.0	203.0	179.0
17:18	7.72	245.0	229.0	209.0	183.0
17:40	8.08	248.0	234.0	211.0	184.0
19:13	9.63	249.0	230.0	200.0	170.0
19:34	9.98	252.0	234.0	205.0	173.0
20:11	10.60	250.0	231.0	195.0	161.0
20:47	11.20	253.0	226.0	194.0	164.0
21:17	11.70	260.0	237.0	213.0	185.0
21:50	12.25	265.0	247.0	217.0	188.0
22:10	12.58	267.0	247.0	214.0	184.0
23:00	13.42	275.0	257.0	219.0	184.0
11/29/94 8:05	22.50	225.0			
8:30	22.92	238.0	237.0	181.0	131.0
8:35	23.00	243.0	244.0	187.0	136.0
8:56	23.35	258.0	250.0	194.0	150.0
9:28	23.88	276.0	257.0	207.0	169.0
9:46	24.18	280.0	257.0	210.0	173.0
10:08	24.55	288.0	265.0	217.0	176.0
10:23	24.80	290.0	263.0	214.0	173.0

Table 7 - November 28 - 30, 1994 (Page 2 of 2)

Real Time	Reference Time (hrs)	Temperature Oil Mid (°F)	Temperature Head Space (°F)	Temperature STR Offgas (°F)	Temperature Cond Inlet (°F)
10:50	25.25	289.0	256.0	208.0	165.0
12:10	26.58	304.0	264.0	217.0	164.0
13:08	27.55	308.0	285.0	217.0	159.0
13:50	28.25	316.0	296.0	228.0	163.0
14:25	28.83	322.0	298.0	227.0	163.0
14:50	29.25	322.0	298.0	220.0	163.0
15:23	29.80	323.0	273.0	163.0	103.0
15:45	30.17	330.0	245.0	223.0	112.0
16:00	30.42	336.0	296.0	239.0	133.0
16:20	30.75	349.0	312.0	254.0	179.0
16:44	31.15	367.0	320.0	258.0	195.0
16:57	31.37	379.0	334.0	286.0	189.0
17:40	32.08	421.0	367.0	305.0	187.0
18:00	32.42	441.0	382.0	276.0	185.0
18:36	33.02	475.0	426.0	268.0	164.0
19:06	33.52	501.0	452.0	254.0	140.0
20:00	34.42	551.0	509.0	275.0	152.0
20:30	34.92	577.0	545.0	310.0	147.0
21:00	35.42	604.0	580.0	379.0	155.0
21:15	35.67	618.0	601.0	472.0	171.0
21:46	36.18	635.0	625.0	516.0	256.0
22:00	36.42	644.0	634.0	541.0	314.0
22:22	36.78	655.0	640.0	585.0	495.0
23:01	37.43	661.0	640.0	565.0	155.0
11/30/94 0:00	38.42	660.0	629.0	404.0	96.0
0:25	38.83	659.0	631.0	404.0	91.0
1:15	39.67	662.0	632.0	431.0	88.0
8:53	47.30	560.0			

Table 8 - May 15 - 16, 1995 (Page 1 of 1)

Real Time	Reference Time (hrs)	Temperature Oil (°C)	Temperature Condenser (°C)	Flow Condensate (ml)
5/15/95 12:00	0.00	33.8	35.3	0.0
12:15	0.25	87.5	35.8	0.0
12:27	0.45	112.8	37.8	0.0
12:32	0.53	110.5		0.0
12:33	0.55			0.0
12:38	0.63	110.9	41.0	0.0
12:50	0.83	112.9	63.0	0.0
13:00	1.00	115.0	70.4	0.0
13:03	1.05	117.0	70.0	0.0
13:11	1.18	120.0	61.2	0.4
13:22	1.37	125.8	70.0	0.6
13:34	1.57	137.0	55.3	0.9
13:43	1.72	147.6	48.1	0.9
13:56	1.93	172.0	45.3	0.9
14:04	2.07	188.6	47.3	1.0
14:09	2.15	192.8		1.0
14:30	2.50	195.0		
15:00	3.00	172.0		
15:30	3.50	136.0		
16:07	4.12	112.0		
16:14	4.23			
5/16/95 9:08	21.13	33.5	32.0	0.3
9:19	21.32	69.1	35.0	0.3
9:23	21.38	81.7	32.3	0.3
9:26	21.43	94.0		0.3
9:37	21.62	128.5	32.3	0.3
10:06	22.10	195.8	24.5	0.35
10:17	22.28	215.1	26.1	0.42
10:27	22.45	230.0	32.0	0.42
10:45	22.75	254.0	33.0	0.42
10:54	22.90	260.0		0.45
11:00	23.00	275.6	35.0	0.45
11:22	23.37	314.0		0.45
11:38	23.63	336.0		0.55
11:47	23.78	344.0	39.2	0.75
11:55	23.92	349.5	39.8	1.15
12:08	24.13	348.0		1.55
12:18	24.30	347.1	39.4	1.75
12:39	24.65	348.3		1.95
13:00	25.00	349.3		2.25
13:05	25.08	349.0	36.9	2.45
13:15	25.25	351.0	38.0	2.45
13:27	25.45	352.7	40.5	2.65
13:45	25.75	352.5		3.25
13:55	25.92	352.5	39.5	3.45
14:14	26.23	300.0		
14:30	26.50	261.0		
14:45	26.75	229.0		
15:05	27.08	200.0		
16:34	28.57	123.3		

Time (hrs)	Oil (°C)	Condenser (°C)	Condensate (ml)
21.13	33.5	32.0	0.3
21.32	69.1	35.0	0.3
21.38	81.7	32.3	0.3
21.43	94.0		0.3
21.62	128.5	32.3	0.3
22.10	195.8	24.5	0.35
22.28	215.1	26.1	0.42
22.45	230.0	32.0	0.42
22.75	254.0	33.0	0.42
22.90	260.0		0.45
23.00	275.6	35.0	0.45
23.37	314.0		0.45
23.63	336.0		0.55
23.78	344.0	39.2	0.75
23.92	349.5	39.8	1.15
24.13	348.0		1.55
24.30	347.1	39.4	1.75
24.65	348.3		1.95
25.00	349.3		2.25
25.08	349.0	36.9	2.45
25.25	351.0	38.0	2.45
25.45	352.7	40.5	2.65
25.75	352.5		3.25
25.92	352.5	39.5	3.45
26.23	300.0		
26.50	261.0		
26.75	229.0		
27.08	200.0		
28.57	123.3		

Table 9 - May 17, 1995 (Page 1 of 1)

Real Time	Referenced Time (hrs)	Temperature Oil Mid (°F)	Temperature Head Space (°F)	Temperature STR Offgas (°F)	Temperature Cond Inlet (°F)
5/17/95 6:30	0.00	156.0	132.0	87.0	81.0
7:00	0.50	162.0	190.0	92.0	83.0
7:30	1.00	181.0	254.0	105.0	88.0
8:00	1.50	207.0	310.0	143.0	95.0
8:30	2.00	223.0	259.7	155.7	94.6
9:00	2.50	232.0	276.0	239.0	208.0
9:30	3.00	235.0	271.0	240.0	214.0
10:00	3.50	240.0	299.0	231.0	219.0
11:00	4.50	269.0	276.0	209.0	160.0
11:30	5.00	281.0	299.0	204.0	112.0
12:00	5.50	300.0	317.0	210.0	105.0
12:30	6.00	325.0	345.0	234.0	127.0
13:00	6.50	354.0	366.0	238.0	109.0
13:30	7.00	384.0	367.0	242.0	105.0
14:00	7.50	412.0	394.0	240.0	103.0
14:30	8.00	442.0	406.0	253.0	102.0
15:00	8.50	472.0	437.0	248.0	101.0
15:30	9.00	500.0	452.0	231.0	96.0
16:00	9.50	530.0	478.0	219.0	96.0
16:30	10.00	553.0	459.0	227.0	100.0
17:00	10.50	581.0	484.0	228.0	106.0
17:30	11.00	604.0	531.0	249.0	102.0
18:00	11.50	628.0	592.0	278.0	105.0
18:30	12.00	648.0	619.0	399.0	114.0
19:00	12.50	660.0	632.0	577.0	265.0
19:30	13.00	664.0	641.0	568.0	271.0
20:00	13.50	664.0	640.0	521.0	137.0
20:30	14.00	668.0	646.0	577.0	217.0
21:00	14.50	667.0	636.0	413.0	103.0
22:00	15.50	665.0	634.0	418.0	88.0
22:30	16.00	660.0	595.0	233.0	84.0
23:00	16.50	653.0	557.0	142.0	84.0
23:30	17.00	647.0	526.0	137.0	84.0

Table 10 - May 18 - 19, 1995 (Page 1 of 2)

Real Time	Reference Time(hrs)	Temperature Oil (°C)	Temperature Condenser (°C)	Organic (ml)	Aqueous (ml)
5/18/95 16:11	0.00	106.2	39	0.0	0.0
16:15	0.07	107.8	39.9	0.0	0.0
16:28	0.28	109.9	47.8	0.0	0.4
16:34	0.38	108.7	52.3	0.0	0.8
16:42	0.52	109.9	60.9	0.0	1.6
16:55	0.73	103.4	66.8	0.0	4.0
17:00	0.82	107	71.1	0.0	6.0
17:03	0.87	105.9	73	0.0	6.7
17:04	0.88	105		0.0	7.4
17:10	0.98	110	62	0.0	9.4
17:14	1.05	108.2	53.6	0.0	10.4
17:30	1.32	110.7	56.2	0.0	11.7
17:33	1.37		71.1	0.0	13.0
17:37	1.43	110.2	67.4	0.0	13.7
17:42	1.52	113	71.7	0.0	15.5
5/19/95 7:03	14.87	27.8	28	0.0	17.4
7:17	15.10	47.1		0.0	17.5
7:32	15.35	79.4	32	0.0	17.5
7:45	15.57	101.6	40	0.0	18.0
7:53	15.70	111.6	49.4	0.0	18.7
8:00	15.82	117.2	66.1	0.0	20.0
8:02	15.85	111.6	83.3	0.0	20.8
8:04	15.88	115.5	74.2	0.0	22.0
8:13	16.03	116.8	68.8	0.0	24.8
8:28	16.28	117.6	57	0.0	28.4
8:44	16.55	120.3		0.0	31.3
8:55	16.73	122.1	60.7	0.0	33.2
9:06	16.92	124.8	60.2	0.0	35.7
9:10	16.98	130.2	59.9	0.0	36.5
9:16	17.08	133.2	65	0.0	38.0
9:25	17.23	134.8	59.7	0.0	40.0
9:35	17.40	147.3	66.2	0.0	42.2
9:50	17.65	164.8	60.6	0.0	45.9
10:12	18.02	213.4	56.5	0.0	50.9
10:27	18.27	206.2	38.1	0.8	52.0
10:45	18.57	235.4	40.5	2.4	52.7
10:52	18.68	253	43.5	3.0	52.9
11:06	18.92	301	52.5	5.0	52.9

Time (hrs)	Oil (°C)	Condenser (°C)	Organic (ml)	Aqueous (ml)
0.00	106.2	39	0.0	0.0
0.07	107.8	39.9	0.0	0.0
0.28	109.9	47.8	0.0	0.4
0.38	108.7	52.3	0.0	0.8
0.52	109.9	60.9	0.0	1.6
0.73	103.4	66.8	0.0	4.0
0.82	107	71.1	0.0	6.0
0.87	105.9	73	0.0	6.7
0.88	105		0.0	7.4
0.98	110	62	0.0	9.4
1.05	108.2	53.6	0.0	10.4
1.32	110.7	56.2	0.0	11.7
1.37		71.1	0.0	13.0
1.43	110.2	67.4	0.0	13.7
1.52	113	71.7	0.0	15.5
14.87	27.8	28	0.0	17.4
15.10	47.1		0.0	17.5
15.35	79.4	32	0.0	17.5
15.57	101.6	40	0.0	18.0
15.70	111.6	49.4	0.0	18.7
15.82	117.2	66.1	0.0	20.0
15.85	111.6	83.3	0.0	20.8
15.88	115.5	74.2	0.0	22.0
16.03	116.8	68.8	0.0	24.8
16.28	117.6	57	0.0	28.4
16.55	120.3		0.0	31.3
16.73	122.1	60.7	0.0	33.2
16.92	124.8	60.2	0.0	35.7
16.98	130.2	59.9	0.0	36.5
17.08	133.2	65	0.0	38.0
17.23	134.8	59.7	0.0	40.0
17.40	147.3	66.2	0.0	42.2
17.65	164.8	60.6	0.0	45.9
18.02	213.4	56.5	0.0	50.9
18.27	206.2	38.1	0.8	52.0
18.57	235.4	40.5	2.4	52.7
18.68	253	43.5	3.0	52.9
18.92	301	52.5	5.0	52.9

Table 10 - May 18 - 19, 1995 (Page 2 of 2)

Real Time	Reference Time(hrs)	Temperature Oil (°C)	Temperature Condenser (°C)	Organic (ml)	Aqueous (ml)
11:20	19.15	337.8	59.3	7.7	53.2
11:25	19.23	349.2	65	9.6	53.5
11:30	19.32	358.4	67.6	11.0	53.7
11:33	19.37	351.5	67.7	12.6	53.7
11:38	19.45	356.3	63.9	15.0	53.7
12:16	20.08	348.8	62.6	27.0	53.7
12:35	20.40	349.5	50.1	33.6	53.7
12:40	20.48	350		35.3	53.7
12:55	20.73	351.7	51.9	38.9	53.7
14:17	22.10	209	34.7	43.1	53.7
14:36	22.42	277.4	43.5	43.3	53.7
14:55	22.73	349	58.7	47.1	53.7
15:10	22.98	351.9	61.2	51.8	53.7
15:18	23.12	352.2	60.6	54.9	53.7
15:43	23.53	351.6	53.8	64.3	53.7
16:05	23.90	352.3	51	70.6	53.7
16:25	24.23	353	47.1	74.8	53.7
5/22/95 6:15	86.07			78.2	53.7

Time (hrs)	Oil (°C)	Condenser (°C)	Organic (ml)	Aqueous (ml)
19.15	337.8	59.3	7.7	53.2
19.23	349.2	65	9.6	53.5
19.32	358.4	67.6	11.0	53.7
19.37	351.5	67.7	12.6	53.7
19.45	356.3	63.9	15.0	53.7
20.08	348.8	62.6	27.0	53.7
20.40	349.5	50.1	33.6	53.7
20.48	350		35.3	53.7
20.73	351.7	51.9	38.9	53.7
22.10	209	34.7	43.1	53.7
22.42	277.4	43.5	43.3	53.7
22.73	349	58.7	47.1	53.7
22.98	351.9	61.2	51.8	53.7
23.12	352.2	60.6	54.9	53.7
23.53	351.6	53.8	64.3	53.7
23.90	352.3	51	70.6	53.7
24.23	353	47.1	74.8	53.7
86.07			78.2	53.7

Table 11 - May 22 - 23, 1995 (Page 1 of 2)

Real Time	Reference Time (hrs)	Temperature Oil (°C)	Temperature Condenser °C)	Organic (ml)	Aqueous (ml)
5/22/95 12:10	0.00	80.7	32.4	0	0
12:25	0.25	104.8	34.6	0	0
12:32	0.37	114.7	35.1	0	0
12:43	0.55	129	36.2	0	0
12:58	0.80	135.2	37.9	0	0
13:57	1.78	100.5	36.3	0	0
14:20	2.17	121	36	0	0
14:50	2.67	148.1	37	0	0.1
15:10	3.00	160.9	38.5	0.3	0.7
15:40	3.50	180.6	38.9	0.9	2
15:43	3.55	182.3	38.9	0.9	2.2
15:48	3.63	183.6	39	1	2.5
15:56	3.77	177.9	39.2	1	3.1
16:03	3.88	170	36.4	1.2	3.2
16:16	4.10	166.4	33.7	1.3	4
16:25	4.25	166.6	33	1.4	4.3
16:41	4.52	171.4	34.8	1.4	4.7
17:05	4.92	190.2	35.3	1.7	5.5
17:10	5.00	194.5	35.4	1.7	5.6
17:40	5.50	214.6	39.9	1.9	7
17:52	5.70	222.1	41.3	2	7.8
18:15	6.08	233	58.9	2.5	11.5
18:40	6.50	241	59.4	2.9	17.6
18:50	6.67	244	60.3	3.4	20.1
19:15	7.08	255	61.9	4.4	27.1
19:47	7.62	267	64.1	5.3	36.9
20:05	7.92	269	65.7	6.7	41.8
20:18	8.13	268	55.5	9.5	44.5
5/23/95 12:30	24.33	35.9	28.2	10.7	44.9
13:02	24.87	108.9	29.3	10.7	44.9
13:43	25.55	222	46.5	10.7	45.1
14:23	26.22	263	66.6	12.3	45.7
14:25	26.25	263	68.4	12.3	45.7
14:38	26.47	257	68.2	14.4	46.3
14:45	26.58	254	64.6	14.7	46.5
15:15	27.08	266	82	17.5	46.9

Time (hrs)	Oil (°C)	Condenser (°C)	Organic (ml)	Aqueous (ml)
0.00	80.7	32.4	0	0
0.25	104.8	34.6	0	0
0.37	114.7	35.1	0	0
0.55	129	36.2	0	0
0.80	135.2	37.9	0	0
1.78	100.5	36.3	0	0
2.17	121	36	0	0
2.67	148.1	37	0	0.1
3.00	160.9	38.5	0.3	0.7
3.50	180.6	38.9	0.9	2
3.55	182.3	38.9	0.9	2.2
3.63	183.6	39	1	2.5
3.77	177.9	39.2	1	3.1
3.88	170	36.4	1.2	3.2
4.10	166.4	33.7	1.3	4
4.25	166.6	33	1.4	4.3
4.52	171.4	34.8	1.4	4.7
4.92	190.2	35.3	1.7	5.5
5.00	194.5	35.4	1.7	5.6
5.50	214.6	39.9	1.9	7
5.70	222.1	41.3	2	7.8
6.08	233	58.9	2.5	11.5
6.50	241	59.4	2.9	17.6
6.67	244	60.3	3.4	20.1
7.08	255	61.9	4.4	27.1
7.62	267	64.1	5.3	36.9
7.92	269	65.7	6.7	41.8
8.13	268	55.5	9.5	44.5
24.33	35.9	28.2	10.7	44.9
24.87	108.9	29.3	10.7	44.9
25.55	222	46.5	10.7	45.1
26.22	263	66.6	12.3	45.7
26.25	263	68.4	12.3	45.7
26.47	257	68.2	14.4	46.3
26.58	254	64.6	14.7	46.5
27.08	266	82	17.5	46.9
27.27	273	92	20.2	48

Table 11 - May 22 - 23, 1995 (Page 2 of 2)

Real Time	Reference Time (hrs)	Temperature Oil (°C)	Temperature Condenser °C)	Organic (ml)	Aqueous (ml)
15:26	27.27	273	92	20.2	48
15:36	27.43	282	87.8	23.9	49.9
15:43	27.55	288	103.9	29.5	51.1
15:52	27.70	303	122	40.9	54.9
15:56	27.77	308	133.6	51.1	57.1
15:58	27.80	312	145.7	57.3	58.5
16:02	27.87	320	170	75.1	60.9
16:06	27.93	326	183	92.9	63.1
16:09	27.98	332	191	111.1	65.1
16:12	28.03	334	194	129.5	66.7
16:16	28.10	335	188	148.5	67.7
16:20	28.17	340	177	168.3	68.5
16:23	28.22	344	175	187.7	69.1
16:26	28.27	349	175	207.2	69.6
16:30	28.33	354	174	226.7	70.1
16:34	28.40	354	147	246.2	70.6
16:42	28.53	351	120	265.9	70.9
16:50	28.67	354	120	285.7	71.1
16:59	28.82	356	117	305.7	71.1
17:08	28.97	359	112	325.7	71.1
17:18	29.13	359	110	346.5	71.1
17:29	29.32	358	99.9	366.5	71.1
17:43	29.55	355	106.6	386.5	71.1
17:59	29.82	355	104.4	406.5	71.1
18:16	30.10	355	102	426.5	71.1
18:42	30.53	359	97.4	446.5	71.1
19:03	30.88	355	88.8	466.5	71.1
19:34	31.40	356	93	486.5	71.1
20:05	31.92	354	93	507.1	71.1
20:30	32.33	354	93	519.7	71.1
20:52	32.70	310		526	71.1
5/24/95 7:30	43.33			527.3	71.1

Time (hrs)	Oil (°C)	Condenser (°C)	Organic (ml)	Aqueous (ml)
27.43	282	87.8	23.9	49.9
27.55	288	103.9	29.5	51.1
27.70	303	122	40.9	54.9
27.77	308	133.6	51.1	57.1
27.80	312	145.7	57.3	58.5
27.87	320	170	75.1	60.9
27.93	326	183	92.9	63.1
27.98	332	191	111.1	65.1
28.03	334	194	129.5	66.7
28.10	335	188	148.5	67.7
28.17	340	177	168.3	68.5
28.22	344	175	187.7	69.1
28.27	349	175	207.2	69.6
28.33	354	174	226.7	70.1
28.40	354	147	246.2	70.6
28.53	351	120	265.9	70.9
28.67	354	120	285.7	71.1
28.82	356	117	305.7	71.1
28.97	359	112	325.7	71.1
29.13	359	110	346.5	71.1
29.32	358	99.9	366.5	71.1
29.55	355	106.6	386.5	71.1
29.82	355	104.4	406.5	71.1
30.10	355	102	426.5	71.1
30.53	359	97.4	446.5	71.1
30.88	355	88.8	466.5	71.1
31.40	356	93	486.5	71.1
31.92	354	93	507.1	71.1
32.33	354	93	519.7	71.1
32.70	310		526	71.1
43.33			527.3	71.1

Table 12 - May 25 - 26, 1995 (Page 1 of 1)

Real Time	Reference Time (hrs)	Temperature Oil Mid (°F)	Temperature Head Space (°F)	Temperature STR Offgas (°F)	Temperature Cond Inlet (°F)	Flow Cond. (lb)
5/25/95 6:30	0.00	216.0	168.0	104.0	79.0	
7:02	0.53	218.0	198.0	118.0	83.0	0.0
7:29	0.98	229.0	242.0	137.0	89.0	
7:43	1.22	234.0	229.0	178.0	95.0	
8:00	1.50	236.0	259.0	243.0	210.4	
8:30	2.00	236.0	253.0	232.0	208.0	4.0
8:36	2.10	235.0	237.0	223.0	178.0	6.0
9:00	2.50	236.0	248.0	233.0	210.0	7.5
9:30	3.00	237.0	264.0	244.0	213.0	15.5
10:00	3.50	239.0	260.0	230.0	212.0	25.5
10:30	4.00	243.0	276.0	247.0	214.0	35.5
11:00	4.50	248.0	273.0	252.0	214.0	46.0
11:30	5.00	255.0	282.0	251.0	214.0	56.0
12:00	5.50	262.0	285.0	259.0	215.0	64.5
12:30	6.00	276.0	305.0	269.0	215.0	75.0
12:46	6.27	286.0	303.0	271.0	215.0	
13:00	6.50	292.0	313.0	276.0	215.0	83.5
13:30	7.00	310.0	325.0	281.0	216.0	91.5
14:00	7.50	331.0	339.0	292.0	215.0	100.0
14:30	8.00	358.0	355.0	297.0	214.0	105.5
15:00	8.50	383.0	369.0	300.0	209.0	109.5
15:30	9.00	411.0	385.0	311.0	212.0	113.0
16:00	9.50	440.0	403.0	302.0	192.0	115.5
16:30	10.00	465.0	426.0	286.0	152.0	118.0
17:00	10.50	496.0	455.0	260.0	132.0	
17:30	11.00	520.0	476.0	256.0	108.0	121.0
18:00	11.50	548.0	498.0	261.0	117.0	
18:30	12.00	575.0	520.0	282.0	117.0	124.0
19:00	12.50	600.0	550.0	267.0	103.0	
19:30	13.00	623.0	587.0	307.0	110.0	
19:45	13.25	634.0	600.0	360.0	167.0	
20:00	13.50	642.0	615.0	402.0	157.0	125.0
20:15	13.75	650.0	626.0	491.0	212.0	
20:30	14.00	655.0	635.0	566.0	329.0	131.0
20:45	14.25	660.0	641.0	594.0	501.0	
21:00	14.50	664.0	645.0	600.0	502.0	138.0
21:30	15.00	662.0	620.0	465.0	162.0	141.0
22:00	15.50	667.0	646.0	585.0	183.0	
22:30	16.00	668.0	644.0	552.0	157.0	
23:10	16.67	672.0	643.0	589.0	142.0	
23:40	17.17	672.0	651.0	609.0	514.0	
23:59	17.48	672.0	647.0	581.0	204.1	
5/26/95 0:30	18.00	672.0	648.0	566.0	173.0	
1:00	18.50	675.0	656.0	620.0	443.0	
1:40	19.17	673.0	650.0	569.0	152.0	
2:00	19.50	675.0	655.0	620.0	238.0	
2:19	19.82	675.0	650.0	587.0	194.0	
2:39	20.15	672.0	643.0	512.0	165.0	296.0

Time (hrs)	Oil Mid (°F)	Head Space (°F)	STR Offgas (°F)	Cond Inlet (°F)	Condensate (lb)
0.00	216.0	168.0	104.0	79.0	
0.53	218.0	198.0	118.0	83.0	0.0
0.98	229.0	242.0	137.0	89.0	
1.22	234.0	229.0	178.0	95.0	
1.50	236.0	259.0	243.0	210.4	
2.00	236.0	253.0	232.0	208.0	4.0
2.10	235.0	237.0	223.0	178.0	6.0
2.50	236.0	248.0	233.0	210.0	7.5
3.00	237.0	264.0	244.0	213.0	15.5
3.50	239.0	260.0	230.0	212.0	25.5
4.00	243.0	276.0	247.0	214.0	35.5
4.50	248.0	273.0	252.0	214.0	46.0
5.00	255.0	282.0	251.0	214.0	56.0
5.50	262.0	285.0	259.0	215.0	64.5
6.00	276.0	305.0	269.0	215.0	75.0
6.27	286.0	303.0	271.0	215.0	
6.50	292.0	313.0	276.0	215.0	83.5
7.00	310.0	325.0	281.0	216.0	91.5
7.50	331.0	339.0	292.0	215.0	100.0
8.00	358.0	355.0	297.0	214.0	105.5
8.50	383.0	369.0	300.0	209.0	109.5
9.00	411.0	385.0	311.0	212.0	113.0
9.50	440.0	403.0	302.0	192.0	115.5
10.00	465.0	426.0	286.0	152.0	118.0
10.50	496.0	455.0	260.0	132.0	
11.00	520.0	476.0	256.0	108.0	121.0
11.50	548.0	498.0	261.0	117.0	
12.00	575.0	520.0	282.0	117.0	124.0
12.50	600.0	550.0	267.0	103.0	
13.00	623.0	587.0	307.0	110.0	
13.25	634.0	600.0	360.0	167.0	
13.50	642.0	615.0	402.0	157.0	125.0
13.75	650.0	626.0	491.0	212.0	
14.00	655.0	635.0	566.0	329.0	131.0
14.25	660.0	641.0	594.0	501.0	
14.50	664.0	645.0	600.0	502.0	138.0
15.00	662.0	620.0	465.0	162.0	141.0
15.50	667.0	646.0	585.0	183.0	
16.00	668.0	644.0	552.0	157.0	
16.67	672.0	643.0	589.0	142.0	
17.17	672.0	651.0	609.0	514.0	
17.48	672.0	647.0	581.0	204.1	
18.00	672.0	648.0	566.0	173.0	
18.50	675.0	656.0	620.0	443.0	
19.17	673.0	650.0	569.0	152.0	
19.50	675.0	655.0	620.0	238.0	
19.82	675.0	650.0	587.0	194.0	
20.15	672.0	643.0	512.0	165.0	296.0

Time (hrs)	Oil Mid (°F)	Cond Inlet (°F)	Condensate (lb)
0.00	216.0	79.0	
0.53	218.0	83.0	0.0
0.98	229.0	89.0	
1.22	234.0	95.0	
1.50	236.0	210.4	
2.00	236.0	208.0	4.0
2.10	235.0	178.0	6.0
2.50	236.0	210.0	7.5
3.00	237.0	213.0	15.5
3.50	239.0	212.0	25.5
4.00	243.0	214.0	35.5
4.50	248.0	214.0	46.0
5.00	255.0	214.0	56.0
5.50	262.0	215.0	64.5
6.00	276.0	215.0	75.0
6.27	286.0	215.0	
6.50	292.0	215.0	83.5
7.00	310.0	216.0	91.5
7.50	331.0	215.0	100.0
8.00	358.0	214.0	105.5
8.50	383.0	209.0	109.5
9.00	411.0	212.0	113.0
9.50	440.0	192.0	115.5
10.00	465.0	152.0	118.0
10.50	496.0	132.0	
11.00	520.0	108.0	121.0
11.50	548.0	117.0	
12.00	575.0	117.0	124.0
12.50	600.0	103.0	
13.00	623.0	110.0	
13.25	634.0	167.0	
13.50	642.0	157.0	125.0
13.75	650.0	212.0	
14.00	655.0	329.0	131.0
14.25	660.0	501.0	
14.50	664.0	502.0	138.0
15.00	662.0	162.0	141.0
15.50	667.0	183.0	
16.00	668.0	157.0	
16.67	672.0	142.0	
17.17	672.0	514.0	
17.48	672.0	204.1	
18.00	672.0	173.0	
18.50	675.0	443.0	
19.17	673.0	152.0	
19.50	675.0	238.0	
19.82	675.0	194.0	
20.15	672.0	165.0	296.0

Table 13 - May 25, 1995 (Page 1 of 1)

Real Time	Reference Time(hrs)	Temperature Oil (°C)	Temperature Condenser (°C)	Flow Condensate	
				Organic (ml)	Aqueous (ml)
5/25/95 7:47	0.00	28.2	30.5	0.0	0.0
8:06	0.32	84.6	39.7	0.0	0.0
8:21	0.57	133.0	44.6	0.0	0.0
8:39	0.87	179.0	48.9	0.3	0.3
8:57	1.17	214.0	64.4	0.5	1.1
9:08	1.35	231.0	62.9	2.3	1.5
9:20	1.55	248.0	72.1	5.6	1.6
9:30	1.72	269.0	96.5	13.9	1.6
9:48	2.02	288.0	33.2	17.6	1.6
9:53	2.10	294.0	33.1	17.7	1.6
10:00	2.22	304.0		17.9	1.6
10:05	2.30	303.0	43.4	18.2	1.6
10:12	2.42	302.0	67.6	18.9	1.6
10:25	2.63	281.0	66.0	21.6	1.6
10:34	2.78	280.0	74.0	23.4	2.3
10:51	3.07	290.0		25.5	3.3
11:06	3.32	304.0	52.0	28.0	3.5
11:12	3.42	309.0	64.3	28.9	3.6
11:29	3.70	333.0	94.0	40.9	3.6
11:39	3.87	344.0	79.0	48.5	5.0
11:46	3.98	350.0	79.8	51.9	5.8
12:07	4.33	354.0		57.1	7.0
12:38	4.85	355.0	57.1	60.6	7.8
13:19	5.53	355.8	37.9	61.3	8.0
14:15	6.47	354.0	45.9	62.2	8.1
14:40	6.88	358.8	42.8	65.1	8.6
15:18	7.52	359.5	48.8	66.1	8.8
16:09	8.37	359.5	60.4	67.9	8.8
Final				68.7	

Appendix E

Analytical Data

Table of Contents

February 5, 1994 Hot Run

Table 1.1. Sample Log for February 5, 1994 Hot Run E.1
Table 1.2. February 5, 1994 Hot-Run PCB Analytical Results (On Site GC/MS Results) E.3
Table 1.3. February 5, 1994 Hot-Run PCB Analytical Results (SWRI EPA Method 680-SIM) E.5
Table 1.4. February 5, 1994 Hot-Run PCB Analytical Results (SWRI Method 8080) E.6
Table 1.5. February 5, 1994 Hot-Run Dioxin/Furan Analytical Results (SWRI EPA Method 8280) E.7

February 10, 1994 Hot Run

Table 2.1. Sample Log for February 10, 1994 Hot Run E.8
Table 2.2. February 10, 1994 Hot-Run PCB Analytical Results (On Site GC/MS Results) E.9
Table 2.3. February 10, 1994 Hot-Run PCB Analytical Results (SWRI EPA Method 680-SIM) E.10
Table 2.4. February 10, 1994 Hot-Run PCB Analytical Results (SWRI Method 8080) E.11
Table 2.5. February 10, 1994 Hot-Run Dioxin/Furan Analytical Results (SWRI EPA Method 8280) E.12
Table 2.6. Additional Analytical Data from February 1994 Hot Runs E.13

November 1994 Hot Run

Table 3.1. Sample Log for November 1994 Hot Run E.14
Table 3.2. November 1994 Hot-Run PCB Analytical Results (On Site GC/MS Results) E.16
Table 3.3. November 1994; Hot-Run PCB Analytical Results (SWRI EPA Method 680-SIM) E.17
Table 3.4. November 1994, Hot-Run Dioxin/Furan Analytical Results (SWRI EPA Method 8280) E.18
Table 3.5. Additional Analytical Data from November 1994 Hot Run E.19

May 1995 STR Testing

Table 4.1. Sample Log for May 1995 STR Testing E.20
Table 4.2. May 1995 STR Testing Analytical Results E.21

Table 1.1. Sample Log for February 5, 1994 Hot Run

Sample ID No.	Sample Date	Sample Time	Sample Location	Sample Description
Feed Soil				
F020505	2-5-94	10:00 - 12:00	feed conveyer	2-hour feed composite, sample approximately 50% rock, 90% dry weight
F020507	2-5-94	13:00	feed conveyer	feed grab sample, 92% dry weight
F020510	2-5-94	12:00 - 14:00	feed conveyer	2-hour feed composite, sample approximately 70% rock, 88% dry weight
F020515	2-5-94	14:00 - 16:00	feed conveyer	2-feed composite, 86% dry weight
F020520a	2-5-94	16:00 - 18:00	feed conveyer	2-hour feed composite, 88% dry weight
F020520b	2-5-94	16:00 - 18:00	feed conveyer	2-hour feed composite, 89% dry weight, sample collection duplicate
F020523	2-5-94	18:00 - 20:30	feed conveyer	2 1/2-hour feed composite, 89% dry weight
Treated Soil				
P020501	2-5-94	12:45	product bin	grab sample of product
P020502	2-5-94	13:15	product bin	grab sample of product
P020505	2-5-94	12:30 - 14:15	product bin	2-hour product composite
P020507	2-5-94	15:15	product bin	grab sample of product
P020509	2-5-94	16:15	product bin	grab sample of product
P020510	2-5-94	14:15 - 16:15	product bin	2-hour product composite
P020512	2-5-94	17:15	product bin	grab sample of product
P020515	2-5-94	16:15 - 18:15	product bin	2-hour product composite
P020517	2-5-94	19:15	product bin	grab sample of product
P020520	2-5-94	18:15 - 20:15	product bin	2-hour product composite
P020523	2-5-94	20:15 - 21:15	product bin	1-hour product composite
P020524	2-5-94	21:45	product bin	grab sample of product
P020525	2-5-94	22:15	product bin	grab sample of product
P020526	2-5-94	after run	product bin	2" diameter hardened ball of fines found in product bin
Offgas				
A020501	2-5-94	12:13	offgas	offgas line after ID fan, prior to carbon cabinets
A020502	2-5-94	13:49	offgas	offgas line between carbon cabinets
A020503	2-5-94	15:38	offgas	offgas line after both carbon cabinets
Residuals				
B020501	2-5-94	23:30	baghouse drum	baghouse drum after run, drum not mixed
C020501	2-5-94	23:30	cyclone drum	cyclone drum after run, drum not mixed
W020510	2-9-94	09:10	filter press	loaded activated carbon from filter press, 71% dry weight

Table 1.1. (continued)

Sample ID No.	Sample Date	Sample Time	Sample Location	Sample Description
Water and Oil				
W020501	2-5-94	22:30	scrub loop	scrub loop at end of run
W020502	2-7-94	09:30	Tank 501	floating scum from top of T501
W020503	2-7-94	09:30	Tank 501	oil from bottom of T501 (i.e., density of oil greater than water)
W020504	2-7-94	12:47	Tank 502	batch 1 scrub water sample prior to addition of activated carbon
W020505	2-7-94	18:00	filter press	batch 1 scrub water after GAC addition, and after filter press
W020506	2-7-94	18:00	carbon drums	batch 1 scrub water between 55 gal drums for final polishing
W020507	2-7-94	18:00	carbon drums	batch 1 scrub water after both 55-gal drums (i.e., final treated water)
W020508	2-8-94	14:30	Tank 502	batch 2 scrub water sample prior to addition of activated carbon
W020509	2-8-94	17:00	carbon drum	batch 2 scrub water after both 55 gal drums (i.e, final treated water)

Table 1.2. February 5, 1994 Hot-Run PCB Analytical Results (On Site GC/MS Results)

Sample Identification	Total PCB (units)	Concentration by Homolog									
		Cl-1	Cl-2	Cl-3	Cl-4	Cl-5	Cl-6	Cl-7	Cl-8	Cl-9	Cl-10
Feed Soil											
F020505	695 ppm	<0.5	<0.5	<0.5	<0.5	33	381	258	23	<0.5	<0.5
F020507	330 ppm	<0.5	<0.5	<0.5	<0.5	45	202	83	<0.5	<0.5	<0.5
F020507	401 ppm	<0.5	<0.5	<0.5	<0.5	56	244	101	<0.5	<0.5	<0.5
F020510	288 ppm	<0.5	<0.5	<0.5	<0.5	7	128	133	21	<0.5	<0.5
F020515	292 ppm	<0.5	<0.5	<0.5	<0.5	15	120	135	22	<0.5	<0.5
F020520(a)	636 ppm	<0.5	<0.5	<0.5	<0.5	37	314	258	27	<0.5	<0.5
F020520(b)	752 ppm	<0.5	<0.5	<0.5	<0.5	69	400	244	39	<0.5	<0.5
F020523	1188 ppm	<0.5	<0.5	<0.5	<0.5	75	632	422	60	<0.5	<0.5
Treated Soil											
P020501	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P020502	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P020505	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P020507	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P020509	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P020510	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P020512	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P020515	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P020517	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P020520	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P020523	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P020524	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P020525	3.8 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	2	2	<0.5	<0.5	<0.5
P020526	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Offgas											
A020501	<0.5 μg/ml	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
A020502	<0.5 μg/ml	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
A020503	0.05 μg/ml	<0.5	<0.5	<0.5	<0.5	<0.5	1*	<0.5	<0.5	<0.5	<0.5
Residuals											
B020501	13,910 ppm	<0.5	<0.5	<0.5	<0.5	1359	8659	3893	<0.5	<0.5	<0.5
C020501	17,956 ppm	<0.5	<0.5	<0.5	<0.5	1184	9436	6640	696	<0.5	<0.5
W0205010	8875 ppm	<0.5	<0.5	<0.5	249	1800	4598	2228	<0.5	<0.5	<0.5

Table 1.2. (continued)

Sample Identification	Total PCB (units)	Concentration by Homolog									
		Cl-1	Cl-2	Cl-3	Cl-4	Cl-5	Cl-6	Cl-7	Cl-8	Cl-9	Cl-10
Water & Oil											
W020501	67,400 µg/L	<0.5	<0.5	<0.5	<0.5	11281	44500	11600	<0.5	<0.5	<0.5
W020502	906 ppm	<0.5	<0.5	<0.5	<0.5	153	606	147	<0.5	<0.5	<0.5
W020502	1573 ppm	<0.5	<0.5	<0.5	<0.5	262	1049	262	<0.5	<0.5	<0.5
W020503	105,400 ppm	<0.5	<0.5	<0.5	<0.5	20227	69867	15307	<0.5	<0.5	<0.5
W020504	983 ppm	<0.5	<0.5	<0.5	<0.5	262	459	262	<0.5	<0.5	<0.5
W020505	129 µg/L	<0.5	<0.5	<0.5	5	24	80	20	<0.5	<0.5	<0.5
W020506	4.64 µg/L	<0.5	<0.5	<0.5	<0.5	1	4	<0.5	<0.5	<0.5	<0.5
W020507	5.48 µg/L	<0.5	<0.5	<0.5	<0.5	1	4	<0.5	<0.5	<0.5	<0.5
W020508	8279 µg/L	<0.5	<0.5	<0.5	<0.5	1295	5346	1638	<0.5	<0.5	<0.5
W020509	<0.5 µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

* = sample concentrated

Table 1.3. February 5, 1994 Hot-Run PCB Analytical Results (SWRI EPA Method 680-SIM)

Sample Identification	Total PCB (units)	Concentration by Homolog									
		Cl-1	Cl-2	Cl-3	Cl-4	Cl-5	Cl-6	Cl-7	Cl-8	Cl-9	Cl-10
Feed Soil											
F020510	204 ppm	U	U	U	2.3	77	42	27	53	3	U
F020515	1075 ppm	U	U	U	2.5	83	540	380	65	4.1	U
Treated Soil											
P020505	0.31 ppm	U	U	U	U	U	0.2	0.1	0.011	U	U
P020510	0.005 ppm	U	U	U	U	U	0.005	U	U	U	U
P020515	0.004 ppm	U	U	U	U	U	0.004	J	U	U	U
P020520	0.004 ppm	J	U	U	U	U	0.004	U	U	U	U
P020523	<0.003 ppm	J	U	U	U	U	J	U	U	U	U
Residuals											
B020501	20,017 ppm	1.9	9.1	37	24	3100	11000	5400	430	15	U
C020501	17,913 ppm	J	1.8	13	72	1600	9100	6500	600	26	U
Water & Oil											
W020509	0.09 µg/L	U	U	U	0.09	J	J	U	U	U	U

U = Undetected Analyte
J = Below the method detection limit

Table 1.4. February 5, 1994 Hot-Run PCB Analytical Results (SWRI Method 8080)

Sample Identification	Total PCB (units)	Arochor Concentration						
		1016	1221	1232	1242	1248	1254	1260
Feed Soil								
F020515	1300 ppm	U	U	U	U	U	U	1300
Treated Soil								
P020510	0.008 ppm	U	U	U	U	U	U	JP
P020515	0.005 ppm	U	U	U	U	U	U	J
P020520	0.009 ppm	U	U	U	U	U	U	J
Residuals								
B020501	11,000 ppm	U	U	U	U	U	U	11,000
C020501	14,000 ppm	U	U	U	U	U	U	14,000

U = Undetected Analyte
J = Below the method detection limit

Table 1.5. February 5, 1994 Hot-Run Dioxin/Furan Analytical Results (SWRI EPA Method 8280)

Sample Identification (units of measure)	Concentration by Homolog							
	Dioxins				Furans			
	Total TCDD	Total PeCDD	Total HxCCD	Total HpCCD	Total TCDF	Total PeCDF	Total HxCDF	Total HpCDF
Feed Soil								
F020515 (ppb)	U	J	2.603	11.308	3.773	21.21	27.395	10.628
Treated Soil								
P020515 (ppb)	U	U	U	U	U	U	U	U
Residuals								
B020501 (ppb)	52.302	111.691	170.326	118.697	11135.510	5898.416	1418.916	77.741
C020501 (ppb)	29.541	113.156	194.135	110.245	6382.343	7362.870	3519.821	173.524

U = Undetected Analyte
J = Below the method detection limit

Table 2.1. Sample Log for February 10, 1994 Hot Run

Sample ID No.	Sample Date	Sample Time	Sample Location	Sample Description
Feed Soil				
F021001	2-10-94	09:32 - 12:30	feed conveyer	3-hour feed composite, 88% dry weight
F021002	2-10-94	13:30 - 14:30	feed conveyer	2 1/2-hour feed composite, 91% dry weight
Treated Soil				
P021001	2-10-94	10:30	product bin	grab sample of product
P021002	2-10-94	11:00	product bin	grab sample of product
P021003	2-10-94	11:30	product bin	grab sample of product
P021004	2-10-94	12:00	product bin	grab sample of product
P021005	2-10-94	13:00	product bin	grab sample of product
P021006	2-10-94	11:30 - 13:30	product bin	2-hour product composite
P021008	2-10-94	15:00	product bin	grab sample of product
P021009	2-10-94	14:00 - 15:50	product bin	2-hour product composite
P021011	2-10-94	16:30	product bin	grab sample of product
P021012	2-10-94	~12:00	product bin	clay ball (approximately 6 in. dia) found in product bin
Offgas				
OG21001	2-10-94	13:40	offgas	offgas line after both carbon cabinets
Residuals				
AC021001	2-14-94	08:00	filter press	loaded activated carbon from filter press, 53% dry weight
B021001	2-12-94	16:00	baghouse drum	baghouse drum after run, drum not mixed
C021001	2-12-94	16:00	cyclone drum	cyclone drum after run, drum not mixed
Water				
W021001	2-11-94	17:30	Tank 502	after mixing T501 and T502 for 2 hours, before carbon addition
W021002	2-12-94	10:00	filter press	scrub water after GAC addition, and after filter press
W021003	2-12-94	10:30	carbon drum	scrub water after both 55 gal drums (i.e., final treated water)
W021003	2-14-94	not recorded	Tank 601	scrub water after both 55 gal drums (i.e., final treated water)

Table 2.2. February 10, 1994 Hot-Run PCB Analytical Results (On Site GC/MS Results)

Sample Identification	Total PCB (units)	Concentration by Homolog									
		Cl-1	Cl-2	Cl-3	Cl-4	Cl-5	Cl-6	Cl-7	Cl-8	Cl-9	Cl-10
Feed Soil											
F021001	1223 ppm	<0.5	<0.5	<0.5	<0.5	74	638	458	53	<0.5	<0.5
F021002	1366 ppm	<0.5	<0.5	<0.5	<0.5	125	714	467	60	<0.5	<0.5
Treated Soil											
P021001	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P021002	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P021003	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P021004	12 ppm	<0.5	<0.5	<0.5	<0.5	1	7	4	<0.5	<0.5	<0.5
P021005	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P021006	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P021008	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P021009	3.7 ppm	<0.5	<0.5	<0.5	<0.5	1	3	<0.5	<0.5	<0.5	<0.5
P021011	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
P021012	348 ppm	<0.5	<0.5	<0.5	<0.5	22	186	140	<0.5	<0.5	<0.5
Offgas											
OG021001	<0.5 µg/ml	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Residuals											
AC021001	44,998 ppm	<0.5	<0.5	<0.5	<0.5	6360	24957	13077	604	<0.5	<0.5
B021001	10,921 ppm	<0.5	<0.5	<0.5	<0.5	1538	5681	3434	268	<0.5	<0.5
C021001	4045 ppm	<0.5	<0.5	<0.5	<0.5	318	1973	1591	163	<0.5	<0.5
Water											
W021001	94,342 µg/L	<0.5	<0.5	<0.5	980	18140	41296	32970	956	<0.5	<0.5
W021002	2754 µg/L	<0.5	<0.5	<0.5	52	468	1705	530	<0.5	<0.5	<0.5
W021003	2.4 µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	2	1	<0.5	<0.5	<0.5
W021003	16.6 µg/L	<0.5	<0.5	<0.5	<0.5	3	9	5	<0.5	<0.5	<0.5

Table 2.3. February 10, 1994 Hot-Run PCB Analytical Results (SWRI EPA Method 680-SIM)

Sample Identification	Total PCB (units)	Concentration by Homolog									
		Cl-1	Cl-2	Cl-3	Cl-4	Cl-5	Cl-6	Cl-7	Cl-8	Cl-9	Cl-10
Feed Soil											
F021001	1865 ppm	U	U	U	3.6	180	960	640	76	4.9	U
Treated Soil											
P021006	0.01 ppm	.002	U	U	U	U	0.008	U	U	U	U
P021009	0.015 ppm	0.005	U	U	U	U	0.01	U	U	U	U

U = Undetected Analyte
J = Below the method detection limit

Table 2.4. February 10, 1994 Hot-Run PCB Analytical Results (SWRI Method 8080)

Sample Identification	Total PCB (units)	Arochor Concentration						
		1016	1221	1232	1242	1248	1254	1260
Feed Soil								
F021001	2400 ppm	U	U	U	U	U	U	2400
Treated Soil								
P021006	0.029 ppm	U	U	U	U	JP	JP	U

U = Undetected Analyte
J = Below the method detection limit

Table 2.5. February 10, 1994 Hot-Run Dioxin/Furan Analytical Results (SWRI EPA Method 8280)

Sample Identification (units of measure)	Concentration by Homolog							
	Dioxins				Furans			
	Total TCDD	Total PeCDD	Total HxCCD	Total HpCCD	Total TCDF	Total PeCDF	Total HxCDF	Total HpCDF
Feed Soil								
F021001 (ppb)	U	U	1.993	9.918	4.556	25.728	29.958	12.286
Treated Soil								
P021006 (ppb)	U	U	U	0.203	U	U	J	0.244

U = Undetected Analyte
J = Below the method detection limit

Table 2.6. Additional Analytical Data from February 1994 Hot Runs

Sample Identification	Analysis	Result	Detection Limit
F021001	% Ash	80.81%.	NA
	% Moisture	11.6 %	NA
	Bicarbonate	12,300 mg/Kg $CaCO_3$	50
	Carbonate	15,700 mg/Kg $CaCO_3$	50
	TRPH	785 ppm (dry basis)	NA
B020501	% Solubility	9.1 %	NA
	Bicarbonate	31,900 mg/Kg $CaCO_3$	50
	Carbonate	19,600 mg/Kg $CaCO_3$	50
	TRPH	6541 ppm	NA
C020501	% Solubility	26.4 %	1
	Bicarbonate	109,000 mg/Kg $CaCO_3$	50
	Carbonate	100,000 mg/Kg $CaCO_3$	50
	TRPH	7721 ppm	NA
W020509	Total Solids	352 mg/L	NA
W021003	Total Solids	750 mg/L	NA

NA = not available or applicable

Table 3.1. Sample Log for November 1994 Hot Run

Sample ID No.	Sample Date	Sample Time	Sample Location	Sample Description
Feed				
FC00001	11-19-94	07:22 - 11:00	feed conveyer	4-hour feed composite
FC00002	11-19-94	11:30 - 15:00	feed conveyer	4-hour feed composite
FC00007	11-20-94	09:00 - 12:00	feed conveyer	4-hour feed composite
FC00009	11-20-94	16:30 - 20:00	feed conveyer	4-hour feed composite
FC00010	11-19-94 11-20-94	07:23 16:00	feed conveyer	33-hour feed composite
Treated Soil				
PC00001	11-19-94	08:45 - 12:15	product bin	4-hour product composite
PC00002	11-19-94	12:45 - 16:15	product bin	4-hour product composite
PC00003	11-19-94	17:00 - 20:00	product bin	4-hour product composite
PC00004	11-19-94	21:00 - 23:59	product bin	4-hour product composite
PC00005	11-20-94	01:00 - 04:00	product bin	4-hour product composite
PC00009	11-20-94	17:30 - 21:00	product bin	4-hour product composite
PC00010	11-19-94 11-20-94	08:45 16:00	product bin	32-hour product composite
Other Samples				
AC00001	11-28-94	08:00	filter press	loaded activated carbon from filter press
BH00001	11-22-94	13:00	baghouse drum	baghouse drum after run, drum not mixed
CY00001	11-22-94	13:00	cyclone drum	cyclone drum after run, drum not mixed
S00001	11-25-94	not recorded	scrub loop	heavy oil collected from bottom of oil water separator
Water/Oil				
W00002	11-19-94	13:25	O/W Sep inlet	scrub water at inlet to oil/water separator
W00004	11-19-94	22:15	O/W Sep inlet	scrub water at inlet to oil/water separator
W00005	11-19-94	22:15	O/W Sep out	scrub water at outlet of oil/water separator
W00006	11-20-94	05:50	O/W Sep inlet	scrub water at inlet to oil/water separator
W00008	11-20-94	20:20	O/W Sep inlet	scrub water at inlet to oil/water separator
W00009	11-22-94	09:00	carbon drums	batch 1 scrub water after 55 gal drums (i.e., final treated water)
W00010	11-22-94	09:00	filter press	batch 1 scrub water sample after filter press
W00011	11-24-94	10:15	carbon drum	batch 2 scrub water after 55 gal drums (i.e, final treated water)
W00012	11-24-94	17:31	filter press	batch 3 scrub water, after filter press
W00013	11-24-94	17:40	carbon drums	batch 3 scrub water after 55 gal drums (i.e., final treated water)
W00014	11-28-94	12:00	STR condenser	condensate from STR
W00015	11-28-94	13:00	STR condenser	condensate from STR
W00016	11-28-94	14:00	STR condenser	condensate from STR

Table 3.1. (continued)

Sample ID No.	Sample Date	Sample Time	Sample Location	Sample Description
W00017	11-28-94	15:00	STR condenser	condensate from STR
W00018	11-28-94	16:00	STR condenser	condensate from STR
W00019	11-28-94	22:10	STR condenser	condensate from STR
W00020	12-1-94	09:00	Tank 602	condensate from T-602, generated during foam/boil over
STR Slurry				
O00001	11-28-94	10:00	STR	homogenized STR feed (oil slurry)
O00002	11-28-94	16:15	STR condenser	oil from STR foam over/boilover
O00003	12-1-94	08:30	STR	treated oil slurry from STR
O00004	12-1-94	11:30	drum	treated oil pumped from STR to storage drum

Table 3.2. November 1994 Hot-Run PCB Analytical Results (On Site GC/MS Results)

Sample Identification	Total PCB (units)	Concentration by Homolog									
		Cl-1	Cl-2	Cl-3	Cl-4	Cl-5	Cl-6	Cl-7	Cl-8	Cl-9	Cl-10
Feed Soil											
FC00001	1100 ppm	<0.5	<0.5	<0.5	<0.5	100	290	540	110	50	<0.5
FC00007	560 ppm	<0.5	<0.5	<0.5	<0.5	36	130	330	65	<0.5	<0.5
FC00009	660 ppm	<0.5	<0.5	<0.5	<0.5	30	160	380	90	<0.5	<0.5
Treated Soil											
PC00001	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PC00002	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PC00003	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PC00004	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PC00005	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Residuals											
AC00001	42,000 ppm	50	150	300	2000	8000	14000	16000	1100	20	<0.5
AC00001	48,000 ppm	60	150	350	1600	9000	20000	15500	1200	<0.5	<0.5
S00001	160,000 ppm	400	800	900	7200	35000	64000	49000	2300	<0.5	<0.5
Water and Oil											
W00002	12,000 µg/L	60	150	170	1300	1600	3400	4300	640	14	<0.5
W00009	3 µg/L	<0.5	<0.5	<0.5	<0.5	0.5	1	1	<0.5	<0.5	<0.5
W00010	200 µg/L	0.3	1	1	8	40	70	70	6	<0.5	<0.5
W00010	180 µg/L	0.3	1	1	8	30	70	60	5	<0.5	<0.5
W00011	3 µg/L	<0.5	<0.5	<0.5	<0.5	1	1	1	<0.5	<0.5	<0.5
W00012	5100 µg/L	4	16	30	180	1000	1500	2200	160	2	<0.5
W00013	3 µg/L	<0.5	<0.5	<0.5	0.2	1	1	1	<0.5	<0.5	<0.5
W00014	300 µg/L	30	40	70	140	7	15	<0.5	<0.5	<0.5	<0.5
W00015	830 µg/L	85	280	60	230	<0.5	80	95	<0.5	<0.5	<0.5
W00016	660 µg/L	100	170	30	200	30	60	70	<0.5	<0.5	<0.5
W00017	490 µg/L	75	100	50	200	10	30	20	<0.5	<0.5	<0.5
W00018	4100 µg/L	400	460	120	230	400	1100	1300	120	<0.5	<0.5
W00019	3500 ppm	1500	500	200	400	280	510	60	<0.5	<0.5	<0.5
W00020	30 ppm	<0.5	<0.5	<0.5	30	<0.5	2	<0.5	<0.5	<0.5	<0.5
STR Slurry											
O00001	2500 ppm	<0.5	<0.5	<0.5	150	360	900	1050	<0.5	<0.5	<0.5
O00001	2800 ppm	<0.5	<0.5	<0.5	4	340	760	1500	200	<0.5	<0.5
O00002	2800 ppm	<0.5	20	30	100	400	900	1200	100	<0.5	<0.5
O00003	380 ppm	100	40	10	180	40	6	<0.5	<0.5	<0.5	<0.5
O00004	1340 ppm	100	150	200	490	230	160	10	<0.5	<0.5	<0.5

Table 3.3. November 1994; Hot-Run PCB Analytical Results (SWRI EPA Method 680-SIM)

Sample Identification	Total PCB (units)	Concentration by Homolog									
		Cl-1	Cl-2	Cl-3	Cl-4	Cl-5	Cl-6	Cl-7	Cl-8	Cl-9	Cl-10
Feed Soil											
FC00002	1722 ppm	U	U	U	5	180	840	560	130	7	J
FC00007	1098 ppm	U	U	U	3	120	530	360	81	4	J
FC00010	1252 ppm	J	0.2	U	3	140	600	410	94	5	J
Treated Soil											
PC00002	0.062 ppm	J	J	J	J	0.005	0.036	0.021	J	U	U
PC00009	0.296 ppm	J	J	U	0.005	0.043	0.109	0.053	0.086	U	U
PC00010	0.168 ppm	J	J	0.004	0.009	0.027	0.076	0.044	0.008	U	U
Residuals											
AC00001	856 ppm	U	U	U	U	36	110	700	10	U	U
BH00001	109,274 ppm	J	16	78	570	8700	50000	41000	8600	310	U
CY00001	15,713 ppm	J	19	79	460	3900	1400	8300	1500	55	U
S00001	366,185 ppm	340	1000	2745	13000	86000	190000	65000	81000	U	U
Water & Oil											
W00011	1.09 μg/L	U	U	U	J	0.29	0.65	0.15	U	U	U
STR Slurry											
O00001	7001 ppm	J	U	U	U	680	4000	2000	310	11	U
O00003	1116 ppm	35	61	100	290	430	200	J	U	U	U

U = Undetected Analyte
J = Below the method detection limit

Table 3.4. November 1994, Hot-Run Dioxin/Furan Analytical Results (SWRI EPA Method 8280)

Sample Identification (units of measure)	Concentration by Homolog							
	Dioxins				Furans			
	Total TCDD	Total PeCDD	Total HxCCD	Total HpCCD	Total TCDF	Total PeCDF	Total HxCDF	Total HpCDF
Feed Soil								
FC00010 (ppb)	9.642	159.174	U	4.714	34.510	71.110	37.879	12.727
Treated Soil								
PC00009 (ppb)	U	U	U	J	U	U	J	J
PC00010 (ppb)	U	U	U	U	U	U	U	U
Residuals								
AC00001 (ppb)	2341.378	3253.002	341.333	13.555	20883.871	6371.423	1104.059	33.953
BH00001 (ppb)	3623.109	11535.715	3348.775	504.920	39590.209	41001.730	15310.097	1151.705
CY00001 (ppb)	1083.869	3290.631	861.359	147.275	9233.247	8470.766	3944.797	486.730
S00001 (ppm)	14.107	28.845	J	J	169.164	80.345	J	J
STR Slurry								
O00001 (ppm)	J	J	J	J	3.146	2.180	J	J
O00003 (ppm)	J	U	U	U	J	J	J	U
Water								
W000011 (ng/L)	U	U	U	U	U	U	U	U

U = Undetected Analyte
J = Below the method detection limit

Table 3.5. Additional Analytical Data from November 1994 Hot Run (Analyses performed by FENA Laboratory Navy PWC, Guam)

Sample Identification	Analysis	Result	Detection Limit
FC00002	TC	103 mg/g	2 mg/g
	Alkalinity (Carbonate/bicarbonate)	920 mg/L $CaCO_3$	NA
FC00007	TC	104 mg/g	2 mg/g
	Alkalinity (Carbonate/bicarbonate)	1250 mg/L $CaCO_3$	NA
FC00009	TC	102 mg/g	2 mg/g
	Alkalinity (Carbonate/bicarbonate)	130 mg/g $CaCO_3$	NA
PC00002	Alkalinity (Carbonate/bicarbonate)	830 mg/g $CaCO_3$	NA
PC00009	Alkalinity (Carbonate/bicarbonate)	850 mg/g $CaCO_3$	NA
W00004	Oil and Grease	160 mg/L	2 mg/L
	TOC	1140 mg/L	2 mg/L
W00005	Oil and Grease	97 mg/L	2 mg/L
	TOC	1015 mg/L	2 mg/L
W00006	Oil and Grease	139 mg/L	2 mg/L
	TOC	1221 mg/L	2 mg/L
W00008	Oil and Grease	139 mg/L	2 mg/L
	TOC	1342 mg/L	2 mg/L
W000012	Oil and Grease	271 mg/L	2 mg/L
	TOC	585 mg/L	2 mg/L
	Alkalinity (Carbonate/bicarbonate)	2000 mg/L $CaCO_3$	NA

NA = not available

Table 4.1. Sample Log for May 1995 STR Testing

Sample ID No.	Sample Date	Sample Time	Sample Location	Sample Description
STR Feed				
MSTR1-1	5-15-95	11:30	2-L STR	feed sample taken after 15 min of agitation, ambient temperature
MSTR2-1	5-17-95	not recorded	2-L STR	feed sample taken after 30 min of agitation, ambient temperature
MSTR3-1	5-18-95	16:00	2-L STR	feed sample take after agitation and heating to 90°C
MSTR4-1	5-22-95	12:04	2-L STR	feed sample after 2 hr of mixing at 80°C
MSTR5-1	5-24-95	07:47	2-L STR	feed sample taken after 15 min of agitation, ambient temperature
FSSTR1-1	5-1595	11:30	400-gal STR	same as MSTR1-1, and O00003 from November 1994
FSSTR2-1	5-24-95	17:30	400-gal STR	sample pulled after mixing and heating to 140°F
FSSTR2-2	5-25-95	14:15	400-gal STR	sample pulled after mixing and heating to 590°F
STR Product				
MSTR1-3	5-16-95	15:05	2-L STR	sample pulled after 2-hr at 350°C, after cooling reactor to 200°C
MSTR2-6	5-18-95	10:00	2-L STR	sample taken after 4-hr at 360°C, and cooling reactor to ambient temp
MSTR3-4	5-19-95	14:20	2-L STR	sample taken after 90 min at 350°C
MSTR3-5	5-22-95	09:00	2-L STR	sample taken after 3-hr at 350°C
MSTR4-5	5-23-95	not recorded	2-L STR	sample taken after 2-hr at 355°C
MSTR4-7	5-24-95	08:00	2-L STR	sample taken after 4-hr at 355°C
MSTR5-2	5-25-95	14:15	2-L STR	sample taken after 2-hr at 355°C
MSTR5-3	5-26-95	02:00	2-L STR	sample taken after 2-hr at 355°C, and 2-hr at 360°C
FSSTR1-2	5-19-95	07:25	400-gal STR	sample taken by ladle on a wire after 3 1/2 hour between 660 and 668°F
FSSTR2-4	5-25-95	22:30	400-gal STR	sample collect via probe after 2 hr at 665°F
FSSTR2-5	5-26-95	00:30	400-gal STR	sample collect via probe after 4 hr at 665°F - 672°F
FSSTR2-6	5-26-95	02:30	400-gal STR	sample collect via probe after 6 hr at 665°F - 675°F
STR Condensate				
MSTR1-2	5-16-95	10:55	MTR	Moisture test receiver, condensate came off between 110°C and 280°C
MSTR2-5	5-17-95	21:06	MTR	Moisture test receiver, condensate collected while reactor at 360°C
MSTR4-4	5-23-95	not recorded	MTR	Moisture test receiver, condensate collected while reactor at 355°C
MSTR5-4	5-26-95	02:00	MTR	composite of condensate for the entire run
FSSTR2-3	5-25-95	21:30	condensate tank	oil condensate from 400-gal STR, collected while reactor was 660°F

Table 4.2. May 1995 STR Testing Analytical Results (Analyses performed via GC/MS at FENA Laboratory Navy PWC, Guam)

Sample Identification	Total PCB (units)	Concentration by Homolog									
		Cl-1	Cl-2	Cl-3	Cl-4	Cl-5	Cl-6	Cl-7	Cl-8	Cl-9	Cl-10
STR Feed											
MSTR1-1 and FSSTR-1, same as O00003 (Nov 1994)	1116 ppm	35	61	100	290	430	200	<0.5	<0.5	<0.5	<0.5
MSTR2-1	20,000 to 30,000 ppm	NA	NA	NA	NA	NA	NA	NA	<0.5	<0.5	<0.5
MSTR3-1	~5000 ppm (no analysis)	<0.5	<0.5	<0.5	<0.5	56	244	101	<0.5	<0.5	<0.5
MSTR4-1	~42,000 ppm	NA	NA	NA	NA	NA	NA	NA	<0.5	<0.5	<0.5
MSTR5-1	~25,000 ppm	NA	NA	NA	NA	NA	NA	NA	<0.5	<0.5	<0.5
FSSTR2-1	850 ppm	125	150	180	<0.5	<0.5	145	250	<0.5	<0.5	<0.5
FSSTR2-2	460 ppm	240	220	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
STR Product											
MSTR1-3	880 ppm	160	470	250	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MSTR2-6	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MSTR3-4	1035 ppm	85	120	650	180	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MSTR3-5	795 ppm	230	345	220	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MSTR4-5	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MSTR4-7	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MSTR5-2	6040 ppm	90	300	1340	1940	1860	510	<0.5	<0.5	<0.5	<0.5
MSTR5-3	868 ppm	28	130	260	195	240	35	<0.5	<0.5	<0.5	<0.5
FSSTR1-2	380 ppm	130	250	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
FSSTR2-4	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
FSSTR2-5	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
FSSTR2-6	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
STR Condensate											
MSTR1-2	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MSTR2-5	5240 ppm	2000	1000	1000	500	500	240	<0.5	<0.5	<0.5	<0.5
MSTR4-4	<0.5 ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MSTR4-6	~23,000 ppm	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MSTR5-4	~33,600 ppm	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FSSTR2-3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

NA = not available