
Superfund

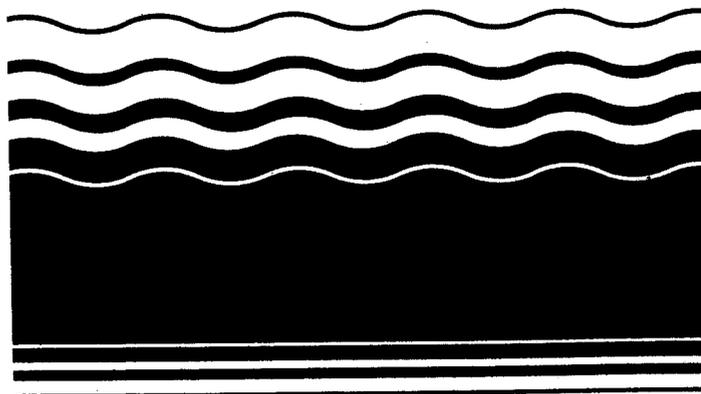


Technology Evaluation Report SITE Program Demonstration Test, Shirco Infrared Incineration System Peak Oil, Brandon, Florida

Volume I

SITE

***SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION***



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**Technology Evaluation Report
SITE Program Demonstration Test,
Shirco Infrared Incineration System,
Peak Oil, Brandon, Florida**

Volume I

by

Seymour Rosenthal
Enviresponse, Incorporated
Livingston, NJ 07039

Cooperative Agreement 68-03-3255

SITE Project Manager

Howard Wall
Risk Reduction Engineering Laboratory
Cincinnati, OH 45268

Risk Reduction Engineering Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, OH 45268

NOTICE

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FOREWORD

The Superfund Innovative Technology Evaluation (SITE) program was authorized in the 1986 Superfund amendments. The program is a joint effort between EPA's Office of Research and Development and Office of Solid Waste and Emergency Response. The purpose of the program is to assist the development of hazardous waste treatment technologies necessary to implement new cleanup standards which require greater reliance on permanent remedies. This is accomplished through technology demonstrations which are designed to provide engineering and cost data on selected technologies.

This is the first in a series of reports which will be prepared by the SITE program. The report provides documentation of the first innovative technology demonstration which took place at the Peak Oil Superfund site in Brandon, Florida. Observation and sampling of a Shirco infrared incinerator took place during the course of a removal operation conducted by EPA Region IV. The SITE effort was directed at obtaining information on the performance cost of the unit for use in assessments at other sites.

Additional copies of this report may be obtained at no charge from EPA's Center for Environmental Research Information, 26 West Martin Luther King Drive, Cincinnati, Ohio, 45268, using the EPA document number found on the report's front cover. Once this supply is exhausted, copies can be purchased from the National Technical Information Service, Ravensworth Bldg., Springfield, VA, 22161, (702) 487-4600. Reference copies will be available at EPA libraries in their Hazardous Waste Collection. You can also call the SITE Clearinghouse hotline at 1-800-424-9346 or 382-3000 in Washington, D.C. to inquire about the availability of other reports.


Thomas W. Devine, Director
Office of Program Management
and Technology


John H. Skinner, Director
Office of Environmental
Engineering and Technology
Demonstration

ABSTRACT

A critical assessment is made of the performance of the transportable Shirco Infrared Thermal Destruction System during three separate test runs under actual operating conditions. The unit was being operated as part of an emergency cleanup action at the Peak Oil Superfund site in Brandon, Florida. An evaluation is provided of the feasibility of utilizing the system as a hazardous waste treatment alternative at other sites throughout the country. A comprehensive process description of the unit includes a diagram of the unit at the Peak Oil site. Field operations documentation includes a discussion of the operational history during the test program, a summary of operating conditions, and the operating log data. The sampling and analytical procedures are summarized, and the final sampling and analytical report and the quality assurance project plan as prepared by the sampling and analytical contractor are provided. Performance data are discussed in detail, and the unit's ability to effectively destroy hazardous constituents in the Peak Oil waste feed is evaluated. Unit cost elements are discussed along with an overall cost evaluation of the transportable Shirco Infrared Thermal Destruction Unit. Operations problems that occurred during the test program are addressed. Mechanical and process problems that occurred during the operation of the unit under start-up and site emergency cleanup conditions are also discussed. Based on the above information, the report provides the initial data and evaluative criteria to enable the EPA to determine the applicability of the Shirco technology to Superfund site investigations and cleanups throughout the country.

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* Volume II contains Appendices A, B, and C: Operating Data Log; Sampling and Analytical Report; and Quality Assurance Project Plan/Test Plan, respectively.

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In addition, we extend our appreciation to contributors from Haztech, Inc., Shirco Infrared Systems Incorporated, and Radian Corporation, the sampling and analytical contractor.

SECTION 1

INTRODUCTION

Beginning in the 1950s Peak Oil, an oil rerefiner, operated a used oil processing facility in Brandon, Florida. Various waste streams from the rerefining operation were dumped into a natural lagoon located on the property. The lagoon quickly became contaminated with PCBs and lead contained in the waste and, as has occurred in the majority of Florida's delicate and shallow aquifer systems, the result was contamination of local drinking water supplies. The United States Environmental Protection Agency (EPA) ranked the site on the National Priorities List (NPL) primarily due to the contamination of groundwater by PCBs.

Because of the existence of an imminent hazard, EPA Region IV initiated and supervised a removal action at the site. The Region contracted with Haztech, Inc., an emergency removal cleanup contractor.

The waste oil sludge residue from the oil reclaiming process, although high in organic content, could not be reclaimed or recycled. With PCB contents ranging up to 100 ppm, the removal action called for mitigation of the human-direct contact threat through the thermal destruction of the waste oil sludge in a high temperature incinerator capable of destroying the PCB contaminants in a cost-effective and environmentally sound manner. Metals that concentrated in the ash would then be dealt with after the thermal destruction of the waste oil sludge was completed.

Initial efforts required that the lagoon be drained of water and mixed with sand, soil, and lime to form a waste soil matrix that could be negotiated by earth-moving equipment. The lime, in addition to providing binding to the moisture-laden soil, also counteracted and neutralized the highly acidic waste produced by the acid-based rerefining process.

In November 1986, Haztech began setting up a transportable thermal destruction system developed by Shirco Infrared Systems, Inc., of Dallas, Texas. Each component of the Shirco system is secured on a wheel-mounted skid and was easily transported by road to the Peak Oil site.

Coincident to this removal action, the EPA had initiated a major new program to further the acceptance and use of alternative and innovative treatment technologies at Superfund sites. The program, called the Superfund Innovative Technology Evaluation, or SITE Program, had been established

in accordance with the Superfund Amendments and Reauthorization Act of October 17, 1986. It is jointly sponsored by the EPA's Office of Research and Development (ORD) and Office of Solid Waste and Emergency Response (OSWER). One of the specific projects under this SITE Program is the technology evaluation of the transportable Shirco infrared thermal system by the EPA's ORD.

With the removal action already underway at the Peak Oil site, it seemed to be an ideal opportunity for the SITE Program to interact with the removal action and evaluate the Shirco system under actual operating conditions.

With the Shirco unit fully operational at the Peak Oil site, it was the intent of the SITE Program to observe the unit operation, collect data, document the mechanical operating history of the system, and, under rigorous QA/QC protocols, obtain samples and perform definitive analyses of the solid waste feed, stack gas, furnace ash, scrubber liquid effluent, scrubber water inlet, scrubber effluent solids, and ambient air during a series of three replicate test runs.

This report is based on monitoring of the unit's operation and discussions with Haztech and Shirco, Inc. Also utilized are existing project cost data and interpretations of the results of sample analyses. The report has been prepared to establish reliable performance and cost information in order to evaluate the applicability of the Shirco technology at the Peak Oil site as well as for use at other sites and applicability with other waste matrices.

SECTION 2

EXECUTIVE SUMMARY

The SITE Program demonstration test of the Shirco infrared[®] incineration system was conducted at the Peak Oil Superfund site in Brandon, Florida during a removal action by EPA Region IV. The Region had contracted with Haztech, Inc., an emergency removal cleanup contractor, to incinerate approximately 7,000 tons of waste oil sludge contaminated with PCBs and lead. The ongoing removal action offered an ideal opportunity for the SITE program to obtain specific operating, design, analytical, and cost information to evaluate the performance of the unit under actual operating conditions. The SITE program also could study the feasibility of utilizing the Shirco transportable infrared incinerator as a viable hazardous waste treatment system at other sites throughout the country. To this end, specific test objectives were:

- o To determine the destruction and removal efficiency (DRE) for PCBs in the Shirco system.
- o To report the unit's ability to decontaminate the solid material being processed and determine the destruction efficiency (DE) for PCBs based on the PCB content of the furnace ash.
- o To evaluate the ability of the unit and its associated air pollution control/scrubber system to limit hydrochloric acid and particulate emissions.
- o To determine whether heavy metals contaminants in the waste feed are chemically bonded or fixated to the ash residue by the process.
- o To determine the effect that the thermal destruction process has in producing combustion byproducts or products of incomplete combustion (PICs).
- o To determine the impact of the unit operation on ambient air quality and potential mutagenic exposure.
- o To develop a set of material balances that defines the major unit stream material flows and componential breakdowns.
- o To provide sufficient unit cost to effectively develop a cost/economic analysis for the unit.
- o To document the mechanical operations history of the unit and analyze and provide potential solutions to chronic unit mechanical problems.

The SITE test program at Peak Oil was conducted from July 31, 1987 to August 4, 1987. During this period, EPA observed the unit operation, collected data, and documented the mechanical operating history of the system and the problems encountered in operating this type of full-scale incineration unit.

The overall program consisted of three separate test runs conducted under the normal operating conditions of the unit; during one of these runs, a duplicate set of samples was taken and analyzed to satisfy rigorous quality assurance/quality control (QA/QC) protocols. EPA documented all operating conditions during the test runs and conducted extensive sampling of the solid waste feed, stack gas, furnace ash, scrubber liquid effluent, scrubber water inlet, scrubber solids, and ambient air. QA/QC audit teams observed and evaluated QA/QC protocols for both the sampling and analytical phases of the test program. The final Quality Assurance Project Plan/Test Plan is presented in Appendix C (Volume II).

Section 4 presents a detailed account of test conditions, and Appendix A (Volume II) contains both operator input and computer spreadsheet data.

Section 5 of this report presents the complete results of all analytical work performed on the samples, including discussions of the sampling and analytical protocols. Appendix B (Volume II) contains the complete Sampling and Analytical Report.

SUMMARY OF RESULTS

Presented below is a summary of the results related to each of the above-defined objectives for the test program. A summary of the key test data is presented in Table 2.1.

o DRE

As discussed in Section 6.2, the Shirco unit achieved a DRE for PCBs in excess of 99.99%. It was not possible to calculate the DRE beyond two decimal places because of the analytical procedures employed.

o Decontamination of Solid Waste and Destruction Efficiency (DE)

The Shirco unit was operated to produce an ash that contained 1 ppm or less of PCB.

Residual PCBs in the ash were less than the 1 ppm operating standard. They varied between 7 ppb on August 1 and 900 ppb on August 3. As discussed in Section 6, the DE for PCBs based on the PCB content of the furnace ash ranged from 83.15% to 99.88%.

TABLE 2.1 SITE DEMONSTRATION TEST RESULTS SUMMARY

| | 8/1/87 | 8/2/87 | 8/3/87 | 8/4/87 |
|--|----------|----------|----------|----------|
| Waste Feed Characteristics | | | | |
| Moisture, wt. % | 16.63 | 16.06 | 14.24 | 14.37 |
| Ash, wt. % | 69.77 | 69.80 | 72.40 | 75.21 |
| HHV, Btu/lb | 2064 | 1639 | 1728 | 2018 |
| PCB, ppm | 5.850 | 3.850 | 5.340 | 3.480 |
| Pb, ppm | 5900 | 4900 | 5000 | 4400 |
| Chlorine, ppm | <1000 | <1000 | <1000 | <1000 |
| Sulfur, ppm | 25300 | 17800 | 18900 | 16700 |
| Chlorine (as HCl), kg/hr | <5 | <5 | <5 | <5 |
| Sulfur (as SO ₂), kg/hr | 200 | 132 | 138 | 125 |
| EP Tox (Pb), mg/L, ppm | 27.00 | 29.00 | - | 24.00 |
| TCLP (Pb), mg/L, ppm | 8.60 | 2.50 | 3.00 | 3.50 |
| Stack Gas | | | | |
| HCl, ppmv | <0.051 | 0.60 | 0.22 | 0.20 |
| SO ₂ , ppmv | 0.99 | 41.80 | 0.96 | 0.91 |
| HCl, g/hr | <0.8 | 8.60 | 2.90 | 2.70 |
| SO ₂ , g/hr | 27.40 | 1070.0 | 22.0 | 20.6 |
| Particulates (@7%O ₂), mg/dscm | 358 | 211 | 173 | 171 |
| PCB, ug/hr | 57.70 | 174.50 | 58.10 | 126.20 |
| Ash | | | | |
| PCB, ppm | 0.01 | 0.240 | 0.900 | 0.540 |
| Pb, ppm | 7100 | 6000 | 6400 | 6200 |
| EP Tox (Pb), mg/l, ppm | 25.0 | 28.0 | 36.0 | 36.0 |
| TCLP (Pb), mg/l, ppm | 0.01 | 0.01 | 0.02 | 0.01 |
| Operating Conditions | | | | |
| Waste Feedrate (avg. daily), kg/hr | 3328 | 3287 | 3626 | 3600 |
| DRE (PCB), wt. % | 99.99967 | 99.99880 | 99.99972 | 99.99905 |
| DE (PCB), wt. % | 99.88 | 93.77 | 83.15 | 84.48 |
| Primary Combustion Chamber | | | | |
| Exhaust Temperature (avg.), F | 1797 | 1836 | 1922 | 1885 |
| Residence Time, min. | 19 | 19 | 18 | 19 |
| Secondary Combustion Chamber | | | | |
| Chamber Temperature (avg.), F | 1886 | 1887 | 1889 | 1907 |
| Residence Time, sec. | >3 | >3 | >3 | >3 |
| Acid Gas Removal Efficiency, wt. % | | | | |
| SO ₂ | >99.9 | >99.1 | >99.9 | >99.9 |

o Particulate Emissions

Over the three test days in which EPA measured stack gas particulate loadings, the results were 358 mg/dscm (8/1/87), 211 mg/dscm (8/2/87), 173 mg/dscm (8/4/87), and 171 mg/dscm (8/4/87). Emissions control system modifications and maintenance on August 2 appear to have lowered particulate emissions to less than the RCRA standard of 180 mg/dscm (@ 7 vol.% O₂).

The data to date, however, indicate the extreme difficulty in meeting particulate emissions requirements and in most instances the inability of the unit's emissions control system to meet particulate emissions requirements of less than 180 mg/dscm, probably due to the excessive fines loading at the emissions control equipment. Section 6.4 and Section 8.2.4 contain detailed discussions of this problem.

o Acid Gas Emissions

During the demonstration tests, HCl and SO₂ emissions rates were minimal. Since the chlorine concentration in the waste feed was below the 0.1 wt.% detection limit, an actual HCl removal efficiency could not be determined. The more difficult to remove SO₂ constituent, however, was reduced by more than 99.9 wt.%, which indicates satisfactory acid gas removal efficiencies. Section 6.3 contains a detailed discussion on the acid gas emissions and removal criteria.

o Metals Fixation and Ash Leaching

One of the objectives of this test program was to determine whether heavy metal contaminants in the waste feed will fixate in the ash residue, rendering the ash nonleachable. The solid waste feed, furnace ash, and scrubber solids were subjected to both the proposed Toxicity Characteristic Leaching Procedure (TCLP) and the EP Toxicity Test Procedure (EP Toxicity) leaching tests. Whereas the TCLP tests produced leachates that did not exceed any of the proposed toxicity characteristic levels (except for one waste feed sample), the EP Toxicity tests produced leachates that exceeded regulatory levels for lead and in some cases for cadmium. It appears that the differences in the test procedures provide a sufficient difference in the pH environment that metals, particularly lead, are rendered soluble and prone to leaching. Sections 6.4 and 6.5 contain additional discussions on metals disposition and leaching characteristics.

o Products of Incomplete Combustion

Small quantities of tetrachlorodibenzofuran (2.1 ng) were

detected in stack gas sampled on August 2. Low levels of some semivolatile organic compounds were identified in all streams and appeared to be related more to external contamination than process contamination and PIC formation. A wide variety of volatile species at low concentrations were present in the stack gas. Their concentrations increased from August 1 to August 4 as the unit operation DE of PCBs and overall combustion efficiency decreased under a lower oxygen availability (reducing conditions) in the primary combustion chamber (PCC), producing higher levels of PICs.

o Ambient Air Sampling and Mutagenic Testing

Ambient air stations placed upwind and downwind of the Shirco unit detected quantities of airborne PCB contaminants. Based on the downwind sampler data it appears the the Peak Oil site boundaries limited the location of the downwind sampler to an area that was significantly exposed to fugitive emissions during the transport of ash from the ash pad to the ash storage area.

Waste feed and ash samples that were collected on August 2 were not mutagenic based on the standard Ames Salmonella mutagenicity assay.

o Material Balances

Based on the operating log data presented in Volume II, Appendix A, and the analytical results presented in Volume II, Appendix B, a series of material balances were developed for each of the test runs conducted on August 1-4, 1987. The balances provide material flows and component breakdowns for the major process streams consistent with a series of defined bases and assumptions, as presented in Section 6.8.

o Cost/Economic Analysis

Several cost scenarios are presented based on a model for a Shirco unit operation equivalent in processing capacity to the unit that operated at Peak Oil, and based on cost data available from Shirco and other sources. The economic analysis presented in Section 7 concludes that in using currently available Shirco transportable infrared incineration systems, commercial incineration costs will range from an estimated \$196 per ton for a Shirco unit operation at an 80% on-stream capacity factor to an estimated \$795 per ton for the operation at the Peak Oil site at a 19% on-stream capacity factor. A normalized total cost per ton of \$416 represents a more realistic interpretation of the costs accrued to the Peak Oil cleanup action based on a 37% on-stream capacity factor.

o Unit Problems

A review of the Haztech, EPA Technical Assistance Team (TAT), and EPA logbooks and progress reports, plus discussions with unit and project personnel, provided a summary of mechanical and operating problems encountered in this first application of a full-scale commercial Shirco incineration system at a Superfund site. These problems were categorized by unit operating sections, and a profile of the major problem areas within the unit were defined and analyzed to ascertain the reasons for and possible solutions to these specific operational difficulties. The waste feed and materials preparation and feed handling, and emissions control systems were the two main problem areas that limited the operation of the unit. The solidified sludge waste feed continually agglomerated, clogged, bridged, and jammed feed preparation and handling equipment. High levels of lead salts contamination and calcium and magnesium salts carryover appeared to have been a continuous source of problems for the emissions control system, which had difficulty in meeting stack emissions criteria. Pretest analysis of the waste feed matrix for its handling and preparation characteristics and effect on incineration system chemistry and processing must be conducted so that the unit is equipped with the proper feed preparation system, materials handling capabilities, and emissions control equipment.

SECTION 3

PROCESS DESCRIPTION

3.1 GENERAL PROCESS DESCRIPTION

Solid waste processed at the Peak Oil site was incinerated in a transportable infrared incinerator, designed and manufactured by Shirco Infrared Systems, Inc. of Dallas, Texas and operated by Haztech, Inc. of Decatur, Georgia. The overall incineration unit consists of a waste preparation system and weigh hopper, infrared primary combustion chamber, supplemental propane fired secondary combustion chamber, emergency bypass stack, venturi/scrubber, exhaust system, and data collection and control systems all mounted on transportable trailers. The system process flow and the overall test site layout are presented schematically in Figure 3.1.

Solid waste feed material is processed by waste preparation equipment designed to reduce the waste to the consistency and particle sizes that can be processed by the incinerator. After transfer from the waste preparation equipment, the solid waste feed is weighed and conveyed to a hopper mounted over the furnace conveyor belt. A feed chute on the hopper distributes the material across the width of the conveyor belt. The feed hopper screw rate and the conveyor belt speed rate are used to control the feedrate and bed depth.

The incinerator conveyor, a tightly woven wire belt, moves the solid waste feed material through the primary combustion chamber where it is brought to combustion temperatures by infrared heating elements. Rotary rakes or cakebreakers gently stir the material to ensure adequate mixing, exposure to the chamber environment, and complete combustion. When the combusted feed or ash reaches the discharge end of the incinerator, it is cooled with a water spray and then is discharged by a screw auger/conveyor to an ash hopper.

The combustion air to the incinerator is supplied through a series of overfire air ports located at various locations along the incinerator chamber and flows countercurrent to the conveyed waste feed material.

Exhaust gas exits the primary combustion chamber into the secondary combustion chamber where propane-fired burners combust any residual organics present in the exhaust gas. The secondary combustion chamber burners are set to burn at a predetermined temperature. Secondary air is supplied to ensure adequate excess oxygen levels for complete combustion. Exhaust gas from the secondary combustion chamber then is

quenched by a water-fed venturi/scrubber to remove particulate matter and acid gases and then transferred to the exhaust stack by an induced draft fan where the gas is discharged to the atmosphere.

The main unit controls and data collection indicators comprising the data collection and control system are housed in a specially designed van.

An emergency bypass stack is mounted in the system directly upstream of the venturi/scrubber for the diversion of hot process gases under emergency shutdown conditions.

3.2 DETAILED PROCESS DESCRIPTION

The transportable incineration unit consists of the following major mechanical subunits and components:

- o Haztech-Supplied Systems
 - Waste Preparation Unit/Weigh Hopper
 - Water Systems
- o Shirco-Supplied Systems
 - Primary Combustion Chamber (PCC)
 - Secondary Combustion Chamber (SCC)
 - Emergency Bypass Stack
 - Venturi/Scrubber
 - Exhaust System
 - Systems Control Van

The Haztech-supplied waste preparation unit and weigh hopper and Shirco-supplied waste feed hopper are site- and waste-specific: they may vary according to the specific matrix being processed.

3.2.1 Waste Preparation Unit/Weigh Hopper

As part of the overall site remediation the sludge lagoon was drained of water and mixed with sand, soil, and lime to form a conditioned waste soil matrix. The lime, in addition to providing a binding medium for the wet matrix, neutralized the highly acidic wastes in the lagoon, the original site contaminant produced as a by-product of the acid-based oil rerefining operation.

The conditioned soil is transferred from the lagoon to the material stockpile area by front-end loaders; a loader then is used to transfer the waste feed to the power screen. The gross waste feed is loaded onto a tipping reject grid where large rocks and debris are rejected. The bulk of the feed falls through the grid to a belt feed hopper. The waste feed then passes through a shredding system and is conveyed to the vibrating power screen assembly. The shredding system and the vibrating screens provide an aerated and conditioned waste feed sized to less than 1 inch while rejecting larger pieces of rocks, roots, and other materials that were not removed at the tipping reject grid.

The prepared waste feed is then loaded into the weigh hopper utilizing a track loader until a predetermined weight is attained. At that time waste feed to the weigh hopper is stopped and waste is conveyed from the weigh hopper to the primary combustion chamber feed hopper by an inclined conveyor belt.

The subsystems described below were transported individually to the Peak Oil hazardous waste site, assembled into one unit, and used to thermally remediate the site. Upon completion of site cleanup the unit was disassembled into its component subsystems and moved to the next scheduled site. This cycle can continue as long as periodic inspections and maintenance of all mechanical systems are accomplished on site and during installation and disassembly.

3.2.2 Primary Combustion Chamber

The primary combustion chamber consists of six electrically powered combustion modules, one feed module, and one discharge module constructed of mild carbon steel. These modules are bolted together and mounted on a skid that has a removable "goose neck" and transportation dolly attached for towing to each designated site.

Each module is insulated with a 1-in layer of ceramic fiber blanket and a 3-mil stainless steel vapor barrier next to the steel shell with additional "Z Block" fiber insulation added as the interior temperature barrier. The interior steel surface of each module is sprayed with stilastic before the insulation is installed to further protect the shell from corrosive volatiles, which might penetrate the insulation at process temperatures. The exterior shell is primed and painted with high-temperature-resistant paint to provide a durable protective surface.

The six electrically powered combustion modules are fired by transversely mounted silicon carbide resistance heating elements, which are insulated from the steel shell with

ceramic sleeves. Electrical connections to the heating elements are made by attaching braided steel straps to their aluminized ends with spring tensioned C-clamps. These electrical connections are protected by ventilated wireways.

The feed material enters the primary combustion chamber through the feed hopper located above the feed module. The feed hopper consists of six 9-in screw augers, which feed the waste in consistent depth across the width of the primary combustion chamber.

Chain-driven cakebreakers are mounted in the powered modules to stir the feed material periodically and increase process efficiency. The cakebreakers are rollers with an array of high-temperature alloy "fingers," which slowly rake through the material on the belt as it moves through the six fired zones (A1 to A3 and B1 to B3) in the primary combustion chamber.

The processed feed material drops off the end of the belt in the discharge module, where it is quenched with water sprays prior to being discharged by the screw conveyor system to the ash bin. The floor of the primary chamber consists of hoppers and external screw conveyors to collect and remove residual ash from the system. Each hopper has a small vibrator attached to the bottom cleanout tube to assist in the removal of ash into the center-mounted collector screw.

As the ash inventory increases in the ash bin, a Bobcat front-end loader transfers the ash to the ash pad where it is stored pending analysis for PCBs and Pb. If the ash meets the required specifications, it is transferred to the ash storage area; if the ash is still contaminated, it is returned to the material stockpile for reprocessing.

The combustion air for the primary combustion chamber is provided by a blower mounted on the skid underneath the last powered module at the discharge end. The combustion air is carried by ducting up both sides of the chamber, along the top edges of the chamber, and into the chamber at strategically located ports. Manually operated gate valves are used to control the flow of combustion air into the primary chamber. The combustion airflow within the chamber is countercurrent to the waste feed flow.

The exhaust gases from the primary chamber exit through the top of the chamber just prior to reaching the feed material inlet chute. They are directed to the adjacent secondary combustion chamber by insulated crossover ducting.

3.2.3 Secondary Combustion Chamber

The secondary combustion chamber shell is constructed and insulated in a manner very similar to the primary combustion

chamber. Its purpose is to thermally destroy the combustible offgas compounds carried in the exhaust gases from the primary chamber. The secondary combustion chamber is fired by four propane or natural gas burners mounted on the inlet end of the chamber.

Combustion air is provided by a blower, duct work, and plenum chamber mounted on the inlet end of the chamber. The four burner blocks also have an independently mounted combustion air blower and duct work for controlling burner flame patterns.

The primary combustion chamber exhaust gases enter the secondary combustion chamber from the top just above the burner flames. The resultant flow turns 90° and passes through a series of unpowered silicon carbide rods. This increases combustion efficiency by creating turbulence. The waste gases then continue to the downstream end of the chamber where they exit through the top of the chamber into a crossover duct leading to the base of the emergency bypass stack.

3.2.4 Emergency Bypass Stack

An emergency bypass stack is mounted between the secondary combustion chamber and the venturi/scrubber. It is designed to divert the high temperature gases more than fifty feet above ground level during an emergency shutdown.

The emergency bypass stack is a vertically mounted rectangular carbon steel shell, insulated in the same manner as the primary and secondary combustion chambers. It is sealed at the top with counterweighted doors, which are opened by a compressed air cylinder during an emergency.

3.2.5 Venturi/Scrubber

The normal flow of exhaust gases from the secondary combustion chamber is through the base of the emergency bypass stack where the waste gases are split into two separate streams prior to entering the venturi/scrubber section. Both streams exit the emergency bypass stack into stainless steel quench tubes where the hot waste gases are cooled with quench water sprays prior to entering the dual fiberglass-reinforced plastic (FRP) venturis.

There are several sources of liquid to effect the gas quench. During normal operation the first liquid to contact the hot gas is fresh water sprayed into the gas stream. The next liquid to contact the gas is recycle from the scrubber's chevron recycle pump. By utilizing several independent quench liquids, the downstream scrubber equipment, fabricated in corrosion-resistant resins, is effectively protected from thermal damage.

Water injected into the venturi throats atomizes and increases particulate precipitation as the gases enter the front section of the crossflow-packed scrubber. The particulate entrapped in water droplets drains into an open blowdown holding area in the bottom of this section of the unit. The particulate-free waste gases continue into the downstream section of the scrubber where a caustic wash liquid is injected to neutralize acid vapor in the stream. The neutralized and cleaned gas stream exits the scrubber in a single duct leading to the induced draft blower.

The scrubber consists of four major sections: the quench section where the gases are cooled or quenched by direct evaporation of water, the venturi section where particulate is processed by wetting and agglomeration, the chevron section where the processed particulate is scrubbed out by recycled liquor, and the packed section where the gas is scrubbed of acid gases by recycled chemical liquor.

A chemical mix tank and associated pumps supply an alkali and water solution to the crossflow packing. The chemical solution is added to control system pH. The solution is injected into the recycle stream going to the top of the packing.

The recycle liquors emerge from two banks of pumps. Each bank of pumps consists of two pumps mounted on a skid. Each pump acts as a spare for the other. The first bank takes suction from the chevron recycle sump. This chevron recycle is pumped to the quench section, the venturi section, the chevron section, and the blowdown drain valve. The next bank of pumps takes suction from the crossflow scrubber sump. This scrubber recycle is directed back to the top of the crossflow packing. In addition, as level is built up in the chemical sump due to addition of chemicals and makeup water, it internally overflows into the chevron sump. The blowdown drain valve is activated by a level controller in the chevron recycle sump.

3.2.6 Exhaust System

The induced draft fan draws the scrubbed gases from the scrubber and propels them up the FRP exhaust stack. The exhaust stack is mounted on a pad as a freestanding unit with sampling ladder, platform, and EPA sampling ports attached.

In addition to providing the draft for the transport of the combustion gases from the primary and secondary combustion chambers through the venturi/scrubber system to the exhaust stack, the induced draft fan imparts a slight negative pressure to the entire system. This negative pressure ensures that any system leakage will result in an inflow of ambient air to the unit instead of a leakage of hazardous vapors into the atmosphere.

3.2.7 Systems Control Van

The systems control van is a specially designed unit built to house the primary controls required to start, run, and shut down all subsystems. The control cabinet is located in the rear of the unit and contains all system alarms, annunciators, recorders, manual/off/auto switches, process controllers, and process indicators. The stack gas analyzer and solid state belt drive controller are located in the middle section, and the motor control center is mounted in the front. All electrical power leads and control wiring exit the van through a conduit mounted in the flooring.

Additional facilities that have been constructed at the site include an overall water makeup and scrubber effluent blowdown system.

3.2.8 Water Systems

Makeup city water is first treated in a water conditioner to remove calcium and magnesium salts. As the overall solids content of the recycled water streams increases, scrubber liquid effluent must be removed from the system and replaced with fresh water to prevent excessive solids buildup, which will plug spray nozzles and packing in the venturi/scrubber. The scrubber liquid effluent contains a high solids content due primarily to lead salts carry-over from the lead contained in the waste feed. The effluent first is sent to a clarifier for gross solids removal. The clarified effluent then is pumped to the effluent holding tank; it is further treated in an activated carbon filter and sent to a holding tank where it is pH-adjusted with muriatic acid. It is tested for compliance with standards for local publicly owned treatment works (POTW), and if acceptable is sent to the POTW.

SECTION 4

FIELD OPERATIONS DOCUMENTATION

4.1 OPERATIONAL HISTORY

The overall SITE test program at Peak Oil was initiated on July 31, 1987 at 1316 hours and concluded on August 5, 1987 at 0020 hours. Table 4.1 provides a chronological operational history of the overall program. The table indicates the time frame for each of the stack sampling procedures as described in Section 5, and the several incidents or interventions in unit operations that occurred during the sampling, as discussed below. Additional information that chronicles the SITE demonstration program, particularly as it impacted on the sampling activities, is provided in the trip log section of the Sampling and Analytical Report in Appendix B (Volume II).

- o On July 31, 1987, at 1626 hours, the feedrate to the unit decreased, and the unit stopped for 30 seconds. Although this interrupted the initial stack sampling activities, stack sampling resumed with no apparent problems. At 1702 hours severe weather conditions caused a power outage and a general unit power failure, which adversely affected the stack sampling activities and caused a cessation of the day's overall sampling program; all data and samples taken were judged invalid.
- o On August 1, 1987, at 1500 hours, a severe thunderstorm with accompanying lightning arrived at the site. The unit feed and SASS (PCBs) sampling operations were shut down from 1503 to 1543 hours to protect personnel from the severe electrical nature of the storm. The SASS stack sampling activities for PCBs (1420 to 1920 hours) were not adversely affected by the minimal feed interruption. Sampling resumed after operating personnel stated that the unit was running at normal steady-state conditions. Sufficient sample volume was obtained to ensure a successful PCB analysis within the QAPP guidelines.

During this initial SASS sampling collection volume was reduced due to an inability of the SASS cooling system to maintain the sorbent module below 20°C. This reduced volume may have affected the detection of low concentration organics. A more detailed discussion of this problem is provided in Section 5.

- o The initial particulate emissions data from the August 1 EPA Method 5 stack sampling (0830 to 1030 hours) indicated a particulate emissions rate of 0.1590 grains/dscf. From 0135 to 0625 hours on August 2, the unit was shut down in order to flush the entire scrubber, ID fan, and exhaust

TABLE 4.1. CHRONOLOGICAL OPERATIONAL HISTORY

| <u>Hours</u> | <u>Activity</u> |
|----------------|---|
| July 31, 1987 | |
| 1316 - 1626 | Initiated stack sampling |
| 1626 - 1700 | Feed rate decreased - Reason unknown - Stopped stack sampling |
| 1700 - 1702 | Unit operation stable - Resumed stack sampling |
| 1702 - 1800 | Power outage - Severe weather conditions - Power failure - Sampling equipment failure - Declared data and sampling collection for 8/31 invalid |
| 1800 - 2400 | Unit operation resumed with no data or sampling collection |
| August 1, 1987 | |
| 0830 - 1030 | EPA Method 5 sampling = Particulates, HCl, volumetric flowrate, moisture, metals on particulate |
| 1420 - 1920 | SASS sampling - PCBs |
| 1503 - 1543 | Feed interruption due to severe weather |
| 1650 - 1925 | EPA MM5 sampling - Soluble chromium |
| 1710 - 2010 | VOST sampling - Volatile PP + 10 |
| 2121 - 0130 | SASS sampling - PCDD/PCDF, semivolatile PP + 10. |
| August 2, 1987 | |
| 0135-0625 | Stopped feed unit to flush scrubber system and add chevron demisters |
| 0625 | Unit start-up |
| 1100-1615 | SASS sampling - PCBs |
| 1202-1442 | EPA MM5 sampling - Soluble chromium |
| 1410-1755 | VOST sampling - Volatile PP + 10 |
| 1800-2211 | SASS sampling - PCDD/PCDF, semivolatile PP + 10 |
| 2000-2211 | EPA Method 5 sampling - Particulates, HCl, volumetric flowrate, moisture, metals on particulate |
| August 3, 1987 | |
| 0352-0530 | ID fan and stack wash |
| 1015-1550 | SASS sampling - PCBs and duplicate |
| 1713-1945 | EPA MM5 sampling - Soluble chromium and duplicate |

TABLE 4.1 (continued)

August 4, 1987

| | |
|-------------|---|
| 0410 - 0600 | ID fan and stack wash |
| 0930 - 1445 | SASS sampling - PCDD/PCDF, semivolatile PP + 10, and duplicates |
| 1550 - 1746 | EPA Method 5 sampling - Particulates, HCl, volumetric flowrate, moisture, metals on particulate, and duplicates |
| 2007 - 0020 | VOST sampling - Volatile PP + 10 and duplicate |

=====
Abbreviations

| | |
|--------|---|
| HCl | Hydrochloric Acid |
| SASS | Source Assessment Sampling System |
| PCB(s) | Polychlorinated biphenyl(s) |
| MM5 | Modified Method 5 sampling train |
| VOST | Volatile Organic sampling train |
| PP+10 | Priority Pollutants Plus 10 highest peaks |
| PCDD | Polychlorinated Dibenzodioxin |
| PCDF | Polychlorinated Dibenzofuran |
| ID | Induced Draft |

stack system and install additional chevron demisters at the scrubber outlet. The unit was restarted at 0625 hours with SASS stack sampling for PCBs beginning at 1100 hours. EPA Method 5 stack sampling activities that were initiated at 2000 hours indicated a distinct improvement in particulate emissions rate at 0.0939 grains/dscf. On August 3 and 4, at 0352 to 0530 hours and 0410 to 0600 hours, respectively, on-stream ID fan and stack wash procedures were employed. The August 3 particulate emissions rate was 0.0768 grains/dscf, and the August 4 duplicate sample particulate emissions rate, 0.0761 grains/dscf.

4.2 OPERATING CONDITIONS SUMMARY

Since the SITE demonstration test program was conducted during the actual removal action, the operating conditions that were recorded during the SITE program and the normal process conditions employed by Haztech during the site cleanup are identical. The actual unit log data, as compiled by Haztech, is presented in Appendix A (Volume II). Tables 4.2 to 4.9 present spreadsheet summaries of the Haztech operating log data, discussed below, taken during the validated SITE test program period from August 1 to August 4, 1987.

4.2.1 Waste Feed Rate

Although waste feedrates varied at times because of short-term power outages and equipment problems, as chronicled in Section 4.1, the average waste feedrate to the primary combustion chamber (PCC) remained fairly constant at 3.6 to 4.0 tons/hr.

4.2.2 PCC Residence Time

With the waste feedrate remaining fairly constant, the solids were retained on the movable woven wire belt in the PCC for approximately 18 to 19 minutes as they were thermally decontaminated.

4.2.3 PCC Temperature

The PCC temperatures were controlled, through addition of combustion air and use of auxiliary electric power to the infrared heating rods, at between 1470^oF and 1790^oF in Zone A and 1740^oF and 1340^oF in Zone B. The temperature of the PCC exhaust vapors to the secondary combustion chamber (SCC) was maintained between 1830^oF and 1920^oF.

For the August 1 operation, where the waste feed heating value was 20-25% greater than the heating value of the waste feed to the unit during the August 2-4 operations, the PCC infrared rods were not in use; the PCC was operating in an autogenous

mode with higher combustion air flows. With the reduction in waste feed heating value during the August 2-4 operations, supplemental electrical energy input to the infrared rods through the heating element power centers (HEPC) was employed to maintain PCC temperatures.

4.2.4 SCC Temperature and Residence Time

The SCC employed on the Shirco unit, which is heated by propane burners under SCC temperature control, was maintained between 1840^oF and 1910^oF. SCC residence times, based on estimated SCC gas flows and an effective SCC gas residence volume, were consistently above 3 seconds.

4.2.5 SCC Propane Fuel Usage

With the SCC operating temperatures remaining fairly constant during the test period and the fuel flow to the SCC under temperature control, changes in fuel usage should only occur because of changes in the overall heating requirements of the SCC based on variations in flow or heating value. For the August 2 operation, the waste feed heating value, on average, was approximately 15% lower than the heating value of the waste feed to the unit on August 1, 3, and 4. Consistent with this lower heating value, the propane fuel usage to the SCC on August 2 was higher.

4.3 OPERATING LOG DATA

In addition to the selected operating conditions and data that are presented in Tables 4.2 to 4.9, the following operating log data and supporting information is included in this report as Appendix A (Volume II).

- o Operating log data including board-mounted and local instrument readings. Data is presented on actual operator and computer input sheets.
- o A summary of the operator feed tabulation forms presenting waste feedrates.
- o Graphical presentation of total daily waste feedrates for each month of unit operation.

TABLE 4.2
 SITE DEMONSTRATION TEST PROGRAM
 UNIT OPERATING CONDITIONS
 CONTROL ROOM MOUNTED INSTRUMENT DATA

AUGUST 1, 1987

| | | | | Average | Maximum | Minimum | Standard Deviation | Coefficient of Variance |
|----------------------|------------------|-----------------|------------------|---------|----------|---------|--------------------|-------------------------|
| Feedrate, lb/hr | | | | 7335.83 | 10496.00 | 0.00 | 2791.38 | 38.05 |
| Primary Chamber | Temp., F | Zones | A1 | 1623.42 | 1800.00 | 1330.00 | 111.83 | 6.89 |
| | | | A2 | 1747.79 | 1841.00 | 1507.00 | 82.44 | 4.72 |
| | | | A3 | 1787.38 | 1858.00 | 1574.00 | 64.56 | 3.61 |
| | | | B1 | 1741.75 | 1793.00 | 1601.00 | 47.20 | 2.71 |
| | | | B2 | 1725.38 | 1813.00 | 1590.00 | 40.71 | 2.36 |
| | | | B3 | 1341.38 | 1626.00 | 1202.00 | 87.14 | 6.50 |
| | | | Exhaust | 1797.33 | 1936.00 | 1323.00 | 121.83 | 6.78 |
| Residence Time, min. | | | | 18.77 | 20.00 | 13.90 | 1.15 | 6.15 |
| Secondary Chamber | Temp., F | Chamber | | 1885.79 | 1940.00 | 1780.00 | 35.45 | 1.88 |
| | | Exhaust | | 1846.46 | 1901.00 | 1757.00 | 31.28 | 1.69 |
| Scrubber | Delta P, in. H2O | Venturi 1 | | | | | | |
| | | Venturi 2 | | 19.31 | 21.60 | 14.40 | 1.78 | 9.24 |
| | Temp., F | Quench 1 | | | | | | |
| | | Quench 2 | | 182.38 | 185.00 | 168.00 | 3.97 | 2.18 |
| | Flow, GPM | Quench H2O 1 | | | | | | |
| | | Quench H2O 2 | | 17.92 | 19.32 | 17.36 | 0.40 | 2.26 |
| | | Quench Recycle | | 33.04 | 33.04 | 33.04 | | |
| | | Venturi Recycle | | 138.02 | 140.00 | 135.80 | 1.56 | 1.13 |
| | | Chevron Recycle | | 16.72 | 17.92 | 15.68 | 0.85 | 5.10 |
| | | | Chemical Recycle | 418.00 | 420.00 | 416.00 | 2.00 | 0.48 |
| | pH | | | 8.04 | 8.30 | 7.00 | 0.24 | 3.04 |
| Level | | | 11.55 | 12.50 | 11.20 | 0.23 | 2.00 | |
| Stack Exhaust | O2, % | | 5.83 | 13.50 | 4.50 | 1.81 | 31.04 | |
| | CO2, % | | 9.31 | 10.00 | 7.00 | 0.92 | 9.90 | |
| | CO, ppmv | | 5.92 | 8.00 | 4.00 | 1.08 | 18.20 | |
| | Temp., F | | 179.75 | 188.00 | 165.00 | 4.59 | 2.56 | |
| | Velocity, ft/min | | 2158.33 | 2900.00 | 700.00 | 432.21 | 20.03 | |

TABLE 4.3
 SITE DEMONSTRATION TEST PROGRAM
 UNIT OPERATING CONDITIONS
 FIELD MOUNTED INSTRUMENT DATA

AUGUST 1, 1987

| | | | | Average | Maximum | Minimum | Standard Deviation | Coefficient of Variance | | |
|-------------------|-------------------------|----------------------------|-----------------------------|----------------------|---------|---------|--------------------|-------------------------|-------|-------|
| Primary Chamber | HEPC | Zone A | Volts | A | 0.00 | 0.00 | 0.00 | | | |
| | | | | B | 0.00 | 0.00 | 0.00 | | | |
| | | | | C | 0.00 | 0.00 | 0.00 | | | |
| | | | Amps | A | 0.00 | 0.00 | 0.00 | | | |
| | | | | B | 0.00 | 0.00 | 0.00 | | | |
| | | | | C | 0.00 | 0.00 | 0.00 | | | |
| | | | Zone B | Volts | A | 0.00 | 0.00 | 0.00 | | |
| | | | | B | 0.00 | 0.00 | 0.00 | | | |
| | | | | C | 0.00 | 0.00 | 0.00 | | | |
| | | | Amps | A | 0.00 | 0.00 | 0.00 | | | |
| | | | | B | 0.00 | 0.00 | 0.00 | | | |
| | | | | C | 0.00 | 0.00 | 0.00 | | | |
| | | | | Draft, in. H2O | | 0.06 | 0.10 | 0.06 | 0.01 | 17.38 |
| | | | | Combustion Air, PSI | | 3.20 | 4.00 | 2.40 | 0.39 | 12.24 |
| | | | | Combustion Air, SCFM | | 1657.38 | 1743.39 | 1441.19 | 83.59 | 5.04 |
| Secondary Chamber | | | Quench Air, SCFM | | 0.00 | 0.00 | 0.00 | | | |
| | | | Quench Water, GPM | | 0.00 | 0.00 | 0.00 | | | |
| | | | Combustion Air, PSI | | 3.88 | 5.00 | 3.00 | 0.57 | 14.64 | |
| | | | Combustion Air, SCFM | | 3639.42 | 3940.09 | 3341.10 | 176.35 | 4.85 | |
| | | | Forced Draft Air, PSI | | >20.00 | >20.00 | 19.50 | | | |
| | | | Forced Draft Air, SCFM | | 1536.82 | 2264.72 | 835.58 | 600.93 | 39.10 | |
| | | | Propane, PSI | | 9.54 | 11.00 | 8.00 | 1.28 | 13.44 | |
| | | | Propane, SCFH | | 1220.83 | 1900.00 | 550.00 | 542.55 | 44.44 | |
| Quench Tubes | | | Chamber Draft, in. H2O | | <0.25 | <0.25 | <0.25 | | | |
| | | | Emergency Quench Water, PSI | | 76.33 | 79.00 | 72.00 | 1.65 | 2.16 | |
| | | | Venturi 1, Delta P in. H2O | | | | | | | |
| | | Venturi 2, Delta P in. H2O | | 20.71 | 23.50 | 10.00 | 3.62 | 17.48 | | |
| Scrubber | Chevron | | Delta P, in. H2O | | 0.19 | 0.65 | 0.00 | 0.17 | 89.04 | |
| | | | Blowdown, GPM | | | | | | | |
| | Chemical Demister Total | | Delta P, in. H2O | | 1.20 | 1.50 | 0.50 | 0.26 | 21.78 | |
| | | | Delta P, in. H2O | | 0.16 | 0.23 | 0.10 | 0.06 | 39.17 | |
| | | Delta P, in. H2O | | 1.55 | 1.96 | 1.15 | 0.25 | 15.97 | | |

TABLE 4.4
 SITE DEMONSTRATION TEST PROGRAM
 UNIT OPERATING CONDITIONS
 CONTROL ROOM MOUNTED INSTRUMENT DATA

AUGUST 2, 1987

| | | | | Average | Maximum | Minimum | Standard Deviation | Coefficient of Variance |
|----------------------|------------------|-----------------|------------------|---------|----------|---------|--------------------|-------------------------|
| Feedrate, lb/hr | | | | 7245.79 | 10702.00 | 862.00 | 2185.83 | 30.17 |
| Primary Chamber | Temp., F | Zones | A1 | 1516.21 | 1660.00 | 1261.00 | 122.48 | 8.08 |
| | | | A2 | 1638.26 | 1897.00 | 1544.00 | 73.41 | 4.48 |
| | | | A3 | 1772.74 | 1838.00 | 1696.00 | 39.87 | 2.25 |
| | | | B1 | 1681.95 | 1864.00 | 1591.00 | 59.01 | 3.51 |
| | | | B2 | 1696.32 | 1747.00 | 1663.00 | 25.94 | 1.53 |
| | | | B3 | 1443.00 | 1603.00 | 1335.00 | 73.05 | 5.06 |
| | | | Exhaust | 1836.32 | 1940.00 | 1651.00 | 89.95 | 4.90 |
| Residence Time, min. | | | | 18.87 | 20.30 | 17.90 | 0.46 | 2.44 |
| Secondary Chamber | Temp., F | Chamber | | 1886.53 | 1938.00 | 1845.00 | 25.10 | 1.33 |
| | | Exhaust | | 1837.21 | 1883.00 | 1799.00 | 23.75 | 1.29 |
| Scrubber | Delta P, in. H2O | Venturi 1 | | | | | | |
| | | Venturi 2 | | 19.56 | 23.40 | 9.60 | 2.81 | 14.37 |
| | Temp., F | Quench 1 | | | | | | |
| | | Quench 2 | | 193.58 | 207.00 | 184.00 | 7.01 | 3.62 |
| | Flow, GPM | Quench H2O 1 | | | | | | |
| | | Quench H2O 2 | | 18.21 | 18.48 | 17.92 | 0.21 | 1.17 |
| | | Quench Recycle | | 33.04 | 33.04 | 33.04 | 0.00 | 0.00 |
| | | Venturi Recycle | | 128.80 | 140.00 | 119.00 | 7.74 | 6.01 |
| | Chevron Recycle | | 16.21 | 17.08 | 15.12 | 0.67 | 4.11 | |
| | Chemical Recycle | | 360.63 | 416.00 | 344.00 | 19.69 | 5.46 | |
| pH Level | | | 8.44 | 9.80 | 5.00 | 1.06 | 12.55 | |
| | | | 11.57 | 12.00 | 11.50 | 0.11 | 0.97 | |
| Stack Exhaust | | | O2, % | 5.14 | 6.00 | 4.50 | 0.36 | 7.07 |
| | | | CO2, % | 8.46 | 10.00 | 4.00 | 1.50 | 17.79 |
| | | | CO, ppmv | 6.16 | 7.00 | 3.00 | 0.87 | 14.20 |
| | | | Temp., F | 184.79 | 190.00 | 179.00 | 4.03 | 2.18 |
| | | | Velocity, ft/min | 1924.21 | 2500.00 | 1200.00 | 327.39 | 17.01 |

TABLE 4.5
 SITE DEMONSTRATION TEST PROGRAM
 UNIT OPERATING CONDITIONS
 FIELD MOUNTED INSTRUMENT DATA

AUGUST 2, 1987

| | | | | | Average | Maximum | Minimum | Standard Deviation | Coefficient of Variance | | |
|-------------------|-----------------------------|----------------------|--------|-------|---------|---------|---------|--------------------|-------------------------|--------|-------|
| Primary Chamber | HEPC | Zone A | Volts | A | 79.17 | 160.00 | 0.00 | 79.18 | 100.02 | | |
| | | | | B | 74.17 | 150.00 | 0.00 | 74.19 | 100.03 | | |
| | | | | C | 86.67 | 175.00 | 0.00 | 86.68 | 100.02 | | |
| | | | Amps | A | 283.33 | 600.00 | 0.00 | 285.29 | 100.69 | | |
| | | | | B | 277.50 | 595.00 | 0.00 | 279.43 | 100.70 | | |
| | | | | C | 383.33 | 780.00 | 0.00 | 383.57 | 100.06 | | |
| | | | Zone B | Volts | A | 0.00 | 0.00 | 0.00 | | | |
| | | | | | B | 0.00 | 0.00 | 0.00 | | | |
| | | | | | C | 0.00 | 0.00 | 0.00 | | | |
| | | Amps | | A | 0.00 | 0.00 | 0.00 | | | | |
| | | | | B | 0.00 | 0.00 | 0.00 | | | | |
| | | | | C | 0.00 | 0.00 | 0.00 | | | | |
| | | Draft, in. H2O | | | | | 0.06 | 0.07 | 0.05 | 0.01 | 9.62 |
| | | Combustion Air, PSI | | | | | 1.62 | 2.60 | 1.10 | 0.57 | 35.43 |
| | | Combustion Air, SCFM | | | | | 1166.98 | 1562.19 | 951.16 | 195.44 | 16.75 |
| Secondary Chamber | Quench Air, SCFM | | | | | 0.00 | 0.00 | 0.00 | | | |
| | Quench Water, GPM | | | | | 0.00 | 0.00 | 0.00 | | | |
| | Combustion Air, PSI | | | | | | >10.00 | 5.80 | | | |
| | Combustion Air, SCFM | | | | | 4489.42 | 5204.29 | 3702.30 | 576.86 | 12.85 | |
| | Forced Draft Air, PSI | | | | | >20.00 | >20.00 | 19.50 | | | |
| | Forced Draft Air, SCFM | | | | | 1777.74 | 2573.55 | 835.58 | 589.51 | 33.16 | |
| | Propane, PSI | | | | | 8.92 | 11.00 | 8.00 | 1.17 | 13.12 | |
| | Propane, SCFH | | | | | 1383.33 | 1850.00 | 650.00 | 459.77 | 33.24 | |
| | Chamber Draft, in. H2O | | | | | <0.25 | 0.20 | 0.15 | | | |
| Quench Tubes | Emergency Quench Water, PSI | | | | | 76.33 | 80.00 | 69.00 | 3.54 | 4.64 | |
| | Venturi 1, Delta P in. H2O | | | | | | | | | | |
| | Venturi 2, Delta P in. H2O | | | | | 22.50 | 24.00 | 20.00 | 1.26 | 5.59 | |
| Scrubber | Chevron | Delta P, in. H2O | | | | | 0.24 | 0.25 | 0.22 | 0.01 | 4.48 |
| | | Blowdown, GPM | | | | | | | | | |
| | Chemical Demister | Delta P, in. H2O | | | | | 0.73 | 1.20 | 0.50 | 0.33 | 45.00 |
| | | Delta P, in. H2O | | | | | 0.24 | 0.26 | 0.22 | 0.01 | 6.38 |
| Total | | Delta P, in. H2O | | | | | 1.21 | 1.70 | 0.95 | 0.35 | 28.91 |

TABLE 4.6
 SITE DEMONSTRATION TEST PROGRAM
 UNIT OPERATING CONDITIONS
 CONTROL ROOM MOUNTED INSTRUMENT DATA

AUGUST 3, 1987

| | | | Average | Maximum | Minimum | Standard Deviation | Coefficient of Variance |
|-------------------|------------------|----------------------|---------|----------|---------|--------------------|-------------------------|
| Feedrate, lb/hr | | | 7992.75 | 10104.00 | 1018.00 | 1903.83 | 23.82 |
| Primary Chamber | Temp., F | Zones A1 | 1559.33 | 1710.00 | 1364.00 | 110.64 | 7.10 |
| | | A2 | 1687.21 | 1749.00 | 1606.00 | 36.94 | 2.19 |
| | | A3 | 1755.67 | 1857.00 | 1666.00 | 46.46 | 2.65 |
| | | B1 | 1708.75 | 1831.00 | 1615.00 | 66.01 | 3.86 |
| | | B2 | 1656.67 | 1744.00 | 1540.00 | 64.05 | 3.87 |
| | | B3 | 1349.63 | 1533.00 | 1208.00 | 80.59 | 5.97 |
| | | Exhaust | 1922.21 | 2034.00 | 1727.00 | 85.11 | 4.43 |
| | | Residence Time, min. | 17.90 | 19.00 | 15.60 | 0.91 | 5.07 |
| Secondary Chamber | Temp., F | Chamber | 1888.63 | 1943.00 | 1799.00 | 29.14 | 1.54 |
| | | Exhaust | 1847.79 | 1886.00 | 1800.00 | 21.41 | 1.16 |
| Scrubber | Delta P, in. H2O | Venturi 1 | | | | | |
| | | Venturi 2 | 19.21 | 22.20 | 13.20 | 2.00 | 10.39 |
| | Temp., F | Quench 1 | | | | | |
| | | Quench 2 | 200.54 | 212.00 | 186.00 | 8.30 | 4.14 |
| | Flow, GPM | Quench H2O 1 | | | | | |
| | | Quench H2O 2 | 18.14 | 18.48 | 17.92 | 0.14 | 0.77 |
| | | Quench Recycle | 31.13 | 33.04 | 27.44 | 1.73 | 5.57 |
| | | Venturi Recycle | 120.23 | 140.00 | 102.20 | 12.90 | 10.73 |
| | | Chevron Recycle | 16.08 | 18.20 | 13.72 | 1.28 | 7.98 |
| | | Chemical Recycle | 363.33 | 412.00 | 340.00 | 30.89 | 8.50 |
| | pH Level | | 8.04 | 8.50 | 7.00 | 0.36 | 4.43 |
| | | 11.61 | 13.60 | 11.05 | 0.48 | 4.16 | |
| Stack Exhaust | O2, % | | 5.20 | 6.00 | 4.50 | 0.36 | 6.92 |
| | | | 9.40 | 10.00 | 8.50 | 0.41 | 4.34 |
| | | | 6.96 | 8.00 | 6.00 | 0.35 | 5.05 |
| | Temp., F | | 183.25 | 188.00 | 179.00 | 2.89 | 1.58 |
| | | Velocity, ft/min | 1812.08 | 2300.00 | 1400.00 | 311.02 | 17.16 |

TABLE 4.7
 SITE DEMONSTRATION TEST PROGRAM
 UNIT OPERATING CONDITIONS
 FIELD MOUNTED INSTRUMENT DATA

AUGUST 3, 1987

| | | | | Average | Maximum | Minimum | Standard Deviation | Coefficient of Variance | | |
|-------------------|-------------------|----------------------|-----------------------------|---------------------|---------|---------|--------------------|-------------------------|--------|-------|
| Primary Chamber | HEPC | Zone A | Volts | A | 19.44 | 105.00 | 0.00 | 37.30 | 191.83 | |
| | | | | B | 21.67 | 105.00 | 0.00 | 40.69 | 187.79 | |
| | | | | C | 35.00 | 165.00 | 0.00 | 65.57 | 187.36 | |
| | | | Amps | A | 84.44 | 410.00 | 0.00 | 158.61 | 187.83 | |
| | | | | B | 88.33 | 420.00 | 0.00 | 165.60 | 187.47 | |
| | | | | C | 146.11 | 700.00 | 0.00 | 274.08 | 187.58 | |
| | | | Zone B | Volts | A | 0.00 | 0.00 | 0.00 | | |
| | | | | B | 0.00 | 0.00 | 0.00 | | | |
| | | | | C | 0.00 | 0.00 | 0.00 | | | |
| | | | Amps | A | 0.00 | 0.00 | 0.00 | | | |
| | | | | B | 0.00 | 0.00 | 0.00 | | | |
| | | | | C | 0.00 | 0.00 | 0.00 | | | |
| | | | | Draft, in. H2O | | 0.06 | 0.06 | 0.05 | 0.00 | 8.75 |
| | | | | Combustion Air, PSI | | 2.46 | 3.60 | 1.00 | 0.97 | 39.46 |
| | | Combustion Air, SCFM | | 1482.55 | 1864.70 | 945.14 | 361.88 | 24.41 | | |
| Secondary Chamber | | | Quench Air, SCFM | | 0.00 | 0.00 | 0.00 | | | |
| | | | Quench Water, GPM | | 0.00 | 0.00 | 0.00 | | | |
| | | | Combustion Air, PSI | | 7.35 | 8.80 | 0.00 | 2.46 | 33.49 | |
| | | | Combustion Air, SCFM | | 5025.50 | 5650.37 | 3860.02 | 449.54 | 8.95 | |
| | | | Forced Draft Air, PSI | | 17.65 | 20.00 | 0.00 | 5.89 | 33.35 | |
| | | | Forced Draft Air, SCFM | | 2211.12 | 2882.38 | 1378.70 | 408.16 | 18.46 | |
| | | | Propane, PSI | | 7.04 | 10.50 | 4.50 | 2.02 | 28.76 | |
| | | | Propane, SCFH | | 1723.00 | 1900.00 | 1000.00 | 258.19 | 14.98 | |
| | | | Chamber Draft, in. H2O | | <0.25 | <0.25 | 0.23 | | | |
| Quench Tubes | | | Emergency Quench Water, PSI | | 78.80 | 98.00 | 69.00 | 6.94 | 8.81 | |
| | | | Venturi 1, Delta P in. H2O | | | | | | | |
| | | | Venturi 2, Delta P in. H2O | | 20.94 | 25.00 | 18.00 | 2.34 | 11.17 | |
| Scrubber | Chevron | | Delta P, in. H2O | | 0.09 | 0.25 | 0.00 | 0.09 | 108.62 | |
| | | | Blowdown, GPM | | 8.57 | 10.00 | 0.00 | 3.50 | 40.82 | |
| | Chemical Demister | | Delta P, in. H2O | | 0.03 | 0.30 | 0.00 | 0.09 | 300.00 | |
| | | | Delta P, in. H2O | | 0.25 | 0.30 | 0.20 | 0.02 | 9.36 | |
| | | | Total Delta P, in. H2O | | 0.37 | 0.70 | 0.20 | 0.15 | 39.79 | |

TABLE 4.8
 SITE DEMONSTRATION TEST PROGRAM
 UNIT OPERATING CONDITIONS
 CONTROL ROOM MOUNTED INSTRUMENT DATA

AUGUST 4, 1987

| | | | | Average | Maximum | Minimum | Standard Deviation | Coefficient of Variance |
|----------------------|------------------|------------------|---------|---------|----------|---------|--------------------|-------------------------|
| Feedrate, lb/hr | | | | 7936.00 | 10336.00 | 784.00 | 1949.22 | 24.56 |
| Primary Chamber | Temp., F | Zones | A1 | 1469.92 | 1555.00 | 1382.00 | 51.77 | 3.52 |
| | | | A2 | 1649.54 | 1711.00 | 1581.00 | 38.31 | 2.32 |
| | | | A3 | 1730.33 | 1809.00 | 1647.00 | 48.48 | 2.80 |
| | | | B1 | 1624.21 | 1753.00 | 1509.00 | 47.81 | 2.94 |
| | | | B2 | 1593.13 | 1653.00 | 1462.00 | 37.07 | 2.33 |
| | | | B3 | 1360.21 | 1685.00 | 1078.00 | 203.85 | 14.99 |
| | | | Exhaust | 1884.67 | 2083.00 | 1264.00 | 153.09 | 8.12 |
| Residence Time, min. | | | | 18.88 | 19.30 | 17.90 | 0.29 | 1.54 |
| Secondary Chamber | Temp., F | Chamber | | 1906.79 | 1942.00 | 1843.00 | 25.27 | 1.33 |
| | | Exhaust | | 1858.42 | 1898.00 | 1805.00 | 21.11 | 1.14 |
| Scrubber | Delta P, in. H2O | Venturi 1 | | | | | | |
| | | Venturi 2 | | 19.59 | 23.40 | 14.40 | 2.48 | 12.65 |
| | Temp., F | Quench 1 | | | | | | |
| | | Quench 2 | | 188.54 | 194.00 | 184.00 | 2.78 | 1.48 |
| | Flow, GPM | Quench H2O 1 | | | | | | |
| | | Quench H2O 2 | | 18.15 | 18.20 | 17.64 | 0.13 | 0.73 |
| | | Quench Recycle | | 33.01 | 33.04 | 32.48 | 0.12 | 0.37 |
| | | Venturi Recycle | | 138.31 | 140.00 | 134.40 | 1.62 | 1.17 |
| | | Chevron Recycle | | 15.28 | 16.80 | 14.56 | 0.90 | 5.86 |
| | | Chemical Recycle | | 396.17 | 408.00 | 384.00 | 10.03 | 2.53 |
| pH | | | 7.94 | 8.00 | 7.50 | 0.14 | 1.70 | |
| Level | | | 11.55 | 15.00 | 10.00 | 0.87 | 7.52 | |
| Stack Exhaust | O2, % | | 5.27 | 6.50 | 5.00 | 0.37 | 6.98 | |
| | CO2, % | | 8.80 | 10.00 | 5.00 | 0.98 | 11.16 | |
| | CO, ppmv | | 6.88 | 7.00 | 6.00 | 0.33 | 4.81 | |
| | Temp., F | | | 184.83 | 187.00 | 180.00 | 1.86 | 1.01 |
| | Velocity, ft/min | | | 1670.83 | 2000.00 | 1450.00 | 161.32 | 9.66 |

TABLE 4.9
 SITE DEMONSTRATION TEST PROGRAM
 UNIT OPERATING CONDITIONS
 FIELD MOUNTED INSTRUMENT DATA

AUGUST 4, 1987

| | | | | Average | Maximum | Minimum | Standard Deviation | Coefficient of Variance | | |
|------------------------|-----------------------------|----------------------|-------|---------|---------|---------|--------------------|-------------------------|--------|-------|
| Primary Chamber | HEPC | Zone A | Volts | A | 90.83 | 170.00 | 0.00 | 63.40 | 69.80 | |
| | | | B | 91.67 | 170.00 | 0.00 | 60.53 | 66.03 | | |
| | | | C | 112.08 | 175.00 | 0.00 | 69.60 | 62.09 | | |
| | | Amps | A | 356.67 | 660.00 | 0.00 | 240.95 | 67.56 | | |
| | | | B | 378.75 | 660.00 | 0.00 | 247.08 | 65.24 | | |
| | | | C | 474.17 | 760.00 | 0.00 | 294.41 | 62.09 | | |
| | | Zone B | Volts | A | 231.67 | 720.00 | 0.00 | 284.66 | 122.87 | |
| | | | B | 231.67 | 720.00 | 0.00 | 284.66 | 122.87 | | |
| | | | C | 231.67 | 720.00 | 0.00 | 284.66 | 122.87 | | |
| | | Amps | A | 231.67 | 720.00 | 0.00 | 284.66 | 122.87 | | |
| | | | B | 231.67 | 720.00 | 0.00 | 284.66 | 122.87 | | |
| | | | C | 231.67 | 720.00 | 0.00 | 284.66 | 122.87 | | |
| | | Draft, in. H2O | | | | 0.05 | 0.07 | 0.04 | 0.01 | 13.30 |
| | | Combustion Air, PSI | | | | 2.22 | 4.80 | 0.60 | 1.65 | 74.53 |
| | | Combustion Air, SCFM | | | | 1272.80 | 2138.91 | 921.06 | 327.80 | 25.75 |
| Secondary Chamber | Quench Air, SCFM | | | | 0.00 | 0.00 | 0.00 | | | |
| | Quench Water, GPM | | | | 0.00 | 0.00 | 0.00 | | | |
| | Combustion Air, PSI | | | | | >10.00 | 6.80 | | | |
| | Combustion Air, SCFM | | | | 4088.58 | 4867.17 | 3143.04 | 615.38 | 15.05 | |
| | Forced Draft Air, PSI | | | | >20.00 | >20.00 | 19.50 | | | |
| | Forced Draft Air, SCFM | | | | 1909.89 | 2676.49 | 1044.47 | 385.13 | 20.17 | |
| | Propane, PSI | | | | 8.79 | 11.00 | 8.00 | 0.99 | 11.25 | |
| | Propane, SCFH | | | | 1533.33 | 1850.00 | 650.00 | 349.01 | 22.76 | |
| Chamber Draft, in. H2O | | | | <0.25 | 0.25 | <0.25 | | | | |
| Quench Tubes | Emergency Quench Water, PSI | | | | 76.17 | 80.00 | 72.00 | 2.03 | 2.67 | |
| | Venturi 1, Delta P in. H2O | | | | | | | | | |
| | Venturi 2, Delta P in. H2O | | | | 20.08 | 22.00 | 14.00 | 2.84 | 14.15 | |
| Scrubber | Chevron | Delta P, in. H2O | | 0.18 | 0.30 | 0.00 | 0.10 | 53.99 | | |
| | | Blowdown, GPM | | 35.42 | 80.00 | 15.00 | 19.63 | 55.42 | | |
| | Chemical Demister | Delta P, in. H2O | | 0.00 | 0.00 | 0.00 | | | | |
| | | Delta P, in. H2O | | 0.25 | 0.30 | 0.20 | 0.04 | 15.44 | | |
| | | Delta P, in. H2O | | 0.43 | 0.60 | 0.20 | 0.12 | 29.02 | | |

SECTION 5
SAMPLING AND ANALYSIS PROGRAM

The SITE test program on the Shirco infrared incineration system at the Peak Oil site was conducted with the unit operating at normal conditions as summarized in Section 4. The overall program consisted of three separate test runs. During one of these three test runs, a duplicate set of samples was taken at each sampling location and analyzed for all the parameters defined in the analytical protocol. Table 5.1 presents a summary of the test program including sampling frequencies, sampling methods, analytical parameters, and analytical methods for each sample source. The Sampling and Analytical Report and the Quality Assurance Project Plan are provided in their entirety as Appendices B and C in Volume II of this Technical Evaluation Report.

It should be noted that in the discussions that follow, references to various sampling and analytical protocols are included. These recommended methods for sampling and analyzing samples are coded as follows:

- o "A" and "S" refers to Arthur D. Little, Inc., "Sampling and Analysis Methods for Hazardous Waste Combustions," EPA 600/8-84-002, PB84-155845, February, 1984.
- o "ASTM" refers to American Society for Testing Materials, "Annual Book of ASTM Standards," Philadelphia, Pennsylvania.
- o "EPA Method" refers to Code of Federal Regulations 40CFR Part 60, Appendix A, Revised as of July 1, 1985.
- o "M" refers to USEPA "Methods for Chemical Analysis of Water and Wastes," EPA-600/4-79-020, March, 1979.
- o "SW" refers to USEPA, "Test Methods for Evaluating Solid Waste-Physical/Chemical Methods," SW-846, Third Edition, 1986.
- o "SASS" refers to USEPA, "Modified Method 5 Train and Source Assessment Sampling System Operator's Manual," EPA-600/8-85-003, February, 1985.
- o "VOST" refers to USEPA, "Protocol for the Collection and Analysis of Volatile POHCs Using VOST," EPA-600/8-85-003, February, 1985.

TABLE 5.1. SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM FOR THE PEAK OIL SITE, BRANDON, FLORIDA

| Source | Sample Collection Frequency | Sampling Method | Analysis Parameters | Analysis Method |
|-----------|--|--|--|---|
| Stack Gas | Composite over 3- to 6-hour period | EPA Method 5 with 0.1 N NaOH | Particulate matter HCl Volumetric flowrate Moisture Metals (particulate on filter) | EPA Method 5 Ion Chromatography EPA Methods 1-4 EPA Method 4 SW 6010,7060,7041,7421 7740,7470/7471 |
| | Composite over 3- to 6-hour period | SASS with XAD-2 (SW0020) | PCB | EPA 680 |
| | Composite over 3- to 6-hour period | SASS with XAD-2 (SW0020) | PCDD/PCDF Semivolatile Priority Pollutants (plus 10 higher peaks) | SW 8280 SW 8270 |
| | Composite over 4 hour period | Modified Method 5 (No filter/0.1 N NaOH) | Soluble Chromium | M218.4 |
| | | Gas bag (Grab) | CO ₂ , O ₂ | EPA Method 3 |
| | 6 pairs of samples over 2-hour period (one aqueous condensate) | VOST (SW0030) | Volatile Priority Pollutants (plus 10 highest peaks) | SW 8240 |
| | Continuous | Continuous emission monitors | O ₂ CO ₂ CO THC NO _x | Paramagnetic NDIR NDIR FID Chemiluminescence |

(continued)

TABLE 5.1 (continued)

| Source | Sample Collection Frequency | Sampling Method | Analysis Parameters | Analysis Method |
|------------------|---|-----------------|--|--|
| Solid Waste Feed | Grab sample once per hour and composite | S007 | Chlorine | A003 |
| | | | PCDD/PCDF | SW8280 |
| | | | PCB | EPA 680 |
| | | | Metals | SW 6010,7060,7041, 7421,7740,7470/7471 |
| | | | TCLP (Proposed) | Fed. Reg. Vol. 51, No. 114 |
| | | | EP Toxicity | C004, SW1310 |
| | | | Volatile Priority Pollutants (plus 10 highest peaks) | SW8240 |
| | | | Semivolatile Priority Pollutants (plus 10 highest peaks) | SW8270 |
| | | | Moisture, Ash | A001 |
| | | | Ultimate Higher Heating Value | A003 |
| TCD - Organics | A011 | | | |
| GRAV - Organics | A012 | | | |
| Scrubber Solids | Grab sample once per hour and composite | S007 | PCB | EPA 680 |
| | | | PCDD/PCDF | SW8280 |
| | | | Chlorine | A003 |
| | | | Metals | SW 6010,7060,7041 7421,7740,7470/7471 |
| | | | EP Toxicity | C004, SW1310 |
| | | | TCLP (Proposed) | Fed. Reg. Vol. 51, No. 114 |
| | | | Volatile Priority Pollutants (plus 10 highest peaks) | SW 8240 |

(continued)

TABLE 5.1 (continued)

| Source | Sample Collection Frequency | Sampling Method | Analysis Parameters | Analysis Method |
|----------------------|---|--|--|---------------------------------------|
| | | | Semivolatile Priority Pollutants (plus 10 highest peaks) | SW 8270 |
| | | | Ash | A001 |
| | | | Ultimate | A003 |
| Scrubber Water inlet | Grab sample every 15 minutes and composite | S004 | PCB | EPA 680 |
| | | | PCDD/PCDF | EPA 8280 |
| | | | pH | M150.1 |
| | | | Chloride | Ion Chromatography |
| | | | Metals | SW 6010,7060,7041,7421,7740,7470/7471 |
| | | | Volatile Priority Pollutants (plus 10 highest peaks) | SW 8240 |
| | | | Semivolatile Priority Pollutants (plus 10 highest peaks) | SW 8270 |
| | | | Total Organic Carbon | M415.1 |
| | | | Total Suspended Solids | M160.1 |
| | | | Total Dissolved Solids | M160.2 |
| Ambient Air | Continuous over 24-hour period; one upwind and one downwind | General Metal Works Model PS-1 Air Sampler w/ Polyurethane Foam (PUF) Plugs and Florisil Sorbent | PCB | EPA 680 |
| Furnace Ash | Grab sample once per hour and composite | S007 | PCB | EPA 680 |
| | | | PCDD/PCDF | SW 8280 |
| | | | Metals | SW 6010,7060,7041,7421,7740,7470/7471 |

(continued)

TABLE 5.1 (continued)

| Source | Sample Collection Frequency | Sampling Method | Analysis Parameters | Analysis Method |
|--|---|-----------------|--|--|
| 3 4 Scrubber Liquid Effluent | Grab sample once per hour and composite | S004 | EP Toxicity | C004, SW1310 |
| | | | TCLP (Proposed) | Fed. Reg. Vol. 51, No. 114 |
| | | | Volatile Priority Pollutants (plus 10 highest peaks) | SW 8240 |
| | | | Semivolatile Priority Pollutants (plus 10 highest peaks) | SW 8270 |
| | | | Moisture, Ash | A001 |
| | | | Chlorine | A003 |
| | | | TCO - Organics | A011 |
| | | | GRAV - Organics | A012 |
| | | | PCB | EPA 680 |
| | | | PCDD/PCDF | EPA 8280 |
| | | | pH | M150.1 |
| | | | Chlorine | Ion Chromatography |
| | | | Metals | SW 6010,7060,7041, 7421,7740,7470/7471 |
| | | | EP Toxicity | C004, SW1310 |
| TCLP (Proposed) | Fed. Reg. Vol. 51, No. 114 | | | |
| Volatile Priority Pollutants (plus 10 highest peaks) | SW 8240 | | | |
| Semivolatile Priority Pollutants (plus 10 highest peaks) | SW 8270 | | | |
| Total Organic Carbon | M415.1 | | | |
| Total Suspended Solids | M160.1 | | | |
| Total Dissolved Solids | M160.2 | | | |

- o "EPA" refers to USEPA, "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," EPA-600/4-82-057.

5.1 SAMPLING PROCEDURES

5.1.1 Sampling Locations

The sampling locations are depicted in Figure 5.1. The streams sampled were:

1. Stack Gas
2. Solid Waste Feed
3. Furnace Ash
4. Scrubber Liquid Effluent
5. Scrubber Effluent Solids
6. Scrubber Water Inlet
7. Ambient Air

5.1.1.1 Stack Gas

Secondary combustion chamber gases were drawn through the scrubber unit by an induced draft fan and exhausted out a fiberglass-reinforced plastic (FRP) stack. The stack was mounted on a pad as a freestanding unit and had a diameter of 32 in. Two orthogonal stack sampling ports with 4-in flanged extensions were approximately 34.5 ft from ground level. Two additional orthogonal 3-in ports were located about 2 ft above the 4-in ports. Haztech's continuous monitors utilized one of the 3-in ports. A sampling platform accessible by a ladder was at the sampling level.

5.1.1.2 Solid Waste Feed

The solid waste feed samples were obtained at the point where the waste feed transferred from the weigh hopper to the conveyor belt, which services the incinerator feed hopper. The solid waste feed dropped from the weigh hopper directly onto the feed hopper conveyor, providing an easily accessible point. Grab samples were taken hourly in one-liter amber glass bottles.

5.1.1.3 Furnace Ash

Primary furnace ash was augered from the primary combustion chamber to a metal holding bin. The ash was removed from the bin by a front-end loader and deposited on a concrete pad prior to disposal. The ash samples were scooped directly from

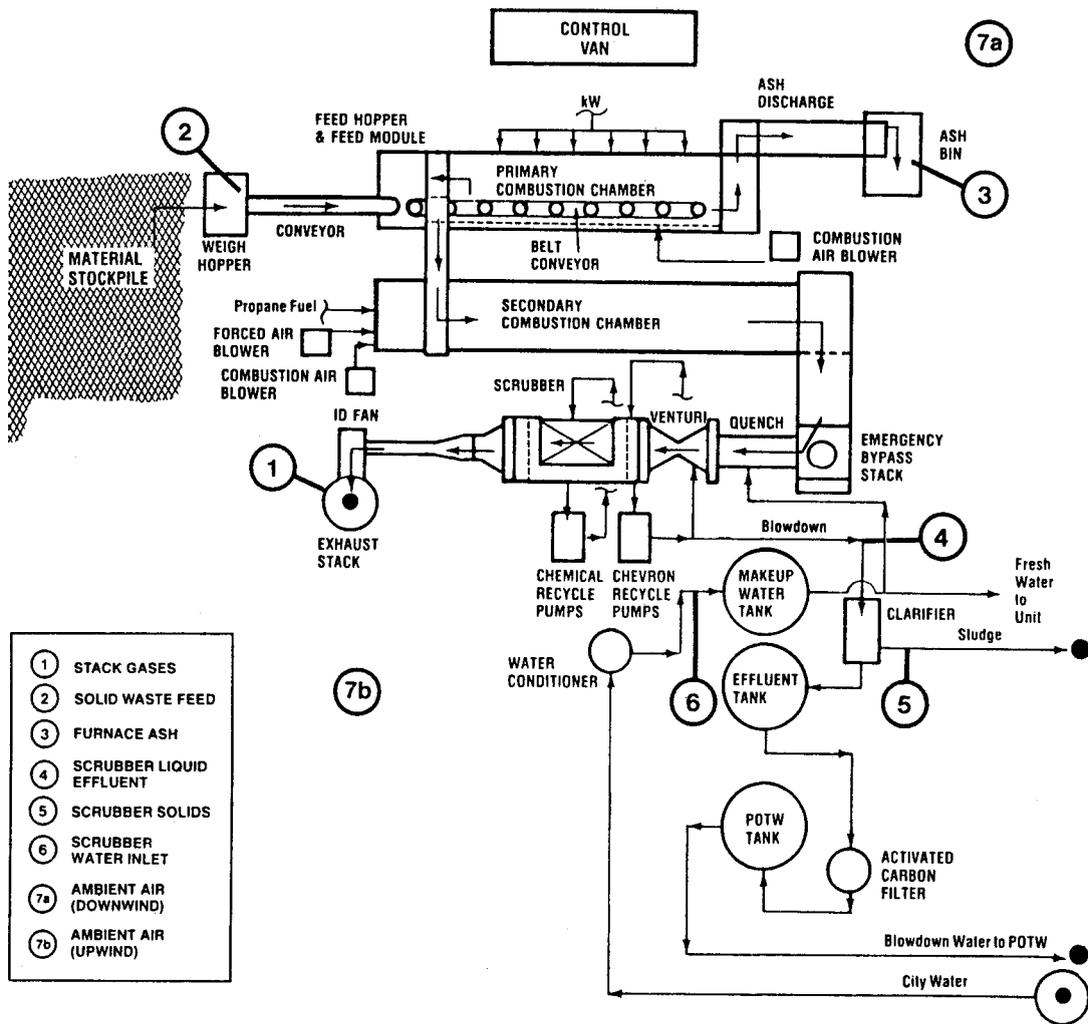


Figure 5.1. Sampling locations.

the ash bin. Grab samples were taken hourly in one-liter amber glass bottles.

5.1.1.4 Scrubber Liquid Effluent

Scrubber liquid effluent was recycled to the utilized venturi throat and quench tubes and chevron section of the scrubber. A portion of the effluent was collected and was blown down to a clarifier for solids separation before being transferred to the effluent holding tank. Samples of the scrubber liquid effluent were obtained from a tap at the discharge of the chevron recycle pump. Grab samples were taken hourly in 50-mL amber glass bottles and two 40-mL volatile organic analysis (VOA) vials.

5.1.1.5 Scrubber Effluent Solids

Particulate matter and salts were removed from the exhaust combustion gas by the venturi/scrubber system. Scrubber water was periodically blown down to a clarifier where the particulate matter and salts settled out and collected at the bottom of the clarifier. Grab samples from the clarifier were taken hourly in one-liter amber glass bottles.

5.1.1.6 Scrubber Water Inlet

A sample of the scrubber makeup water was taken at the conclusion of the test program from the hose outlet of the fresh water pump discharge to the makeup water tank. The sample was collected in a one-liter amber glass bottle.

5.1.1.7 Ambient Air

Ambient concentrations of PCBs were monitored during testing at site boundaries. One upwind and one downwind ambient air sample were collected over a 24-hour period.

5.1.2 Process Data

Haztech operating personnel recorded process data during the test periods at hourly intervals. Selected process data is tabulated in Section 4. The actual operating log data, process data sheets, and a summary of the waste feedrate tabulation forms are included in Appendix A (Vol. II).

5.1.3 Stack Gas Sampling Procedures

Sampling procedures for collection of stack gas samples are described in the following sections.

5.1.3.1 EPA Method 5

The stack gas was sampled for measurement of particulate matter, HCl, volumetric flowrate, moisture, and metals using

an EPA Method 5 sampling train. The method was modified by including 0.1 N NaOH in the impingers to collect HCl.

Based on EPA Method 5, a sample of particulate-laden flue gas was withdrawn isokinetically using a gooseneck nozzle and heat-traced glass-lined probe. The particulate matter was collected on a glass fiber filter maintained at a temperature in the range of $248 \pm 25^{\circ}\text{F}$. The particulate mass was determined gravimetrically from the residues collected on the filter, in the probe, and in associated glassware prior to the filter. Exiting the filter, the flue gas entered a chilled impinger train where HCl was collected in the first two Greenburg-Smith impingers, containing 200 mL of 0.1 N NaOH. A third dry impinger was employed to collect condensate or mist carry-over from the previous impingers. The third impinger was a modified Greenburg-Smith type. The fourth impinger contained a known weight of silica gel desiccant to collect remaining moisture. A pump and dry gas meter were used to control and monitor the gas flowrate.

During collection of EPA Method 5 samples, S-type pitot measurements were taken at traverse points in the flue gas duct to determine the isokinetic sampling rate. The pitot differential pressure measurements, along with the flue gas composition (CO_2 , O_2 , N_2 , H_2O) were also used to determine the volumetric flue gas flowrate by correlation to the cross-sectional area of the duct at the sampling location. Grab samples of the stack gas were collected to determine the concentrations of CO_2 and O_2 directly and N_2 by difference, in accordance with EPA Method 3 protocol. The moisture content of the sample gas was measured during the runs following EPA Method 4 protocol.

At the end of the sampling period, the nozzle, probe liner, and glassware preceding the filter housing were rinsed with acetone and deionized water to remove particulate matter. The resulting wash was evaporated, and the mass of particulate residue was determined gravimetrically. The glass fiber filter was removed from the filter holder, desiccated for 24 hours, and weighed to determine the mass of particulate on the filter. The total mass of particulate present on the filter and in the probe then was divided by the total volume of gas sampled to determine the particulate loading.

The impingers used during particulate sampling were weighed before and after sampling to determine the moisture content of the flue gas. The HCl concentration of the flue gas was determined by analyzing two sodium hydroxide impingers for chloride. Since the impinger solutions are caustic, CO_2 was also removed. To account for the CO_2 removal, the 0.1 N NaOH impinger solutions also were analyzed for carbonate. The metered gas sample volume was adjusted using the carbonate analytical values.

The particulate matter collected on the glass fiber filter was analyzed for metals. The measured metals concentration along with the particulate loading and flue gas flowrate were used to determine the emission rates of those metals.

5.1.3.2 Source Assessment Sampling System (SASS)

A SASS train was used to collect samples of the stack gases for the determination of PCBs, SV-PP+10, PCDDs, and PCDFs.

The sampling system consisted of a heated probe, a heated filter, a condenser, a sorbent module containing an organic adsorption resin (XAD-2) that was used for efficient collection of vapor phase organics, and a pumping and metering unit. Because of the low particulate loading in the gas stream, the three cyclones of the SASS were removed from the train for sampling. The probe was a stainless steel sheath, which contained a heat-traced stainless steel sample liner. A gooseneck nozzle of proper size to allow near-isokinetic sample collection was attached to the probe. The flue gas velocity was measured at the nozzle tip by an S-type pitot. Either an oil manometer or Magnehelic^R differential pressure gauge was used to measure the pressure drop of the pitot. The probe was fixed to the heated enclosure, which housed a high-efficiency glass fiber filter. The enclosure was maintained at a temperature of 400^oF.

From the heated filter, the sample gas entered a water-cooled condenser, then the XAD-2 sorbent module, and then a condensate trap, which collected the aqueous condensate.

From the condensate trap the gas entered three dry impingers, which collected any mist carry-over from the condensate trap. A fourth impinger containing a desiccant dried the sample gas prior to metering. The sample gas was drawn by two double diaphragm pumps, and the sample gas volume was measured using a dry gas meter.

The design of the SASS train precluded traversing of the stack. Sample collection was performed at a fixed point of average gas velocity, selected based on previously determined velocity traverse data. The SASS probe included an S-type pitot and thermocouple to measure sample gas velocity to determine the isokinetic flowrate.

During the initial test with the SASS train it was noted that the temperature being maintained around the XAD-2 cartridge was approximately 30^oC. The method specifically states the XAD-2 temperature must not exceed 20^oC for efficient capture of semivolatile organics. The SASS run was stopped until the proper temperature could be achieved. The problem was linked to the stack gas temperature and sampling rate and the condenser chiller, which seemed to be functioning marginally.

At a sampling rate sufficient to collect 30 m³ of gas in 6 hours as called for in the QAPP, the SASS chiller could not maintain the XAD-2 cartridge below 20°C.

The decision was made to sample at a lower flowrate that would permit sufficient cooling of the stack gases. Due to the heavy particulate loading in the gas it was not possible to compensate for the lower flowrate by increasing the sampling time, as the filter would clog with particulates. The net result of this problem was that each SASS test collected less than the desired 30 m³ of gas. This smaller sample volume may have affected the detection of low concentration organics.

Based on the above, six SASS samples were collected with gas volumes ranging from 7.31 to 12.06 m³ (258 to 426 ft³). Sample collection times were approximately five hours for each SASS sampling period.

5.1.3.3 Soluble Chromium

Soluble chromium (hexavalent chromium) sampling was conducted according to the procedures (with modifications) currently being used by the EPA's Emission Measurement Branch (EMB) for sampling hexavalent chromium emissions from municipal waste incinerators. This procedure involves the use of an EPA Method 5 sampling train with the following modifications:

- o 0.1 N NaOH impingers in place of water
- o No filter
- o A glass nozzle in place of stainless steel
- o 0.1 N NaOH rinse to recover the sample
- o Minimal 0.1 N NaOH in the sample recovery process

The nozzle, probe liner, and pre-impinger glassware rinse were added to the impinger catches, and the sample was analyzed by atomic absorption spectroscopy. The soluble chromium sampling train was run approximately 4 hours at a fixed point of average flue gas velocity in order to achieve adequate analytical sensitivity.

5.1.3.4 Volatile Organic Sampling Train (VOST)

The stack gas was sampled for volatile organic compounds and priority pollutants (plus the 10 highest peaks) using the VOST (Volatile Organics Sampling Train). The VOST was designed to collect volatile organics with boiling points at around or below 100°C using a pair of adsorbent resin traps in series.

Volatile organics were removed from the gas in sorbent resin traps maintained at 68⁰ F. The first resin trap contained Tenax, and the second trap contained Tenax followed by petroleum-based charcoal. After sampling, the resin traps were sealed and returned to the laboratory for analysis. A 20-L sample of gaseous effluent was collected using a glass-lined probe. A dry gas meter was used to measure the volume of gas passed through the pair of traps.

During the test, the VOST run consisted of collecting six pairs of traps, with each pair of traps exposed to sample gas for 20 minutes at the 1.0 L/min flowrate. After daily sampling, two 40-ml VOA vials were used to collect the aqueous condensate collected in the condenser. Three analyses were performed on the six resin trap pairs and on one of the aqueous condensate vials. The samples were collected at a fixed point of average gas velocity in the duct. Isokinetic sampling was not required since the volatile POHCs are in the gas phase.

5.1.3.5 Molecular Weight

Stack gas was collected at a fixed point in the stack gas bags for determination of O₂ and CO₂ concentrations. The samples were extracted through a stainless steel probe and passed through a silica gel impinger to dry the gas before collection in the gas bag. Analysis was conducted by EPA Method 3.

5.1.3.6 Continuous Emission Monitors (CEMs)

CEMs were used during the demonstration test to continuously monitor the concentrations of CO, CO₂, O₂, NO_x, and THC at the stack. Stack gas was withdrawn from the stack and transported to the instrumentation located at ground level. A stainless steel probe was inserted into the stack, and a heat-traced Teflon sample line was used to transport the sample to the instrumentation. The sample line was maintained at a temperature of 300⁰F. The stack gas was conditioned prior to analysis, removing both particulate matter and water.

Stack gas first entered an impinger train having a series of short-stemmed impingers (as condensers) immersed in an ice bath. After the impinger train, particulate matter was removed by a glass fiber filter. After filtration, the stack gas was further dried using a Perma-Pure dryer, which utilizes a water vapor permeable membrane.

The stack gas was drawn by a Teflon^R-coated diaphragm pump located between the filter and the Perma-Pure dryer. Stack gas for the five instruments discussed below was drawn from a manifold downstream of the pump.

A Bendix Model 85-105CA analyzer was used to measure CO concentration in the stack gas. This instrument is a nondispersive infrared (NDIR) analyzer, which measures the concentration of CO by infrared absorption at a characteristic wavelength. To measure the CO₂ concentration in the stack gas, an MSA Model 303 NDIR analyzer was used. This instrument measures the concentration of CO₂ by infrared absorption at a characteristic wavelength.

A Taylor Model 540A oxygen analyzer was used to determine the O₂ concentration of the stack gas. The Taylor 540A measures oxygen concentrations on the basis of the strong paramagnetic properties of O₂ compared to other compounds present in combustion gases. In the presence of a strong magnetic field, O₂ molecules become temporary magnets. The Taylor 540A determines the sample gas O₂ concentration by detecting the displacement torque of the sample test body in the presence of a magnetic field.

A TECO Model 10 analyzer was used to measure the concentration of NO_x present in the stack gas. This instrument determines NO_x concentrations by converting all nitrogen oxides present in the sample gas to nitric oxide and then reacting the nitric oxide with ozone. The reaction produces a chemiluminescence proportional to the NO_x concentration in the sample gas. The chemiluminescence is measured using a high-sensitivity photomultiplier.

A Beckman Model 400A was used to continuously measure the concentration of hydrocarbons present in the flue gas. The analyzer utilizes a hydrogen flame ionization detector. The sensor is a burner; a regulated flow of sample gas passes through a flame sustained by regulated flows of a fuel gas and air. Within the flame, the hydrocarbon components of the sample stream undergo a complex ionization that produces electrons and positive ions. Polarized electrodes collect these ions, causing current to flow through an electronic measuring circuit. The ionization current is proportional to the rate at which carbon atoms enter the burner and is, therefore, a measure of the concentration of hydrocarbons in the original sample.

5.1.4 Solid and Liquid Sampling Procedures

Sampling procedures used to collect samples from solid and liquid streams are described in this section.

5.1.4.1 Solid and Liquid Sample Container Preparation

Sample containers for the solid and liquid samples were organic-free and sealed prior to receipt in the field. All sample bottles used for solid and liquid samples were amber glass with Teflon[®] cap liners.

All sample bottles were purchased new from I-Chem Research, Inc. in Hayward, California. Each sample bottle that was used to store samples for organic analysis was pre-cleaned using the following procedure: clean initially with a phosphate-free soap; rinse three times with tap water; rinse three times with deionized water; rinse with nitric acid; rinse three times with deionized water; rinse with methylene chloride; bake in an oven for 6 hours at 200°C; allow to cool, and then cap.

5.1.4.2 Solid Sampling Procedures

Samples of the solid waste feed, furnace ash, and scrubber solids were collected using a trowel or scoop as specified in Method S007.

Solid grab samples were taken at one-hour intervals. Approximately 1000 g of solid waste feed were collected for each grab sample. The individual solid grab samples from each run were composited into a single sample prior to analysis. The total mass of the composited solid sample was no less than 1000 g.

5.1.4.3 Liquid Sampling Procedures

Scrubber liquid effluent and scrubber water inlet samples were collected using the tap sampling procedure Method S004. Liquid samples were collected hourly during each sampling period. The sample tap was flushed each time (allowed to flow briefly) before the sample was collected. This ensured that any stagnant accumulation of solids or other contaminants present in the tap would not affect the sample integrity.

For the integrated grab sample, a minimum of 100 mL was collected from each grab subsample; the total grab sample volume for the run was about 1 to 2 L.

At each sample collection, two 40-mL VOA sample vials were also collected for analysis of V-PP+10. The vials were filled completely and no air bubbles allowed to remain in the bottles. The VOA samples were composited at the time of analysis by syringe accumulation from the selected subsamples, thus producing one sample per test period for analysis.

5.1.5 Ambient Air Sampling Procedures (PCBs)

Ambient air both upwind and downwind of the test site was sampled and analyzed for PCBs during the program. The upwind and downwind General Metals Works Inc. (GMW) Model PS-1 air samplers were placed based on wind direction. The wind direction was checked at least once per hour. Since samplers could not be moved once sampling began, if the average wind direction deviated by more than 90°, ambient sampling was terminated for that period. Ambient PCB concentrations were determined using the polyurethane foam (PUF) technique.

5.1.6 Sampling Equipment Calibration Procedures

An important function in maintaining data quality is the check-out and calibration of the source sampling equipment. Using referenced procedures, the equipment was calibrated prior to field sampling at the Radian laboratories, and the results have been properly documented and retained.

5.1.6.1 S-Type Pitot Tube

The EPA has specified guidelines, as presented in Section 3.1.1 of EPA Document 600/4-77-027b, "Quality Assurance Handbook for Air Pollution Measurement Systems," August, 1977, concerning the construction and geometry of an acceptable S-type pitot tube. Only S-type pitot tubes meeting the required EPA specifications were used during this project. Prior to the field sampling, the pitot tubes were inspected and documented as meeting EPA specifications.

5.1.6.2 Sampling Nozzle

EPA Method 5 prescribes the use of stainless steel gooseneck nozzles for isokinetic particulate sampling. All nozzles used for the EPA Method 5 particulate sampling and Modified Method 5 sampling were thoroughly cleaned, visually inspected, and calibrated according to the procedure outlined in Section 3.4.2 of EPA Document 600/4-77-027b.

5.1.6.3 Differential Pressure Gauge

Magnehelic^R gauges were used during this project to measure differential and static pressures. In Section 3.1.2 of EPA Document 600/4-77-027b, the technique used to calibrate the Magnehelic^R is described. The Magnehelic^R gauges were calibrated prior to field sampling and checked at a single representative value following the field sampling.

5.1.6.4 Temperature Measuring Device

During source sampling, accurate temperature measurements are required. Thermocouple temperature sensors were calibrated using the procedure described in Section 3.4.2 of EPA Document 600/4-77-027b. All sensors were calibrated prior to field sampling.

5.1.6.5 Dry Gas Meter

Dry gas meters (DGMs) were used in the SASS, Modified Method 5, Method 5, and VOST trains to monitor the sampling rate and to measure the sample volume. All dry gas meters were calibrated (documented correction factor at standard conditions) just prior to the departure of the equipment to the field. A posttest calibration check was performed after

the equipment was returned to Radian in Austin, Texas. The pretest and posttest calibrations should agree within 5 percent.

The dry gas meters used in the SASS, Modified Method 5, and Method 5 trains were calibrated using the calibration system procedure outlined in Section 3.3.2 of EPA Document 600/4-77-027b.

Rockwell DGMs were used during the SASS, Modified Method 5, and Method 5 tests. A Singer Model DTM-115 low flow DGM was used during the VOST testing.

5.1.6.6 Analytical Balance

During the field measurement program, the analytical balances were calibrated over the expected range of use with standard weights (NBS Class S) on a daily basis. Measured values were required to agree within ± 0.1 mg.

5.1.6.7 CEMs

Calibrations of all continuous monitors were accomplished by introducing standard gases at the front end of the CEM sampling probe prior to and after daily sampling. This allowed for the assessment of any impact by the sample gas conditioning system, including the heat traced sample line, on the pollutants being monitored. All instruments underwent multipoint linearity checks (two points plus zero), bracketing the predicted sample values. These checks were performed at the beginning and end of the sampling program.

An analytical blank and a single-point response factor (RF) standard was analyzed daily prior to testing for all continuous monitors. A single-point drift check was also performed by analyzing the same standard used for the single-point RF determination at the end of each day of testing.

5.1.6.8 PUF Ambient Air Sampler Calibration

Calibration of the General Metal Works (GMW) PS-1 sampler was performed using a GMW Model 40 orifice calibration unit (OCU). The GMW PS-1 samplers were calibrated prior to inception of the project, and recalibrated at the end of the project. The calibration information was recorded on a standardized data form.

5.1.7 Sample Custody

Sample custody procedures for this program were based on EPA-recommended procedures. Since samples were analyzed on site, as well as at Radian's permanent laboratory facilities and at Huffman Labs, the custody procedures used emphasize careful

documentation of monitoring, sample collection, field analytical data, and the use of chain-of-custody records for samples being transported.

The field sampling leader was responsible for ensuring that proper custody and documentation procedures were followed for the field sampling and field analytical efforts. He was assisted in this effort by the sampling personnel involved in sample recovery.

All sampling data, including sampling times, locations, and any specific considerations associated with sample acquisition, was recorded on preformatted data sheets. Following sample collection, all samples were logged into a master logbook (bound notebook) and given a unique alphanumeric identification number. Any specific sample preservation, storage, or on-site analysis information was also noted. Sample labels and chain-of-custody seals were completed and affixed to the sample container. Finally, chain-of-custody forms were completed by any personnel handling samples.

Each shipment of samples to be analyzed by Huffman Labs was given a batch number. Shipping containers were sealed using a chain-of-custody seal. Samples were shipped to Huffman Labs in ice chests and were kept cool (approx. 4°C) with "blue ice" packs surrounding them. Transportation of the samples was accomplished via overnight courier. A sample custodian tracked the samples sent to Huffman from receipt through analyses by a computerized chain-of-custody program developed for Huffman Labs.

5.2 ANALYTICAL PROCEDURES

Samples of solid waste feed, scrubber liquid effluent, scrubber effluent solids, scrubber water inlet, furnace ash, liquids and solids from stack gas, and ambient air were analyzed for parameters as specified in Table 5.1. The analytical scheme and descriptions of the analytical methods follow.

5.2.1 Solid Streams Analysis

Solid streams including solid waste feed, furnace ash, and scrubber effluent solids were analyzed for PCBs, PCDD/PCDF, metals, V-PP+10, SV-PP+10, TCLP and EP Toxicity toxicity characteristics, chlorine, moisture, ash, higher heating value, and ultimate analysis. The solid waste feed and furnace ash also were analyzed for total chromatographable and gravimetric organic content (TCO and GRAV).

5.2.2 Liquid Streams Analysis

The scrubber water samples including scrubber liquid effluent and scrubber water inlet were analyzed for PCB, PCDD/PCDF, pH, chlorine, metals, V-PP +10, SV-PP+10, total organic carbon, total suspended solids, and total dissolved solids. The scrubber liquid effluent also was analyzed for TCLP and EP Toxicity toxicity characteristics.

5.2.3 Stack Gas Analysis

Stack gases were analyzed using continuous emission monitoring systems (CEMs) for carbon monoxide, carbon dioxide, oxygen, nitrogen oxides, and total hydrocarbons. Grab samples also were collected during each test run and analyzed for carbon dioxide and oxygen using an Orsat analyzer (EPA Method 3).

EPA Method 5 samples were collected for analysis of particulate matter, moisture, flowrate, and HCl.

Four sets of VOST samples were collected for analysis of V-PP+10. Six VOST tube pairs and two condensate vials were collected for each VOST sample, for a total of 24 tube pairs and 8 condensate vials. Three analyses were obtained from each set of six VOST tube pairs collected; one condensate vial also was analyzed.

EPA Modified Method 5 (MM5) samples were collected for analysis of soluble chromium.

SASS samples were collected and analyzed for PCBs, PCDD/PCDF, and SV-PP+10.

5.2.4 Ambient Air

Ambient air samples were collected daily upwind and downwind of the incineration system using a PUF (polyurethane foam) sampler. PUF samples were analyzed for PCBs.

5.2.5 V-PP+10 Analysis

V-PP+10 analyses were conducted on several types of samples, including solid, liquid, and gas phase samples. The solid and liquid incinerator samples include:

- o Solid Waste Feed
- o Furnace Ash
- o Scrubber Liquid Effluent
- o Scrubber Water Inlet

o Scrubber Effluent Solids

The gas phase samples include stack gas samples collected by VOST. V-PP+10 analysis of each type of sample used the following techniques.

5.2.5.1 Stack Gas Analysis for V-PP+10

The VOST was used to collect samples of the stack gases for quantitation of the V-PP+10. The Tenax and Tenax/charcoal sorbent traps were analyzed according to SW-5040. Volatile compounds were separated and detected using GC/MS as outlined in SW-8240.

5.2.5.2 Liquid and Solid Sample Analysis for V-PP+10

V-PP+10 compounds in liquid and solid samples were analyzed using SW-8240. The method details the purge and trap procedure for preparing field samples for GC/MS analysis.

5.2.6 SV-PP+10 Analysis

SV-PP+10 analyses were conducted on all samples streams.

5.2.6.1 Stack Gas Analysis for SV-PP+10 Analysis

SV-PP+10 analysis using SW-8270 was performed on the stack gas samples collected using the SASS. SV-PP+10 and PCDD/PCDF were analyzed in the same SASS sample. Surrogates applicable to both analyses were injected into the samples prior to extraction. SV-PP+10 analyses were completed prior to initiation of cleanup steps for the PCDD/PCDF analysis.

5.2.6.2 Liquid and Solid Sample Analysis for SV-PP+10

Samples of the solid waste feed, scrubber liquid effluent, scrubber water inlet, scrubber effluent solids, and furnace ash were analyzed by SW-8270. Liquid samples were extracted using SW-3520. Solid samples were extracted using SW-3540. Extracts of liquid and solid samples were analyzed for semivolatile organic contaminants using GC/MS.

5.2.7 PCB Analysis

EPA 680 was used to analyze stack gas, PUF ambient air samples, and solid and liquid samples for PCBs by GC/MS. GC/MS analysis using selected ion monitoring is superior for PCB analysis of gas samples. This type of analysis monitors for ions indicative of biphenyls with two chlorines, three chlorines, etc. The results are usually quantitated as chlorinated biphenyl congeners instead of by Aroclor number (1254, 1260, etc.), as is common in GC/ECD analysis.

5.2.7.1 Stack Gas Analysis for PCBs

Samples of the stack gases were collected using a SASS train with XAD-2 as the adsorbent resin for PCB analysis. The samples were recovered using methanol and methylene chloride. The SASS train provides three subsamples: the glass fiber filter; methanol and methylene chloride rinses of the probe, the filter holder, and the condenser/resin trap; and the aqueous condensate. These subsamples were extracted separately and then combined for analysis.

5.2.7.2 Liquid, Solid, and Ambient Air Sample Analysis for PCBs

EPA 680 was used to analyze the solid waste feed, furnace ash, scrubber liquid effluent, scrubber water inlet, and scrubber solids, and the ambient air PUF plugs for PCBs. Solid samples and PUF plugs were Soxhlet-extracted using SW-3540. Liquid samples were extracted using SW-3520.

5.2.8 PCDDs and PCDFs Analysis

All sampled streams were analyzed for PCDDs and PCDFs.

5.2.8.1 Stack Gases Analysis for PCDDs and PCDFs

Stack gas samples for analysis of PCDDs and PCDFs collected using a SASS train were analyzed according to SW-8280. PCDD/PCDF analyses were performed on the same SASS samples that were analyzed for SV-PP+10.

The XAD-2 resin and filter were Soxhlet-extracted using SW-3540. The aqueous condensate was extracted by SW-3520, which is a continuous liquid/liquid extraction.

5.2.8.2 Liquid and Solid Samples Analysis for PCDDs and PCDFs

The liquid and solid samples collected for PCDDs and PCDFs measurements were analyzed using SW-8280. Aqueous samples were extracted by continuous liquid/liquid extracting according to SW-3520. SW-3540, which is a Soxhlet extraction technique, was used to extract solids.

5.2.9 Metals

Samples of the stack gas particulate matter, solids, and liquids were analyzed for metals by inductively coupled argon plasma emission spectroscopy (ICAP) using SW-6010, and by atomic absorption spectroscopy (AAS) using SW-7060, 7041, 7421, 7740, and 7470/7471. The solid samples and particulate matter collected on the filter of the EPA Method 5 train were solubilized using SW-3050. Prior to analysis, liquid samples

were prepared by using SW-3020. Lithium metaborate and sodium carbonate fusion techniques were used to recover silicon and boron.

The samples were analyzed for a total of thirty-one elements. The volatile elements (lead, arsenic, antimony, selenium, and mercury) were analyzed by AAS. Arsenic, antimony, lead, and selenium were determined using graphite furnace techniques (SW-7060, 7041, 7421, and 7740, respectively). Mercury was determined by the cold vapor technique (SW-7470/7471). Aqueous samples (SW-7470) were acidified prior to analysis.

5.2.10 Soluble Chromium

Stack gas samples were analyzed for soluble chromium (hexavalent chromium) using EPA 218.4. By this method, the hexavalent chromium is chelated using ammonium pyrrolidine dithiocarbamate. The chelated chromium is then extracted from the sample medium using methyl ethyl ketone. The solvent extract is then analyzed by flame atomic absorption spectroscopy.

The stability of hexavalent chromium is not completely understood, and EPA 218.4 recommends chelation and extraction as soon as possible. The stack gas samples for soluble chromium analysis were chelated and extracted on site after sample collection.

5.2.11 EP Toxicity Test Procedure

All samples with the exception of scrubber water inlet and stack gas were analyzed by SW-1310. The method involves the acidic extraction of solid samples followed by analysis of specific trace metals. The EP Toxicity Test Procedure was performed for trace metals only, specifically arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver.

5.2.12 Toxicity Characteristic Leaching Procedure

All samples with the exception of scrubber water inlet and stack gases were analyzed by the proposed Toxicity Characteristic Leaching Procedure (TCLP). TCLP was proposed by EPA to expand toxicity characteristic analyses to include additional chemicals and to incorporate a new extraction procedure. Extraction for volatiles involves acidic extraction in a zero headspace extractor, which is rotated in an end-over-end fashion at 30 ± 2 rpm. Extraction for metals and semivolatiles uses the same procedure except that it is done in a glass container rather than in the zero headspace. The metals were analyzed as described for EP Toxicity. The organic contaminants were analyzed using SW-8240 and 8270.

5.2.13 Subcontract Analysis

Huffman Labs analyzed the solid waste feed, furnace ash, and scrubber effluent solids for chlorine, ash, and ultimate analysis, and the solid waste feed for higher heating value.

5.2.13.1 Chlorine Analysis

Chlorine analyses of the solid waste feed, furnace ash, and scrubber effluent solids were performed using ASTM D808. The samples were combusted in an oxygen bomb containing an alkaline solution. The alkaline solution was analyzed for chlorine (as chloride) using titration.

5.2.13.2 Ash Analysis

The ash content of the solid waste feed, furnace ash, and scrubber effluent solids was determined using ASTM D3174. The sample is ignited, and after burning is ashed at 1427⁰F in a muffle furnace. The residue then is weighed.

5.2.13.3 Ultimate Analysis (C, H, O, S, N, Moisture)

The solid waste feed, furnace ash, and scrubber effluent solids were analyzed for elemental concentrations using A003 for ultimate analysis. The procedure involves the analysis of carbon, hydrogen, nitrogen, sulfur, and moisture. Oxygen is determined by difference. A003 is a conglomerate of ASTM methods. ASTM D3178 analyzes for carbon and hydrogen by burning the samples in a combustion system followed by fixation of the products of combustion in an absorption train for analysis. Nitrogen is analyzed by ASTM D3179. The nitrogen in the sample is converted to ammonium salts by destructive digestion. Ammonia is recovered and analyzed titrimetrically. ASTM D3177 is used to measure sulfur using bomb calorimetry. The recovered sulfur is precipitated as BaSO₄ and determined gravimetrically. Moisture is determined by ASTM D3173, which is a gravimetric technique involving drying of the sample.

5.2.13.4 Higher Heating Value Analysis

The higher heating value (HHV) of the solid waste feed was determined using a bomb calorimeter, according to ASTM D2015-77.

5.2.14 TSS and TDS Analysis

The concentration of Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) present in the scrubber liquid effluent and scrubber water inlet was determined using gravimetric procedures EPA M160.1 and M160.2, respectively.

5.2.15 pH Analysis

The pH of the scrubber liquid samples was determined using a portable pH meter in accordance with EPA M150.1.

5.2.16 Particulate Matter

Particulates were measured in the stack gas using EPA Method 5.

5.2.17 Flue Gas Moisture

The moisture content of the gas streams was determined using the technique specified in EPA Method 4.

5.2.18 HCl Determination

For the determination of HCl in the stack gas, samples of gas were passed through a series of impingers immersed in an ice bath. The first two impingers contained 200 mL of 0.1 N NaOH and were Greenburg-Smith-type impingers. Following the first two impingers were a dry, modified Greenburg-Smith impinger and an impinger containing a desiccant. The sample was analyzed using an ion chromatograph following Method 27 from the "FGD Chemistry and Analytical Methods Handbook" Volume 2, Radian Corporation, 1984.

5.2.19 Carbon Dioxide

During the sampling for HCl the collection of CO₂ in the 0.1 N NaOH impinger is a consideration to be addressed. Because the impinger solutions are caustic, CO₂ was also removed from the stack gas. Thus, the metered sample gas volume was low by the amount of CO₂ removed by the impinger solutions.

5.2.20 Oxygen and Carbon Dioxide Analysis

Grab bag samples were collected in the field according to EPA Method 3 for CO₂ and O₂. These samples were analyzed within 3 hours of collection using an Orsat analyzer.

5.2.21 Total Chromatographable and Gravimetric Organic Contents

To further support the results of the proximate and ultimate analyses of the solid waste feed and furnace ash, samples of these matrices also were analyzed for total chromatographable organics (TCO), which have boiling points between 100°C and 300°C, and gravimetric (GRAV) components, which have boiling points in excess of 300°C.

5.2.22 Total Organic Carbon

Total organic carbon in the scrubber liquid effluent and scrubber water inlet was determined using EPA method 415.1. During analysis the sample is converted to CO₂ by catalytic combustion, which is measured directly by an infrared detector. The amount of CO₂ formed is directly proportional to the organic carbon content.

SECTION 6

PERFORMANCE DATA EVALUATION

6.1 INTRODUCTION

Based on the operating data presented in Section 4 and Appendix A (Volume II) and the analytical results presented in Appendix B (Volume II), an evaluation was conducted to determine the effectiveness of the Shirco transportable infrared incinerator in treating the waste feed matrix at the Peak Oil site and the feasibility of employing similar units as hazardous waste treatment systems at other sites throughout the country. To this end, the following evaluation objectives were established:

- o To determine DRE levels for PCBs.
- o To demonstrate the success of the unit in decontaminating the solid material being processed and to determine the DE levels for PCBs.
- o To evaluate the ability of the unit and its associated air pollution control/scrubber system to limit hydrochloric acid and particulate emissions.
- o To determine whether heavy metals contaminants in the waste feed are chemically bonded or fixated to the ash residue by the process.
- o To determine the effect that the thermal destruction process has in producing combustion by-products.
- o To determine the impact of the unit operation on ambient air quality and potential mutagenic exposure.
- o To develop unit material balances that define the overall stream and component flows through the unit during the SITE demonstration runs.

6.2 DESTRUCTION AND REMOVAL EFFICIENCY (DRE)

6.2.1 PCB Destruction and Removal Efficiency

PCBs were analyzed in the solid waste feed, furnace ash, scrubber effluent solids, stack gas, scrubber liquid effluent,

and scrubber water inlet. The DRE calculation for PCBs is based on the following:

$$DRE = \frac{W_{in} - W_{out}}{W_{in}} \times 100$$

where: W_{in} = mass rate of PCBs fed to incinerator
 W_{out} = mass emission rate of PCBs in stack gas

As shown in Table 6.1, the unit achieved a DRE for PCBs of 99.99%. It was not possible to calculate the DRE beyond two decimal places because of the analytical procedures employed.

It should be noted that the unit was operated to produce an ash that contained 1 ppm or less of PCB. The PCB concentration in the waste feed to the unit varied from 5.85 to 3.48 ppm during the tests. These low PCB concentrations in the waste feed were the result of mixing the original oily waste having up to 100 ppm of PCBs with the PCB-free surrounding soil, lime, and sand so that the resulting material could be handled and processed as a solid waste. Because of the low PCB concentration in the resulting waste feed matrix a unit operation based on a DRE for PCBs was impractical because of the difficulty in measuring extremely low PCB concentrations in the stack emissions.

6.2.2 Decontamination of Solid Waste and Destruction Efficiency

In addition to the impractical measurement of low PCB concentrations in the stack emissions, as discussed above, the DRE calculation, which only considers the PCB mass rate of flow comparison between the waste feed and the stack emissions, does not account for the PCB mass rate of flow in the furnace ash and scrubber effluent.

Residual PCBs in the furnace ash were less than the 1 ppm operating standard, ranging from 0.007 ppm on August 1 to 0.9 ppm on August 3 (Table 6.2). DE was determined by the formula

$$DRE = \frac{W_{in} - W_{out}}{W_{in}} \times 100$$

where: W_{in} = mass rate of PCBs fed to incinerator
 W_{out} = mass rate of PCBs in the stackgas, furnace ash, and scrubber effluent

With the plant operations precluding the measurement of the mass flowrate of the furnace ash and scrubber streams,

TABLE 6.1. DESTRUCTION AND REMOVAL EFFICIENCY OF PCBs (a)

| Date Stack Gas Collection Time | PCB Concentration in Waste Feed (ng/g) | Waste Feed Rate(b) (kg/hr) | PCB Mass Feed Rate (g/hr) | PCB Concentration in Stack Gas (ug/m ³) | Stack Gas Flowrate (dscfm) | PCB Mass Emission Rate (mg/hr) | DRE (%) |
|---|--|-------------------------------------|---------------------------------------|--|----------------------------------|--|------------|
| 8/1 14:30-19:20 | 5850 | 3,020 | 17.7 | 0.0062 | 5520 | 0.0577 | (c) |
| 8/2 11:00-16:15 | 3850 | 3,730 | 14.4 | 0.0220 | 4670 | 0.1745 | (c) |
| 8/3 10:15-15:50 | 5340 | 3,830 | 20.5 | 0.0070 | 4900 | 0.0581 | (c) |
| 8/4 10:15-15:50 | 3480 | 3,830 | 13.3 | 0.0138 | 5390 | 0.1262 | (c) |

(a) As calculated using 40 CFR 761.3 and 40 CFR 264.343.

(b) Determined over the respective stack gas sampling period.

(c) DRE could only be calculated to 99.99% because of the analytical procedures employed.

TABLE 6.2. RESULTS OF PCB ANALYSES ON SOLIDS STREAMS

| | Solid Waste Feed | | | | Scrubber Solids | | | | | Furnace Ash | | | | |
|--------------------------------------|------------------|---------------|-----------------|---------------------|-----------------|---------------|-----------------|------------------|-----------------|---------------|---------------|-----------------|------------------|-----------------|
| | 8/1 (ng/g) | 8/2 (ng/g) | 8/3-4 (ng/g) | 8/3-4D(c) (ng/g) | 8/1 (ng/g) | 8/2 (ng/g) | 8/3-4 (ng/g) | 8/3-4D (ng/g) | Blank (ng/g) | 8/1 (ng/g) | 8/2 (ng/g) | 8/3-4 (ng/g) | 8/3-4D (ng/g) | Blank (ng/g) |
| Monochlorobiphenyl | <60 | <50 | <50 | <40 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Dichlorobiphenyl | 160 | 120 | 190 | 130 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Trichlorobiphenyl | 820 | 720 | 780 | 570 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | 61 | 28 | <2 |
| Tetrachlorobiphenyl | 790 | 440 | 830 | 440 | <2 | <2 | <2 | <2 | <2 | <2 | 22 | 120 | 63 | <2 |
| Pentachlorobiphenyl | 310 | 270 | 490 | 200 | <2 | <2 | <2 | <2 | <2 | <2 | 16 | 42 | 46 | <2 |
| Hexachlorobiphenyl | 1700 | 1100 | 1600 | 1300 | <2 | <2 | <2 | <2 | <2 | 7 | 112 | 400 | 185 | <2 |
| Heptachlorobiphenyl | 2200 | 1300 | 1600 | 940 | <2 | <2 | <2 | <2 | <2 | <2 | 89 | 280 | 213 | <2 |
| Octachlorobiphenyl | <60 | <50 | <50 | 45 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Nonachlorobiphenyl | <60 | <50 | <50 | <40 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Decachlorobiphenyl | <60 | <50 | <50 | <40 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Total PCB (a) | 5850 | 3850 | 5340 | 3480 | 0 | 0 | 0 | 0 | 0 | 7 | 240 | 900 | 540 | 0 |
| Destruction Efficiency (DE), wt.%(b) | | | | | | | | | | 99.88 | 93.77 | 83.15 | 84.48 | |

(a) Total PCB calculated according to 40 CFR 761.3

(b) Destruction Efficiency (DE) = 100% x (PCB in waste feed - PCB in furnace ash) / PCB in waste feed

(c) 8/3-4D refers to the duplicate sample collected on 8/3-4.

a conservative basis for calculating DE was employed based on the PCB concentrations in the waste feed and the furnace ash. The DE or removal of the PCBs from the waste feed ranged from 99.88 wt.% (August 1) to 83.15 wt.% (August 3) as shown on Table 6.2.

There was an insufficient range of operating conditions studied during these tests to determine whether the unit can process waste feed matrices with higher PCB contaminant levels than those encountered at Peak Oil. The data obtained during the SITE program, however, do provide some insight into the effect of process conditions on this aspect of the unit's performance, as discussed below.

Under the processing conditions of the PCC as presented in Appendix A and summarized in Section 4.2, and based on the PCB analyses presented in Table 6.2, the PCB content in the ash residue increased as the waste feedrate increased and combustion airflow to the PCC decreased. This decrease in oxygen availability resulted in a deterioration of decontamination performance under more reducing conditions. This conclusion is further supported by the Total Chromotographable Organics (TCO) and Gravimetric (GRAV) analyses of the ash, which measure extractable organics. These correlated closely with residual PCB contents in the ash. As shown in Table 6.3, they increased from about 3 percent on the first day of testing to about 12 percent on the second day to over 19 percent during the third test. The destruction of carbon also is consistent with this trend. As shown in Table 6.4, 68% of the carbon was destroyed during the first day of testing, and an average of 59% was destroyed during the third day.

6.3 ACID GAS REMOVAL

Measured HCl emission rates ranged from less than 0.8 to 8.6 g/hr. Since the chlorine concentration in the solid waste feed was below the 0.1% detection limit, it is impossible to determine actual HCl removal efficiency. However, SO₂ emissions were less than 1100 g/hr with an average 149 kg/hr SO₂ feedrate giving an average removal of SO₂ in excess of 99%, as shown in Table 6.5. SO₂ is more difficult to remove than HCl in a caustic scrubber, and the tests show that HCl removal should be in excess of the 99% determined for SO₂ removal.

6.4 PARTICULATE EMISSIONS

As shown in Table 6.6, the emissions during the first day were 358 mg/dscm. The unit was cleaned and mechanical adjustments were made resulting in a 211 mg/dscm emission rate during the second day. The unit finally passed the RCRA particulate emissions standard of 180 mg/dscm on the third day with a 172 mg/dscm (average of duplicate measurements) emission rate.

TABLE 6.3. RESULTS OF TCO AND GRAVIMETRIC ANALYSES

| | Total Chromatographable Organic (ug/g) | Gravimetric (g/g) | Total Extractable Organics (wt.%) | Percent of Feed (wt.%) |
|-------------------------|--|----------------------|--|------------------------------|
| Solid Waste Feed | | | | |
| 8/1 | 343 | 0.1266 | 12.7 | 100 |
| 8/2 | 322 | 0.0887 | 8.9 | 100 |
| 8/3-4 | 212 | 0.0906 | 9.1 | 100 |
| 8/3-4D(a) | 222 | 0.0934 | 9.3 | 100 |
| Furnace Ash | | | | |
| 8/1 | 41.90 | 0.0042 | 0.4 | 3.3 |
| 8/2 | 7.14 | 0.0109 | 1.1 | 12.2 |
| 8/3-4 | 29.10 | 0.0174 | 1.7 | 19.2 |
| 8/3-4D | 16.50 | 0.0167 | 1.7 | 17.9 |

(a) 8/3-4D refers to the duplicate sample collected on 8/3-4.

TABLE 6.4. RESULTS OF PROXIMATE AND ULTIMATE ANALYSES OF SOLIDS STREAMS

| Components, wt.% | Solid Waste Feed | | | | Ash | | | | Scrubber Effluent Solids (a) | | | |
|------------------|------------------|-------|-------|-----------|-------|-------|-------|--------|------------------------------|-------|-------|--------|
| | 8/1 | 8/2 | 8/3-4 | 8/3-4D(b) | 8/1 | 8/2 | 8/3-4 | 8/3-4D | 8/1 | 8/2 | 8/3-4 | 8/3-4D |
| Moisture | 16.63 | 16.06 | 14.24 | 14.37 | 17.91 | 16.01 | 16.82 | 16.11 | 55.64 | 47.43 | 49.94 | 46.72 |
| Carbon | 7.61 | 6.94 | 7.77 | 6.97 | 2.43 | 2.06 | 3.53 | 2.57 | 1.03 | 1.27 | 2.48 | 3.23 |
| Hydrogen | 2.18 | 2.16 | 2.3 | 2.00 | 1.61 | 6.85 | 1.70 | 1.44 | 0.40 | 0.33 | 0.27 | 0.34 |
| Oxygen | 17.85 | 19.26 | 15.59 | 14.10 | 13.31 | 15.02 | 13.52 | 13.88 | <0.50 | <0.50 | <0.50 | <0.50 |
| Nitrogen | 0.06 | 0.06 | 0.05 | 0.05 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.03 |
| Sulfur | 2.53 | 1.78 | 1.89 | 1.67 | 2.85 | 2.33 | 2.29 | 2.25 | 10.33 | 9.76 | 7.30 | 6.41 |
| Chlorine | <0.10 | <0.10 | <0.10 | <0.10 | 0.19 | <0.01 | 0.26 | 0.21 | <0.10 | 0.10 | <0.10 | <0.10 |
| Ash | 69.77 | 69.80 | 72.40 | 75.21 | 79.59 | 79.72 | 78.68 | 79.63 | 102.39 | 92.24 | 92.15 | 89.62 |
| HHV (Btu/lb) | 2064 | 1639 | 1728 | 2018 | | | | | | | | |

(a) Analyses of scrubber effluent solids are on a dry basis.

(b) 8/3-4D refers to the duplicate sample collected on 8/3-4.

TABLE 6.5. STACK GAS HCl, SO₂, AND ACID GAS REMOVAL EFFICIENCY

| Date | Time | Sample Total Cl (mg) | Sample Total SO ₂ (mg) | Sample Volume (dscf) | Stack Gas Flowrate (dscfm) | HCl Conc. (ppmv) | SO ₂ Conc. (ppmv) | HCl Emission Rate (g/hr) | SO ₂ Emission Rate (g/hr) |
|---------|-------------|----------------------|-----------------------------------|----------------------|----------------------------|------------------|------------------------------|--------------------------|--------------------------------------|
| 8/1 | 08:30-10:23 | <0.092 | 3.13 | 41.44 | 6040.00 | <0.051 | 0.99 | <0.8 | 27.4 |
| 8/2 | 20:00-22:11 | 0.960 | 118.00 | 36.93 | 5590.00 | 0.600 | 41.80 | 8.6 | 1070.0 |
| 8/4 | 15:50-17:44 | 0.340 | 2.60 | 35.54 | 5000.00 | 0.220 | 0.96 | 2.9 | 22.0 |
| 8/4D(a) | 15:52-17:46 | 0.300 | 2.35 | 33.82 | 4930.00 | 0.200 | 0.91 | 2.7 | 20.6 |

(a) 8/4D refers to the duplicate sample collected on 8/4.

| Date | Average Feedrate (kg/hr) | Ultimate Analysis Solid Waste Feed | | Input To Scrubber | | Removal Efficiency | |
|---------|--------------------------|------------------------------------|-----------|-------------------|-------------------------|--------------------|------------------------|
| | | (wt.% S) | (wt.% Cl) | HCl (kg/hr) | SO ₂ (kg/hr) | HCl (wt.%) | SO ₂ (wt.%) |
| 8/1 | 3953.00 | 2.53 | <0.10 | NA | 200 | NA | >99.9 |
| 8/2 | 3696.00 | 1.78 | <0.10 | NA | 132 | NA | >99.1 |
| 8/4 | 3655.00 | 1.89 | <0.10 | NA | 138 | NA | >99.9 |
| 8/4D(a) | 3738.00 | 1.67 | <0.10 | NA | 125 | NA | >99.9 |

(a) 8/4D refers to the duplicate sample collected on 8/4.

TABLE 6.6 PARTICULATE LOADING

| Date | Time | Sample Volume (dscf) | Stack Gas Flowrate (dscfm) | Particulate Loading | | Particulate Emission Rate (kg/hr) | O2 Content (vol.%) (a) | Particulate Loading Corrected to 7% O2 (b) | | Isokinetic (%) |
|---------|-------------|----------------------|----------------------------|---------------------|-----------|-----------------------------------|------------------------|--|-----------|----------------|
| | | | | (grains/dscf) | (mg/dscm) | | | (grains/dscf) | (mg/dscm) | |
| 8/1 | 08:30-10:23 | 41.444 | 6,040 | 0.1432 | 322 | 3.36 | 8.39 | 0.1590 | 358 | 90.7 |
| 8/2 | 20:00-22:11 | 36.932 | 5,590 | 0.0866 | 195 | 1.88 | 8.09 | 0.0939 | 211 | 88.2 (c) |
| 8/4 | 15:50-17:44 | 35.536 | 5,000 | 0.0696 | 157 | 1.35 | 8.31 | 0.0768 | 173 | 93.9 |
| 8/4D(d) | 15:52-17:46 | 33.822 | 4,930 | 0.0689 | 155 | 1.32 | 8.32 | 0.0761 | 171 | 90.7 |

(a) Measured by continuous monitor.

(b) Calculated using the following formula: $corr.=act.x14/21-y$, where y equals measured O2 concentration.

(c) Outside acceptable limit.

(d) 8/4D refers to the duplicate sample collected on 8/4.

As presented in Table 6.7, lead concentrations averaged 0.65% in the ash, 10% in the scrubber effluent solids, and 58% in the stack gas particulate.

6.5 LEACHING CHARACTERISTICS

The solid waste feed, furnace ash, and scrubber effluent solids were subjected to the EP Toxicity and proposed TCLP tests to evaluate the toxicity characteristics of these materials.

The EP Toxicity and the TCLP data present a contradictory picture regarding the effect of the process on leaching characteristics. The EP Toxicity data did not indicate that the process "encapsulates" or ties up heavy metals (lead) in the ash to prevent leaching. The EP Toxicity data, presented in Appendix B, Volume II, Table 2-24, show that lead content in the ash exceeded the 5 ppm toxicity characteristic standard. The measured lead content of leachates for feed material and ash are almost equal, indicating that the process appears not to affect leaching characteristics for lead.

In contrast to the EP Toxicity data, the TCLP data show that the lead content for both the feed and ash were less than the proposed toxicity characteristic standard of 5 ppm, as shown in Appendix B, Volume II, Table 2-23. Measured lead concentrations were an order of magnitude lower in the TCLP leachate (about 2 ppm compared to about 30 ppm for EP Toxicity).

The significant differences in results from these two analytical techniques have been documented in a recent Oak Ridge National Laboratory report (ORNL, "Leaching of Metals from Alkaline Wastes by Municipal Waste Leachate," ORNL/TM-11050, March, 1987). It appears that the differences in the test procedures and alkalinity of the matrix provide a difference in the pH environment that is sufficient to affect the solubility and leachability of heavy metals, particularly lead.

6.6 PRODUCTS OF INCOMPLETE COMBUSTION

Small quantities of products of incomplete combustion (PICs) were identified in the sampled streams from the unit. No polychlorinated dibenzodioxins (PCDDs) or polychlorinated dibenzofurans (PCDFs) were identified in any of the sampled streams above detection limits with the exception of trace quantities (2.1 ng) of tetrachlorodibenzofuran (TCDF) found in the stack gas sampled on August 2 (See Appendix B, Volume II, Table 2-6).

TABLE 6.7. DISPOSITION OF LEAD IN THE SYSTEM

| | | ----- (wt.%) ----- | | | |
|-----------------|------------------------|--------------------|-------|-------|-----------|
| Stream | Location | 8/1 | 8/2 | 8/3-4 | 8/3-4D(a) |
| Solid waste | Before Primary Chamber | 0.59 | 0.49 | 0.50 | 0.44 |
| Ash | After Primary Chamber | 0.71 | 0.60 | 0.64 | 0.62 |
| Scrubber solids | Scrubber | 8.90 | 9.00 | 9.00 | 13.00 |
| Stack gas | Stack | 60.00 | 54.00 | 60.00 | 58.00 |

(a) 8/3-4D refers to the duplicate sample collected on 8/3-4.

Low levels of some semivolatile organic compounds were identified in all streams. These compounds were primarily phthalates, which may be the result of contamination from plastic components in the process, sampling equipment, or laboratory apparatus. Other semivolatile compounds included aromatic, polyaromatic, and chlorinated aromatic hydrocarbons. Low levels of pyrene, chrysene, anthracene, naphthalenes, and chlorinated benzene were identified in the waste feed stream; although possible PICs, they must be discounted to some extent, based on their original introduction to the unit with the waste feed. These results are presented in Appendix B, Volume II, Tables 2-8, 2-9, and 2-10.

Low concentrations of volatile organics were measured in the stack gas, as shown in Appendix B, Volume II, Table 2-13. They include halogenated methanes, chlorinated organics, and aromatic hydrocarbons including BTX compounds. These volatile organics increased in the stack gas from August 1 to August 4 and followed a similar trend for the carbon and TCO/GRAV destruction observed in the ash (See Section 6.2.2). This is consistent with the PCC operating under a decreased oxygen availability (reducing conditions), producing higher levels of PICs and reduced decontamination efficiencies.

No volatile organics were identified in the water streams. Low levels (ppb) of chlorinated hydrocarbons and BTX compounds were measured in all solid streams as shown in Appendix B, Volume II, Table 2-11.

Low levels of BTX compounds, carbon disulfide, chloroform, di- and trichlorofluoromethane, di- and trichloroethane, and methylene chloride were identified in the waste feed. Methylene chloride, a solvent used during testing, was also detected in laboratory and field blanks. Based on the above, these compounds, although possible PICs, must be discounted to some extent based on their introduction to the unit from an external source and because of possible contamination.

6.7 AMBIENT AIR SAMPLING AND MUTAGENIC TESTING

Information and data compiled during the SITE program test runs has resulted in the following summary discussions concerning the ambient air monitoring and mutagenic exposure that is associated with the operation of the transportable Shirco Infrared Thermal Destruction Unit.

6.7.1 Ambient Air Sampling

Ambient air monitoring stations placed upwind and downwind of the Shirco unit, as discussed and illustrated in Section 5, were designed to collect airborne PCB contaminants. The sampling modules were analyzed for PCBs; the results are presented in Appendix B, Volume II, Table 2-4. Based on the

downwind sampler data, it appears that the Peak Oil site boundaries limited the location of the downwind sampler to an area that was significantly exposed to fugitive emissions during the transport of ash from the ash pad to the ash storage area.

6.7.2 Mutagenic Testing

Samples of the waste feed and ash were collected on August 2 and forwarded to the EPA Health Effects Laboratory, Research Triangle Park, North Carolina for mutagenic testing. The results of these tests indicate that although the samples contain hazardous contaminants, they are not mutagenic based on the standard Ames Salmonella mutagenicity assay. The confirmation memo attesting to these activities is provided here as Figure 6.1.

6.8 MATERIAL BALANCES

Tables 6.8 to 6.11 present material balances of the Shirco SITE test runs conducted on August 1-4, 1987. The tables are based on the operating log data presented in Appendix A and the analytical results presented in Appendix B, Volume II. In order to provide a series of consistent and closed balances, the following bases were established and assumptions made in developing the material flows and component breakdowns.

- o The total solid waste feedrate is based on a 24-hour average hourly rate for the specified test day.
- o Measured stack gas flowrates and oxygen concentrations were assumed to be accurate based on the defined protocols for the measurement of particulate emissions to demonstrate compliance with government regulatory standards.
- o Measured propane fuel flows to the secondary combustion chamber were assumed to be accurate.
- o The difference between the oxygen concentrations of the secondary combustion chamber exit gas and the stack gas was used to determine air leakage into the system through the safety vent and the scrubber system. No additional air leakage into the system was assumed.
- o Combustion airflows were adjusted to meet the measured stack gas flowrates.
- o The ultimate analysis of the waste feed was adjusted to be consistent with the gas stream oxygen concentration at the secondary combustion chamber exit. It is based on the combustion of carbon and hydrogen to carbon dioxide and water.



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
 HEALTH EFFECTS RESEARCH LABORATORY
 RESEARCH TRIANGLE PARK
 NORTH CAROLINA 27711

DATE: January 13, 1988

SUBJECT: Mutagenicity of Peak Oil Soil Samples

FROM: David M. DeMarini, Ph.D.
 HERL/GTD/GBB (MD-68)

TO: Howard Wall
 HWERL

This memo is to confirm that we received and tested two soil samples from the Peak Oil Superfund site in Tampa, FL. One sample was soil from the site before it was treated in the incinerator. The second sample was soil after it had been treated in the incinerator. We extracted both samples with dichloromethane to extract the organic components from the soils. GC analysis showed a series of peaks similar to what one might expect with an oil sample. This is consistent with the fact that the soil was contaminated with waste oil. The incineration procedure had a clear effect on reducing the amount of extractable organic material in the soil. The "before" soil had 6.25% of extractable organic material, but the "after" soil had only 0.14%. This is a considerable reduction and supports continued use of the incineration process.

The dichloromethane extracts were concentrated, solvent exchanged into dimethyl sulfoxide, and tested in the standard Ames Salmonella mutagenicity assay. The results were negative for both samples, i.e., the samples were not mutagenic, and the highest doses tested were 10 mg of organic extract per petri dish, which is an exceedingly high dose. One might interpret the results of the "after" soil sample as weakly positive because there is a two-fold increase over the control (30 vs. 61 rev/plate at 2000 µg/plate). However, this is a very weak response at a very high dose and not terribly significant. It is, however, reproducible. The S9 used was from rat liver, and S9 is a portion of homogenized rat liver containing enzymes that can metabolize chemicals in the sample to electrophilic compounds that could interact with DNA and cause mutation. An example of some of the results in strain TA98 of Salmonella is presented below. If you have any questions, please give me a call at FTS 629-1510.

| Dose (µg/plate) | TA98 +S9 Revertants/plate | |
|--------------------|------------------------------|-------|
| | Before | After |
| 0 (control) | 30 | |
| 500 | 43 | 33 |
| 1000 | 45 | 56 |
| 2000 | 48 | 61 |
| 3000 | 43 | 51 |
| 4000 | 39 | 44 |
| 5000 | 34 | 40 |

Figure 6.1. Memo: Mutagenicity of Peak Oil soil samples.

- o The ash component of the solid waste feed is the total inorganic ash content of the feed.
- o The ash plus scrubber solids outlet stream includes the total inorganic ash content from the solid waste feed less the particulates exiting with the stack gas. The ash plus scrubber solids stream also includes the non-combusted organics that originally entered the unit with the solid waste feed.
- o The stack gas stream components include:
 - Water which consists of the water entering the system plus the water produced in the combustion process
 - The elemental constituents of the CO₂, SO₂, O₂, and N₂ flows.
- o Chlorine and HCl flows were insignificant and were not accounted for in the balances.

TABLE 6.8
MATERIAL BALANCE
AUGUST 1, 1987

| COMPONENTS, LB/HR | SOLID WASTE | QUENCH | PRIMARY | SECONDARY | + | FORCED | PROPANE | AIR | TOTAL |
|-------------------|----------------|-----------------|-----------------|------------|----------------|-----------|---------------|----------------|-----------------|
| | FEED | WATER | COMBUSTION | COMBUSTION | | DRAFT AIR | | LEAKAGE | IN |
| ----- | ----- | ----- | AIR | AIR | | | ----- | ----- | ----- |
| WATER | 1219.95 | 12311.83 | | | | | | | 13531.78 |
| CARBON | 1127.79 | | | | | | 115.64 | | 1243.43 |
| HYDROGEN | 323.07 | | | | | | 25.90 | | 348.97 |
| OXYGEN | 0.00 | | 4734.17 | | 1308.52 | | | 1170.24 | 7212.93 |
| NITROGEN | 5.36 | | 15590.24 | | 4309.24 | | | 3878.76 | 23783.60 |
| SULFUR | 252.71 | | | | | | | | 252.71 |
| CHLORINE | 0.00 | | | | | | | | 0.00 |
| ASH | 4406.95 | | | | | | | | 4406.95 |
| TOTAL | <u>7335.83</u> | <u>12311.83</u> | <u>20324.41</u> | | <u>5617.76</u> | | <u>141.54</u> | <u>5049.00</u> | <u>50780.37</u> |

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TABLE 6.8 (CONT.)
MATERIAL BALANCE
AUGUST 1, 1987

| COMPONENTS, LB/HR | ASH | + | SCRUBBER SOLIDS | STACK GAS | TOTAL OUT |
|-------------------|-----|---|--------------------|--------------|--------------|
| WATER | | | 0.00 | 15478.16 | 15478.16 |
| CARBON | | | 198.16 | 1045.27 | 1243.43 |
| HYDROGEN | | | 131.29 | 0.00 | 131.29 |
| OXYGEN | | | 0.00 | 5484.16 | 5484.16 |
| NITROGEN | | | 3.73 | 23784.34 | 23788.07 |
| SULFUR | | | 232.42 | 20.27 | 252.69 |
| CHLORINE | | | 0.00 | 0.00 | 0.00 |
| ASH | | | 4399.54 | 7.41 | 4406.95 |
| TOTAL | | | 4965.14 | 45819.61 | 50784.75 |

TABLE 6.9
MATERIAL BALANCE
AUGUST 2, 1987

| COMPONENTS, LB/HR | SOLID WASTE FEED | QUENCH WATER | PRIMARY COMBUSTION AIR | SECONDARY COMBUSTION AIR | + FORCED DRAFT AIR | PROPANE | AIR LEAKAGE | TOTAL IN |
|-------------------|---------------------|-----------------|------------------------------|--------------------------------|--------------------------|---------|----------------|-------------|
| WATER | 1163.67 | 11004.63 | | | | | | 12168.30 |
| CARBON | 874.54 | | | | | 131.01 | | 1005.55 |
| HYDROGEN | 272.19 | | | | | 29.34 | | 301.53 |
| OXYGEN | 0.00 | | 4095.84 | | 1308.52 | | 904.07 | 6308.43 |
| NITROGEN | 5.29 | | 13488.20 | | 4309.24 | | 2997.43 | 20800.16 |
| SULFUR | 199.96 | | | | | | | 199.96 |
| CHLORINE | 0.00 | | | | | | | 0.00 |
| ASH | 4730.14 | | | | | | | 4730.14 |
| TOTAL | 7245.79 | 11004.63 | 17584.04 | | 5617.76 | 160.35 | 3901.50 | 45514.07 |

TABLE 6.9 (CONT.)
 MATERIAL BALANCE
 AUGUST 2, 1987

| COMPONENTS, LB/HR | ASH | + | SCRUBBER SOLIDS | STACK GAS | TOTAL OUT |
|-------------------|-----|---|--------------------|-----------------|-----------------|
| WATER | | | 0.00 | 14215.17 | 14215.17 |
| CARBON | | | 175.96 | 829.60 | 1005.56 |
| HYDROGEN | | | 72.60 | 0.00 | 72.60 |
| OXYGEN | | | 0.00 | 4490.43 | 4490.43 |
| NITROGEN | | | 1.71 | 20800.56 | 20802.27 |
| SULFUR | | | 199.02 | 0.94 | 199.96 |
| CHLORINE | | | 0.00 | 0.00 | 0.00 |
| ASH | | | 4725.99 | 4.15 | 4730.14 |
| TOTAL | | | 5175.28 | 40340.85 | 45516.13 |

TABLE 6.10
MATERIAL BALANCE
AUGUST 3, 1987

| COMPONENTS, LB/HR | SOLID WASTE FEED | QUENCH WATER | PRIMARY COMBUSTION AIR | SECONDARY COMBUSTION AIR | + FORCED DRAFT AIR | PROPANE | AIR LEAKAGE | TOTAL IN |
|-------------------|---------------------|-----------------|------------------------------|--------------------------------|--------------------------|---------|----------------|-------------|
| WATER | 1344.38 | 9209.45 | | | | | | 10553.83 |
| CARBON | 948.15 | | | | | 163.18 | | 1111.33 |
| HYDROGEN | 280.66 | | | | | 36.55 | | 317.21 |
| OXYGEN | 0.00 | | 3111.76 | | 1308.52 | | 1063.61 | 5483.89 |
| NITROGEN | 4.86 | | 10247.54 | | 4309.24 | | 3526.39 | 18088.03 |
| SULFUR | 211.28 | | | | | | | 211.28 |
| CHLORINE | 0.00 | | | | | | | 0.00 |
| ASH | 5203.42 | | | | | | | 5203.42 |
| TOTAL | 7992.75 | 9209.45 | 13359.30 | | 5617.76 | 199.73 | 4590.00 | 40968.99 |

TABLE 6.10 (CONT.)
 MATERIAL BALANCE
 AUGUST 3, 1987

| COMPONENTS, LB/HR | ASH | + | SCRUBBER SOLIDS | STACK GAS | TOTAL OUT |
|-------------------|---------|---|--------------------|--------------|--------------|
| WATER | | | 0.00 | 12008.20 | 12008.20 |
| CARBON | | | 321.02 | 790.32 | 1111.34 |
| HYDROGEN | | | 154.60 | 0.00 | 154.60 |
| OXYGEN | | | 0.00 | 4192.08 | 4192.08 |
| NITROGEN | | | 1.82 | 18087.92 | 18089.74 |
| SULFUR | | | 208.26 | 3.02 | 211.28 |
| CHLORINE | | | 0.00 | 0.00 | 0.00 |
| ASH | 5200.44 | | | 2.98 | 5203.42 |
| TOTAL | | | 5886.14 | 35084.52 | 40970.66 |

TABLE 6.11
MATERIAL BALANCE
AUGUST 4, 1987

| COMPONENTS, LB/HR | SOLID WASTE FEED | QUENCH WATER | PRIMARY COMBUSTION AIR | SECONDARY COMBUSTION AIR | + | FORCED DRAFT AIR | PROPANE | AIR LEAKAGE | TOTAL IN |
|-------------------|---------------------|-----------------|------------------------------|--------------------------------|---|---------------------|---------|----------------|-------------|
| WATER | 1334.84 | 9458.93 | | | | | | | 10793.77 |
| CARBON | 971.07 | | | | | | 145.24 | | 1116.31 |
| HYDROGEN | 287.45 | | | | | | 32.53 | | 319.98 |
| OXYGEN | 0.00 | | 3244.75 | | | 1308.52 | | 1010.43 | 5563.70 |
| NITROGEN | 4.83 | | 10685.46 | | | 4309.24 | | 3350.07 | 18349.60 |
| SULFUR | 209.78 | | | | | | | | 209.78 |
| CHLORINE | 0.00 | | | | | | | | 0.00 |
| ASH | 5128.03 | | | | | | | | 5128.03 |
| TOTAL | 7936.00 | 9458.93 | 13930.21 | | | 5617.76 | 177.77 | 4360.50 | 41481.17 |

TABLE 6.11 (CONT.)
MATERIAL BALANCE
AUGUST 4, 1987

| COMPONENTS, LB/HR | ASH | + | SCRUBBER SOLIDS | STACK GAS | TOTAL OUT |
|-------------------|---------|---|--------------------|--------------|--------------|
| WATER | | | 0.00 | 12290.77 | 12290.77 |
| CARBON | | | 316.86 | 799.46 | 1116.32 |
| HYDROGEN | | | 152.60 | 0.00 | 152.60 |
| OXYGEN | | | 0.00 | 4234.03 | 4234.03 |
| NITROGEN | | | 1.80 | 18349.57 | 18351.37 |
| SULFUR | | | 205.56 | 4.22 | 209.78 |
| CHLORINE | | | 0.00 | 0.00 | 0.00 |
| ASH | 5125.12 | | | 2.91 | 5128.03 |
| TOTAL | | | 5801.94 | 35680.96 | 41482.90 |

SECTION 7

ECONOMICS

7.1 INTRODUCTION

The classical cost analysis addresses the cost aspects of a capital facility in two main categories: capital costs, and operating and maintenance costs.

Capital costs include both depreciable and nondepreciable cost elements. Depreciable costs include direct costs for site development, capital equipment, and equipment installation. Indirect costs include 1) engineering services prior to unit construction, such as feasibility studies and consultant costs; 2) administrative tasks, such as permitting; 3) construction overhead and fee; and 4) contingencies. Nondepreciable costs include start-up costs for vendor personnel and operator training, trial or test run expenses, working capital, and land purchase, which is a direct cost that is nondepreciable.

Operating and maintenance costs include variable, semivariable, and fixed cost elements. Variable operating cost elements include utilities and residual/water disposal costs. Semivariable costs include unit labor and maintenance costs, and laboratory analyses. Fixed costs include depreciation, insurance, and taxes.

The above breakdown of cost elements, however, is based on a permanently sited hazardous waste incinerator. The Shirco thermal destruction unit as employed at the Peak Oil site is a transportable skid-mounted unit that will not be located permanently at a site. Cost analysis, therefore, is based on different sets of cost elements.

In general, the costs for a transportable thermal hazardous waste destruction facility fall into three categories: capital costs, mobilization/demobilization, and operations. Capital costs include all costs that can be amortized over the service life of the unit and can be subdivided into direct, indirect, and nondepreciable cost elements. Mobilization/demobilization costs are associated with start-up and shutdown at a given site, and can be accrued as semivariable operating and maintenance costs. They can be amortized while the unit is transported to and located and operated at a given site. Operating costs include variable utility costs, semivariable labor and maintenance costs, and fixed costs such as depreciation, insurance, and taxes.

In addition, for a mobile unit, several capital cost elements defined for the permanently sited unit should be redefined into a different cost element category. These include the direct costs for site development and the direct costs for engineering studies, which now will be accrued on a site-specific basis and as such become mobilization/demobilization costs. They now fall under semivariable operating and maintenance costs.

Based on the above, an overall cost element breakdown, as illustrated in Section 7.2, Table 7.1, can be developed.

Included in Section 7.3, Table 7.2 is an economic model for a current-case ideal Shirco transportable unit operation that is equivalent in processing capacity to the unit that operated at the Peak Oil site. It should be noted that cost data on the operations at Peak Oil reflect extremely high, indirect and nondepreciable capital costs and variable and semivariable operating and maintenance costs, due to the first-of-a-kind start-up nature of the Shirco unit at the Peak Oil emergency cleanup site. Under more normal operating conditions, the unit, with a nominal capacity of 100 tons per day, should have remained at the Peak Oil site for a maximum of four months in order to treat the approximately 7,000 tons of waste feed. Instead the unit remained at the site for approximately 12 months, which included 9 months of actual operation under intermittent conditions caused by a series of operating problems, as discussed in Section 8.2.

7.2 COST ELEMENTS

A detailed discussion of each of the cost elements defined in Table 7.1 is provided in the following:

7.2.1 Capital Costs: Direct Costs

The current costs for the design, engineering, materials and equipment procurement, fabrication, and installation of the Shirco transportable infrared incinerator are included as direct costs. These costs include all the subsystems and components installed on their respective skids and trailers, but do not include the costs of the tractors for the transport of the trailers. Waste preparation equipment, ash conveyors, and auxiliary equipment such as an air compressor or water treatment facilities are not included.

7.2.2 Capital Costs: Indirect Costs

7.2.2.1 Administrative/Permitting

Administrative costs associated with regulatory compliance issues for an incinerator are numerous and varied. The costs that are being accrued under this cost element reflect overall non-site-related regulatory activities. These activities

TABLE 7.1. OVERALL COST ELEMENT BREAKDOWN

=====

CAPITAL COST

Direct - Depreciable

- o Equipment Fabrication/
Construction

Direct - Nondepreciable

- o Land Purchase

Indirect - Depreciable

- o Engineering
- o Administrative/Permitting
- o Contingency

Indirect - Nondepreciable

- o Operations Procedures/Training
- o Initial Start-up/Shakedown
- o Trial Burns
- o Working Capital

OPERATING AND MAINTENANCE COSTS

Variable

- o Fuel
- o Power
- o Water
- o Chemicals
- o Residue/Water Disposal

Semivariable

- o Labor
- o Maintenance
- o Analyses
- o Mobilization/Demobilization
 - Site Preparation/Logistics
 - Transportation/Setup
 - On-Site Checkout
 - Site-Specific Permitting/Engineering Services
 - Working Capital
 - Decontamination/Demobilization

Fixed

- o Depreciation
 - o Insurance
 - o Taxes
- =====

include establishing national or regional permit requirements, preparing initial permit applications, and supporting permit application information throughout the permit issuance process. Once the final permits are issued, recordkeeping, inspection, survey response to permitting agencies, and additional reporting activities may be required.

Reporting activities include the preparation of technical support data; the trial burn results, sampling and analysis plan, and quality assurance project plan by in-house engineering personnel; and RCRA/TSCA permit forms by a senior engineering consultant working with in-house staff. Administrative costs associated with reporting activity cover time, travel, and per diem for consultant and in-house staff interfacing with Federal EPA officials; and in-house administrative and clerical staff functions. The preparation of the final trial burn report by in-house engineering personnel would also be included.

7.2.2.2 Contingency

In any cost estimate, contingency costs approximating 10% of the direct capital cost is an acceptable factor; this allows for unforeseen or poorly defined cost definitions.

7.2.3 Capital Costs: Nondepreciable Costs

7.2.3.1 Operations Procedures and Training

In order to ensure the safe, economical, and efficient operation of the unit, operating procedures and a program to train operators are necessary. These associated costs will accrue: the preparation of a unit health and safety and operating manual; and the development and implementation of an operator training program, equipment decontamination procedures, and automated management and reporting procedures.

7.2.3.2 Initial Start-up/Shakedown

After the incineration system has been fabricated and operations procedures and operator training has been completed, the overall unit must be initially started and operated to check the mechanical and technical integrity of the equipment and its controls. The unit would first be operated without the use of the infrared rods or the secondary combustion chamber burners in order to check the movement of solids through the unit in a "cold" mode. The unit then would be operated on a nonhazardous feed matrix under a "hot" mode, with the infrared rods and the secondary combustion chamber burners in operation. Both Shirco and customer personnel would participate in this start-up/shakedown.

7.2.3.3 Trial Burns

Under current TSCA regulations, hazardous waste incineration facility owner/operators usually are required to perform a trial burn as the final step in obtaining an operating permit.

In addition to the administrative and permitting costs defined in Section 7.2.2.1, costs are accrued for the execution of the TSCA trial burn to prove overall system performance.

The costs for such a trial burn includes labor and materials for the sampling and analysis activities, travel and per diem for the sampling team, and other miscellaneous costs that may be attributable to the execution of the trial burn exclusive of administrative support.

It should be noted that these nondepreciable capital costs only are accrued for TSCA trial burn activities; site-specific permit and trial burn activities are considered semivariable operating costs that accrue under the mobilization/demobilization cost element breakdown discussed in Section 7.2.5.4.

7.2.3.4 Working Capital

Although the unit is a transportable system, it will require a supply of maintenance materials attributable to a nondepreciable capital cost. Maintenance materials account for approximately one-half of the total maintenance cost, and three-month inventories are usually maintained.

Other working capital includes fuel and chemicals inventory, which are obtained at each site and will accrue as a semivariable operating and maintenance cost under the mobilization/demobilization cost element breakdown.

7.2.4 Operating and Maintenance Costs: Variable Costs

Variable operating cost elements for this unit include fuel, power, water, chemicals, and residue/water disposal. They are defined as variable operating cost elements because they can usually be expressed in terms of dollars per unit flow of waste disposed, and as such, these costs are more or less proportional to overall facility utilization during specific site operations.

7.2.4.1 Fuel

The fuel requirements for the unit include natural gas or propane fuel for the secondary combustion chamber heating requirements.

7.2.4.2 Power

The power requirements for the unit include the electrical requirements for the motors that power the pumps, fans, augers, mixers, and primary combustion chamber belt drive. Also included is the electrical requirement for the primary combustion chamber infrared rods, which supply the initial combustion heat to the waste feed. One of the factors affecting the electrical requirement of these infrared rods is the heating value of the waste matrix being incinerated.

Although not reflected in this more generalized economic/cost model of the Shirco unit, the Peak Oil operation, during the SITE test program, was operating in an autogenous mode. Once the primary combustion chamber had reached its operating temperature, the waste feed was of sufficiently high heating value to self-sustain primary combustion without the use of the infrared rods and their electrical power heat source.

Auxiliary electrical requirements for trailer power, site lighting, etc., are minimal and are assumed to be included in the total power needs.

7.2.4.3 Water

Water use is based on an estimate of the blowdown requirements from the scrubber system, water losses due to evaporation, and carry-over with the stack gas and ash residue. All other water needs are satisfied through the internal recirculation of water from the scrubber system.

7.2.4.4 Chemicals

The main chemical requirement is caustic soda solution for acid gas scrubbing.

7.2.4.5 Residue/Water Disposal

Costs will accrue for the disposal of ash in a suitable landfill. Unit disposal costs for landfilling depends on location and on whether toxic metals are present. If toxic metals are present, secure landfilling is required.

Scrubber water blowdown will be routed to a municipal or regional treatment facility if the wastewater meets the treatment facility's specifications.

7.2.5 Operating and Maintenance Costs: Semivariable Costs

7.2.5.1 Labor

Operating personnel for the Shirco unit, based on three shifts, totals 22 persons. This includes 16 process operators, 3 supervisors, and 3 laboratory and safety persons.

7.2.5.2 Maintenance

Maintenance materials and labor costs are extremely difficult to estimate and cannot be predicted as functions of a few simple waste and facility design characteristics, because a myriad of site-specific factors can dramatically affect maintenance requirements. The discussions in Section 8.2 clearly show the impact of site-related factors on the various problems encountered during the operation of the unit that required constant maintenance activities.

7.2.5.3 Analyses

In order to ensure that the unit is operating efficiently and meeting environmental standards, a program for continuously analyzing waste feed, ash, and water quality is required.

7.2.5.4 Mobilization/Demobilization

As discussed in Section 7.1, the following costs will accrue to the Shirco unit at each specific site. The costs are site-specific and may vary widely depending on the nature and location of the site. They include site preparation and logistics, transportation and setup, construction supervision, on-site check-out, site-specific permitting and engineering services, working capital, and decontamination/demobilization.

- o Site Preparation/Logistics--The costs associated with site preparation and logistics include advanced planning and management, detailed site design and development, auxiliary and temporary equipment and facilities, water conditioning, emergency and safety equipment, and site staff support. Soil excavation, feedstock preparation, and feed handling costs are also included.
- o Transportation and Setup--The cost of transportation and setup includes disassembly of the unit at its present location and transport to a new location. Present Shirco designs are totally skid-mounted and equipped with hydraulic levelers. The trailers can be moved into place without removing equipment, thus significantly minimizing setup time and costs.
- o On-site Check-out--Once the unit has been set up, it is necessary to shakedown the system to ensure that no damage occurred as a result of disassembly, transport, and reassembly.
- o Site-specific permitting and engineering Services--In addition to the TSCA trial burn activities discussed in Section 7.2.3.3, site-specific permitting and trial burn activities may be required. Both in-house and consultant technical support and engineering services may be required to support these efforts.

- o Working Capital--Fuel inventory for the secondary combustion chamber heat source and caustic soda solution inventory for the scrubber's acid gas removal operation are obtained at each site and as such are site-specific semivariable operating costs.
- o Decontamination/Demobilization--With the completion of activities at a specific site, the unit must be decontaminated and demobilized before being transported to its next location. Costs that will accrue to this cost element include the final burnout of residual material in the system, field labor and supervision, decontamination equipment and materials, utilities, security, health and safety activities, and site staff support.

7.2.6 Operating and Maintenance Costs: Fixed Costs

- o Depreciation--Because incineration is a capital-intensive waste treatment option, the overall costs must include an annualized capital investment cost or depreciation. On a simplified basis, a 10-yr straight-line depreciation adequately addresses this fixed cost for this cost and economic analysis.
- o Insurance and Taxes--Depending on site location and the specific tax strategy employed for the ownership and operation of the unit, insurance and taxes will vary from 5% to 10% of the fixed capital investment on a yearly basis. For this analysis, insurance and taxes are estimated to represent 10% of the direct capital cost of the unit.

7.3 OVERALL COST EVALUATION

An economic model for an efficiently operated current-cost Shirco transportable infrared incinerator unit operation equivalent in processing capacity to the unit that operated at Peak Oil is presented in Table 7.2. The model is based on an analysis of cost data available from several sources as defined in the notes that accompany the table. This model represents an operation with an 80% on-stream capacity factor equivalent to 292 operating days/year at 100 tons/day or 29,200 tons/year. The total cost per ton for this model is \$196.90.

In actual operation, the Peak Oil unit was on site for approximately one year and processed a total of 7000 tons of waste feed. Assuming that only variable operating and maintenance costs remain constant on a per ton basis, the remaining costs will increase because of the reduction in annual waste feed throughput from 29,200 tons to 7,000 tons.

TABLE 7.2. ECONOMIC MODEL FOR SHIRCO UNIT, PEAK OIL

| <u>CAPITAL COST</u> | <u>\$MM/YR</u> | <u>\$/TON</u> |
|--|----------------|---------------|
| <u>Direct - Depreciable</u> | | |
| Equipment Fabr./Constr. | 3.25 | - |
| <u>Indirect - Depreciable</u> | | |
| Adm./Permt. (10% Direct Costs) | 0.33 | 11.30 |
| Contingency (10% Direct Cost) | 0.33 | 11.30 |
| <u>Indirect - Nondepreciable</u> | | |
| Operations Proc./Training | 0.20 | 6.85 |
| Initial Start-up/Shakedown (5% Direct Cost) | 0.16 | 5.48 |
| Trial Burns | 0.30 | 10.27 |
| Working Capital (10% Maint. Cost) | 0.04 | 1.37 |
| <u>OPERATING AND MAINTENANCE COSTS</u> | | |
| <u>Variable</u> | | |
| Fuel (\$3.50/1000 cf) | 0.01 | 0.34 |
| Power (\$0.04/kwh) | 0.08 | 2.74 |
| Water (\$0.80/1000 gal.) | 0.02 | 0.68 |
| Chemicals | 0.03 | 1.03 |
| Residue/Water Disposal | 0.10 | 3.42 |
| <u>Semivariable</u> | | |
| Labor | 0.85 | 29.11 |
| Living | 0.48 | 16.44 |
| Maintenance (10% Deprec. Capital) | 0.39 | 13.36 |
| Analyses | 0.10 | 3.42 |
| Mobilization/Demobilization | | |
| Site Prep. | 0.80 | 27.40 |
| Transp./Setup & On-site Checkout (5% Direct Cost) | 0.16 | 5.48 |
| Site Permit | 0.10 | 3.42 |
| Working Capital | 0.05 | 1.71 |
| Decon./Demobil. | 0.05 | 17.12 |
| <u>Fixed</u> | | |
| Depreciation (10 yrs. St. Line) | 0.39 | 13.36 |
| Insurance & Taxes (10% Direct Cost) | 0.33 | <u>11.30</u> |
| TOTAL COST PER TON | | 196.90 |

TABLE 7.2 (continued)

NOTES

1. Unit capacity at 100 tons/day.
2. 80% on-stream factor at 292 days/yr.
3. Total annual throughput at 29,200 tons.
4. Equipment life at 10 years.
5. Unit at a specific site for one year.
6. Cost values obtained from Shirco; McCormick, R.J., et al., Cost For Hazardous Waste Incineration, Noyes Publications, New Jersey, 1985; Mortensen, H., et al., Destruction of Dioxin-Contaminated Solids and Liquids by Mobile Incineration, Contract No. 68-03-3255, USEPA Hazardous Waste Engineering Research Laboratory, Land Pollution Control Division, Releases Control Branch, Edison, NJ, 1987.
7. Utilities Consumption Estimate
1,200 max installed KVA
2,200°F Afterburner Temperature
300 installed HP
140 GPM water usage
8. Labor Estimate
16 Operators at \$10.50/hr. and 2 OT hrs./wk./man
3 Supervisors at \$20.00/hr.
3 Lab/Safety at \$11.50/hr.
50% Overhead Rate
\$75/day per diem for 16 men.
Full year commitment to unit by personnel.
9. Cost data accuracy \pm 30%

Based on the unit capacity of 100 tons per day, the on-stream capacity factor is reduced from 80% or 292 operating days/year to 19% or 70 operating days/year. Based on the above, the total cost per ton for this actual operating case is \$795.32.

The above two cases represent the extremes of the potential cost per ton for the overall operation of the Shirco unit as mobilized for a cleanup action. An analysis of the Peak Oil on-stream time reveals that the unit actually processed waste feed at 25 tons/day or greater for 89 days during the 243 days of operation from February 13, 1987 to October 13, 1987, for an average on-stream capacity factor of 37%. It was assumed that at 25 tons/day, the unit approached a continuous operation rather than an unstable start-up/shutdown mode. Based on the unit being able to operate at 100 tons/day, the annual throughput at a 37% capacity factor would have been 13,500 tons of waste feed. Applying this annual throughput to the ideal economic model presented in Table 7.2 results in a total cost per ton of \$416.

Based on the above scenarios, it can be expected that as the Shirco unit is operated more frequently, the on-stream capacity factor should improve as the first-of-a-kind start-up problems are eliminated and/or minimized. In addition, some of the indirect and nondepreciable capital costs will decrease. Based on this, the total cost per ton for employing this Shirco unit at other cleanup sites will approach the economic model presented in Table 7.2. For the specific Peak Oil emergency cleanup operation, the cost analysis that assumes unit operation based on a 37% on-stream factor represents a reasonable accounting of the actual costs that accrued to this project. Based on this assumption, the total cost per ton for the emergency cleanup at Peak Oil is approximately \$416 ± 30%.

SECTION 8

PROBLEMS DURING TESTING

8.1 DEMONSTRATION TEST PROBLEMS

During the SITE demonstration performed between July 31, 1987 and August 4, 1987 several problems occurred that resulted in possibly questionable or missing data. These problems can be categorized as operational events or procedural deficiencies as described below.

8.1.1 Operational Events

During the operation of the unit, several upsets, operating interventions and unit shutdowns occurred. These operational events are presented in Section 4.1.

8.1.2 Procedural Deficiencies

With the SITE test program taking place at the Peak Oil site emergency cleanup during a difficult first-of-a-kind start-up of a Shirco transportable infrared incinerator, the program encountered several problems that impacted on the collection of data.

- o The unit instrumentation did not include the measurement of makeup water and scrubber blowdown water flows.
- o Ash flowrates were not measured.
- o Although electrical consumption was metered, hourly readings requested by the SITE investigators were either erroneously taken or not taken.
- o The specific consumption of chemicals was not recorded on an as-used basis.
- o Collection of cost data at the Peak Oil site was designed to provide the specific information required by the EPA to define contract costs. Cost data collection was not designed to clearly define the specific cost elements for cost/economic analysis of the unit -- particularly in terms of this first-of-a-kind start-up operation.

8.2 OVERVIEW OF UNIT PROBLEMS

During the operating period from December 31, 1986 through August 4, 1987 the Shirco unit experienced operating and unit

design problems consistent with the first application of a full-scale commercial thermal destruction unit at a Superfund site.

A review of the Haztech, TAT, and EPA logbooks, and progress reports provided a summary of the problems that occurred during the start-up and operation of the unit. The major operating problems then were categorized by unit operating sections; a profile of the major problem areas within the unit then was defined and analyzed to ascertain the reasons for these specific operational difficulties.

8.2.1 Feed Preparation Section

The feed preparation section of the system is one of the keys to the successful operation of the Shirco unit. The feed must be properly prepared to meet the design requirements of the unit. Feed preparation to the proper size and consistency is a direct function of the matrix's characteristics; similarly, the feed weighing and conveying system will be impacted by the waste's physical and handling properties. Regardless of whether the system is designed and provided by the unit's operator or Shirco, preoperation analyses and materials handling investigations must be conducted to ensure the successful application of the myriad of materials handling equipment and processes to the specific site waste feed matrix.

8.2.1.1 Crusher/Shredder/Power Screen

The Peak Oil waste feed matrix was a solidified sludge that was prone to agglomeration and caused clogging, bridging, and jamming of the original crusher equipment. Prior to the SITE demonstration test (May 10, 1987), the crusher was replaced with a power screen that shredded, screened, and aerated the feed to a consistency and size that was accommodated by the Shirco feeder.

8.2.1.2 Conveyor

Conveyor system problems included spillage of waste feed, waste material sticking to the conveyor belt, and an inability to adjust feedrate from the conveyor to the unit's feeder system. Modifications to the conveyor system included the addition of a "skirt" below the conveyor to catch spillage, a conveyor scraper that minimized sticking, and a variable speed controller and revised motor arrangement that provided feedrate control.

Although the overall conveyor system provided waste feed to the Shirco unit, preoperation analyses and materials handling

investigation must be conducted to provide a system that is adaptable to the specific waste matrix encountered at the Peak Oil site.

8.2.2 Primary Combustion Chamber Section

8.2.2.1 Feed Inlet

The screw augers and their motor drives experienced continuous clogging and overload problems. The feed system required continuous attention by operating personnel and the addition of "bridgebreakers" to reduce the bridging of the agglomerating waste feed.

As is the case with the feed preparation section, the design configuration of the feed inlet section and the screw augers should be specific to the waste feed matrix. The flight pitch, height, and gear reduction of the feed auger should be designed based on preoperation investigations and tests on waste feed materials and feed handling.

The screw augers are designed with reversing capability, and the motor drives are designed for a 50% overload based on adequate feed preparation. If the feed is not properly crushed, screened, and prepared, the augers' materials handling efficiency will decrease; bridging and plugging problems, particularly with an agglomerating feed matrix, will occur causing significant overload and eventual burnout to the motor drives. Again we see the need for preoperation testing and evaluation of the waste feed matrix vis a vis the entire feed handling system.

8.2.2.2 Ash Outlet

The ash removal system required frequent maintenance and unit downtime. The cooling screw and incline screw were continually clogging and breaking, and their motor drivers would overload and burn out. When the screws were reversed to dislodge material under the screw flights, breakage and further abuse of the motors would occur. Significant dusting and odor problems also were evident in and around the ash removal system.

In addition to the design limitations discussed above, the intermittent failure of the original feed preparation system (i.e., crusher and screen) to deliver a consistently sized waste feed would allow unprepared materials to enter the unit. The unprepared feed caused occasional jamming and blockage of the ash discharge system. Plugging of the incline screw was also caused by the buildup of ash in the discharge chute and improper control and monitoring of the ash quench facilities.

In early 1987 the cooling screw and incline screw design were changed; larger motors and gear reducers were installed to further correct overload, plugging, and motor burnout. A viable solution to future designs could entail the installation of a larger diameter screw operating at lower RPM than the small, high-RPM screw conveyor, which proved to be a high-maintenance item subject to substantial wear over a short period of time.

Another alternative, a wet system design, does not appear to be viable; it brings with it substantial equipment maintenance and environmental concerns when dealing with a liquid abrasive ash solution.

The dusting problems that were continually present at the ash removal system can be minimized by careful control and monitoring of the ash quench water flow, especially during start-up or periods of interrupted ash discharge. Potential odor problems are inherent to the quench operation and will vary in severity with the waste material. In any event, unit and site setup should take into account these potential health problems; ash removal and storage should be located for minimal exposure to operating personnel and traffic.

8.2.2.3 Miscellaneous Systems

In addition to the feed inlet and ash outlet systems, problems also occurred with conveyor belt failures, cakebreaker failures, and belt conveyor system maintenance.

A mobile unit moving from site to site will be subject to metallurgical degradation if one assumes that a single alloy will be adequate for all applications. Knowledge of the physical and chemical characteristics of the feed is essential in selecting the appropriate alloy(s). The original belt installed at the Peak Oil site was provided with several test sections of various alloys. Because of the nature of the feed material and minimal knowledge of its chemical characteristics, this approach was selected so that if belt failure did occur, an appropriate alloy then could be installed. Due to the chlorine and sulfur content of the initial feed material, certain test sections did fail and were replaced with the standard Type-314 stainless steel alloy. A properly cured Type-314 stainless steel belt has provided reliable service through the completion of the project. Belt specifications and subsequent construction materials may require occasional changes due to the unique characteristics of a particular feed material.

As with the belt, metallurgical considerations for the cakebreakers are dictated by the physical and chemical properties of the feed material and subsequent furnace environment. Corrosion problems are resolved through the

selection of the appropriate alloy for the feed material characteristics. At Peak Oil, the original alloy was not compatible with the waste feed. In addition, possibly due to the mechanical failures in feed screening and crushing noted earlier and to the resultant feeding of unsized or nonspecification waste material, the cakebreakers also may have been subject to severe stress when these articles were encountered, causing cakebreaker failure.

Although problems were encountered with the belt conveyance system, it appears that the roller bearing specifications do not require any changes. Proper attention to lubricant choice and a rigorous maintenance schedule are required to ensure a long roller bearing and belt conveyance system operating life.

8.2.3 Secondary Combustion Chamber Section

Unlike the feed preparation and primary combustion chamber sections, which are burdened with the processing of an abrasive, unsized, and undefined waste feed matrix, the secondary combustion chamber is similar to the afterburner design of a majority of hazardous waste incinerators. It ensures the complete destruction of the hazardous volatiles produced in the primary combustion chamber by combusting the vapors at temperatures of up to 2300⁰F with a minimum of maintenance problems.

For this Peak Oil operation, the only operating problem that affected the secondary combustion chamber was the failure of several burner blocks. Proper curing of the burner blocks is required prior to achieving operating temperatures. A slow curing of the burner blocks prior to operation may not have been fully performed. In addition, numerous start-ups and shutdowns of the unit subjected the blocks to cooling and heating cycling that adversely affected block life. Changes to the burner block have been incorporated in the current design to allow for symmetrical expansion and contraction and minimization of stress points observed at Peak Oil, and to move the flame front farther away from the blocks, thus extending their life.

8.2.4 Emissions Control Section

8.2.4.1 Quench/Venturi System

The original quench/venturi system design consisted of two stainless steel quench tubes where the hot exhaust gases from the secondary combustion chamber are cooled with quench water sprays. The cooled gases enter the dual fiberglass reinforced plastic (FRP) venturis where water injection at the venturi throats atomizes and increases particulate precipitation as the gases proceed into the scrubber system. The system, as operated, was modified to a one pass quench/venturi flow with

a venturi pressure drop exceeding 15 psi. There were indications based on the cracking and scorching of the FRP venturi section and warpage of the scrubber internals that the systems may have been subjected to excessive process temperatures probably caused by a failure of the quench system and its cooling sprays. The high temperatures exhibited by the gas exiting the quench system probably were the result of low gas flow and subsequent channeling of the exhaust gas stream through only one pass of the dual quench tubes and venturis. Because of the channeling, the gas stream was not exposed to the full cooling effect of the spray nozzles, and damage to the downstream FRP systems resulted.

The particulate precipitation effect at the venturis also suffered due to the channeling of the low gas flow. In addition, the cracking of the FRP venturi section also may have occurred because the anchor bolts on the venturi support structure may not have been loosened during installation of the system to allow for thermal expansion of the quench tubes. Compounding the loss in cooling and particulate removal efficiency caused by the gas channeling was the plugging of the water sprays, which reduced the overall quench and venturi water flows and spray coverage. This plugging may have been caused by an excessive salts content in the quench water caused by a number of factors, including the following factors:

- o A sodium carbonate neutralizing agent in the scrubber packed section contained a substantial amount of inert materials that did not dissolve.
- o System makeup water was introduced containing calcium and magnesium sulfates and chlorides, which precipitated from solution with the addition of sodium carbonate.
- o Fines material, probably lead oxide, carried over into the vapor stream and precipitated at the emissions control system.
- o The use of lime in the initial waste feed preparation neutralization introduced further salts into the system.

Based on the above it is apparent that the preoperation testing of the waste feed matrix to determine feed preparation and materials handling characteristics also should include a careful study of the overall chemistry of the unit operation, including neutralizing solutions, waste feed salts content, and makeup water quality. Each of the above factors was addressed during the operation at Peak Oil to minimize their effect on the overall system. The unit operation was changed over to caustic neutralization, which used a known concentration and purity of caustic solution. Furthermore, a water softening system was added to treat the hardness of the

unit's makeup water. The spray nozzles and their installation were also changed to alleviate this problem.

A potential solution to these problems is the clarification and removal of salts from the scrubber water circulation and blowdown streams. This is a viable method of providing fresh water makeup and a potentially closed-loop or zero-discharge scrubbing system. Under normal operating conditions, however, the clarification of the recycle or recirculation water is not required if the incoming water is properly treated and the blowdown rate is sufficient for the removal of sludge and particulate from the scrubber sump.

An additional solution that should be examined in future designs is the redesign of the venturis to accommodate a wider range of operation and, therefore, a higher pressure drop. This design will increase particulate precipitation and lessen the potential carry-over of fines. This solution, however, will require additional design requirements for the FRP scrubber system and ID fan to accommodate the increased vacuum conditions.

8.2.4.2 Scrubber System

The scrubber is a horizontal cross-flow design. Gases pass horizontally through the chevron section and concurrent sprays and then through the packed section perpendicular to the downward vertical flow of acid gas-neutralizing scrubbing liquid. Contact of the gas with the thin film created on the packed section internals allows for efficient mass transfer of contaminants from the gas to liquid phase. The scrubbed gas then flows through a chevron blade mist eliminator before discharging.

The scrubber design as discussed above is a proven design that is capable of scrubbing exhaust gases and meeting regulatory requirements for acid gas removal and particulate loading. The scrubber system at Peak Oil, however, apparently could not control particulate emissions at the quantities and quality of the particulates encountered. The scrubber problems point out the need to perform preoperation testing of the waste feed matrix for overall unit chemistry impact on the water circulation streams and scrubber design. Because of the excessive fines loadings and excessive salts content in the scrubber water streams as discussed in Section 8.2.4.1, the scrubber system not only exhibited high stack particulate loadings, but also was burdened by the significant salts buildup in the scrubber water streams requiring higher blowdown and fresh makeup water rates.

Because of the critical role that the scrubber system plays in controlling particulate emissions and the problems encountered at Peak Oil, several design changes should be investigated

that will enable the transportable scrubber system to accommodate severe submicron particulate and salt loadings and effectively treat emission gases. These changes could include:

- o The reorientation of spray and distribution nozzles/headers and the introduction of additional or new scrubber internals to effect increased scrubber efficiency.
- o The total replacement of the horizontal scrubber system with a more efficient vertical or wet electrostatic precipitator design that will be transportable and provide the increased efficiencies that a countercurrent or electrostatic scrubbing system can provide over a cross-flow design.

8.2.4.3 Induced Draft Fan System

Because of the particulate carry-over from the scrubber, plating of the induced draft fan blades would occur causing blade imbalance and fan vibration. It does not appear that the design of the fan is contributing to the problem. A water spray system has been added at the fan to periodically wash the blades of plated salts and minimize vibration problems. Enabling the scrubber system to minimize particulate carry-over could eliminate the chronic problems encountered at the induced draft fan.