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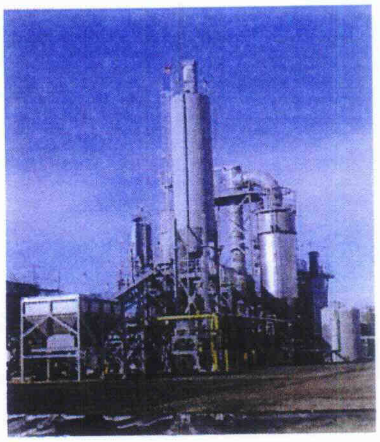

Sediment Decontamination Demonstration Program: Cement-Lock® Technology Phase I Pilot Test

FINAL REPORT

Prepared under subcontract to ENDESCO Clean Harbors, L.L.C. by:

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Submitted to:

NEW JERSEY DEPARTMENT OF TRANSPORTATION
OFFICE OF MARITIME RESOURCES
P.O. Box 837
Trenton, New Jersey 08625

August 2006

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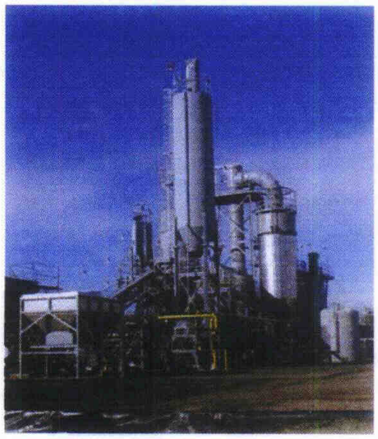

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EXECUTIVE SUMMARY

This is the final report for the Cement-Lock® Technology Phase I Pilot Test of the New Jersey Department of Transportation Office of Maritime Resources (NJ-DOT/OMR) Sediment Decontamination Demonstration Program. The report describes the work performed by ENDESCO Clean Harbors, L.L.C. (ECH, Des Plaines, IL) for NJ-DOT/OMR under Agency Order Number AO #9345380 from June 2000 through December 2005. Other funding for this program has been provided by the U.S. Environmental Protection Agency Region 2 and the U.S. Army Corps of Engineers (New York District) with technical and contractual support from Brookhaven National Laboratory and Gas Research Institute (GRI, Des Plaines, IL).

Cement-Lock Technology: Cement-Lock Technology is a thermo-chemical manufacturing process – developed by the Gas Technology Institute (GTI, Des Plaines, IL) and Unitel Technologies (Mount Prospect, IL) – that not only decontaminates dredged sediment but also converts it into construction-grade cement. The construction-grade cement can be used in general construction projects where ordinary Portland cement is used. The technology can treat organic as well as inorganic contaminants at widely varying concentrations. It is also applicable to a variety of wastes including contaminated soils, debris from brownfields, construction and demolition, industrial chemical wastes, sludges, and incinerator residues, among others. During processing, all of the waste is converted to cement, which can be beneficially used.

The major objectives of the Phase I Pilot Test were to: 1) process a bulk quantity of sediment dredged from a harbor navigation channel through the Cement-Lock demo plant, 2) demonstrate the effectiveness of the technology for treating organic as well as inorganic contaminants in the sediment, 3) show that the organic contaminants were actually destroyed and not just transferred to another medium, 4) determine the leachability of the treated sediment by subjecting it to the TCLP (Toxicity Characteristic Leaching Procedure, EPA Method 1311) and MEP (Multiple Extraction Procedure, EPA Method 1320) protocols, 5) show that the treated material qualifies for a beneficial use application, and 6) show that the sediment processing cost can be \$35 per cubic yard (yd^3) or less.

The project objectives have been achieved. The results of the Cement-Lock Technology Phase I Pilot Test are summarized below.

Sediment: For the Phase I Pilot Test, sediment dredged from the Stratus Petroleum site in Upper Newark Bay was provided to ECH by NJ-DOT/OMR. The bulk quantity of sediment (about 500 yd^3) was screened to -¼ inch to remove oversized debris and then dewatered to about 55 weight percent water in a belt press. The dewatered sediment was brought to the site in twenty 20-yd^3 lined and tarped roll-off containers.

Demo Plant Operating Modes: During the Phase I Pilot Test, the Cement-Lock demo plant was operated in both slagging and non-slagging modes. In the tests conducted under slagging mode, the sediment was converted to Ecomelt®, which is the non-crystalline remediated product from Cement-Lock processing. Ecomelt® can be ground to cement fineness and then blended with a lime source, such as ordinary Portland cement, to yield construction-grade cement.

In the test conducted under non-slagging mode, the sediment was converted to EcoAggMat (Ecological Aggregate Material). EcoAggMat can be beneficially used without further treatment, as fill or as a partial replacement for sand in mortar.

Sediment Treatment Capacity: The demo plant was operated at a sediment processing rate of about 1,000 pounds per hour (about ½ yd^3/hour) during both the slagging and non-slagging test campaigns. This was well above the rate of 100 lb/hr originally proposed by ECH for the pilot test. The nominal throughput capacity of the demo plant without any process enhancements is about 10,000 yd^3/year or a little more than 1⅓ yd^3/hour. A commercial-scale Cement-Lock plant would be designed to treat up to 500,000 yd^3/year of sediment using multiple processing modules. From this quantity of sediment, a commercial plant would produce about 243,000 ton/year of Ecomelt for incorporation in construction-grade cement.

Sediment Treated/Beneficial Use Product Generated: Approximately 20 yd^3 (about 20 tons) of sediment was processed through the plant during slagging-mode testing. In total, about 2 tons of Ecomelt were generated – the balance (about 8 tons) was in the form of large clinkers or slag. Approximately 80 yd^3 (about 80 tons) of sediment were processed through the plant in non-slagging mode. About 53 tons of EcoAggMat were produced from the sediment.

Ecomelt – Suitable for Beneficial Use: The initial sample of Ecomelt was subjected to the EPA TCLP test. The sample was essentially non-leachable as none of the priority elements was detected in the leachate above the analytical detection limits. The Ecomelt was then converted to construction-grade cement and tested for compressive strength. The compressive strength of the construction-grade cement was 5190 psi after 28 days of curing. This exceeds the ASTM (American Society for Testing and Materials) C-150 requirement for Portland cement (4060 psi) and the ASTM C-595 requirement for blended cement (3480 psi).

EcoAggMat – Suitable for Beneficial Use: The EcoAggMat was essentially devoid of any organic contamination. The following table compares the organic contaminant levels in the as-fed sediment with those of the thermally treated EcoAggMat product. The New Jersey Residential Direct Contact Soil Cleanup Criteria (NJ RDCSCC) is included for comparison. These results show that the EcoAggMat readily meets NJ RDCSCC. The level of polychlorinated biphenyls (PCBs) in the sediment was reduced by 99.97 percent to 0.22 μg/kg in the EcoAggMat.

	Stratus Petroleum Sediment		NJ Residential Direct Contact Soil Cleanup Criteria
Sample	As-Fed	**EcoAggMat**	
Contaminant	---------------------- μg/kg ----------------------		
Benzo (a) Anthracene	**361***	< 1.2**	*900*
Benzo (b) Fluoranthene	**669**	< 1.8	*900*
Benzo (k) Fluoranthene	**187**	< 1.4	*900*
Benzo (a) Pyrene	**411**	< 2.5	*660*
Bis (2-Ethylhexyl) Phthalate	**517**	< 5.2	*49,000*
Chrysene	**375**	< 2.1	*9,000*
Indeno (1,2,3-cd) Pyrene	**192**	< 1.1	*900*
4,4'-DDT	< 21	< 24	*2,000*
Total PCB	**367.1**	**0.22**	*490*
	-------------------- ng/kg (pg/g) --------------------		
2,3,7,8-TCDD	**88.7**	< 0.50	N/A
Dioxin/Furan, TEQ	**141.4**	**2.08**	N/A
PCB, TEQ	**11.1**	**0.03**	N/A

* **Bold**-faced font = analyte detected.
** < = Less than the analytical detection limit.

The concentrations of non-volatile metals in the EcoAggMat are also well below the NJ RDCSCC as shown below.

Sample	Stratus Petroleum Sediment		NJ Residential Direct Contact Soil Cleanup Criteria
	As Fed	**EcoAggMat**	
	------------------------ mg/kg ------------------------		
Arsenic	**9.1***	**9.2**	*20*
Barium	**66.3**	< 29.1**	*700*
Cadmium	**1.32**	< 0.7	*39*
Copper	**79.5**	**29.4**	*600*
Chromium (total)	**88.6**	**27.0**	*(Cr VI) 240*
Lead	**72.5**	**4.3**	*400*
Mercury	**1.78**	< 0.04	*14*
Nickel	**20.7**	**20.5**	*250*
Selenium	< 1.9	< 1.7	*63*
Silver	**2.0**	< 1.4	*110*
Zinc	**131.9**	**43.5**	*1,500*

* **Bold**-faced font = analyte detected.
** < = less than the analytical detection limit.

The EcoAggMat was also subjected to the TCLP, SPLP (Synthetic Precipitation Leaching Procedure), and MEP tests to determine its aqueous leaching potential. In the TCLP, the sample is leached for 18±2 hours in a solution of acetic acid (pH of 4.93). In the SPLP, the sample is leached for 18±2 hours in a solution of sulfuric and nitric acids (pH of 4.20). As shown in the following table, chromium was detected in the EcoAggMat leachate from both the TCLP and SPLP tests at 29.0 and 13.3 μg/L, respectively. These values are well below the TCLP limit of 5,000 μg/L and the NJ GWQC limit of 70 μg/L.

The MEP test consists of a series of sequential extractions of the sample first in a solution of acetic acid (pH maintained at 5, EPA Method 1310) followed by nine extractions in a sulfuric and nitric acid solution (pH of 3.0). The highest leachate concentration and the leachate concentration on the final day of leaching are presented in the table. Arsenic, barium, chromium, and lead were detected during the MEP testing. Arsenic was detected in several extractions, but was highest (9.06 μg/L) on the last day of leaching. Lead was detected at 6.28 μg/L on the first day of leaching, but was below the detection limit on the last day. Chromium was detected on the first day of leaching and on several subsequent leaching days, but not on the last day. The concentrations of arsenic and lead in the leachate exceeded the NJ GWQC. The concentration of barium and chromium were well below the NJ GWQC.

These results emphasize the need for testing the Cement-Lock demo plant with sediment under slagging conditions producing Ecomelt as the Cement-Lock Technology was originally developed.

EcoAggMat (thermally treated sediment) Leachability Results						
	TCLP 1311*	TCLP Limits	SPLP 1312	MEP (1320) Highest	MEP (1320) Last†	NJ GWQC Limits
Contaminant	µg/L					
Arsenic	< 500	5,000	< 500	**9.06**	**9.06**	3
Barium	< 1000	100,000	< 1000	**133**	< 100	2,000
Cadmium	< 5	1,000	< 5	< 4	< 4	4
Chromium	**29.0**	5,000	**13.3**	**29.3**	< 10	70
Copper	< 25	NA	< 25	< 10	< 10	1,300
Lead	< 500	5,000	< 500	**6.28**	< 5	5
Manganese	NA	NA	NA	< 10	< 10	50
Mercury	< 0.2	200	< 0.2	< 0.285	< 0.285	2
Nickel	< 40	NA	< 40	< 40	< 40	100
Selenium	< 500	1,000	< 500	< 20	< 20	40
Silver	< 10	5,000	< 10	< 10	< 10	40
Zinc	< 20	NA	< 20	< 20	< 20	2,000

* EPA Leachability method number.
** < = Less than the analytical detection limit.
† Concentration of leachate on last day of MEP.

The EcoAggMat was approved by the NJ Department of Environmental Protection for placement at the former BASF site in Kearny, NJ, which was undergoing remediation. The EcoAggMat was placed at the BASF site in early May 2006 and was beneficially used as fill.

Other tests conducted by CTLGroup (formerly Construction Technology Laboratories, Skokie, IL) under subcontract to the EPA Superfund Innovative Technology Evaluation (SITE) program showed that EcoAggMat could be used as a partial replacement for sand (up to 50 volume percent) in mortar mixtures.

Environmental Sampling: The emissions from the Ecomelt Generator were sampled to determine the efficiency of the equipment for capturing and/or destroying organic or inorganic contaminants. The emissions of potential air pollutants from the demo plant were assessed during the non-slagging campaign in March 2005. The EPA SITE Program provided the stack sampling, environmental sampling and analytical work for the Phase I Pilot test.

The air data collected by the EPA SITE program showed emission rates of SO_2 of < 0.024 lb/hr

(< 0.8 ppmdv at 7% O_2), NOx of 1.53 lb/hr (76 ppmdv at 7% O_2), carbon monoxide of 0.02 lb/hr (1.7 ppmdv at 7% O_2), and total hydrocarbons (as methane) of < 0.01 lb/hr (< 1.4 ppmdv at 7% O_2). These are well within the NJ-DEP Air Quality Permit limits.

The concentration of PCBs in the stack was measured at 0.13 μg/dscm (at 7% O_2), which corresponds to an emission rate of 1.42×10^{-6} lb/hr. Of the PCBs fed to the system, 99.49 percent was destroyed, 0.03 percent appeared in the EcoAggMat, and 0.48 percent appeared in the flue gas. The emission rate of specific SVOCs (semi-volatile organic compounds) analyzed in the stack was below the analytical detection limit of 3.53×10^{-6} lb/hr each. Bis (2-ethylhexyl) phthalate, a common laboratory contaminant, was also detected in the flue gas.

The concentration of polychlorinated dioxin (PCDD) and furan (PCDF) congeners in the stack was measured at 0.35 ng/dscm (at 7% O_2). For comparison, the EPA New Source Performance Standard for PCDDs and PCDFs emitted from large municipal waste incinerators is 30 ng/dscm (at 7% O_2: ref. 40 CFR 60.52b). The emission rate of PCDDs and PCDFs from the stack totaled 2.86×10^{-9} lb/hour. Overall, 99.84 percent of the dioxins and furans fed to the system were destroyed, 0.10 percent appeared in the EcoAggMat, and 0.06 percent appeared in the flue gas.

On a toxicity equivalency (TEQ) basis (including full detection-limit accounting for non-detected species), 99.02 percent of the TEQ from PCDD, PCDF, and PCB congeners in the sediment-modifier mixture fed to the Cement-Lock demo plant was destroyed. The balance appeared in the flue gas (0.23 percent) and the EcoAggMat (0.75 percent). The TEQ of the EcoAggMat itself was 2.08 ng/kg from PCDD and PCDF congeners and 0.03 ng/kg from PCBs.

Samples of spent lime and granulator quench water also showed trace levels of PCDD and PCDF congeners and PCBs. These samples were taken near the mid-point of the 17-day campaign in March 2005 and the contaminant accumulation rate could not be accurately determined. If the rate of contaminant accumulation is assumed to be constant up to the sampling time, then the estimated TEQ of the PCDD and PCDF congeners and PCBs in the spent lime and granulator quench water represents less than 0.0015 percent of the total contaminant TEQ load.

The concentration of mercury entering the activated carbon bed was 14.6 μg/acm (6.79×10^{-4} lb/hr) while that exiting the stack measured 0.14 μg/acm (5.61×10^{-6} lb/hr or 0.049 lb/year).

This represents 99.2 percent collection efficiency across the activated carbon bed. The NJ-DEP Air Quality Permit required a minimum of 70 percent mercury collection efficiency and a maximum emission of 0.64 lb/year. The activated carbon in the bed still has significant mercury capture/holding capacity and will be replaced well before its theoretical capacity is reached. The spent activated carbon will be sent to a company, such as U.S. Ecology, for reprocessing.

The samples of spent lime collected from the baghouse did not have any specific SVOCs above the analytical detection limit, which ranged from 1.2 to 9.6 μg/kg. The common laboratory contaminant, bis (2-ethylhexyl) phthalate, was also detected in these samples. Samples of water from the quencher/granulator also did not contain any SVOCs above the analytical detection limit, which ranged from 0.0053 to 0.083 μg/L. These samples did contain trace metal contaminants at low levels, but no mercury was detected.

These results show that the organic contaminants in the sediment were destroyed and not merely transferred to other media or the flue gas. Some of the more volatile trace metal contaminants were removed from the sediment and transferred to the spent lime and quench water (with the exception of mercury noted above). In a commercial Cement-Lock plant, most of these process streams will be recycled to the feed section for ultimate incorporation into the Ecomelt, so that the spent lime and granulator quench water will not contain the trace metal contaminants.

Economic Evaluation and Assessment: The preliminary economics of the Cement-Lock technology for treating sediment from navigation channels were evaluated based on recent cost and technology related factors. Per the assumptions posited, the break-even tipping fee for a commercial-scale Cement-Lock facility processing 500,000 yd^3/year of sediment dredged from navigation channels in the NY/NJ Harbor is \$34.97/yd^3. The economics include revenues from the sale of pulverized Ecomelt valued at \$80/ton and the export of electric power to the grid generated from waste heat recovery. The economics are based on a total installed cost of \$81,626,000 for the "n^{th}" plant, 75:25 debt-to-equity ratio, 20-year period of depreciation and capital recovery, and a natural gas cost of \$9/million Btu. Estimated capital and operating costs for on-site sediment storage, screening, and handling were also included in the economic evaluation.

The sensitivity of the break-even tipping fee to variations in natural gas cost, plant throughput capacity, processing rate, and Ecomelt product price were also determined. As expected, the tipping fee increases with increasing natural gas cost, decreasing sediment processing rate (% of rated capacity), decreasing plant throughput capacity, and decreasing Ecomelt selling price. The cost of natural gas has the most effect on break-even tipping fee as it represents about 50 percent of the total operating and capital expense.

Cement-Lock is an energy intensive technology and, as mentioned above, its economics are sensitive to the cost of fuel. The cost of fuel (natural gas) used in the economic assessment was based on the average cost of natural gas during a recent 24-month span in Public Service Electric & Gas' service area. An extended average for natural gas cost was taken rather than a "snapshot" cost from the period following the devastation of the U.S. Gulf Coast by Hurricanes Katrina and Rita, which sent local PSE&G natural gas prices to near $17/million Btu.

The Cement-Lock Technology is flexible regarding co-processing of other materials with sediment, some of which have significant calorific value. For example, supplemental or alternate fuels, such as waste petroleum oils and sludges, tanker bottoms, municipal solid wastes, municipal sewage sludges, and shredded tires can be used to reduce energy-related costs. Some of these materials have tipping fees associated with their use, which increase revenues and enhance the Cement-Lock economics.

Problems Encountered: ECH encountered Cement-Lock demo plant equipment-related problems in the following areas: 1) consistent feeding of sediment to the demo plant system, metering of modifiers to be blended with the sediment, 2) discharging of slag from the drop-out box, and 3) weather. Principle among these problems was the inability of the Ecomelt Generator to continuously discharge slag from the rotary kiln. Slag accumulated in the drop-out box instead of falling into the granulator to be quenched.

Solutions Developed/Attempted: 1) ECH attempted to address the sediment feeding problem by air-drying the sediment and pre-blending the air-dried sediment with modifiers. This ameliorated the sediment and modifier metering problems. However, even the air-dried and pre-blended sediment continued to stick in the rotating screw conveyors.

2) ECH attempted to address the slag discharging problem through a umber of approaches: By reducing the sediment-modifier feed rate, reducing the kiln rotation rate, adding more flux to the sediment-modifier mixture, increasing kiln temperature, installing additional burners around the drop-out box, limiting excess air infiltration, varying the slag discharge opening in the drop-out box, adding manually operated mechanical slag breakers to the system, and extending the lip under the nose of the kiln itself. These actions were not effective.

3) To address cold weather operation, ECH had the demo plant water lines and some of the air lines insulated and heat-traced to prevent freezing. The sediment storage area and the feed conveying equipment were both exposed to the weather. These areas would need to be enclosed and heated or operations restricted to warmer weather.

Equipment Modification Design Study: ECH conducted an equipment modification design study as part of the NJ-DOT/OMR project. The objectives of Task 6 were to develop equipment modifications, and estimate costs and schedule to remedy the problems described above. The study was conducted from August through December 2005. Based on the results of this study, it was recommended that the existing feeding system be replaced by ground-level sediment-modifier mixer, screening the sediment-modifier mixture through an ALLU-type screening bucket to feed a covered belt conveyor, and using a V-Ram feeder to feed the kiln. It was further recommended that the auxiliary burners be removed from drop-out box, the walls of the drop-out box be made vertical, and space be opened in front of the kiln nose allowing slag to flow directly into the quencher below. The complete results of the study have been submitted to NJ-DOT/OMR separately.[5]

Issues Remaining: The issues remaining to be resolved are whether or not the recommended modifications to the sediment and modifier feeding systems and the slag discharging system of the demo plant developed during Task 6 will be effective. The best way to assess this is to implement the recommended modifications and test them. Similarly, the best way to assess the ultimate effectiveness of the technology for remediating contaminated sediments is to conduct detailed analysis of the Ecomelt produced from the modified equipment.

Conclusions: The Cement-Lock Technology has successfully achieved the objectives of the Phase I Pilot Test of the NJ Sediment Decontamination Demonstration Project. Dredged sediment has been remediated and converted to two beneficial use products – Ecomelt (slagging mode) and EcoAggMat (non-slagging mode). The EcoAggMat satisfies New Jersey Residential Direct Contact Soil Cleanup Criteria and was determined to be suitable for use as structural fill. All of the EcoAggMat produced during the pilot test has been beneficially used at the BASF site in Kearny, NJ. The Ecomelt also can be used as a partial replacement for Portland cement in concrete. The required break-even tipping fee for sediment dredged from navigational channels in a large, n^{th} commercial-scale Cement-Lock facility has been estimated to be $34.97/yd^3.

Recommendations: It is recommended that the modifications suggested in the Task 6 Equipment Modification Design Study be implemented. Upon completion of the plant modifications, a test should be conducted with some of the unprocessed Stratus Petroleum sediment remaining at the plant to confirm that the modifications are effective. Following the Confirmation Test, ECH recommends that the Cement-Lock demo plant be used to treat about 200 tons of mechanically dewatered Passaic River sediment. This extended plant operation will span about three weeks. ECH's parent company, GTI, is planning to contract directly with the U.S. EPA to complete this work.

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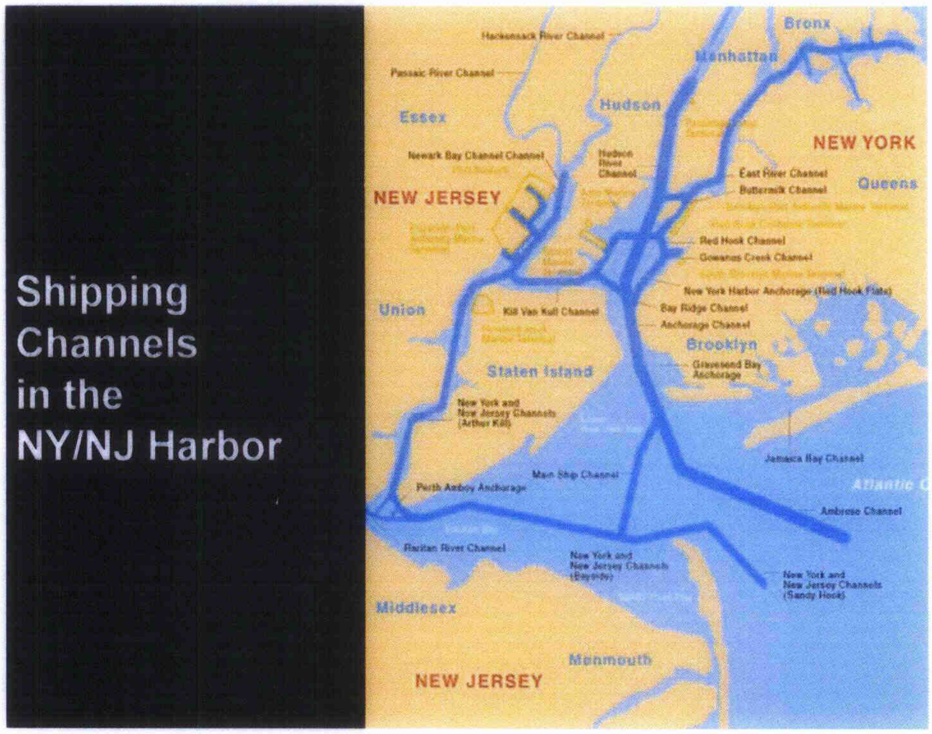
I. INTRODUCTION

The New York/New Jersey Harbor has a natural depth of about 19 feet. Because of this, as a major regional shipping hub, the harbor is laced with about 240 miles of navigation shipping channels (see diagram below) that must be periodically dredged to maintain the required depths for ocean-going cargo vessels. Due to unacceptably high levels of contaminants – both organic and inorganic – most of the sediment dredged from the harbor is no longer suitable for ocean disposal and must be treated as necessary and beneficially used or disposed of elsewhere.



New Jersey Sediment Decontamination Demonstration Project

In 1998, the State of New Jersey Department of Commerce and Economic Development Office of Maritime Resources issued an RFP (Request for Proposals) for technologies that could effectively and economically decontaminate sediment dredged from the navigation channels in the NY/NJ Harbor. It was also necessary to demonstrate that the decontaminated sediment could be beneficially used and even sold in the marketplace. The cost to the user (exclusive of dredging costs) of decontaminating the sediment must also be less than $\$35/yd^3$ dredged for a large-scale project.

Fifteen proposals were submitted in response to the RFP. After a detailed evaluation, the Cement-Lock Technology was one of the five technologies selected by the New Jersey Dredging Project Facilitation Task Force (appointed by then New Jersey Governor Christine Todd Whitman) to participate in a two-phased program to evaluate and demonstrate technologies for decontaminating dredged sediment. The sediment for the Phase I Pilot test and the Phase II demonstration test was to be dredged from navigation channels in the NY/NJ Harbor.

Cement-Lock® Technology

The Cement-Lock®[1] Technology is a thermo-chemical remediation technology that converts contaminated sediment and other wastes into construction-grade cement – a marketable product for beneficial use. Cement-Lock was developed by the Gas Technology Institute (GTI, Des Plaines, IL) and Unitel Technologies (Mount Prospect, IL) in response to the need identified by the U.S. Environmental Protection Agency Region 2 and the U.S. Army Corps of Engineers (New York District) under the federal Water Resource Development Act (WRDA). An objective of the WRDA Sediment Decontamination Program was to foster the development of sediment decontamination technologies and bring them to commercial readiness on a fast track for utilization in the NY/NJ harbor area and to find beneficial uses for the sediment.

Under the WRDA Program, GTI conducted tests in bench-scale as well as continuously operating pilot-scale equipment using Newtown Creek (New York) sediment to prove the concept of the technology. The results of these tests were very encouraging and have been published elsewhere.[1,2] All the organic contaminants present in the sediment were destroyed; the inorganic contaminants were immobilized in the cement matrix; and the compressive strength of the cement produced from these tests surpassed the requirements for Portland cement as required by ASTM (American Society for Testing and Materials) standards.

In the Cement-Lock process, the mixture of sediment and modifiers is charged to a rotary kiln melter (Ecomelt® Generator). The Ecomelt Generator is maintained at a temperature in the range of 2400° to 2600°F by combustion of natural gas or other fuels with air. This temperature yields a melt with a manageable viscosity and causes the minerals in the sediment and modifier mixture

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[1] Cement-Lock® consulting services for waste treatment available from Volcano Group L.L.C.

to react together. During processing, the sediment-modifier mixture is thermo-chemically transformed from the recognizable feed materials to a homogeneous melt. All nonvolatile heavy metals originally present in the sediment are incorporated into the melt matrix via an ionic replacement mechanism. The melt flows slowly through the Ecomelt Generator like lava as the kiln rotates. The melt then falls by gravity through a plenum and into water, which immediately quenches and granulates the melt. The quenched and granulated material, called Ecomelt®, is removed from the quench granulator by a drag conveyor, which also partially dewaters it.

Flue gas from the Ecomelt Generator flows into the Secondary Combustion Chamber (SCC), which provides an additional 2 seconds of residence time at a minimum temperature of 2200°F to ensure complete destruction of any organic compounds that survive the severe thermal conditions in the Ecomelt Generator. Flue gas exiting the SCC is rapidly cooled via direct water injection to prevent the formation or recombination of dioxin or furan precursors. In a commercial application, the thermal energy of the flue gas could be used to raise steam in a heat recovery steam generator.

Powdered lime (CaO) is injected into the cooled gas to capture acid gases [i.e., sulfur dioxide (SO_2) and hydrogen chloride (HCl)] and sodium and potassium chlorides from seawater. The sulfur/salt/spent lime mixture is removed from the flue gas stream by a baghouse. The spent lime from the baghouse is containerized and shipped to a landfill. In a commercial Cement-Lock application, a portion of the spent lime may be recycled to the front of the plant for use as a modifier. Volatile heavy metals, such as mercury, are removed from the flue gas as it passes through a fixed bed of activated carbon pellets. Cleaned flue gas is vented to the atmosphere at about 350°F via an induced draft (I.D.) fan.

Cement-Lock Demonstration Plant

ENDESCO Clean Harbors, L.L.C. (ECH, a wholly owned GTI subsidiary) installed a Cement-Lock demonstration plant on a 2-acre parcel of land at the International Matex Tank Terminal (IMTT) in Bayonne, NJ. The demo plant incorporates the major equipment components needed to demonstrate and characterize the process (Figure 1). The final steps in producing Cement-Lock construction-grade cement – grinding and blending the Ecomelt with Portland cement or another lime source – can be accomplished at an off-site facility. The demo plant has a nominal throughput capacity of 10,000 yd^3 of sediment per year. With process enhancements (sediment drying, oxygen enrichment), its throughput can be increased to 30,000 yd^3/year.

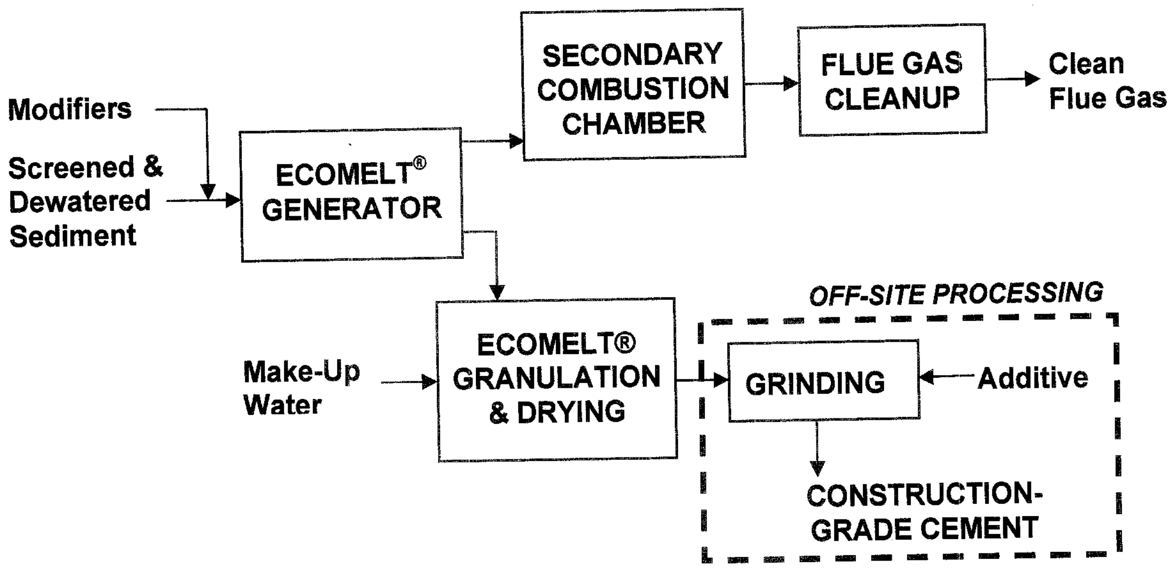

Figure 1. Process Flow Diagram for Cement-Lock Demonstration Plant

Figure 2 shows the Ecomelt Generator and Secondary Combustion Chamber (SCC) from the South. The Ecomelt Generator is a 30-foot long by 10-foot diameter rotary kiln at right. The kiln is connected to the SCC at left via the drop-out box. The drop-out box and Ecomelt Granulator are at center. Visible at the back left is the Flue Gas Quencher.

Figure 3 shows the overall Cement-Lock demo plant from the Northeast. At far left is the 100-yd^3 sediment storage hopper. To the right of the sediment storage hopper is the 25-yd^3 alternate feed hopper. An inclined screw conveyor connects the feed hoppers to the charging deck. The large vessel at center is the Modifier 1 hopper. The much smaller Modifier 2 hopper is immediately to the left of the Modifier 1 hopper. The Flue Gas Quencher and the quench water storage tank are also shown at the right.

This report summarizes the work conducted at the Cement-Lock demonstration plant at IMTT, Bayonne, NJ. The project was initiated on June 3, 2000 upon execution of Agency Order AO #9345380 between ECH and the New Jersey Department of Transportation Office of Maritime Resources. Site selection was completed in July 2001. Construction of the demo plant was initiated in June 2002 and completed in July 2003. Commissioning and start-up followed immediately thereafter. Operations continued through March 2005.

Figure 2. The Cement-Lock Demonstration Plant from the South

Figure 3. The Cement-Lock Demonstration Plant from the Northeast

A chronological history of the construction, installation, commissioning, and start-up and operation activities at the Cement-Lock demonstration plant is included in Appendix A. A topical report describing the demo plant operations and results was prepared by GTI for Brookhaven National Laboratory[3].

II. PERMITTING REQUIREMENTS

ENDESCO Clean Harbors (ECH) was required to obtain the following permits to construct and operate the Cement-Lock demonstration plant for the Phase I Pilot Test: 1) New Jersey Acceptable Use Determination, 2) New Jersey Air Quality Permit, and 3) City of Bayonne permits.

NJ Acceptable Use Determination

The Acceptable Use Determination (AUD) was issued by the New Jersey Department of Environmental Protection Office of Dredging and Sediment Technology (File No. 0714-99-0001.1). The major points of the AUD cover the following:

1) Storage of up to 500 yd^3 of sediment from the Stratus Petroleum Newark Terminal berthing area in lined and covered roll-offs at the Passaic Valley Sewerage Commissioners location in Newark, NJ
2) Transport and off-loading of the sediment into the lined and bermed sediment storage area at IMTT, Bayonne, NJ
3) Construction of the Cement-Lock demonstration plant
4) Operation of the Cement-Lock demonstration plant with the stored sediment, and
5) Beneficial use of the Ecomelt product in suitable construction projects.

It was necessary for ECH to request a modification to the existing AUD in February 2005 to accommodate the operation of the Cement-Lock demo plant in non-slagging mode. As Ecomelt is only produced under slagging conditions, the beneficial use of the thermally treated product – EcoAggMat – needed to be defined. Letters were secured from BASF Corporation, Florham Park, NJ and EnCap Golf Holdings, East Rutherford, NJ in which these companies agreed to accept the thermally treated material provided that it met placement criteria specific to each location. These letters as well as the revised AUD from NJ-DEP are included in Appendix B.

ECH had also applied for a Waterfront Development Permit when it was pursuing a site located near the waterfront in Linden, NJ. The NJ-DEP issued a waterfront development permit to ECH that included an AUD (Permit No. 2009-90-0015.8). The issuance and effective date was August 14, 2000. The expiration date was August 14, 2005. However, one of the restrictions on the Waterfront Development Permit was that –

"The permittee shall not commence construction of the Cement Lock™ demonstration plant, including site preparation or grading, until such time as BP Oil (The ISRA responsible party, Case #95445) completes delineation and remediation of this area, and has received written approval from the NJDEP/Bureau of Environmental Evaluation and Cleanup Responsibility Assessment that no further investigation of Land Area 1 is required."

As the abovementioned cleanup was not accomplished during the period of the lease with the TOSCO Tremley Point Terminal, ECH withdrew its interest in that site.

NJ Air Quality Permit

The Air Pollution Control Pre-Construction Permit was issued to ECH by the New Jersey Department of Environmental Protection Office of Environmental Regulation, Division of Air Quality, Air Quality Permitting Element (Appendix B). The Permit Activity ID Number is PCP020001. The Facility ID Number is 12454. The approval date was March 12, 2003 and the expiration date is March 11, 2008. The Air Quality Permit was issued under the Environmental Improvement Pilot Test (EIPT) category of NJ permits.

The conditions of the Air Quality Permit limit the amount of specific air pollutants that may be emitted during processing of no more than 520 tons of sediment. The details of these limits are included in Appendix B.

City of Bayonne Permits

Building permits for the installation of the foundation, electrical, and plumbing work for the plant were issued by the City of Bayonne on December 26, 2002.

III. DEMO PLANT OPERATION AND LABORATORY-SCALE TESTING

The Cement-Lock demonstration plant was operated in slagging mode beginning with its initial start-up in December 2003 through October 2004. The Cement-Lock demo plant was operated in non-slagging mode for one extended-duration campaign during March 2005. In preparation for the non-slagging test, GTI conducted a preliminary test in laboratory-scale equipment to determine if the selected conditions would result in a remediated, beneficial use product. During the non-slagging demo plant test, the U.S. Environmental Protection Agency Superfund Innovative Technology Evaluation (SITE) Program conducted both environmental as well as stack sampling.

The following describes the slagging mode operating, non-slagging mode operation, the non-slagging laboratory-scale evaluation, planning for non-slagging demo plant operation, beneficial use and acceptable use determination, and the quality assurance project plan.

Slagging Mode Operations

Five tests were conducted in the Cement-Lock demo plant in slagging mode. Four of the tests were successful in that Ecomelt was produced. The fifth test was not successful because the drag conveyor in the Ecomelt Granulator jammed before sediment feeding could be initiated. For these tests, the temperature in the Ecomelt Generator ranged from 2425° to 2525°F. The Secondary Combustion Chamber burner was not fired during the slagging tests, but its temperature ranged from 2260° to 2309°F and varied with the actual temperature of the flue gas exiting the Ecomelt Generator. The feed rate of sediment and/or sediment-modifier mixture to the kiln ranged from 500 to over 1800 pounds per hour.

Non-Slagging Mode Operation

Beginning in early January 2005, RPMS Consulting Engineers (RPMS) and their mechanical, electrical, and insulating contractors worked to prepare the Cement-Lock demo plant for non-slagging mode operations. The work included repair of frozen/cracked piping, addition of insulation and heat tracing to water and several air lines, installation of a conveyor belt system and electrical hookup, recalibration of selected instruments, and preparation of EcoAggMat collection stands. Around-the-clock plant operation was initiated on March 5. Plant operations continued until March 21, when the decision was made to halt sediment feeding and begin to cool the system.

A chronological history of the construction, installation, commissioning, and start-up and operation activities at the Cement-Lock demonstration plant is included in Appendix A

Laboratory-Scale Evaluation

The laboratory-scale evaluation included a determination of the ash fusion characteristics of the sediment-modifier mixture and unmixed sediment, a batch test with the sediment-modifier mixture under non-slagging conditions, and an environmental evaluation of the thermally treated product from the batch test to determine organic destruction as well as leaching characteristics. The results are discussed below.

To determine the appropriate temperature at which to operate the rotary kiln, we performed ash fusion tests on samples of the sediment-modifier mixture and unmixed sediment. The results of these tests presented below show that the initial deformation temperature of the sediment-modifier mixture is 2140°F or about 140°F lower than that of the unmixed sediment. The initial deformation temperature provides an indication of the temperature at which particles may begin to stick together and agglomerate into larger particles. The fluid temperatures for the sediment-modifier mixture and unmixed sediment are 2180° and 2455°F, respectively. Based on these results, the operating temperature for the rotary kiln was targeted in the range of 1800° to 1900°F to provide an operating margin.

Sample	Sediment-Modifier Mixture	Unmixed Sediment
	Ash Fusion Temperature (Oxidizing), °F	
Initial Deformation (IT)	2140	2280
Softening (ST)	2155	2325
Hemispherical (HT)	2165	2370
Fluid (FT)	2180	2455

A laboratory-scale batch test was conducted to determine if the conditions for non-slagging demo plant operation would achieve the desired organic destruction and reduce leachability of the treated product. The conditions for the laboratory-scale test were a nominal 1800°F and a one-hour solids residence time at temperature.

Prior to the test, a sample of wet sediment was blended with modifiers according to the Cement-Lock recipe. As much of the sediment on-site had been previously premixed with modifiers, air-dried and premixed sediment was prepared for the batch test.

About one kilogram of the premixed sample was partially dried to reduce its moisture content. The feed material was gray in color. During drying, the sample shrank and formed irregular clumps. These clumps were manually broken to about -½ inch, which exposed additional surface area. It was expected that during the non-slagging demo plant test, the rotation of the kiln would cause the blended sediment-modifier mixture to break up into smaller particles as well. The partially dried sample was then put into the furnace that had been heated to 1800°F. After one hour at temperature, the power to the furnace was shut off and the sample was allowed to cool.

As shown in Figure 4 (below), the thermally treated material from the laboratory-scale test had a uniformly rusty (reddish) color, probably from iron oxide. Also visible in the clumps were inclusions of limestone ($CaCO_3$), most of which had calcined to lime (CaO) during treatment. Smaller size particles are also present in the photo.

Figure 4. EcoAggMat Produced in Laboratory-Scale Furnace

Upon breaking, the exposed fresh surface of the clumps had the same color as the external surface indicating that treatment was uniform.

Samples of the sediment-modifier mixture and the thermally treated product were submitted for analysis of volatile and semi-volatile organic constituents and metals (As, Ba, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, and Zn). The thermally treated product was also subjected to the TCLP (Toxicity Characteristic Leaching Procedure) and MEP (Multiple Extraction Procedure) leachability tests. The results of the analyses for organic compounds and metals are presented in Table 1. The results of TCLP and MEP leaching tests are presented in Table 2.

Table 1. Results of Non-Slagging Laboratory-Scale Test with Sediment-Modifier Mixture

Sample	Sediment-Modifier Feed	EcoAggMat
Organic Compounds	------------ µg/kg ------------	
Benzene	< 5*	< 5
Ethylbenzene	< 5	< 5
Xylenes	< 10	< 10
Methylene Chloride	< 5	< 5
Acetone	< 10	**42**$^{+}$
Carbon Disulfide	< 5	< 5
1,1-Dichloroethene	< 5	< 5
1,1-Dichloroethane	< 5	< 5
Chloroform	< 5	< 5
1,2-Dichloroethane	< 5	< 5
2-Butanone	**57****	< 10
1,1,1-Trichloroethane	< 5	< 5
Carbon tetrachloride	< 5	< 5
Bromodichloromethane	< 5	< 5
1,2-Dichloropropane	< 5	< 5
cis-1,3-Dichloropropene	< 5	< 5
Trichloroethene	< 5	< 5
Dibromochloromethane	< 5	< 5
1,1,2-Trichloroethane	< 5	< 5
Methyl tert-Butyl Ether	< 5	< 5
trans-1,3-Dichloropropene	< 5	< 5
Bromoform	< 5	< 5
4-Methyl-2-Pentanone	< 10	< 10
2-Hexanone	**15**	< 10
Tetrachloroethene	< 5	< 5
1,1,2,2-Tetrachloroethane	< 5	< 5
Chlorobenzene	< 5	< 5
Styrene	< 5	< 5
1,2-Dibromo-3-Chloropropane	< 5	< 5
1,2-Dibromoethane	< 5	< 5
Dichlorodifluoromethane	< 5	< 5
trans-1,2-Dichloroethene	< 5	< 5
Trichlorofluoromethane	< 5	< 5
Vinyl Chloride	< 5	< 5
Chloromethane	**28**	< 5
Bromoethane	< 5	< 5
Chloroethane	< 5	< 5
1,2,2-Trichlorotrifluoroethane	< 5	< 5
1,2,4-Trichlorobenzene	< 5	< 5
1,2-Dichlorobenzene	< 5	< 5
1,3-Dichlorobenzene	< 5	< 5

Table 1. Results of Non-Slagging Laboratory-Scale Test
with Sediment-Modifier Mixture

Sample	Sediment-Modifier Feed	EcoAggMat
Organic Compounds	------------ µg/kg ------------	
1,4-Dichlorobenzene	< 5	< 5
Isopropylbenzene	< 5	< 5
cis-1,2-Dichloroethene	< 5	< 5
Methyl Acetate	**18**	< 5
Cyclohexane	< 5	< 5
Methylcyclohexane	< 5	< 5
Toluene	**800**$^{+}$	**76**$^{+}$
Isopropyl Benzene	**500**$^{+}$	< 120
1,2,4,5-Tetrachlorobenzene	< 330	< 330
2,4,5-Trichlorophenol	< 330	< 330
2,4,6-Trichlorophenol	< 330	< 330
2,4-Dichlorophenol	< 330	< 330
2,4-Dimethylphenol	< 330	< 330
2,4-Dinitrophenol	< 1700	< 1700
2,4-Dinitrotoluene	< 1700	< 1700
2,6-Dinitrotoluene	< 330	< 330
2-Chloronaphthalene	< 330	< 330
2-Chlorophenol	< 330	< 330
2-Methylnaphthalene	< 330	< 330
2-Methylphenol	< 330	< 330
2-Nitroaniline	< 1700	< 1700
2-Nitrophenol	< 670	< 670
3,3-Dichlorobenzidine	< 1700	< 1700
3- & 4-Methylphenol	< 670	< 670
3-Nitroaniline	< 1700	< 1700
4,6-Dinitro-2-Methylphenol	< 1700	< 1700
4-Bromophenylphenyl Ether	< 330	< 330
4-Chloro-3-Methylphenol	< 330	< 330
4-Chloroaniline	< 670	< 670
4-Chlorodiphenyl Ether	< 330	< 330
4-Nitroaniline	< 1700	< 1700
4-Nitrophenol	< 1700	< 1700
Acenaphthene	< 330	< 330
Acenaphthalyne	< 330	< 330
Acetophenone	< 330	< 330
Anthracene	< 330	< 330
Benzo (a) Anthracene	**630**	< 330
Benzo (a) Pyrene	**730**	< 330
Benzo (b) Fluoranthene	**670**	< 330
Benzo (g,h,i) Perylene	**500**	< 330
Benzo (k) Fluoranthene	**810**	< 330
Bis (2-Chloroethoxy) Methane	< 330	< 330
Bis (2-Chloroethyl) Ether	< 330	< 330
Bis (2-Chloroisopropyl) Ether	< 330	< 330
Bis (2-Ethylhexyl) Phthalate	**3300**	< 330

Table 1. Results of Non-Slagging Laboratory-Scale Test
with Sediment-Modifier Mixture

Sample	Sediment-Modifier Feed	EcoAggMat
Organic Compounds	------------ µg/kg ------------	
Butyl benzyl Phthalate	< 670	< 670
Chrysene	**790**	< 330
Di-N-Butylphthalate	< 330	< 330
Di-N-Octylphthalate	< 330	< 330
Dibenzo (a,h) Anthracene	< 330	< 330
Dibenzofuran	< 330	< 330
Diethylphthalate	< 330	< 330
Dimethylphthalate	< 330	< 330
Fluoranthene	**810**	< 330
Fluorene	< 330	< 330
Hexachlorobenzene	< 330	< 330
Hexachlorobutadiene	< 670	< 670
Hexachlorocyclopentadiene	< 330	< 330
Hexachloroethane	< 330	< 330
Indeno (1,2,3-cd) pyrene	**420**	< 330
Isophorone	< 330	< 330
N-Nitroso-N-Propylamine	< 670	< 670
N-Nitrosodiphenylamine	< 330	< 330
Naphthalene	< 330	< 330
Nitrobenzene	< 330	< 330
Pentachlorophenol	< 1700	< 1700
Phenanthrene	< 330	< 330
Phenol	< 330	< 330
Pyrene	**860**	< 330
Carbazole	< 330	< 330
Biphenyl	< 330	< 330
Benzaldehyde	< 330	< 330
Caprolactam	< 330	< 330
Atrazine	< 330	< 330
Priority Trace Elements	------------ mg/kg ------------	
Arsenic	**8.4**	< 0.75
Barium	**94**	**47**
Cadmium	**0.94**	**0.41**
Chromium	**97**	**12**
Copper	**98**	**27**
Lead	**87**	**13**
Mercury	**3.4**	< 0.10
Nickel	**25**	**8.2**
Selenium	**1.9**	< 0.75
Silver	**2.0**	< 0.75
Zinc	**140**	**28**

* < = Less than the analytical detection limit.
** **Bold**-faced values indicate analyte detected.
$^{+}$ Possible laboratory contamination.

Table 2. Results of MEP Leaching Test (EPA Method 1320) on EcoAggMat from Non-Slagging Laboratory-Scale Test

	MEP**								
Sampling Day	EP Tox* Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9
Analyte	mg/L								
Arsenic	< 0.10[+]	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Barium	**0.42**[++]	**0.29**	< 0.10	< 0.03	< 0.10	< 0.10	< 0.20	< 0.20	< 0.10
Cadmium	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Chromium	**0.79**	< 0.05	**0.075**	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Lead	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Mercury	< 0.002	<0.002	<0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Selenium	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Silver	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

* EP Toxicity (EPA No. 1310) test is conducted with dilute acetic acid solution.
** Subsequent MEP extractions are conducted with dilute nitric and sulfuric acid solution.
[+] < = Less than the analytical detection limit.
[++] **Bold**-faced values indicate analyte detected.

The results in Table 1 above showed that the proposed kiln operating conditions of 1800°F and one hour residence time would be adequate for destroying organic compounds found in the sediment. The presence of volatile toluene and isopropyl benzene in the feed and toluene in the product is unexpected since these compounds were not reported in previous feed analyses. The results in Table 2 show that the thermally treated product EcoAggMat was essentially non-leachable. For example, the TCLP leachability of barium from the EcoAggMat was 0.42 mg/L. The TCLP regulatory limit for barium leachability from material destined for a landfill is 100 mg/L. The TCLP leachability of chromium from the EcoAggMat was 0.79 mg/L. The TCLP regulatory limit for chromium leachability from material destined for a landfill is 5 mg/L. The other TCLP results were below the analytical detection limit.

The results of the MEP procedure showed that none of the priority metals leached from the EcoAggMat sample past Day 2 above the detection limit. It is interesting to note that chromium was detected in the leachate on Day 2, but not Day 1. The detection limit for chromium was 0.05 mg/L (or 50 µg/L), which is less than the NJ Ground Water Quality Criteria (GWQC) for chromium (70 µg/L). The detection limit for both arsenic and lead was 0.10 mg/L (100 µg/L), while the GWQC limit for arsenic is 3 µg/L and the GWQC limit for Pb is 5 µg/L.

Overall, the results of the laboratory-scale evaluation showed that the target operating conditions of 1800°F and nominal one-hour residence time (at temperature) would be sufficient to remediate the sediment-modifier mixture. The next step was to plan for non-slagging demo plant operations.

Planning for Non-Slagging Demo Plant Operations

Operating the demo plant under non-slagging conditions required several operational changes compared with slagging operation. The most significant was to reduce the temperature of the rotary kiln to prevent the sediment-modifier mixture from incipient melting and agglomerating into larger particles as it tumbled through the kiln. The temperature must be high enough to ensure that organic contaminants present are completely destroyed. During processing, the material will tumble through the rotary kiln, exit the drop-out box, and fall into the granulator, where the thermally treated product – named EcoAggMat (for Ecological Aggregate Material) – will be cooled with water. The wet EcoAggMat will be conveyed out of the granulator via the drag conveyor and collected in Super Sacks with plastic liners. The Super Sacks (about one yd^3 capacity) will be stored on-site pending shipment to the off-site beneficial use location.

Other conditions were to be maintained as if the system were being operating in slagging mode. For example, the secondary combustion chamber (SCC) was to be maintained at a temperature in the range of 2100° to 2200°F. The air pollution control equipment (flue gas quencher, lime feeder, baghouse, and activated carbon bed) was to be operated per standard procedures.

The melt burners and the auxiliary burners installed in the drop-out box will not be fired during non-slagging operations. This was to conserve energy and to ensure that the treated product did not begin to melt.

The target feed rate of the sediment-modifier mixture was 2,000 pounds per hour. The limiting factor in the system throughput capacity was the SCC burner. The SCC burner was needed to increase the temperature of the rotary kiln flue gas to the required range to achieve complete burnout of organic compounds and carbon monoxide. In previous tests conducted under slagging conditions, the SCC temperature remained at an elevated level without having to fire the SCC burner.

Table 3 summarizes the effect of increasing the rotary kiln temperature on the estimated processing capacity of the overall system. The data in the table shows that if the rotary kiln temperature is 1700°F and the SCC temperature is 2100°F, the maximum feed rate (wet sediment plus modifiers) is 2,376 lb/hour. Increasing the kiln temperature to 1900°F increases the maximum feed rate to 4,631 lb/hour. Operating the kiln at any higher temperature could result in unwanted melting and agglomeration of the sediment-modifier mixture. Also, the SCC must be operated at a minimum of 2100°F to meet the NJ-DEP Air Quality Permit requirement (SCC temperature must be > 2100°F while feeding sediment). The maximum firing capacity of the SCC burner is 6 million Btu/hour. Overall, the nominal feed rate that can be sustained under non-slagging conditions is about 1 to 2 tons per hour.

Table 3. Effect of Increasing the Rotary Kiln Temperature on Feed Mixture Processing Capacity

Calculated Case No.	**1**	**2**	**3**	**4**
Rotary kiln temperature, °F	1700	1800	1900	2000
SCC temperature, °F	2100	2100	2100	2100
Feed mixture to kiln, lb/hr	2,376	3,085	4,631	6,428
Moisture in feed mixture, wt %	31	31	31	31
Sediment to kiln, lb/hr	**1,850**	**2,400**	**3,600**	**5,000**
Estimated moisture in sediment, wt %	40	40	40	40
Limestone to kiln, lb/hr	456	592	888	1233
Alumina to kiln, lb/hr	28	37	57	78
Fluorspar to kiln, lb/hr	42	56	86	117
Nat Gas to kiln, million Btu/hr (HHV)	8.42	11.05	16.62	24.27
Nat Gas to SCC, million Btu/hr (HHV)	6.08	6.04	6.06	5.16
Gas residence time in kiln, sec	11.6	8.5	5.4	3.6
Gas residence time in SCC, sec	4.4	3.7	2.5	2.0
Oxygen in kiln off-gas, vol % (dry basis)	4.00	4.01	4.01	4.01
Quencher off-gas flow rate, lb/hr	21,600	25,900	35,300	46,600
Lime to quencher off-gas, lb/hr	32	42	63	87
Spent lime from baghouse, lb/hr	51	66	98	137
Wet EcoAggMat from granulator, lb/hr	1,488	1,932	2,902	4,028

Beneficial Use and Acceptable Use Determination

As the product from the non-slagging test was not Ecomelt, but EcoAggMat, a revised Acceptable Use Determination (AUD) was required from the NJ-DEP. Two viable beneficial uses for EcoAggMat were defined: One use was as clean fill at the BASF site restoration project in Kearny, NJ. Another use was as a partial replacement for sand in BASF Corporation's foam core concrete construction panels. Material that was not thermally treated through the Cement-Lock demo plant could be used as fill at the EnCap Golf site at the Meadowlands, NJ.

As mentioned in Section II (Permitting Requirements), ECH received letters from BASF and EnCap Golf confirming that they would take the thermally treated product (BASF) or the untreated sediment (EnCap) from the Cement-Lock test provided that each met appropriate placement specifications. ECH subsequently received a revised AUD from NJ-DEP (Appendix B). In early May 2006, the EcoAggMat was delivered to the BASF site in Kearny and beneficially used as fill.

Quality Assurance Project Plan

The quality assurance project plan (QAPP) originally prepared by the EPA SITE program in conjunction with GTI and ECH required modification and approval as a result of switching from slagging to non-slagging mode of operation of the Cement-Lock demo plant. GTI worked with EPA SITE to accommodate the changes required in the QAPP (Appendix C).

IV. DISCUSSION OF PILOT TEST RESULTS

Since the Cement-Lock demo plant began shakedown and commissioning in July 2003, a total of six tests have been conducted in the unit. Five tests were conducted in slagging mode with the objective of producing Ecomelt – a beneficial use product with pozzolanic properties that can be converted into construction-grade cement. The sixth test was conducted in non-slagging mode. The objective of the non-slagging test was to remediate the sediment and to generate a beneficial use product that could be used as a partial replacement for aggregate in concrete or as clean fill.

The following discusses the: 1) Demo plant tests operating conditions and results, 2) EPA SITE Program air emissions data from the non-slagging demo plant campaign, 3) environmental data on Ecomelt and EcoAggMat from the demo plant, 4) environmental data on spent lime and granulator quench water, 5) cement properties of Ecomelt, and 6) physical properties of EcoAggMat.

Demo Plant Tests Operating Conditions and Results

A total of six tests have been conducted in the Cement Lock demonstration plant. Tests in slagging mode were conducted on December 10, 2003; July 16, 2004; July 22, 2004; September 22, 2004; and October 27, 2004. These tests were terminated involuntarily due to slag buildup in the discharge section of the kiln. However, short periods of steady-state operation were achieved for these tests and the data analysis is presented below. The demo plant was operated in non-slagging mode for 17 days during March 2005 and that test was terminated voluntarily. The steady-state operation period on March 11, 2005 was selected for data analysis because of the concurrent availability of EPA SITE stack flue gas analysis.

The key operating conditions of the Cement-Lock demo plant tests are summarized in Table 4. As Test No. 4 was not successful in producing Ecomelt, its results are omitted from the table. The significant conclusions are:

1. For all slagging tests, the kiln operating temperature was maintained above 2400°F measured by thermocouples TE-201A and B. These thermocouples are located at the discharge end of the kiln and measure the gas-phase temperature. The temperature of the refractory-lined walls inside the kiln were measured by optical pyrometer and found to be 50° to 100°F higher than the control thermocouple (TE-201A and B) readings.

2. The operating temperature of the kiln was reduced to 1835°F for the non-slagging test conducted in March 2005.

3. The averaged pressure in the kiln was maintained at -0.3 inch water gauge (w.g.) for the slagging tests and it was increased to -0.1 inch w.g. for the non-slagging test to reduce the air leakage into the kiln.

4. The rotational speed of the kiln was maintained in the range of 0.3 to 0.4 rpm for the tests.

5. Based on the above rpm, the solids residence time in the kiln averaged 80 to 100 minutes for all tests.

6. The gas residence time in the kiln ranged from 3.2 to 3.5 seconds for the slagging tests. The gas residence time in the kiln for the non-slagging test was unable to be determined because of a malfunction of the flow measurement instrument.

7. For Test No. 3 (July 22, 2004), the flow rate of water to the overflow weir and sprays was decreased from 90 to 20 gpm (gallons per minute). This resulted in an increase of the average drop-out box temperature from 1850° to 2200°F.

8. For Test No. 5 (October 27, 2004), the faulty components of the melt burner system were repaired and the open area of the drop-out box was decreased by about 50 percent. This resulted in an increase of the average drop-out box temperature from 2200° to 2400°F.

9. The secondary combustion chamber (SCC) burner was not fired for the slagging tests because the temperatures of the flue gas entering the SCC already exceeded the required temperatures for contaminant destruction. The temperature in the SCC was above 2300°F for all slagging tests.

10. The SCC burner was fired for the non-slagging test and the temperature in the SCC was maintained at an average of 2110°F.

11. The gas residence time in the SCC was in the range of 2.2 to 2.5 seconds for all tests.

12. The oxygen and carbon monoxide concentrations in the stack gas were above 7 volume percent (dry basis) and 3 ppm (dry volume basis), respectively, for the slagging tests measured by the Continuous Emission Monitoring System (CEMS). This concentration of oxygen showed that a high amount of ambient air leaked into the kiln mostly through the solids inlet and air seal assemblies of the kiln.

13. The oxygen concentration in the stack gas was 12.5 volume percent (dry basis) for the non-slagging test. This was a result of ambient air leaking into the system through the open covers of the solids feeding equipment. Excess air also leaked into the kiln through the rotating seals.

Table 4. Operating Conditions of Cement-Lock Demo Plant Tests

Test No.	**1**	**2**	**3**	**5**	**6**
Test Date	12/10/03	7/16/04	7/22/04	10/27/04	3/11/05
Ecomelt Generator (rotary kiln)					
Operating Mode	---------------- Slagging ----------------				Non-Slagging
Temperature, °F	2425	2400	2455	2450	1835
Pressure, inches w.g.	-0.3	-0.4	-0.3	-0.3	-0.1
Drop-Out Box Temperature, °F	1909	1855	2218	2400	1720
Kiln Speed, rpm	0.3	0.4	0.3	0.3	0.3
Gas Residence Time, sec.	3.5	3.5	3.3	3.2	N/A
Solids Residence Time, min.	80	80	80	80	80
Secondary Combustion Chamber					
SCC Burner	---------------- Not Fired ----------------				Fired
Temperature, °F	2309	2260	2280	2285	2110
Gas Residence Time, sec.	2.5	2.5	2.3	2.3	2.2
Granulator Temperature, °F	150	185	182	170	170
Quencher Outlet Temperature, °F	300	335	335	320	320
Baghouse Outlet Temperature, °F	333	285	292	280	270
Activated Carbon Bed Outlet Temperature, °F	289	217*	216*	215*	230
Stack Gas Temperature, °F	335	297	302	292	245
Stack Gas Composition					
O_2, vol % (dry basis)	14.1	7.2	6.9	8.4	12.6
CO_2, vol % (dry basis)	N/A**	N/A	N/A	N/A	4.5
H_2O (water vapor), mol %	N/A	N/A	N/A	N/A	40.7
CO, ppm (dry volume) @ 7% O_2	3	3	3		1.7
NOx, ppm (dry volume) @ 7% O_2	N/A	N/A	N/A	N/A	76.3
SO_2, ppm (dry volume) @ 7% O_2	N/A	N/A	N/A	N/A	< 0.8
THC (total hydrocarbons), ppm (dry volume) @ 7% O_2	N/A	N/A	N/A	N/A	< 1.4

* Unresolved low temperature of activated carbon bed outlet.
** N/A = Not available.

Heat and mass balances were calculated for Cement-Lock demo plant tests (No. 2, 3, 5, and 6); the results are summarized in Tables 5 to 8. The significant conclusions are:

1. The non-slagging test has better heat and mass balance closures than the slagging tests. This is mainly because a detailed stack gas analysis was available for the non-slagging test such that the air leakage flow rate could be more accurately estimated by using a forced nitrogen balance.

2. The flow rates of air leakage for slagging testes were estimated by matching the calculated oxygen concentrations in the stack gas against the concentrations measured by the CEMS. The results were then confirmed by pressure-drop calculations across the solids feeder and air seals of the kiln. This approach involved more input and output streams and it was less accurate than using the forced nitrogen balance since nitrogen is an inert species and can be used as a tracer through the system.

3. The mass balance shows high air leakage for all tests. This means a high amount of excess air was present in the kiln and SCC. Solids feeding devices with improved air seals must be used in future tests to minimize air leakage and reduce natural gas consumption. This will also increase the plant capacity and thermal efficiency.

4. The fraction of air leakage to the processing equipment downstream of the kiln was estimated by assuming the oxygen concentrations at the kiln exit were about 2 percent less than that in the stack gas based on the experimental results of on-line sampling of the kiln exit gas using a special GTI hot-gas sampling probe.

5. The basis for the heat balance is 70°F and liquid water. The higher heating value (HHV) of natural gas was 23,058 Btu/lb and the natural gas was assumed to be 100 percent methane. The higher heating value of raw sediment was 420 Btu/lb (dry basis), and the heat of limestone calcination was 768 Btu/lb.

6. Measured external shell temperatures of the kiln, SCC, flue gas quencher, baghouse, and activated carbon bed were used to calculate the heat losses from the equipment vessels. Ambient temperatures of 70° and 40°F were assumed for the slagging and non-slagging test, respectively, zero wind speed, and an emissivity of 0.96 were used to determine the heat transfer coefficients.

The calculated material balances ranged from 102.8 to 111.9 percent. The calculated energy balances ranged from 99.3 to 110.8 percent.

Table 5. Heat and Mass Balance for Cement-Lock Test No. 2 on 7/16/04

From 7/16/04 10:00 To 7/16/04 14:00

Input Streams	**lb/hr**	**Btu/hr**	**Output Streams**	**lb/hr**	**Btu/hr**
Sediment/Modifiers to Kiln	1,000	160,991	Stack Gas	37,903	19,228,928
Natural Gas to Kiln & SCC	844	19,468,496	Ecomelt	610	23,790
Combustion Air to Kiln & SCC	11,643	0	Total Heat Loss		2,497,954
Air Leakage	7,400	0			
Water to Granulator	500	0			
Water to Quencher	11,500	0			
Air to Quencher	2,000	0			
Total	34,887	19,629,487	**Total**	38,513	21,750,672

Mass Balance (Out/In), % 110.4
Heat Balance (Out/In), % 110.8

Table 6. Heat and Mass Balance for Cement-Lock Test No. 3 on 7/22/04

From 7/22/04 15:00 To 7/22/04 19:00

Input Streams	**lb/hr**	**Btu/hr**	**Output Streams**	**lb/hr**	**Btu/hr**
Sediment/Modifiers to Kiln	500	80,321	Stack Gas	39,425	19,504,388
Natural Gas to Kiln & SCC	887	20,441,921	Ecomelt	300	11,700
Combustion Air to Kiln & SCC	12,403	0	Total Heat Loss		2,497,954
Air Leakage	7,700	0			
Water to Granulator	500	0			
Water to Quencher	11,500	0			
Air to Quencher	2,000	0			
Total	35,490	20,522,242	**Total**	39,725	22,014,042

Mass Balance (Out/In), % 111.9
Heat Balance (Out/In), % 107.3

Table 7. Heat and Mass Balance for Cement-Lock Test No. 5 on 10/27/04

From 10/27/04 11:00 To 10/27/04 16:00

Input Streams	**lb/hr**	**Btu/hr**	**Output Streams**	**lb/hr**	**Btu/hr**
Sediment/Modifiers to Kiln	600	94,210	Stack Gas	39,930	18,592,625
Natural Gas to Kiln & SCC	887	20,441,921	Ecomelt	370	14,430
Combustion Air to Kiln & SCC	13,164	0	Total Heat Loss		2,497,954
Air Leakage	8,600	0			
Water to Granulator	500	0			
Water to Quencher	11,000	0			
Air to Quencher	2,000	0			
Total	36,751	20,536,131	**Total**	40,300	21,105,009

Mass Balance (Out/In), %	109.7
Heat Balance (Out/In), %	102.8

Table 8. Heat and Mass Balance for Cement-Lock Test No. 6 on 3/11/05

From 3/11/05 07:00 To 3/11/05 19:00

Input Streams	**lb/hr**	**Btu/hr**	**Output Streams**	**lb/hr**	**Btu/hr**
Sediment/Modifiers to Kiln	1,000	250,917	Stack Gas	43,709	15,784,216
Natural Gas to Kiln & SCC	802	18,495,071	EcoAggMat	615	20,295
Combustion Air to Kiln & SCC	12,272	-92,038	Total Heat Loss		2,388,626
Air Leakage	17,258	-129,434			
Water to Granulator	500	-10,000			
Water to Quencher	8,750	-175,000			
Air to Quencher	616	-4,623			
Air to Baghouse	1,933	-14,495			
Total	43,131	18,320,398	**Total**	44,324	18,193,137

Mass Balance (Out/In), % 102.8
Heat Balance (Out/In), % 99.3

EPA SITE Program Air Emissions Data

The EPA SITE Program conducted environmental sampling of the main system stack as well as feeds and products during the non-slagging test on March 10 and 11, 2005. The complete results of the air emissions sampling are included in Appendix P. The flue gas from the stack was sampled for the following components: O_2, CO_2, CO, HCl, Cl_2, NOx, SO_2, THC (total hydrocarbons), SVOCs, PCB congeners, and dioxin and furan congeners. Also, the inlet to the activated carbon bed was sampled for the same components so that the collection efficiency across the bed could be determined. The results are presented in Table 9.

The concentration of oxygen in the flue gas averaged 12.6 mole percent (dry basis). For combustion of natural gas (as methane), this represents excess air of 135 percent above the stoichiometric requirement. The NJ Air Quality Permit requires a minimum of 2 mole percent (dry basis) oxygen in the flue gas while feeding sediment. The data show that CO emissions averaged 1.7 ppm (dry volume basis, corrected to 7% O_2). The emission of NOx was low (76.3 ppm dry volume basis, corrected to 7% O_2) in view of the fact that no specific NOx control equipment is included in the demo plant. The 30-million Btu/hour primary burner is a low-NOx burner.

Table 9. Summary of Air Emission Data Including Flow Rates from Non-Slagging Cement-Lock Demo Plant Test (March 2005)

Sample Location	Inlet to Activated Carbon Bed (A-304)	System Outlet Stack (S-304)
Component		
O_2	NA	12.6 mol %
CO_2	NA	4.5 mol %
CO	NA	1.7 ppm dv @ 7% O_2 (0.02 lb/hr)
HCl	1.5 ppm dv* @ 7% O_2, (0.023 lb/hr)	23.4 ppm dv @ 7% O_2 (0.37 lb/hr)
Cl_2	< 0.06 ppm (< 0.0015 lb/hr)	< 0.02 ppm (< 0.0004 lb/hr)
NOx	NA	76.3 ppm dv @ 7% O_2 (1.53 lb/hr)
SO_2	NA	< 0.8 ppm dv @ 7% O_2 (< 0.024 lb/hr)
THC (total hydrocarbons)	NA	< 1.4 ppm dv @ 7% O_2 (< 0.01 lb/hr)
Arsenic	< 0.112 µg/acm** (< 5.20 x 10^{-6} lb/hr)	0.29 µg/acm (1.18 x 10^{-5} lb/hr)
Barium	0.70 µg/acm (3.27 x 10^{-5} lb/hr)	3.05 µg/acm (1.23 x 10^{-4} lb/hr)
Cadmium	1.04 µg/acm (4.77 x 10^{-5} lb/hr)	0.15 µg/acm (6.17 x 10^{-6} lb/hr)
Chromium	0.47 µg/acm (1.71 x 10^{-5} lb/hr)	2.75 µg/acm (1.11 x 10^{-4} lb/hr)

Table 9. Summary of Air Emission Data Including Flow Rates from Non-Slagging Cement-Lock Demo Plant Test (March 2005)

Sample Location	**Inlet to Activated Carbon Bed (A-304)**	**System Outlet Stack (S-304)**
Component		
Copper	0.23 μg/acm (1.07 x 10^{-5} lb/hr)	4.23 μg/acm (1.7 x 10^{-4} lb/hr)
Lead	0.10 μg/acm (4.75 x 10^{-6} lb/hr)	6.11 μg/acm (2.46 x 10^{-4} lb/hr)
Mercury	14.6 μg/acm (6.79 x 10^{-4} lb/hr)	0.14 μg/acm (5.61 x 10^{-6} lb/hr)
Nickel	0.72 μg/acm (3.3 x 10^{-5} lb/hr)	2.20 μg/acm (8.85 x 10^{-5} lb/hr)
Selenium	< 0.112 μg/acm (< 5.2 x 10^{-6} lb/hr)	< 0.126 μg/acm (< 5.07 x 10^{-6} lb/hr)
Silver	< 0.112 μg/acm (< 5.2 x 10^{-6} lb/hr)	0.32 μg/acm (1.29 x 10^{-5} lb/hr)
Zinc	7.9 μg/acm (3.64 x 10^{-4} lb/hr)	5.44 μg/acm (2.18 x 10^{-4} lb/hr)
Benzo (a) Anthracene	< 3.83 x 10^{-6} lb/hr	< 3.53 x 10^{-6} lb/hr
Benzo (a) Pyrene	< 3.83 x 10^{-6} lb/hr	< 3.53 x 10^{-6} lb/hr)
Benzo (b) Fluoranthene	< 3.83 x 10^{-6} lb/hr	< 3.53 x 10^{-6} lb/hr
Benzo (k) Fluoranthene	< 3.83 x 10^{-6} lb/hr	< 3.53 x 10^{-6} lb/hr
Bis (2-Ethylhexyl) Phthalate	1.41 x 10^{-4} lb/hr	3.24 x 10^{-4} lb/hr
Chrysene	< 3.83 x 10^{-6} lb/hr	< 3.53 x 10^{-6} lb/hr
Indeno (1,2,3-c,d) Pyrene	< 3.83 x 10^{-6} lb/hr	< 3.53 x 10^{-6} lb/hr
Total Dioxins/Furans	4.0 ng/dscm† @ 7% O_2 (3.72 x 10^{-8} lb/hr)	0.35 ng/dscm @ 7% O_2 (2.86 x 10^{-9} lb/hr)
Total PCBs	0.14 μg/dscm @ 7% O_2 (1.49 x 10^{-6} lb/hr)	0.13 μg/dscm @ 7% O_2 (1.42 x 10^{-6} lb/hr)

* ppm dv = Parts per million dry volume basis.
** μg/acm = Micrograms per actual cubic meter.
† μg/dscm = Micrograms per dry standard cubic meter.

The concentration of mercury entering the activated carbon bed was 14.6 μg/acm (6.79 x 10^{-4} lb/hr) while that exiting the stack measured 0.14 μg/acm (5.61 x 10^{-6} lb/hr or 0.049 lb/year). The NJ Air Quality Permit specifies a maximum mercury emission of 0.64 lb/year. The mercury capture efficiency of the activated carbon bed was calculated to be 99.2 percent. High mercury capture efficiency was expected and is well above the NJ Air Quality Permit minimum requirement of 70 percent removal efficiency. Analysis of other samples showed that mercury was below the analytical detection limit in the EcoAggMat, baghouse dust (spent lime), and the granulator quencher water.

The concentrations of cadmium and zinc also showed reductions across the activated carbon bed. Zinc and cadmium were reduced by 40.1 and 87.1 percent, respectively. As cadmium and zinc are in the same family in the Periodic Table of Elements as mercury, they are expected to behave in a similar manner.

The activated carbon in the adsorber bed still has significant mercury capture/holding capacity. Well before the activated carbon approaches its theoretical mercury holding capacity, it will be returned to an activated carbon reprocessor, such as U.S. Ecology, for reprocessing. The mercury and other volatile metals will be recovered during the reprocessing procedure.

The concentrations of hydrogen chloride (HCl) and several metals, specifically As, Ba, Cr, Cu, Pb, Ni, and Ag, were several times higher in the stack compared to those measured concurrently at the inlet to the activated carbon bed (see Table 9). These unexpected results occurred during two sequential days of sampling. That the HCl and metals concentrations increased across the activated carbon bed indicates that there was a non-sediment source for these materials. For example, the activated carbon (Norit Americas RB-4C) itself contains acid-extractable copper, zinc, and chloride at 5, 1, and 3 mg/kg, respectively. However, the HCl emission rate measured from the stack can only be partially explained by the chloride content of the activated carbon. Extra chromium and nickel could have come from the steel hold-down screens or another stainless steel sources downstream from the activated carbon bed. One non-sediment source of lead is solder (although some solder available today is lead-free). Some of the metals (As, Ag) were already at low levels and, per discussion with Tetra Tech (4), their excess could be attributed to statistical scatter. Notwithstanding these results, the quantities of materials exiting the stack were well below the NJ Air Quality Permit limits.

The total quantity of dioxins and furans fed to the system in the sediment-modifier mixture was 5.11×10^{-6} lb/hr. About 0.10 percent (5.06×10^{-9} lb/hr) of the total appeared in the EcoAggMat product. About 0.06 percent (2.86×10^{-9} lb/hr) appeared in the stack flue gas. The balance of 99.84 percent was destroyed during the thermal processing and converted to products of complete combustion, namely CO_2, H_2O, and trace amounts of hydrogen chloride (HCl, which was removed from the flue gas stream by lime powder). The contaminants were destroyed and not merely transferred to another medium.

The emission of total dioxins and furans (PCDDs and PCDFs) from the system stack was measured at 0.35 ng/dscm (corrected to 7% O_2). This is significantly lower than the EPA's New Source Performance Standard for emissions of dioxins and furans from large municipal waste incineration facilities of 30 ng/dscm (corrected to 7% O_2: from 40 CFR 60.52b). On a toxicity equivalency (TEQ) basis (including full detection-limit accounting for non-detected species), 99.02 percent of the TEQ (from dioxins, furans, and PCBs) in the sediment-modifier mixture fed to the Cement-Lock demo plant was destroyed and not merely transferred to another medium. The remainder of the TEQ appeared in the stack gas (0.23 percent) and the EcoAggMat (0.75 percent).

Samples of spent lime and granulator quench water also showed trace levels of PCDD and PCDF congeners and PCBs. However, as these samples were taken near the mid-point of the 17-day campaign in March 2005, the contaminant accumulation rate can not be accurately determined. If the rate of contaminant accumulation is assumed to be constant up to the sampling time, then the estimated TEQ of the PCDD and PCDF congeners and PCBs in the spent lime and granulator quench water represents less than 0.0015 percent of the total contaminant TEQ load.

The total quantity of PCBs fed to the system in the sediment-modifier mixture amounted to 2.94 x 10^{-4} lb/hr. About 0.03 percent (9.54 x 10^{-8} lb/hr) of the PCBs fed appeared in the EcoAggMat. About 0.48 percent (1.42 x 10^{-6} lb/hr) appeared in the stack flue gas. Thus, 99.49 percent of the PCBs in the feed were destroyed and converted to products of complete combustion.

The emission rates of specific semi-volatile organic compounds (SVOCs) analyzed in the stack were below the analytical detection limit of 3.53 x 10^{-6} lb/hr each. Bis (2-ethylhexyl) phthalate was detected in the inlet to the activated carbon bed as well as the stack gas. The concentration of this compound, although relatively small in itself, was higher in the stack sample than that of the carbon bed inlet. As discussed above, this implies that there was a non-sediment source of BEHP. Possible sources of BEHP could be hydraulic fluid from the cylinder used to modulate the I.D. fan and lubricating oil for the I.D. fan rotor.

Tables 10, 11, 12, and 13 present the detailed analytical results of flue gas samples for PCB congeners, dioxin and furan congeners, trace metals, and SVOCs (semi-volatile organic compounds), respectively. **G1** is the inlet to the Activated Carbon (AC) bed. **G2** is the main system stack outlet. **R1** or **R2** is the run number. The data in these tables were from the data validation work performed by EPA SITE as part of the overall project. The tables list the quantity of material captured during sampling in nanograms (ng) or micrograms (µg) as appropriate. To calculate concentrations of PCB congeners, dioxin and furan congeners, and

PAHs in the flue gas, divide the amount listed in the table by the volume of flue gas sampled from either the AC bed inlet or the stack outlet: 3.59 or 4.03 dry standard cubic meters (dscm), respectively. To calculate concentrations of trace metals in the flue gas, divide the amount listed in the table by the volume of flue gas sampled from either the AC bed inlet or the stack outlet: 1.71 or 1.75 dscm, respectively.

Table 10. Detailed Analysis of Flue Gas Samples for PCB Congeners

Sample	**G1-R1** AC Bed Inlet		**G1-R2** AC Bed Inlet		**G2-R2** Stack Outlet		**Field Blank**	
Congener	------------------ ng (nanograms)* ------------------							
PCB 1	53.2	J	43.2	J	1.54	J	0.087	UJ
PCB 2	45.3	J	39.8	J	0.852	J	0.0596	UJ
PCB 3	41	J	44.4	J	1.0	J	0.0479	UJ
PCB 4	3.72	J	4.42	J	5.63	J	0.184	UJ
PCB 5	1.29	J	1.35	J	1.37	J	0.0579	U
PCB 6	2.65	J	3.34		4.26		0.0567	U
PCB 7	1.45	J	1.61		1.36		0.0558	U
PCB 8	6.01	J	8.0	J	12.4	J	0.0552	U
PCB 9	1.37	J	1.52		1.27		0.0612	U
PCB 10	0.237	J	0.289		0.223		0.0234	J
PCB 11	9.88	J	13.5		19.5		0.355	U
PCB 12 & 13	4.63	J	4.62	J	1.61	J	0.0548	UJ
PCB 14	0.227	J	0.239	J	0.0487	U	0.0581	U
PCB 15	4.71	J	5.86		6.81	J	0.0635	U
PCB 16	0.3	J	4.55		9.12	J	0.0634	U
PCB 17	3.13		4.29		8.27	J	0.0443	U
PCB 18 & 30	5.03		8.16		16.5		0.0879	U
PCB 19	0.698	J	0.846	J	1.38	J	0.0168	U
PCB 20 & 28	9.07		12.2		21.8		0.139	U
PCB 21 & 33	5.56		7.27		12.8		0.0825	U
PCB 22	3.04		4.02		7.3		0.0619	U
PCB 23	0.114		0.123		0.0493		0.0121	U
PCB 24	0.00814	U	0.184	J	0.116	J	0.0103	UJ
PCB 25	0.69	J	1.0		1.62		0.0153	U
PCB 26 & 29	1.58		2.1		3.73		0.0286	UJ
PCB 27	0.413		0.561		1.11		0.011	U
PCB 31	0.829		11.5		19.0		0.128	UJ
PCB 32	1.72		2.54		3.96	J	0.0265	UJ
PCB 34	0.0446	J	0.0717	J	0.0956	J	0.0122	U
PCB 35	0.479		0.536		0.689		0.00857	U
PCB 36	0.041		0.0409		0.04	U	0.00896	U

Table 10. Detailed Analysis of Flue Gas Samples for PCB Congeners

Sample	G1-R1 AC Bed Inlet		G1-R2 AC Bed Inlet		G2-R2 Stack Outlet		Field Blank	
Congener	------------------ ng (nanograms)* ------------------							
PCB 37	2.07		2.77		4.29		0.0495	U
PCB 38	0.167		0.113	J	0.0355	U	0.00795	U
PCB 39	0.139	J	0.172		0.0322	U	0.0279	U
PCB 40 & 71	1.7		2.41		3.08		0.0359	U
PCB 41	0.386		0.412		0.671		0.00814	U
PCB 42	1.16		1.56		2.03		0.0226	U
PCB 43	0.249		0.358		0.48		0.0148	U
PCB 44, 47, & 65	8.97		12.1		17.1		0.0965	U
PCB 45 & 61	1.77		2.32		3.17		0.0358	J
PCB 46	0.224		0.329		0.454		0.0129	U
PCB 48	1.02		1.33		1.82		0.0208	U
PCB 49 & 69	2.43		3.28		4.42		0.0442	U
PCB 50 & 53	0.548		0.77		0.96		0.0176	J
PCB 52	5.38		6.71		10.3		0.0782	U
PCB 54	0.0184	U	0.0196	UJ	0.0334	J	0.00731	U
PCB 55	0.0925		0.038	U	0.0348	U	0.0127	U
PCB 56	1.06		1.41		2.43		0.0372	UJ
PCB 57	0.0237	U	0.0345	U	0.0316	U	0.0116	U
PCB 58	0.022	U	0.032	U	0.0293	U	0.0107	U
PCB 59, 62, & 75	0.49		0.602		0.509		0.00709	U
PCB 60	0.603		0.764		1.46		0.0157	UJ
PCB 61, 70, 74, & 76	5.51		7.14		12.0		0.0984	U
PCB 63	0.144		0.181	J	0.308		0.0115	U
PCB 64	1.59		2.13		2.88		0.0238	UJ
PCB 66	1.89		2.47		4.15		0.0414	U
PCB 67	0.125		0.161	J	0.272		0.0106	U
PCB 68	0.954		1.38		2.41		0.0102	U
PCB 72	0.0223	U	0.0324	U	0.0297	U	0.0109	U
PCB 73	0.0175	U	0.0593		0.072		0.0069	U
PCB 77	0.433		0.614	J	1.01		0.0132	U
PCB 78	0.024	U	0.0348	U	0.0319	U	0.0117	U
PCB 79	0.143		0.0292	U	0.0267	U	0.00978	U
PCB 80	0.0204	U	0.0296	U	0.0271	U	0.00993	U
PCB 81	0.0502	J	0.0826	J	0.0451	J	0.0116	U
PCB 82	0.428		0.507		0.914		0.0244	U
PCB 83	0.0311	U	0.335		0.328	J	0.0214	U
PCB 84	1.09		1.5		2.02		0.0272	U
PCB 85, 116, & 117	0.436		0.0354	U	0.804	J	0.0165	U

Table 10. Detailed Analysis of Flue Gas Samples for PCB Congeners

Sample	G1-R1 AC Bed Inlet	G1-R2 AC Bed Inlet	G2-R2 Stack Outlet	Field Blank
Congener	------------------ ng (nanograms)* ------------------			
PCB 86, 87, 97, 108, 119, & 125	3.35	4.35	7.36	0.0851 UJ
PCB 88 & 91	0.636	0.812	1.2	0.0203 U
PCB 89	0.0509 J	0.0741 J	0.0926	0.0224 U
PCB 90, 101, & 113	5.05	6.36	$11.0	0.0905 U
PCB 92	0.921	1.19	1.93	0.0217 U
PCB 93 & 100	0.027 U	0.0397 U	0.0511 J	0.0185 U
PCB 94	0.0317 U	0.0468 U	0.0522 J	0.0218 U
PCB 95	3.65	4.75	7.1	0.073 UJ
PCB 96	0.0442 U	0.045	0.064	0.0237 U
PCB 98 & 102	0.0339 U	0.271	0.385	0.0233 U
PCB 99	1.66	2.2	3.88	0.0291 U
PCB 103	0.0359 J	0.0505	0.0738 J	0.0191 U
PCB 104	0.0351 U	0.0205 U	0.0302 U	0.0193 U
PCB 105	0.595	0.812	1.27	0.0331 U
PCB 106	0.232 U	0.412 U	0.375 U	0.0166 U
PCB 107 & 124	0.196 U	0.347 U	0.316 U	0.014 U
PCB 109	0.155 U	0.275 U	0.25 U	0.0111 U
PCB 110 & 115	4.24 J	5.98 J	8.77 J	0.126 UJ
PCB 111	0.0229 U	0.0337 U	0.0102 U	0.0157 U
PCB 112	0.0276 U	0.0406 U	0.0123 U	0.0189 U
PCB 114	0.203 U	0.353 U	0.318 U	0.0149 U
PCB 118	1.83	2.36	4.11	0.055 U
PCB 120	0.022 U	0.0324 U	0.0098 U	0.0151 U
PCB 121	0.0222 U	0.0328 U	0.0099 U	0.0153 U
PCB 122	0.204 U	0.362 U	0.33 U	0.0146 U
PCB 123	0.221 U	0.375 U	0.331 U	0.0152 U
PCB 126	0.197 U	0.362 U	0.297 U	0.0142 U
PCB 127	0.196 U	0.348 U	0.316 U	0.014 U
PCB 128 & 166	0.203	0.284	0.557	0.013 U
PCB 129, 138, & 163	1.77	2.51	4.54	0.0822 U
PCB 130	0.233 J	0.164	0.281	0.0159 U
PCB 131	0.0761 J	0.042 U	0.0926	0.0148 U
PCB 132	0.803	1.08	1.9	0.0306 UJ
PCB 133	0.0255 U	0.0412 U	0.0766 J	0.0145 U
PCB 134	0.279 J	0.146 J	0.256	0.0403 J
PCB 135 & 151	0.941	1.28	1.86	0.0266 U
PCB 136	0.408	0.547	0.879	0.0152 U
PCB 137	0.122	0.167 J	0.255	0.012 U

Table 10. Detailed Analysis of Flue Gas Samples for PCB Congeners

Sample	G1-R1 AC Bed Inlet		G1-R2 AC Bed Inlet		G2-R2 Stack Outlet		Field Blank	
Congener	------------------ ng (nanograms)* ------------------							
PCB 139 & 140	0.0409	J	0.04	J	0.0279	U	0.0123	U
PCB 141	0.416	J	0.565		0.975		0.0163	U
PCB 142	0.0292	U	0.0472	U	0.0376	U	0.0166	U
PCB 143	0.029	U	0.0469	U	0.0373	U	0.0165	U
PCB 144	0.173		0.219		0.367		0.0156	U
PCB 145	0.0206	U	0.0256	U	0.0139	U	0.0124	U
PCB 146	0.42	J	0.353		0.629		0.0109	U
PCB 147 & 149	1.68		2.67		4.61		0.0153	U
PCB 148	0.0271	U	0.0337	U	0.0182	U	0.0163	U
PCB 150	0.0208	U	0.0259	U	0.0168	J	0.0125	U
PCB 152	0.0204	U	0.0254	U	0.0137	U	0.0122	U
PCB 153 & 168	1.79		2.4		4.22		0.0448	U
PCB 154	0.0289	J	0.0333	J	0.065		0.0138	U
PCB 155	0.0238	U	0.0294	U	0.0574		0.0139	U
PCB 156 & 157	0.132		0.316	U	0.269		0.147	U
PCB 158	0.192		0.256		0.453		0.0101	U
PCB 159	0.0289	U	0.248	U	0.0705	J	0.117	U
PCB 160	0.0227	U	0.0367	U	0.0292	U	0.0129	U
PCB 161	0.0216	U	0.0349	U	0.0278	U	0.0123	U
PCB 162	0.029	U	0.249	U	0.0449	U	0.118	U
PCB 164	0.102	J	0.123		0.25		0.0127	U
PCB 165	0.0197	U	0.0319	U	0.0254	U	0.0112	U
PCB 167	0.0649		0.244	U	0.117		0.12	U
PCB 169	0.0273	U	0.244	U	0.038	U	0.117	U
PCB 170	0.186		0.267	J	0.44		0.0363	J
PCB 171 & 173	0.0687	J	0.039	U	0.216		0.0238	U
PCB 172	0.0147	U	0.0509		0.0769		0.0252	U
PCB 174	0.277		0.378	J	0.605		0.0233	U
PCB 175	0.0161	J	0.0252	U	0.013	U	0.0172	U
PCB 176	0.0721		0.0866		0.164		0.0127	U
PCB 177	0.135		0.236	J	0.347		0.024	U
PCB 178	0.074		0.117	J	0.142	J	0.0178	U
PCB 179	0.207		0.281		0.418		0.0123	U
PCB 180 & 193	0.46		0.655		1.01		0.0281	J
PCB 181	0.0113	U	0.0317	U	0.0218	U	0.0193	U
PCB 182	0.0182	U	0.0287	U	0.0147	U	0.0196	U
PCB 183 & 185	0.247		0.377		0.636	J	0.0195	U
PCB 184	0.011	U	0.023	J	0.0289	J	0.0118	U
PCB 186	0.0119	U	0.0187	U	0.00962	U	0.0128	U

Table 10. Detailed Analysis of Flue Gas Samples for PCB Congeners

Sample	G1-R1 AC Bed Inlet		G1-R2 AC Bed Inlet		G2-R2 Stack Outlet		Field Blank	
Congener	------------------ ng (nanograms)* ------------------							
PCB 187	0.391		0.558		0.915		0.0198	U
PCB 188	0.0154	U	0.023	U	0.0136	U	0.0163	U
PCB 189	0.0655	U	0.0749	U	0.0125	U	0.0105	U
PCB 190	0.0409		0.0584	J	0.0838	J	0.0214	U
PCB 191	0.0116	U	0.0326	U	0.0224	U	0.0199	U
PCB 192	0.0113	U	0.0316	U	0.0217	U	0.0193	U
PCB 194	0.0558		0.067	J	0.101	J	0.0243	U
PCB 195	0.0223	U	0.0495	U	0.054	J	0.0341	U
PCB 196	0.0479	U	0.0339	U	0.111	J	0.0264	U
PCB 197 & 200	0.0319	U	0.0449	J	0.055	J	0.0176	U
PCB 198 & 199	0.133	J	0.114		0.253		0.0278	U
PCB 201	0.0317	U	0.0249	J	0.0395	J	0.0174	U
PCB 202	0.0308	U	0.0222	U	0.0722	J	0.0162	U
PCB 203	0.0468	U	0.0331	U	0.118	J	0.0258	U
PCB 204	0.0321	U	0.0228	U	0.0128	U	0.0177	U
PCB 205	0.0123	U	0.0267	U	0.0123	U	0.0197	U
PCB 206	0.0393	J	0.0509	J	0.067		0.033	U
PCB 207	0.0224	J	0.0354	U	0.0264	U	0.027	U
PCB 208	0.019	J	0.0322	U	0.0346	J	0.0211	U
PCB 209	0.0263	J	0.0302	J	0.0415		0.0124	U
Total TEQ	0.0205		0.0394		0.0311		0.00269	

J = The analyte was detected. The reported numerical value is considered to be estimated for quality control reasons.
U = The analyte was not detected. The reported numerical value is the sample detection limit.
UJ = The analyte was not detected. The reported sample detection limit is considered estimated for quality control reasons.
* To calculate the concentration of each PCB congener in the flue gas, divide the amount listed by the volume of flue gas sampled from either the AC bed inlet or the stack outlet: 3.59 or 4.03 dscm, respectively.

Table 11. Detailed Analysis of Flue Gas Samples for Dioxin and Furan Congeners

Sample	G1-R1		G1-R2		G2-R2		Field Blank	
	AC Bed Inlet				Stack Outlet			
Congener	ng (nanograms)*							
2,3,7,8-Tetrachlorodibenzo(p)dioxin	0.00758	U	0.0136	U	0.00812	U	0.00792	U
1,2,3,7,8-Pentachlorodibenzo(p)dioxin	0.0128	EMPC	0.0197	U	0.01	U	0.01	U
1,2,3,4,7,8-Hexachlorodibenzo(p)dioxin	0.021	EMPC	0.0274	EMPC	0.00704	EMPC	0.0127	U
1,2,3,6,7,8-Hexachlorodibenzo(p)dioxin	0.0433	J	0.0534	J	0.0072	J	0.0117	U
1,2,3,7,8,9-Hexachlorodibenzo(p)dioxin	0.0413	J	0.0456	U	0.012	U	0.0127	U
1,2,3,4,6,7,8-Heptachlorodibenzo(p)dioxin	0.286		0.388		0.0278	J	0.0134	EMPC
Octachlorodibenzo(p)dioxin	0.232		0.289		0.13	U	0.0846	EMPC
2,3,7,8-Tetrachlorodibenzofuran	0.0246	J	0.0211	EMPC	0.0113	J	0.006	U
1,2,3,7,8-Pentachlorodibenzofuran	0.027	J	0.0257	J	0.0127	J	0.01	U
2,3,4,7,8-Pentachlorodibenzofuran	0.0388	J	0.0327	J	0.0118	EMPC	0.00424	U
1,2,3,4,7,8-Hexachlorodibenzofuran	0.015	EMPC	0.0138	EMPC	0.00808	J	0.01	U
1,2,3,6,7,8-Hexachlorodibenzofuran	0.0162	J	0.0169	EMPC	0.0084	J	0.01	U
2,3,4,6,7,8-Hexachlorodibenzofuran	0.0333	J	0.0303	J	0.0088	J	0.01	U
1,2,3,7,8,9-Hexachlorodibenzofuran	0.0127	J	0.0423	U	0.0107	U	0.01	U
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.022	J	0.0166	EMPC	0.0211	EMPC	0.01	U
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.0141	U	0.0156	U	0.01	U	0.01	U
Octachlorodibenzofuran	0.0412	EMPC	0.0275	U	0.0202	U	0.0103	EMPC
Total Tetrachlorodibenzo (p) Dioxins	1.82		1.89		0.011	U	0.013	U
Total Pentachlorodibenzo (p) Dioxins	1.29		1.39		0.0214		0.014	U
Total Hexachlorodibenzo (p) Dioxins	1.93		2.36		0.0481		0.015	U
Total Heptachlorodibenzo (p) Dioxins	0.513		0.664		0.0601		0.0134	U
Total Tetrachlorodibenzofurans	0.995		0.717		0.177		0.00392	
Total Pentachlorodibenzofurans	0.495	J	0.433	J	0.116		0.00232	
Total Hexachlorodibenzofurans	0.249	J	0.165		0.0531		0.01	U
Total Heptachlorodibenzofurans	0.0304		0.00928		0.0101		0.01	U
Total TEQ	0.0651		0.0802		0.0326		0.0292	

J = The analyte was detected. The reported numerical value is considered to be estimated for quality control reasons.
U = The analyte was not detected. The reported numerical value is the sample detection limit.
UJ = The analyte was not detected. The reported sample detection limit is considered estimated for quality control reasons.
EMPC = Estimated Maximum Possible Concentration
* To calculate the concentration of each PCDD or PCDF congener in the flue gas, divide the amount listed by the volume of flue gas sampled from either the AC bed inlet or the stack outlet: 3.59 or 4.03 dscm, respectively.

Table 12. Detailed Analysis of Flue Gas Samples for Trace Metals

Sample	G1-R1-A	G1-R1-B	G1-R2-A	G1-R2-B	G2-R1-A	G2-R1-B	G2-R2-A	G2-R2-B	Field Blank
Location	AC Bed Inlet				Stack Outlet				
Metal	---------- µg (micrograms)* ----------								
Mercury	69.71	70.61	61.4	61.7	0.614	0.6	0.5 U	0.5 U	0.5 U
Arsenic	0.5 U	0.5 U	0.5 U	NA	1.89	1.67	1.55	NA	0.5 U
Barium	5.75	5.72	5.27	NA	13.3	12.4	16.2	NA	2.36
Cadmium	3.92	3.94	5.66	NA	0.89	0.794	0.775	NA	0.2 U
Chromium	2.68	2.65	3.43	NA	13.3	12.4	12	NA	1.4
Copper	2.73	2.66	3.17	NA	19.4	17.3	19.1	NA	1.9
Lead	0.833	0.837	1.08	NA	32	29.1	18.9	NA	0.5 U
Nickel	3.11	3.06	4.63	NA	10.6	9.45	8.81	NA	0.682
Selenium	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U
Silver	0.5 U	0.5 U	0.624 U	NA	0.96 U	0.876 U	1.63 U	NA	2.74
Zinc	37	37.1	40.3	NA	34.5	30.7	17.8	NA	3.68
Hydrogen chloride	1,920	NA	80 U	NA	34,300	NA	714	NA	30 U
Chlorine	109 J	NA	20 UJ	NA	20 U	NA	20 UJ	NA	20 UJ

J = The analyte was detected. The reported numerical value is considered to be estimated for quality control reasons.
U = The analyte was not detected. The reported numerical value is the sample detection limit.
UJ = The analyte was not detected. The reported sample detection limit is considered estimated for quality control reasons.
* To calculate the concentration of each metal in the flue gas, divide the amount listed by the volume of flue gas sampled from either the AC bed inlet or the stack outlet: 1.71 or 1.75 dscm, respectively.

Table 13. Analysis of Flue Gas Samples for Semi-Volatile Organic Compounds

Sample	G1-R1	G1-R2	G2-R2	Field Blank
	AC Bed Inlet		Stack Outlet	
Analyte	--------------- µg (micrograms)* ---------------			
Benzo (a) Anthracene	0.8 U	0.8 U	0.8 U	0.8 U
Benzo (a) Pyrene	0.8 U	0.8 U	0.8 U	0.8 U
Benzo (b) Fluoranthene	0.8 U	0.8 U	0.8 U	0.8 U
Benzo (k) Fluoranthene	0.8 U	0.8 U	0.8 U	0.8 U
Bis (2-Ethylhexyl) Phthalate	32.3	26.6	73.3	1.15
Chrysene	0.8 U	0.8 U	0.8 U	0.8 U
Indeno (1,2,3-cd) Pyrene	0.8 U	0.8 U	0.8 U	0.8 U

U = The analyte was not detected. The reported numerical value is the sample detection limit.
* To calculate the concentration of each SVOC in the flue gas, divide the amount listed by the volume of flue gas sampled from either the AC bed inlet or the stack outlet: 3.59 or 4.03 dscm, respectively.

Environmental Data on Ecomelt and EcoAggMat

The general leachability of the Ecomelt sample generated during demo plant test No. 1 is compared with that of the EcoAggMat from the laboratory-scale test in Table 14. The TCLP (EPA Method 1311) and EP Tox (EPA Method 1310) are similar tests in that both employ dilute acetic acid solution leaching of the sample. There are some differences. In the EP Tox test, the pH of the leaching solution is monitored and adjusted during the leaching period that continues for 24 hours. In the TCLP test, the pH of the leaching solution is not adjusted while the leaching continues for 18±2 hours.

Table 14. Results of Leaching Tests on Ecomelt from Demo Plant Test No. 1
and EcoAggMat from Non-Slagging Laboratory-Scale Test

Sample	Ecomelt (Test No. 1)		EcoAggMat (lab-scale)		TCLP Regulatory Limit
Analyte	mg/kg	TCLP, mg/L	mg/kg	EP Tox,+ mg/L	mg/L
Arsenic	**2.3***	< 0.1**	< 0.75	< 0.1	5
Barium	**240**	< 0.1	**47**	**0.42**	100
Cadmium	< 0.15	< 0.02	**0.41**	< 0.02	1
Chromium	**100**	< 0.05	**12**	**0.79**	5
Lead	**19**	< 0.1	**13**	< 0.1	5
Mercury	< 0.1	< 0.002	< 0.10	< 0.002	0.2
Selenium	< 0.75	< 0.2	< 0.75	< 0.2	1
Silver	< 0.75	< 0.02	< 0.75	< 0.02	5

* **Bold**-faced values indicate analyte detected.
** < indicates less than the analytical detection limit.
+ Data reproduced from Table 2 (page 14).

The results show that the Ecomelt sample from demo plant Test No. 1 did not leach any priority metals above the analytical detection limits. The EcoAggMat leached barium and chromium at 0.42 and 0.79 mg/L, respectively. Both are well below the regulatory limit for landfill disposal.

The results of TCLP and SPLP tests conducted by EPA SITE on a sample of EcoAggMat generated during demo plant Test No. 6 (March 2005) are presented in Table 15. Low levels of chromium were detected in the samples along with small quantities of bis (2-ethylhexyl) phthalate. The results of leaching tests conducted by EPA SITE under the MEP (Multiple Extraction Procedure) protocol are presented in Table 16. In the MEP, the sample is leached according to the EP Toxicity test (EPA Method 1310) first. Then for nine sequential tests, the sample is subjected to leaching with a dilute nitric and sulfuric acid solution. The intent of the MEP is to determine the suitability of a sample for a beneficial use, for example, as fill, but not for disposal in a landfill.

Table 15. Results of TCLP and SPLP Tests on Six (6) Samples of EcoAggMat (thermally treated sediment)

Leaching Test	TCLP	SPLP	NJ GWQC Limits	TCLP Limits
	Averaged Results			
Analyte	---------------------- µg/L ----------------------			
4,4'-DDT	< 0.256*	< 0.22	0.1	NA
Benzo (a) Anthracene	< 0.006	< 0.007	0.1	NA
Benzo (a) Pyrene	< 0.007	< 0.007	0.1	NA
Benzo (b) Fluoranthene	< 0.005	< 0.006	0.2	NA
Benzo (k) Fluoranthene	< 0.011	< 0.012	0.5	NA
Chrysene	< 0.073	< 0.079	5	NA
Bis (2-Ethylhexyl) Phthalate	**0.23****	< 0.108+	3	NA
Indeno (1,2,3-cd) Pyrene	< 0.006	< 0.006	0.2	NA
Arsenic	< 500	< 500	3	5,000
Barium	< 1000	< 1000	2,000	100,000
Cadmium	< 5	< 5	4	1,000
Chromium	**29.0**	**13.3**	70	5,000 / 100++
Copper	< 25	< 25	1,300	--
Lead	< 500	< 500	5	5,000
Mercury	< 0.20	< 0.20	2	200
Nickel	< 40	< 40	100	NA
Selenium	< 500	< 500	40	1,000
Silver	< 10	< 10	40	5,000
Zinc	< 20	< 20	2,000	NA

* < Indicates less than the analytical detection limit.
** **Bold**-faced values indicate analyte detected.
+ Spurious high sample value was omitted in this average – likely sample contamination.
++ U.S. EPA primary drinking water standard.

Table 16. Averaged Results of MEP (EPA Method 1320) Tests on Three (3) Samples of EcoAggMat (thermally treated sediment)

Sample	EcoAggMat										
Leaching Test	MEP**										
Sampling Day	EP Tox* Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	NJ GWQC
Analyte	µg/L										
Benzo (a) Anthracene	< 0.007[+]	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.008	< 0.007	0.1
Benzo (a) Pyrene	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.009	< 0.008	0.1
Benzo (b) Fluoranthene	< 0.006	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.007	< 0.006	0.2
Benzo (k) Fluoranthene	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011	< 0.014	< 0.012	0.5
Chrysene	< 0.078	< 0.073	< 0.073	< 0.073	< 0.073	< 0.073	< 0.073	< 0.073	< 0.096	< 0.082	5
Bis (2-Ethylhexyl) Phthalate	< 0.125	< 0.078	< 0.078	< 0.410	< 0.145	< 0.149	< 0.452	< 0.061	< 0.103	< 0.183	3
Indeno (1,2,3-cd) Pyrene	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.008	< 0.007	0.2
Arsenic	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	3
Barium	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	2,000
Cadmium	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	4
Chromium	**29.3**[++]	**12.7**	**12.3**	**12.7**	< 10	**10.0**	**13.7**	< 10	< 10	< 10	70
Copper	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	< 25	1,300
Lead	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	5
Mercury	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	2
Nickel	< 40	< 40	< 40	< 40	< 40	< 40	< 40	< 40	< 40	< 40	100
Selenium	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	40
Silver	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	40
Zinc	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2,000

* EP Toxicity test (EPA Method No. 1310) is conducted with dilute acetic acid solution on Day 1.
** Subsequent MEP extractions are conducted with dilute nitric and sulfuric acid solutions.
[+] < less than the analytical detection limit.
[++] **Bold**-faced values indicate analyte detected.

The data presented in Table 16 are the average of three samples analyzed (the complete results are presented in Appendix P). The results show that the EcoAggMat leached chromium at 29.3 μg/L on Day 1. Subsequent leaching episodes showed chromium at about 12 μg/L on Day 2, 3, and 4, but no Cr was detected on Day 5. Chromium was again detected on Days 6 and 7. Days 8, 9, and 10 showed no Cr above the analytical detection limit. These values are well below the NJ Ground Water Quality Criterion (NJ GWQC) for Cr of 70 μg/L.

Although no other metals were detected in the MEP leachates, the analytical detection limits for As, Cd, Pb, and Se were above the NJ GWQC. Therefore, ECH arranged for a sample of EcoAggMat to be retested per the MEP with analytical detection limits that were comparable to the NJ GWQC. The results of these extractions (Table 17), which were conducted according to the NJ MEP protocol, showed low levels of arsenic that exceeded the NJ GWQC of 3 μg/L on Day 1 and Days 3 through 7. The As concentration in the leachate ranged from 3.07 to 9.06 μg/L. Lead was also detected in the leachate on Day 1 at a concentration of 6.28 μg/L, which exceeded the NJ GWQC for Pb of 5 μg/L.

Table 17. NJ Protocol MEP Test on EcoAggMat (thermally treated sediment)

Leaching Test	NJ MEP Protocol*							
	---------- μg/L ----------							
Sampling Day	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	NJ GWQC
Arsenic	**3.23**+	< 3**	**3.07**	**4.80**	**6.49**	**6.13**	**9.06**	3
Barium	**133**	< 100	< 100	< 100	< 100	< 100	< 100	2,000
Cadmium	< 4	< 4	< 4	< 4	< 4	< 4	< 4	4
Chromium	< 10	< 10	< 10	< 10	< 10	< 10	< 10	70
Copper	< 10	< 10	< 10	< 10	< 10	< 10	< 10	1,300
Lead	**6.28**	< 5	< 5	< 5	< 5	< 5	< 5	5
Manganese	< 10	< 10	< 10	< 10	< 10	< 10	< 10	50
Mercury	< 0.285	< 0.285	< 0.285	< 0.285	< 0.285	< 0.285	< 0.285	2
Nickel	< 40	< 40	< 40	< 40	< 40	< 40	< 40	100
Selenium	< 20	< 20	< 20	< 20	< 20	< 20	< 20	40
Silver	< 10	< 10	< 10	< 10	< 10	< 10	< 10	40
Zinc	< 20	< 20	< 20	< 20	< 20	< 20	< 20	2,000

* NJ MEP Protocol extractions are conducted with dilute nitric and sulfuric acid solutions.
** < less than the analytical detection limit.
\+ **Bold**-faced values indicate analyte detected.

Interestingly, chromium, which was detected in the leachate from the TCLP, SPLP, and initial MEP tests, was not detected in the leachate during the NJ MEP Protocol retest of the

EcoAggMat. These results emphasize the need for testing the Cement-Lock demo plant with sediment under slagging conditions producing Ecomelt as the Cement-Lock Technology was originally developed.

As discussed above, the sediment-modifier mixture was subjected to temperatures well below the initial deformation temperature of the mineral matter. Therefore, the EcoAggMat product would not have experienced sintering of the mineral matter, which would have reduced the incidence of metals leaching. These results point to the need for testing the Cement-Lock demo plant under slagging conditions producing Ecomelt as the Cement-Lock Technology was originally developed.

The chemical analysis of the EcoAggMat product was also determined on several samples collected during the March 2005 campaign. The results of the analysis are summarized in Table 18 and compared with NJ Direct Contact Soil Cleanup Criteria for both residential and non-residential applications. The results show that the EcoAggMat is suitable for use under the more stringent residential applications. The analysis of a sample of EcoAggMat for pesticides is included in Table 19. The results show that the EcoAggMat sample was devoid of pesticides.

Tables 20, 21, 22, and 23 present the detailed analytical results of samples of lime, modifier, sediment, and EcoAggMat for PCB congeners, dioxin and furan congeners, trace metals, and SVOCs (semi-volatile organic compounds). The tables list the quantity of material captured during sampling in nanograms (ng) or micrograms (μg) as appropriate. As mentioned before, the data in these tables were from the data validation work performed by EPA SITE as part of the overall project.

Table 18. Averaged Analysis of Six (6) As-Fed Samples of Sediment and Six (6) EcoAggMat Samples from Cement-Lock Demo Plant Test (March 11, 2005)

Sample	Stratus Petroleum Sediment		NJ Direct Contact Soil Cleanup Criteria	
	As-Fed	EcoAggMat	Non-Residential	Residential
Contaminant	---------------------- µg/kg ----------------------			
Benzo (a) Anthracene	**361***	< 1.2**	*4,000*	*900*
Benzo (b) Fluoranthene	**669**	< 1.8	*4,000*	*900*
Benzo (k) Fluoranthene	**187**	< 1.4	*4,000*	*900*
Benzo (a) Pyrene	**411**	< 2.5	*660*	*660*
Bis (2-Ethylhexyl) Phthalate	**517**	< 5.2	*210,000*	*49,000*
Chrysene	**375**	< 2.1	*40,000*	*9,000*
Indeno (1,2,3-cd) Pyrene	**192**	< 1.1	*4,000*	*900*
4,4'-DDT	< 21	< 24	*9,000*	*2,000*
Total PCBs	**367.1**	**0.22**	*2,000*	*490*
	------------------ ng/kg (pg/g) ------------------			
2,3,7,8-TCDD	**88.7**	< 0.50	N/A	N/A
Dioxin/Furan, TEQ	**141.4**	**2.08**	N/A	N/A
PCB, TEQ	**11.1**	**0.03**	N/A	N/A
	--------------------- mg/kg ---------------------			
Arsenic	**9.1**	**9.2**	*20*	*20*
Barium	**66.3**	< 29.1	*47,000*	*700*
Cadmium	**1.32**	< 0.7	*100*	*39*
Copper	**79.5**	**29.4**	*600*	*600*
Chromium (total)	**88.6**	**27.0**	*(Cr VI) 6,100*	*(Cr VI) 240*
Lead	**72.5**	**4.3**	*600*	*400*
Mercury	**1.78**	< 0.04	*270*	*14*
Nickel	**20.7**	**20.5**	*2,400*	*250*
Selenium	< 1.9	< 1.7	*3100*	*63*
Silver	**2.0**	< 1.4	*4100*	*110*
Zinc	**131.9**	**43.5**	*1,500*	*1,500*

***Bold-faced** values indicate analyte detected.
** < Less than the analytical detection limit.
Italicized values are the Direct Contact Soil Cleanup Criteria from the NJ-DEP website http://www.state.nj.us/dep/srp/regs/scc/scc_0599.pdf.

Table 19. Pesticide Analysis of EcoAggMat Sample from Cement-Lock Demo Plant Test (March 11, 2005)

Pesticide	μg/kg	NJ-RDCSCC, μg/kg
alpha-BHC	*< 11.0	--
beta-BHC	< 11.0	--
delta-BHC	< 11.0	--
gamma-BHC (Lindane)	< 11.0	520
Heptachlor	< 11.0	150
Aldrin	< 11.0	40
Heptachlor epoxide	< 11.0	--
Endosulfan I	< 11.0	340,000
Dieldrin	< 11.0	420
4,4'-DDE	< 11.0	2,000
Endrin	< 11.0	17,000
4,4'-DDD	< 11.0	3,000
Endosulfan II	< 11.0	--
4,4'-DDT	< 11.0	2,000
Methoxychlor	< 11.0	280,000
Toxaphene	< 36.8	100
alpha-Chlordane	< 11.0	--
gamma-Chlordane	< 11.0	--
Endrin aldehyde	< 11.0	--
Endosulfan sulfate	< 11.0	--
Endrin ketone	< 11.0	--

* < Less than the analytical method detection limit.

Table 20. Detailed PCB Congener Analysis of Process Samples – Lime, Modifier, Sediment, and EcoAggMat

Sample	SL-01-03102005	SM-01-03102005	SM-02-03102005	SS-01-03102005	SS-03-03102005	SS-05-03102005	SEM-01-03102005	SEM-02-03102005	SEM-03-03102005	SEM-05-03102005
	Lime	Modifier	Modifier	Sediment			EcoAggMat			
Congener	ng/kg									
PCB 1	2.93 U	3.34 U	4.27 J	368 J	602	556 J	2.59 UJ	2.4 U	2.33 U	1.61 UJ
PCB 2	1.69 U	2.34 J	2.72 J	142	165	184	2.28 J	2.07 U	1.99 U	1.44 U
PCB 3	2.55 U	3.73 J	4.17 J	355	453	476	2.51 U	2.5 UJ	3.03 U	2.14 U
PCB 4	4.14 U	6.55 J	11.2	1010	1460	1500	5.04 J	4.52 U	4.68 U	2.07 UJ
PCB 5	0.27 U	0.353 U	1.05	8.29 U	12.7 U	7.8 U	0.54 J	0.475 J	0.41 J	0.47 U
PCB 6	2.17 U	3.36 J	5.07 J	634	856	968	2.14 U	2.01 U	2.34 U	0.46 U
PCB 7	0.882 J	0.889 J	0.995	64.8	76.7	97.9	0.441 U	0.656 J	0.345 U	0.45 U
PCB 8	7.18 U	12.4 U	16.9 J	2120	3010	3040	6.42 U	5.29 U	7.52	5.86 U
PCB 9	1 J	1.34	1.5	93.1	113	139	0.463 U	0.899 J	0.92 J	0.46 U
PCB 10	0.509 U	0.379 U	0.82 J	68.6	108	103	0.269 U	0.462 U	0.404 U	0.58 U
PCB 11	20.7 U	32.9 U	38.4 U	2730	3090	3350	17.8 U	14.7 U	31.3 U	20.50 J
PCB 12 & 13	0.96 J	1.92 J	3.51	1040	1340	1350	0.995 J	0.887 J	1.14 J	0.44 U
PCB 14	0.257 U	0.336 U	0.446 U	8.31 U	12.7 U	7.81	0.447 U	0.338 U	0.374 U	0.46 U
PCB 15	4.97 U	9.99 U	20.3 J	6620	8160	8700	5.14 U	4 U	6.39 U	4.09
PCB 16	2.51 U	4.45 U	11.3 J	963	1250	1690	2.89 U	2.87 U	3.16 U	2.39 U
PCB 17	2.14 UJ	4.11 J	11.8	1530	1960	2430	2.36 U	1.92 UJ	2.1 UJ	1.34 U
PCB 18 & 30	3.84 U	6.9 J	20.6	2220	2860	3710	5.14 U	4.16 U	4.34 UJ	3.05 U
PCB 19	1.31 J	1.69 J	4.52	457	584	634	1.53 J	1.56 J	1.19 U	0.58 UJ
PCB 20 & 28	10.6 U	19 U	49 J	11900	15200	17100	14.3 U	9.56 U	13.7 U	10.30 U
PCB 21 & 33	7 U	10.6 U	18.7 J	2080	2680	3170	7.95 U	5.69 U	6.85 U	6.56 U
PCB 22	4.61 U	8.11 U	14.8 J	2330	2940	3440	6.19 U	4.61 U	6.34 U	4.63 U
PCB 23	0.358 U	0.226 U	0.187 U	5.15 J	8.18 J	9.16 J	0.129 U	0.137 U	0.137 U	0.19 U
PCB 24	0.336 U	0.294 J	0.382 J	40.2	45.2	54.5	0.229 J	0.148 J	0.121 J	0.17 U
PCB 25	0.7 U	1.73 J	4.68	1310	1710	1810	0.764 U	0.804 U	0.76 U	0.74 U
PCB 26 & 29	1.32 UJ	2.93 J	8.51	2020	2600	2880	1.91 U	1.46 U	1.82 U	1.31 U
PCB 27	0.435 J	0.552 J	2.47	395	499	562	0.427 J	0.402 J	0.334 J	0.27 J
PCB 31	7.37 U	14.4 J	35.6	8230	10600	12100	10.2 U	7.56 U	9.33 U	8.04 U
PCB 32	1.34 U	2.77 J	7.56	1150	1440	1670	1.71 U	1.39 U	1.62 U	1.22 U
PCB 34	0.338 U	0.213 U	0.281 J	49	63.6	78.9	0.131 U	0.139 U	0.139 U	0.19 U
PCB 35	0.398 U	1 J	1.8 J	368	505	487	0.546 U	0.32 U	0.499 U	0.37 J
PCB 36	0.34 U	0.347 U	0.421 U	8.4 U	13.2	14.7	0.306 U	0.281 U	0.277 U	0.14
PCB 37	7.4 U	10.6 U	20 J	5840	7920	7830	8.69 U	5.99 U	8.25 U	4.48 U
PCB 38	0.365 U	0.372 U	0.452 U	12.3 J	13.1 J	12.1 J	0.337 U	0.309 U	0.304 U	0.14 U
PCB 39	0.311 U	0.317 U	0.385 U	63.7	69.4	79.6	0.32 U	0.293 U	0.289 U	0.13 U
PCB 40 & 71	2.2 UJ	2.72 U	14.5	2920	3590	3830	2.51 U	2.19 U	1.53 U	2.41 U

Table 20. Detailed PCB Congener Analysis of Process Samples – Lime, Modifier, Sediment, and EcoAggMat

Sample	SL-01-03102005	SM-01-03102005	SM-02-03102005	SS-01-03102005	SS-03-03102005	SS-05-03102005	SEM-01-03102005	SEM-02-03102005	SEM-03-03102005	SEM-05-03102005
	Lime	Modifier	Modifier	Sediment			EcoAggMat			
Congener	ng/kg									
PCB 41	0.596 UJ	0.701 UJ	1.93 J	116	175	207	0.619 U	0.69 U	0.696 U	0.64 J
PCB 42	1.19 UJ	1.6 U	9.54	1940	2470	2600	2.16 J	1.58 U	0.882 U	1.40
PCB 43	0.407 U	0.731 U	2.17	251	274	322	0.524 U	0.475 U	1 U	0.54 U
PCB 44, 47 & 65	4.72 U	6.44 J	31.8	5450	6510	7020	5.85 U	4.63 U	3.85 U	4.69 UJ
PCB 45 & 61	0.99 UJ	1.9 J	8.75	1960	2590	2620	1.58 U	1.54 U	1.32 U	1.19 UJ
PCB 46	0.49 U	0.655 U	2.37 J	692	844	885	0.401 U	0.422 U	0.494 U	0.38 U
PCB 48	0.921 U	1.28 J	4.97	601 J	677	957	1.39 J	1.09 J	0.952 U	1.05 J
PCB 49 & 69	2.06 UJ	2.96 J	19.6	3210	4360	4740	2.56 J	1.75 U	1.48 U	1.83 U
PCB 50 & 53	0.573 J	1.14	6.54	1810	2250	2320	0.857 J	0.765 J	0.789 J	0.40 UJ
PCB 52	3.31 U	5.55 J	31.5	5020	6450	6820	4.28 U	3.26 UJ	3.02 U	3.55 U
PCB 54	0.319 U	0.361 U	0.419 J	75.9	97.1	91.5	0.221 U	0.231 U	0.275 U	0.16 U
PCB 55	0.796 U	0.32 U	0.511 U	245	281	270	0.152 U	0.376 U	0.259 U	0.61 U
PCB 56	2.13 U	3.62 J	14.1	3500	4340	4530	2.93 U	1.96 U	2.27 UJ	1.54 U
PCB 57	0.625 U	0.252 U	0.401 U	42.5 U	36.8 U	38.2	0.138 U	0.341 U	0.235 U	0.54 U
PCB 58	0.576 U	0.232 U	0.37 U	54.4	61.6	55.9	0.126 U	0.31 U	0.214 U	0.50 U
PCB 59 & 62 & 75	0.237 UJ	0.484 U	3.71	723	902	920	0.605 U	0.412 U	0.431 U	0.35 J
PCB 60	1.75 U	1.96 U	5.38 J	1200	1440	1580	1.86 U	1.29 U	1.62 UJ	1.20 UJ
PCB 61, 70, 74 & 76	8.44 U	13.6 J	54.8	11200	14300	14600	8.86 U	7.01 U	7.39 U	6.21 U
PCB 63	0.689 U	0.277 U	1.3	261	338	362	0.147 U	0.363 U	0.251 U	0.51 U
PCB 64	2.25 U	2.83 U	12.7	2160	2740	2840	2.62 U	1.81 U	1.71 U	2.01 U
PCB 66	4.79 U	8.09 J	34.2	7620	9780	9750	4.74 U	3.4 U	3.68 U	2.56 UJ
PCB 67	0.666 U	0.329 J	1.13 J	244	325	344	0.295 J	0.32 U	0.22 U	0.52 U
PCB 68	0.561 U	0.226 U	0.488 J	108	131 J	146	0.229 J	0.281 U	0.194 U	0.51 U
PCB 72	0.604 U	0.243 U	0.448 J	127	165 J	179	0.127 U	0.313 U	0.216 U	0.53 U
PCB 73	0.182 U	0.326 U	0.355 U	100	101	105	0.232 U	0.21 U	0.444 U	0.25 U
PCB 77	0.705 U	0.928 U	4.14 J	1660	2200	2190	0.823 U	0.607 U	0.789 U	0.65 U
PCB 78	0.66 U	0.266 U	0.423 U	39.4 U	34.2 U	28.1 U	0.145 U	0.357 U	0.247 U	0.55 U
PCB 79	0.556 U	0.224 U	0.899 J	279	341	356	0.125 U	0.309 U	0.213 U	0.47 U
PCB 84	0.536 U	0.216 U	0.344 U	36.1 U	30.5 U	25.1 U	0.122 U	0.302 U	0.208 U	0.46 U
PCB 81	0.725 U	0.363 U	0.459 U	47.1 U	40.4 U	34.5 J	0.178 U	0.432 U	0.3 U	0.66 U
PCB 82	0.556 U	1.32 J	4.91 J	1360	1760	1790	0.435 J	0.487 J	0.459 U	0.60 U
PCB 83	0.462 U	0.471 U	1.7	445	61.6	819	0.333 U	0.274 U	0.386 U	0.49 U
PCB 84	1.42 J	2.23	11.7	4010	4970	5220	1.36 J	1.13 J	0.734 J	1.29 U

Table 20. Detailed PCB Congener Analysis of Process Samples – Lime, Modifier, Sediment, and EcoAggMat

Sample	SL-01-03102005	SM-01-03102005	SM-02-03102005	SS-01-03102005	SS-03-03102005	SS-05-03102005	SEM-01-03102005	SEM-02-03102005	SEM-03-03102005	SEM-05-03102005
	Lime	Modifier	Modifier	Sediment			EcoAggMat			
Congener	ng/kg									
PCB 85, 116, & 117	1.22 J	0.624 J	4.12 J	1440	1190	1890	0.925 J	0.597 J	0.477 J	0.40 U
PCB 86, 87, 97, 108, 119 & 125	4.41 U	8 J	26.9	6240	8110	8320	7.46 J	8.49 J	6.09 U	8.33 UJ
PCB 88 & 91	0.445 U	1.26 J	6.93	2700	3470	3590	0.781 J	0.599 J	0.433 J	0.71 J
PCB 89	0.5 U	0.51 U	0.415 U	219	274	271	0.357 U	0.294 J	0.413 U	0.58 U
PCB 90, 101 & 113	4.36 U	7.45 J	37.8	9410	12300	12500	4.46 U	3.99 U	2.88 U	4.10 U
PCB 92	0.812 J	1.49 J	6.69	2020	2540	2720	0.621 J	0.485 J	0.649 J	0.69 J
PCB 93 & 100	0.407 U	0.415 U	1.1 J	449	544	515	0.29 U	0.239 U	0.338 U	0.47 U
PCB 94	0.52 U	0.531 U	0.435 J	145	181	184	0.317 U	0.261 U	0.367 U	0.59 U
PCB 95	3.36 U	5.39 J	30.7	9640	12900	13300	3.72 U	2.86 U	2.03 U	3.47 U
PCB 96	0.439 U	0.52 U	0.431 U	135	178	183	0.418 U	0.362 U	0.423 U	0.24 U
PCB 98 & 102	0.536 U	0.547 U	2.51	795	1020	1090	0.357 U	0.542 J	0.414 U	0.63 U
PCB 99	1.85 J	3.06 J	18.1	4280	6090	6260	1.6 U	1.42 U	0.851 U	1.69 U
PCB 103	0.397 U	0.405 U	0.621 J	292	381	403	0.289 U	0.238 U	0.335 U	0.49 U
PCB 104	0.396 U	0.448 U	0.344 U	25.8	33	33.9	0.319 U	0.3 U	0.346 U	0.16 U
PCB 105	2.04 U	3.48 J	12.8	3120	4210	4170	1.86 U	1.52 U	1.42 UJ	1.68 U
PCB 106	0.407 U	0.656 U	0.575 U	15.4 U	17.5 U	22.4 U	0.182 U	0.348 U	0.334 U	0.30 U
PCB 107 & 124	0.37 U	0.597 U	1.27 J	299	393	370	0.157 U	0.3 U	0.288 U	0.25 U
PCB 109	0.366 J	0.486 U	2.28	606	787	783	0.138 U	0.264 U	0.254 U	0.20 U
PCB 110 & 115	5.99 U	10.3 J	50	15700	20600	20500	5.25 U	4.19 U	3.75 U	6.28 UJ
PCB 111	0.347 U	0.355 U	0.288 U	3.39 U	4.16 U	237 U	0.223 U	0.184 U	0.259 U	0.38 U
PCB 112	0.406 U	0.414 U	0.336 U	4.29 U	5.28 U	3.01 U	0.294 U	0.242 U	0.34 U	0.47 U
PCB 114	0.427 U	0.7 U	0.608 U	127 J	133	137	0.186 U	0.341 U	0.322 U	0.28 U
PCB 118	4.43 U	0.717 U	32.3	7980	10300	10500	3.75 U	3.52 U	0.319 UJ	3.69 U
PCB 120	0.368 U	0.365 U	0.297 U	75.1	88.1	97.3	0.24 U	0.197 U	0.278 U	0.36 U
PCB 121	0.366 U	0.363 U	0.295 U	5.72 J	8.08 J	8.69 J	0.24 U	0.197 U	0.278 U	0.40 U
PCB 122	0.398 U	0.641 U	0.563 U	118 J	136 U	113	0.164 U	0.315 U	0.302 U	0.26 U
PCB 123	0.447 U	0.69 U	0.639 U	141 J	159	170	0.182 U	0.344 U	0.336 U	0.29 U
PCB 126	0.482 U	0.834 U	0.674 U	84.3 J	80.1	77.1	0.199 U	0.358 U	0.343 U	0.27 U
PCB 127	0.385 U	0.621 U	0.544 U	13.4 U	15.2	19.5 U	0.161 U	0.309 U	0.296 U	0.25 U
PCB 128 & 166	0.504 U	1.32 J	5.09	2270	2850	2950	0.384 U	0.493 U	0.524 U	0.68 U
PCB 129, 138 & 163	4.05 U	8 J	41.9	15600	19500	20000	3.25 U	2.83 U	3.02 U	3.68 U
PCB 130	0.62 U	0.774 U	1.67 J	995	1270	1300	0.469 U	0.462 U	0.64 U	0.51 U

Table 20. Detailed PCB Congener Analysis of Process Samples – Lime, Modifier, Sediment, and EcoAggMat

Sample	SL-01-03102005	SM-01-03102005	SM-02-03102005	SS-01-03102005	SS-03-03102005	SS-05-03102005	SEM-01-03102005	SEM-02-03102005	SEM-03-03102005	SEM-05-03102005
	Lime	Modifier	Modifier		Sediment			EcoAggMat		
Congener	ng/kg									
PCB 131	0.605 U	0.756 U	0.714 U	149	32.7 U	216	0.436 U	0.429 U	0.594 U	0.49 U
PCB 132	1.99 U	3.07 J	13.8	4640	5850	6040	1.6 U	1.5 U	1.21 U	1.56 U
PCB 133	0.62 U	0.774 U	0.731 U	255	338	337	0.441 U	0.434 U	0.602 U	0.47 U
PCB 134	0.565 U	0.706 U	1.48 J	508	774	669	0.394 U	0.388 U	0.538 U	0.46 U
PCB 135 & 151	1.15 J	2.75 J	13.1	5110	6520	6780	1.27 J	1.2 U	0.94 U	1.33 UJ
PCB 136	0.529 J	1 J	5.03	1660	2220	2370	0.524 J	0.546 J	0.487 J	0.49 UJ
PCB 137	0.508 U	0.634 U	2.15	842	951	1080	0.383 U	0.377 U	0.523 U	0.38 U
PCB 139 & 140	0.491 U	0.613 U	0.579 U	272	366	367	0.371 U	0.365 U	0.505 U	0.41 U
PCB 141	0.631 U	1.89 U	6.94 J	1820	2720	2660	0.564 U	0.528 U	0.677 U	0.83 U
PCB 142	0.694 U	0.866 U	0.818 U	26.2 U	38.8 U	50.8 U	0.493 U	0.485 U	0.672 U	0.55 U
PCB 143	0.695 U	0.868 U	0.819 U	26.9 U	39.9 U	52.2 U	0.55 U	0.542 U	0.751 U	0.61 U
PCB 144	0.65 U	0.846 U	1.74 J	636	807	832	0.552 U	0.533 U	0.594 U	0.37 U
PCB 145	0.498 U	0.649 U	0.494 U	4.66 U	7.85 J	6.07 U	0.424 U	0.409 U	0.456 U	0.29 U
PCB 146	0.478 U	1.17	5.45	2030	2650	2630	0.339 U	0.41 J	0.462 U	0.34 U
PCB 147 & 149	3.29 U	5.57 J	32.6	12300	15500	15900	2.94 U	2.22 U	2.28 U	3.09 U
PCB 148	0.665 U	0.866 U	0.659 U	52.2	69.9	70.3	0.57 U	0.55 U	0.613 U	0.38 U
PCB 150	0.54 U	0.703 U	0.535 U	105	138	137	0.433 U	0.418 U	0.486 U	0.30 U
PCB 152	0.512 U	0.666 U	0.507 U	25.9 J	31.8	27.2 J	0.441 U	0.425 U	0.474 U	0.30 U
PCB 153 & 168	2.91 U	6.75 J	37	12700	16200	16600	2.47 U	2.17 U	2.14 U	2.84
PCB 154	0.563 U	0.732 U	0.558 U	528	683	719	0.473 U	0.456 U	0.508 U	0.31 U
PCB 155	0.497 U	0.58 U	0.441 U	155	198	204	0.363 U	0.379 U	0.439 U	0.21 U
PCB 156 & 157	0.562 U	0.976 J	4.36	1220	1600	1650	0.367 U	0.357 U	0.485 J	0.46 UJ
PCB 158	0.506 U	0.705 U	4.08	1340	1670	1710	0.298 U	0.371 U	0.406 U	0.54 UJ
PCB 159	0.558 U	0.58 U	0.663 U	154	211	173	0.334 U	0.336 U	0.269 U	0.15 U
PCB 160	0.484 U	0.604 U	0.57 U	19.9 U	29.5 U	38.6 U	0.391 U	0.385 U	0.534 U	0.415 U
PCB 161	0.497 U	0.62 U	0.586 U	19 U	28.1 U	36.8 U	0.345 U	0.34 U	0.471 U	0.42 U
PCB 162	0.526 U	0.547 U	0.616 U	243 J	383 J	321 J	0.299 U	0.3 U	0.241 U	0.14 U
PCB 164	0.469 U	0.586 U	2.28	917	1280	1230	0.36 U	0.355 U	0.492 U	0.41 U
PCB 165	0.459 U	0.573 U	0.542 U	17 U	25.1 U	32.9 U	0.35 U	0.345 U	0.477 U	0.36 U
PCB 167	0.56 U	0.576 U	1.66 J	567	723	683	0.326 U	0.322 U	0.266 U	0.19 J
PCB 169	0.52 U	0.639 U	0.639 U	73.5 U	74.7 U	51.4 U	0.343 U	0.343 U	0.272 U	0.14 U
PCB 170	0.851 J	1.72	9.98	4090	5270	5370	1.28 U	0.519 U	0.663 U	0.39 U
PCB 171 & 173	0.624 U	0.676 U	3.41	1330	1740	1760	1.22 U	0.496 U	0.634 U	0.35 U
PCB 172	0.657 U	0.712 U	1.52 J	742	963	966	1.26 U	0.512 U	0.655 U	0.34 U
PCB 174	0.856 J	1.67 J	9.92	3660	4600	4940	1.17 U	0.473 U	0.605 U	0.38 U

Table 20. Detailed PCB Congener Analysis of Process Samples – Lime, Modifier, Sediment, and EcoAggMat

Sample	SL-01-03102005	SM-01-03102005	SM-02-03102005	SS-01-03102005	SS-03-03102005	SS-05-03102005	SEM-01-03102005	SEM-02-03102005	SEM-03-03102005	SEM-05-03102005
	Lime	Modifier	Modifier	Sediment			EcoAggMat			
Congener	ng/kg									
PCB 175	0.67 U	0.816 U	0.618 U	198	228	266	0.491 U	0.412 U	0.568 U	0.38 U
PCB 176	0.521 U	0.635 U	1.39	594	727	765	0.392 U	0.329 U	0.454 U	0.30 U
PCB 177	0.656 U	0.711 U	6.58	2880	3660	3660	1.19 U	0.482 U	0.616 U	0.36 U
PCB 178	0.749 U	0.912 U	2.51	1090	1380	1400	0.519 U	0.435 U	0.601 U	0.40 U
PCB 179	0.524 U	0.858 J	4.85	2030	2530	2630	0.382 U	0.32 U	0.442 U	0.29 U
PCB 180 & 193	1.27 U	3.37	21.9	9570	12200	12500	0.994 U	0.832 U	1.02 U	0.81 U
PCB 181	0.51 U	0.552 U	0.822 U	15.1 U	14.4 U	20.3 U	0.978 U	0.397 U	0.508 U	0.30 U
PCB 182	0.676 U	0.824 U	0.623 U	7.84 U	8.48 U	33.6 J	0.527 U	0.441 U	0.609 U	0.39 U
PCB 183 & 185	0.514 U	1.35 J	7.98	3640	4790	4650	1.03 U	0.415 U	0.53 U	0.31 U
PCB 184	0.482 U	0.587 U	0.444 U	5.44 U	19.1 J	21.9 J	0.355 U	0.297 U	0.41 U	0.28 U
PCB 186	0.515 U	0.628 U	0.475 U	6.01 U	6.51 U	7.98 U	0.391 U	0.327 U	0.452 U	0.31 U
PCB 187	0.723 J	2.13	13.5	6380	8100	8260	0.554 J	0.475 J	0.511 U	0.47 U
PCB 188	0.555 U	0.648 U	0.517 U	6.08 U	6.64 U	43.9	0.419 U	0.383 U	0.529 U	0.30 U
PCB 189	0.47 U	0.61 U	0.586 U	127	161	172	0.362 U	0.414 U	0.381 U	0.37 U
PCB 190	0.458 U	0.496 U	1.93	850	1090	1140	0.958 U	0.389 U	0.497 U	0.26 U
PCB 191	0.451 U	0.488 U	0.726 U	147	195	211	0.939 U	0.301 U	0.487 U	0.25 U
PCB 192	0.494 U	0.535 U	0.796 U	14.4 U	13.7 U	19.4 U	0.989 U	0.401 U	0.513 U	0.26 U
PCB 194	0.622 U	0.717 J	5.67 J	2380	2940	3000	0.667 U	0.599 U	0.529 U	0.78 U
PCB 195	0.711 U	0.78 U	2.12 J	823	1060	1090	0.662 U	0.595 U	0.525 U	0.83 U
PCB 196	0.803 U	0.926 U	3.8	1440	1930	1880	0.463 U	0.509 U	0.583 U	0.47 U
PCB 197 & 200	0.67 U	0.773 U	1.04 J	395	535	528	0.355 U	0.39 U	0.448 U	0.36 U
PCB 198 & 199	0.897 U	1.21 J	8.11	3270	4530	4160	0.488 U	0.537 U	0.616 U	0.48 U
PCB 201	0.675 U	0.779 U	0.854 J	432	574	563	0.353 U	0.388 U	0.445 U	0.37 U
PCB 202	0.68 U	0.786 U	2.06	851	1180	1080	0.377 U	0.44 U	0.499 U	0.41 U
PCB 203	0.864 U	0.996 U	4.24 J	1850	2510	2410	0.472 U	0.519 U	0.595 U	0.44 U
PCB 204	0.623 U	0.719 U	0.471 U	3.84 U	5.33 U	6.65 U	0.343 U	0.378 U	0.433 U	0.38 U
PCB 205	0.559 U	0.611 U	0.357 U	109	155	157	0.553 U	0.41 U	0.42 U	0.63 U
PCB 206	0.456 U	0.763 U	4.52	2280	3860	2710	1.54 U	0.558 U	1.04 U	0.60 U
PCB 207	0.378 U	0.627 U	0.477	271	416	322	1.2 U	0.444 U	0.847 U	0.49 U
PCB 208	0.373 U	0.611 U	1.63 J	857	1530	1060	1.21 U	0.457 U	0.887 U	0.46 U
PCB 209	0.742 U	0.778 U	4.07 J	2490	3080	3270	0.768 U	0.558 U	0.652 U	0.30 U
Total TEQ	0.0274	0.0461	0.0442	10.8	11.3	10.85	0.0122	0.0201	0.019	0.014

J = The analyte was detected. The reported numerical value is considered to be estimated for quality control reasons.
U = The analyte was not detected. The reported numerical value is the sample detection limit.
UJ = The analyte was not detected. The reported sample detection limit is considered estimated for quality control reasons.

Table 21. Detailed Dioxin and Furan Congener Analysis of Process Samples – Lime, Modifier, Sediment, EcoAggMat, and Quench Liquid

	SL-01-03102005	SM-01-03102005	SM-02-03102005	SS-01-03102005	SS-03-03102005	SS-05-03102005	SEM-01-03102005	SEM-02-013102005	SEM-03-03102005	SEM-05-03102005	SB-01-03102005	LQ-01-03102005[a]
Sample	Lime	Modifier		Sediment (as fed)			EcoAggMat				Baghouse	Quench Liquid
	ng/kg (pg/g)											ng/L
2,3,7,8-Tetrachlorodibenzo (p) Dioxin	0.184 U	0.196 U	0.283 U	71.4	77.7	117	0.478 U	0.575 U	0.506 U	0.458 U	1.02 U	0.0036 U
1,2,3,7,8-Pentachlorodibenzo (p) Dioxin	0.235 U	0.245 U	0.257 J	3.94 J	4.28 J	4.99 J	0.677 U	0.676 U	0.671 U	0.658 U	2.27 J	0.0025 U
1,2,3,4,7,8-Hexachlorodibenzo (p) Dioxin	0.282 U	0.27 U	0.245 U	3.32 U	3.72 J	4.21 J	0.677 U	0.676 U	0.829 U	0.658 U	2.45 J	0.00472 U
1,2,3,6,7,8-Hexachlorodibenzo (p) Dioxin	0.274 U	0.262 U	0.21 J	16	16.3	16.7	0.677 U	0.676 U	0.806 U	0.658 U	8.41	0.00458 U
1,2,3,7,8,9-Hexachlorodibenzo (p) Dioxin	0.28 U	0.268 U	0.249 J	8.96	9.83	9.55	0.677 U	0.676 U	0.824 U	0.658 U	7.16 U	0.00469 U
1,2,3,4,6,7,8-Heptachlorodibenzo (p) Dioxin	0.198 J	0.245 U	2.11 J	260	264	256	0.818 J	0.508 J	0.601 J	0.826 U	45.3	0.00496 J
Octachlorodibenzo (p) Dioxin	1.41 J	1.19 J	17.7	2820	2810	2770	4.79 J	1.35 U	3.23 J	5.86 J	63.6	0.0381 J
2,3,7,8-Tetrachlorodibenzofuran	0.115 U	0.175 J	0.276 U	12.4	15.3 U	13.7	0.417 J	0.46 J	0.44 U	0.479 J	1.79 U	0.00271 U
1,2,3,7,8-Pentachlorodibenzofuran	0.235 U	0.245 U	0.486 U	10.8	10.7	11.9	0.195 J	0.676 U	0.671 U	0.658 U	1.18 J	0.0025 U
2,3,4,7,8-Pentachlorodibenzofuran	0.235 U	0.245 U	0.486 U	23.5	25.3	30.3	0.677 U	0.676 U	0.671 U	0.658 U	1.89 J	0.0025 U
1,2,3,4,7,8-Hexachlorodibenzofuran	0.235 U	0.245 U	0.486 U	132	134	211	0.677 U	0.676 U	0.671 U	0.658 U	1.54 U	0.00303 U
1,2,3,6,7,8-Hexachlorodibenzofuran	0.235 U	0.245 U	0.206 J	29.7	29.4	38.7	0.677 U	0.676 U	0.671 U	0.658 U	0.952 J	0.0028 U
2,3,4,6,7,8-Hexachlorodibenzofuran	0.235 U	0.245 U	0.486 U	16.3	18	19.7	0.677 U	0.676 U	0.671 U	0.658 U	1.55 J	0.00303 U
1,2,3,7,8,9-Hexachlorodibenzofuran	0.235 U	0.245 U	0.486 U	5 J	5.46 J	7.63	0.677 U	0.676 U	0.671 U	0.658 U	0.696 J	0.00346 U
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.235 U	0.245 U	1.1 U	484	474	691	0.385 J	0.676 U	0.671 U	0.347 J	2.05 J	0.00152 J
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.235 U	0.245 U	0.486 U	14.9	15.2	23.3	0.677 U	0.676 U	0.671 U	0.658 U	0.744 U	0.00352 U
Octachlorodibenzofuran	0.471 U	0.491 U	1.69 J	656	654	1160	0.509 J	1.35 U	1.34 U	0.605 J	2.98 J	0.00733 U
Total Tetrachlorodibenzo (p) Dioxins	0.184 U	0.371 U	0.751 U	122 J	126 J	169 J	1.19 U	1.05 U	1.07 U	0.979 U	290	0.0036 U
Total Pentachlorodibenzo (p) Dioxins	0.439 U	0.442 U	0.257 J	48.4 J	50.5 J	53.7	1.45 U	1.44 U	1.39 J	1.4 U	330	0.00428 U

Table 21. Detailed Dioxin and Furan Congener Analysis of Process Samples – Lime, Modifier, Sediment, EcoAggMat, and Quench Liquid

	SL-01-03102005	**SM-01-03102005**	**SM-02-03102005**	**SS-01-03102005**	**SS-03-03102005**	**SS-05-03102005**	**SEM-01-03102005**	**SEM-02-013102005**	**SEM-03-03102005**	**SEM-05-03102005**	**SB-01-03102005**	**LQ-01-03102005[a]**
Sample	Lime	Modifier		Sediment (as fed)			EcoAggMat				Baghouse	Quench Liquid
	ng/kg (pg/g)											ng/L
Total Hexachlorodibenzo (p) Dioxins	0.61 U	0.559 U	0.459 J	157	164	177	1.67 U	1.54 U	1.55 U	1.81 U	301	0.00472 U
Total Heptachlorodibenzo (p) Dioxins	0.198 J	0.245 U	4.08 J	646	642	628	0.818 J	0.508 J	0.601 J	0.568 J	91.5	0.0107 J
Total Tetrachlorodibenzofurans	0.115 U	0.175 J	0.451 U	303 J	309 J	328 J	0.417 J	0.46 J	0.44 U	0.479 J	20.5 J	0.00271 U
Total Pentachlorodibenzofurans	0.235 U	0.245 U	0.163 J	259 J	306 J	318	0.195 J	0.676 U	0.671 U	0.658 U	19 J	0.0025 U
Total Hexachlorodibenzofurans	0.235 U	0.245 U	0.696 J	389	429	556	0.677 U	0.676 U	0.671 U	0.658 U	13.1 J	0.00346 U
Total Heptachlorodibenzofurans	0.235 U	0.245 U	0.704 U	625	618	863	0.385 J	0.676 U	0.671 U	0.621	4.51 J	0.00484 J
Total TEQ*	0.74	0.78	1.11	117.9	126.2	180.0	2.04	2.16	2.12	2.01	7.36	0.01

U = The analyte was not detected. The reported value is the sample detection limit.
J = The analyte was detected. The reported value is considered to be estimated for quality control reasons.
* Full detection limit accounting was used to calculate the TEQ.

Table 22. Detailed Trace Metals Analysis of Process Samples – Lime, Modifier, Sediment, EcoAggMat, and Quench Liquid

Sample	SS-01-03102005	SS-02-03102005	SS-03-03102005	SS-04-03102005	SS-05-03102005	SS-06-03102005	SM-01-03102005	SM-02-03102005	SL-01-03102005[a]
	Sediment (as fed)						Modifier		Lime
	mg/kg								
Arsenic	9.2	8.5	8.2	9	9	10.4	0.99 U	3.1 U	5.1 U
Barium	71.3	78.2	70.8	74.5	78.2	25 U	20 U	21 U	22
Cadmium	1.2	1.2	1.2	1.8	1.9	0.63 U	0.49 U	0.52 U	0.49 U
Chromium	85.1	93.5	83.7	86.7	90.8	91.7	0.99 U	1.2	2.8
Copper	86	97	85.4	87	93.9	27.9	4.7	2.6 U	6.3
Lead	79.2	90.2	81.6	85.8	94.3	3.8	0.99 U	3.1 U	5.1 U
Mercury	1.8	1.8	1.7	1.9	1.9	1.6	0.03 U	0.031 U	0.031 U
Nickel	21.7	23.1	21.3	22.3	23.9	11.9	4 U	4.1 U	3.9 U
Selenium	2.1 U	2 U	1.2 U	2.2 U	2.2 U	1.6 U	0.99 U	3.1 U	5.1 U
Silver	2	2.2	1.8	2.2	2.4	1.3 U	0.99 U	1 U	0.98 U
Zinc	156	163	136	140	150	46.2	2.4 U	31.8	2.7 U

Sample	SB-01-03102005	SBX-01-03102005	SEM-01-03102005	SEM-02-03102005	SEM-03-03102005	SEM-04-03102005	SEM-05-03102005	SEM-06-03102005
	Baghouse		EcoAggMat					
	mg/kg							
Arsenic	7.7	27.5	11.4	1.4 U	9.8	11.2	10.7	10.4
Barium	52	122	29.9	28 U	27.4	31 U	28 U	30 U
Cadmium	2.5	4.3	0.72 U	0.71 U	0.66 U	0.77 U	0.71 U	0.76 U
Chromium	121	389	34.3 J	1.4 U	31.3 J	36.3 J	29.9 J	28.9 J
Copper	33.8	89.8	32.2 J	3.5 U	34.2 J	35.9 J	35.2 J	35.5 J
Lead	75.8	193	4.8	1.4 U	5.2	4.7	4.5	4.9
Mercury	0.031 U	0.041 U	0.043 U	0.042 U	0.043 U	0.047 U	0.045 U	0.048 U
Nickel	94.5	285	12.8	5.6 U	60	13.6	17.4	13.6
Selenium	5 U	4.4 U	2.1 U	1.4 U	1.6 U	1.6 U	2 U	1.7 U
Silver	1.5	2.8	1.4 U	1.4 U	1.3 U	1.5 U	1.4 U	1.5 U
Zinc	1,660	2,500	50.2	2.8 U	46.5	55	52.6	54

U = The analyte was not detected. The reported value is the sample detection limit.

a. Wet weight given for lime sample.

Table 23. Semi-Volatile Organic Compound Analysis of Process Samples – Lime, Modifier, Sediment, EcoAggMat, and Quench Liquid

Sample	SS-01-03102005	SS-02-03102005	SS-03-03102005	SS-04-03102005	SS-05-03102005	SS-06-03102005	SM-01-03102005	SM-02-03102005
	Sediment (as fed)						Modifier	
	µg/kg							
4,4'-DDT	20 U	21 U	20 U	21 U	21 UJ	21 UJ	17 U	17 U
Benzo (a) Anthracene	421	369	310	327	347	389 J	0.89 U	0.89 U
Benzo (a) Pyrene	420	426	380	393	397	450 J	1.8 U	1.8 U
Benzo (b) Fluoranthene	750	669	590	621	665 J	721 J	1.3 U	7.46
Benzo (k) Fluoranthene	155	207	181	180	181	219 J	0.97 U	0.97 U
Chrysene	365	421	335	350	372	404 J	1.5 U	1.5 U
Bis (2-Ethylhexyl) Phthalate	1,780	1,340 J	1,390	1,450	1,570 J	1570 J	28.5	47.3
Indeno (1,2,3-cd) Pyrene	188	181	181	193	200	210 J	0.81 U	0.82 U

Sample	SL-01-03102005[a]	SB-01-03102005	SBX-01-03102005[b]	SEM-01-03102005	SEM-02-03102005	SEM-03-03102005	SEM-04-03102005	SEM-05-03102005	SEM-06-03102005
	Lime	Baghouse	Duplicate	Solid/EcoAggMat					
	µg/kg								
4,4'-DDT	96 U	91 U	23 U	24 U	23 U	22 U	26 U	24 UJ	25 U
Benzo (a) Anthracene	5 U	4.7 U	1.2 U	1.2 U	1.2 U	1.1 U	1.3 U	1.2 U	1.3 U
Benzo (a) Pyrene	10 U	9.6 U	2.5 U	2.5 U	2.5 U	2.3 U	2.7 U	2.5 U	2.6 U
Benzo (b) Fluoranthene	7.3 U	6.9 U	1.8 U	1.8 U	1.8 U	1.7 U	2 U	1.8 U	1.9 U
Benzo (k) Fluoranthene	5.4 U	5.1 U	1.3 U	1.3 U	1.3 U	1.3 U	1.5 U	1.3 U	1.4 U
Chrysene	8.4 U	8 U	2 U	2.1 U	2 U	1.9 U	2.3 U	2.1 U	2.2 U
Bis (2-Ethylhexyl) Phthalate	41.3	20 U	56.1	5.1 U	5 U	4.8 U	5.6 U	5.1 U	5.4 U
Indeno (1,2,3-cd) Pyrene	4.6 U	4.3 U	1.1 U	1.1 U	1.1 U	1.1 U	1.2 U	1.1 U	1.2 U

U = The analyte was not detected. The reported value is the sample detection limit.
a. Wet weight given for lime sample.
b. Field duplicate sample.

Environmental Data on Other Process Materials

Samples of fresh lime, spent lime from the baghouse and granulator quench water were collected at the end of the March 2005 test campaign. The samples were analyzed for SVOCs and metals. The results of these analyses are presented in Table 24. The analyses of these samples for PCDD and PCDF congeners are presented in Table 25.

Table 24. SVOCs and Metals Analyses of Granulator Quench Water (average), Fresh Lime, and Spent Lime (average) from Cement-Lock Demo Plant Test (March 10, 2005)

Sample	Granulator Quench Water (average)	Fresh Lime	Spent Lime (average)
	--- µg/L ---	------ µg/kg ------	
4,4'-DDT	< 0.0500*	96	< 57
Acenaphthene	< 0.0490	NA**	NA
Acenaphthylene	< 0.0420	NA	NA
Anthracene	< 0.0072	NA	NA
Benzo (a) Anthracene	< 0.0061	< 5	< 3
Benzo (a) Pyrene	< 0.0069	< 10	< 6
Benzo (b) Fluoranthene	< 0.0053	< 7.3	< 4.4
Benzo (g,h,i) Perylene	< 0.0066	NA	NA
Benzo (k) Fluoranthene	< 0.0110	< 5.4	< 3.2
Chrysene	< 0.0730	< 8.4	< 5.0
Dibenz (a,h) Anthracene	< 0.0073	NA	NA
Fluoranthene	< 0.0440	NA	NA
Fluorene	< 0.0150	NA	NA
Indeno (1,2,3-cd) Pyrene	< 0.0059	< 4.6	< 2.7
Naphthalene	< 0.0830	NA	NA
Phenanthrene	< 0.0130	NA	NA
Pyrene	< 0.0070	NA	NA
Bis (2-Ethylhexyl) Phthalate	NA	**41.3**	**38**
	--- µg/L ---	--- mg/kg ---	
Arsenic	**27.3**	< 5.1	**17.6**
Barium	< 200	**22**	**87.0**
Cadmium	< 4	< 0.49	**3.4**
Chromium	**50.0**	**2.8**	**255.0**
Copper	**63.6**	**6.3**	**61.8**
Lead	**42.6**	< 5.1	**134.4**
Mercury	< 0.2	< 0.031	< 0.04
Nickel	< 40	< 3.9	**189.8**
Selenium	< 5	< 5.1	< 4.7
Silver	< 10	< 0.98	**2.2**
Zinc	**203.5**	< 2.7	**2080**

* < Less than the analytical method detection limit.
** NA = Not analyzed.
Bold-faced value = analyte detected in sample. Normal-faced value = the analyte was not detected above the sample detection limit.

Table 25. PCDD and PCDF Congener Analyses of Fresh Lime, Spent Lime, and Granulator Quench Water from Cement-Lock Demo Plant Test (March 10, 2005)

Sample	Fresh Lime	Spent Lime	Granulator Quench Water
Congener	---- ng/kg (pg/g) ----		-- ng/L --
2,3,7,8-Tetrachlorodibenzo (p) Dioxin	< 0.184*	< 1.02	< 0.0036
1,2,3,7,8-Pentachlorodibenzo (p) Dioxin	< 0.235	**2.27**	< 0.0025
1,2,3,4,7,8-Hexachlorodibenzo (p) Dioxin	< 0.282	**2.45**	< 0.00472
1,2,3,6,7,8-Hexachlorodibenzo (p) Dioxin	< 0.274	**8.41**	< 0.00458
1,2,3,7,8,9-Hexachlorodibenzo (p) Dioxin	< 0.28	**7.16**	< 0.00469
1,2,3,4,6,7,8-Heptachlorodibenzo (p) Dioxin	**0.198****	**45.3**	**0.00496**
Octachlorodibenzo (p) Dioxin	**1.41**	**63.6**	**0.0381**
2,3,7,8-Tetrachlorodibenzofuran	< 0.115	< 1.79	< 0.00271
1,2,3,7,8-Pentachlorodibenzofuran	< 0.235	**1.18**	< 0.0025
2,3,4,7,8-Pentachlorodibenzofuran	< 0.235	**1.89**	< 0.0025
1,2,3,4,7,8-Hexachlorodibenzofuran	< 0.235	< 1.54	< 0.00303
1,2,3,6,7,8-Hexachlorodibenzofuran	< 0.235	**0.952**	< 0.0028
2,3,4,6,7,8-Hexachlorodibenzofuran	< 0.235	**1.55**	< 0.00303
1,2,3,7,8,9-Hexachlorodibenzofuran	< 0.235	**0.696**	< 0.00346
1,2,3,4,6,7,8-Heptachlorodibenzofuran	< 0.235	**2.05**	**0.00152**
1,2,3,4,7,8,9-Heptachlorodibenzofuran	< 0.235	< 0.744	< 0.00352
Octachlorodibenzofuran	< 0.471	**2.98**	< 0.00733
Total Tetrachlorodibenzo (p) Dioxins	< 0.184	**290**	< 0.0036
Total Pentachlorodibenzo (p) Dioxins	< 0.439	**330**	< 0.00428
Total Hexachlorodibenzo (p) Dioxins	< 0.61	**301**	< 0.00472
Total Heptachlorodibenzo (p) Dioxins	**0.198**	**91.5**	**0.0107**
Total Tetrachlorodibenzofurans	< 0.115	**20.5**	< 0.00271
Total Pentachlorodibenzofurans	< 0.235	**19**	< 0.0025
Total Hexachlorodibenzofurans	< 0.235	**13.1**	< 0.00346
Total Heptachlorodibenzofurans	< 0.235	**4.51**	**0.00484**
Total TEQ$^+$	**0.74**	**7.24**	**0.0105**

* < Less than the analytical detection limit.
** Bold-faced value = analyte detected in sample.
$^+$ Full detection limit accounting was used to calculate the TEQ.

The data in the Table 24 show that the sample of fresh lime and the spent lime collected from the baghouse did not have any specific SVOCs above the analytical detection limit. Bis (2-ethylhexyl) phthalate was detected in both samples. The spent lime did contain some trace metal contaminants, but no mercury was detected.

The granulator quench water also did not have any SVOCs above the analytical detection limit. The quench water did contain some trace metal contaminants, but no mercury was detected.

The data in Table 25 show that the fresh lime, spent lime, and granulator water contained traces of PCDD and PCDF congeners measured at the nanogram per kilogram (ng/kg or pg/g) level. It should be noted that these samples were taken near the mid-point of the 17-day campaign in March 2005 and the contaminant accumulation rate can not be accurately determined. If the rate of contaminant accumulation is assumed to be constant up to the sampling time, then the estimated TEQ of the PCDD and PCDF congeners in the spent lime and granulator quench water represents less than 0.0015 percent of the total TEQ contaminant load.

When the Cement-Lock system is operated in slagging mode producing Ecomelt, the flue gas stream is subjected to much higher temperatures (2400° to 2600°F compared with 1835°F for the non-slagging test) that will ensure complete destruction of PCDD and PCDF congeners.

From a Cement-Lock process design and operational standpoint, the granulator quench water can be recycled to extinction to the process for additional thermal treatment to destroy PCDD and PCDF congeners. The non-volatile metals in the granulator quench water can thereby be incorporated into the Ecomelt. Similarly, at least a portion of the spent lime can be recycled to the process for additional thermal treatment to destroy PCDD and PCDF congeners, and as a Modifier 1 supplement. The metals in the recycled spent lime can also be incorporated into the Ecomelt. Recycling all of the spent lime is not planned as trace metals will continue to accumulate in the spent lime stream eventually reaching levels that may impact Ecomelt quality.

It is important that these process streams be recycled to the process for additional thermal treatment, so that the spent lime or granulator quench water streams will not contain the trace metal contaminants. The only environmentally acceptable alternative is to dispose of these streams properly.

Cement Properties of Ecomelt

A sample of Ecomelt from Test No. 1 (slagging test, December 10, 2003) was submitted to CTLGroup (formerly Construction Technology Laboratories) for evaluation. CTLGroup conducted XRD (x-ray diffraction) tests on the untreated sediment (Figure 5) for comparison with the Ecomelt (Figure 6). The results showed that the Ecomelt was amorphous, glassy material, whereas the sediment had specific crystalline components.

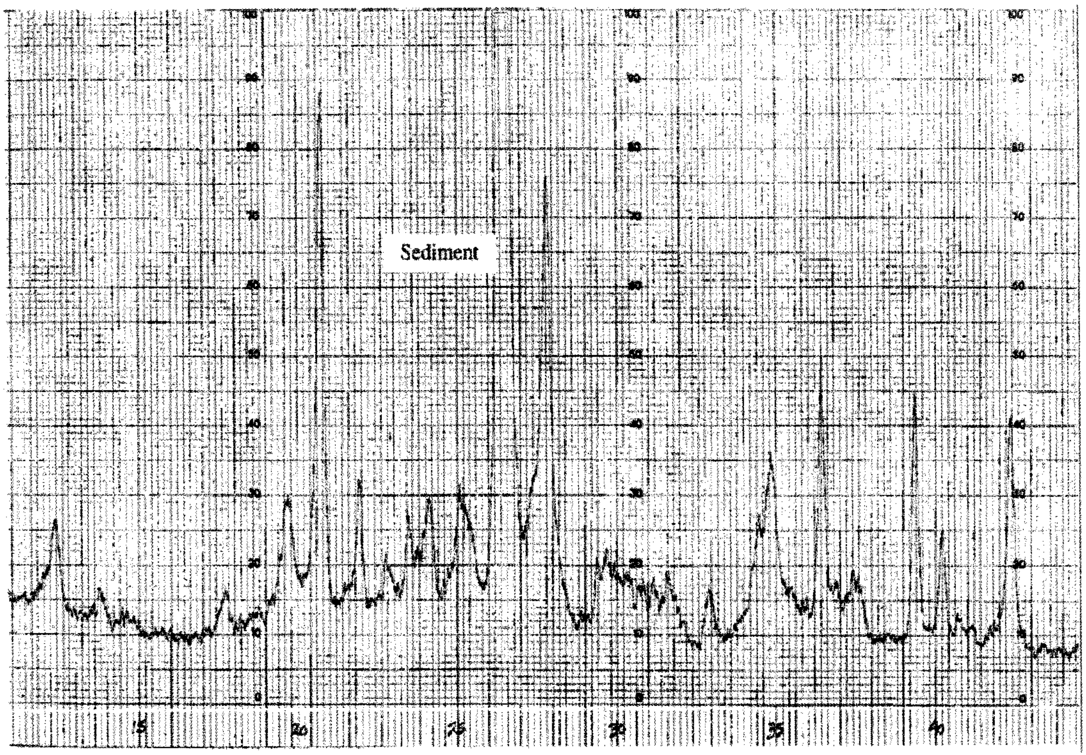

Figure 5. X-Ray Diffraction of Dredged Sediment from Stratus Petroleum – Peaks Indicate Crystalline Phases of Mineral Matter

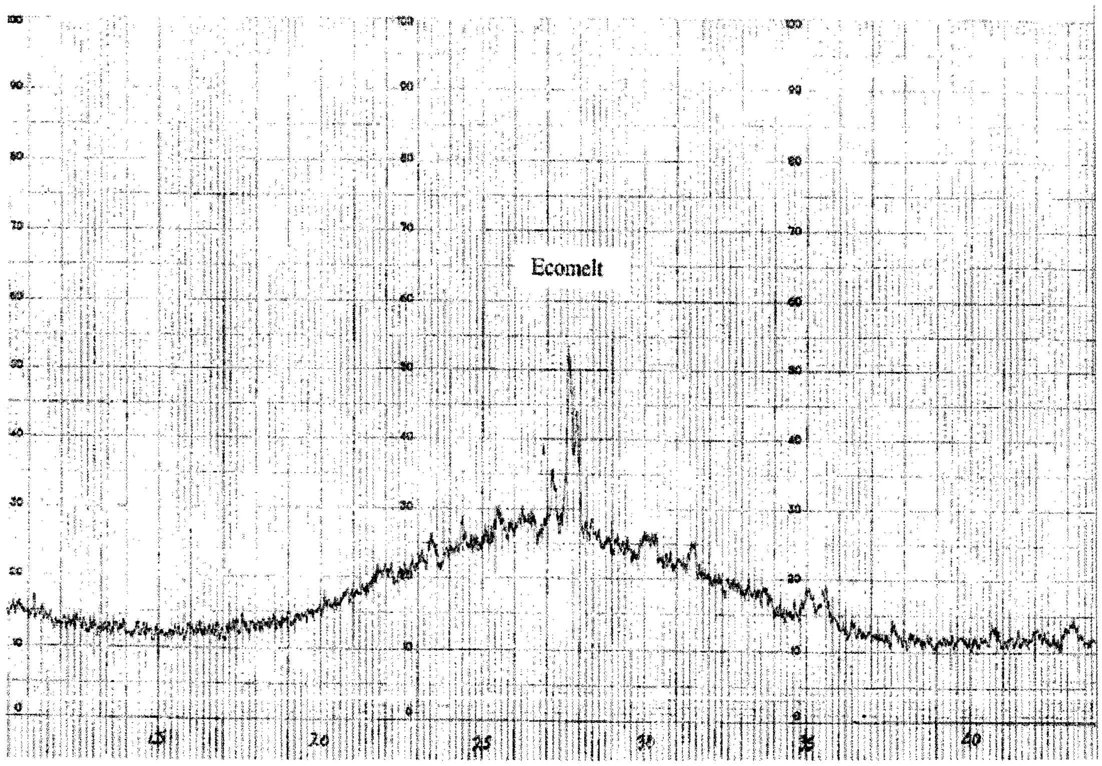

Figure 6. X-Ray Diffraction of Ecomelt from Stratus Petroleum Sediment – Lack of Peaks Indicates Desired Glassy Nature

CTLGroup also conducted tests to determine the compressive strength of the Ecomelt according to ASTM C-109. The results are compared with the compressive strength requirements of Portland cement per ASTM C-150 in Table 26. The results of these tests showed compressive strengths after 1, 3, 7, and 28 days of curing of 750, 1765, 2910, and 5190 psi, respectively, which compare very favorably with previous results. The ASTM standard does not have a 1-day compressive strength requirement. CTLGroup determined this value to gauge the initial curing rate of the Ecomelt sample. The compressive strength results exceed the ASTM requirements for both Portland and blended cements after 7 and 28 days of curing. After 3 days of curing, the compressive strength of Cement-Lock cement was less than that required for blended cements (C-595), but greater than that required for Portland cement (C-150). The results of the ASTM C-1073 test (hydraulic activity of ground Ecomelt in 20 weight percent NaOH solution cured at 55°C for 1 day) was 4380 psi (30.2 MPa). This test is used to estimate the hydraulicity of potential pozzolanic materials. This result is quite favorable.

Table 26. Comparison of Compressive Strength of Ecomelt from Demo Plant Test No. 1 with ASTM Standard Requirements for Portland and Blended Cements

Test Period, Days	Cement-Lock Demo Plant Test No. 1	ASTM Cement Requirements C-595 Blended	ASTM Cement Requirements C-150 Portland
	---------- psi ----------		
1	**750**	NA*	NA
3	**1765**	1890	1740
7	**2910**	2900	2760
28	**5190**	3480	4060

*NA = there is no 1-day compressive strength requirement under these ASTM standards

Physical Properties of EcoAggMat

The physical properties of the EcoAggMat generated during the March 2005 campaign affect its ultimate beneficial use. Targeted uses of EcoAggMat are as clean fill at the BASF site in Kearny, NJ and as a partial replacement for sand in BASF's foam core building panels. The bulk density of the EcoAggMat from the laboratory-scale test was about 35 lb/ft^3. This is roughly the same bulk density as other samples of so-called "lightweight" aggregate.

As a subcontractor to the EPA SITE Program, CTLGroup conducted specific tests to determine the suitability of EcoAggMat as a partial replacement for sand in mortar mixes. Mortar is a prescribed mixture of Portland cement, water, and sand; concrete is a prescribed mixture of Portland cement, water, sand, <u>and</u> gravel. The following tests were conducted on a bulk sample of EcoAggMat:

- Moisture content (ASTM C 566)
- Particle size distribution (ASTM C 136)
- Specific gravity (ASTM C 128)
- Water Absorption (ASTM C 128)
- Reactivity (ASTM C 289)
- Soundness (ASTM C 88)
- Autoclave Expansion (ASTM C 151)
- Air Content (ASTM C 185), and
- Compressive Strength (sample preparation per ASTM C 109).

The as-received sample of EcoAggMat contained 30.1 weight percent water. It was coarse-grained and lumpy. Some material appeared to have set (hardened into lumps), probably due to lime-rich conditions. About 13.5 percent of the sample was less than 100 mesh. As this material is too small for sand replacement, it was segregated from the bulk sample. The specific gravity of the sample was 1.85, which is notably lower than that of sand (2.65). Water absorption by the fairly porous EcoAggMat was 15.6 weight percent. Water absorption by sand is typically < 0.5 weight percent. Thus, the water demand would be higher for mortars made with EcoAggMat as a partial replacement for sand.

The reactivity of EcoAggMat was determined according to ASTM C-289. In this standard, the sample of material is reacted with sodium hydroxide solution to determine the extent of dissolution. The results showed the EcoAggMat to be non-reactive. The soundness test (ASTM C-88) simulates extended weathering of a material by repeated immersion of the sample in a magnesium sulfate solution over the course of seven days. The results showed a weight loss of 6.21 percent, which is well below the specified maximum limit of 15 percent for fine aggregates.

For autoclave expansion (ASTM C-151), air content (ASTM C-185), and compressive strength (ASTM C-109 sample preparation) tests, CTLGroup prepared samples of mortar with different blends of EcoAggMat and Ottawa sand, Portland cement and water. The blends of EcoAggMat and Ottawa sand were prepared on a volume basis rather than a weight basis because the specific gravity of the EcoAggMat was much lower than that of Ottawa sand.

EcoAggMat : Ottawa Sand Blend	EcoAggMat, vol %	Ottawa Sand, vol %
3:1	75	25
1:1	50	50
0:1 (control)	0	100

The results of autoclave expansion tests showed an average of 0.10 percent expansion for the 3:1 sample, 0.09 percent for the 1:1 sample, and 0.07 percent for the control (0:1). ASTM C-150 (Portland cement standard) allows a maximum of 0.8 percent expansion for this test. The air content of the samples was determined to be 5.5 percent for the 3:1 sample, 5.2 percent for the 1:1 sample and 9.1 percent for the control. ASTM C-150 allows a maximum of 12 percent air content for this test.

CTLGroup determined the compressive strength of 2-inch cubes of EcoAggMat-Ottawa sand blends and control (no EcoAggMat) after 3, 7, and 28 days of curing (hardening). The results of these tests are presented below and compared with the compressive strength requirement for Portland cement (per ASTM C-150). The results show that the compressive strength of the EcoAggMat-sand blends increased with curing time, similar to the mortar made with sand alone. The 3:1 EcoAggMat-sand blend fell short of the 28-day compressive strength requirement. The 1:1 EcoAggMat-sand blend achieved lower, but comparable compressive strengths to those of the control.

Sample	3:1 Eco:Sand	1:1 Eco:Sand	Control (0:1 Eco:Sand)	ASTM C-150 Requirement for Portland Cement
Test Period, days	------------------------------ Compressive Strength, psi ------------------------------			
3	2070	2360	2910	1740
7	2860	3400	4220	2760
28	3540	4490	4850	4060

Overall, the results show that EcoAggMat can be used as a partial replacement (up to 50 volume percent) for sand in mortars. CTLGroup said that additional testing would be required. The report prepared by CTLGroup is included in Appendix Q.

V. ECONOMIC EVALUATION AND ASSESSMENT

A major objective of the overall Sediment Decontamination Demonstration Project is to demonstrate that the treatment technology can be economically viable in the NY/NJ Harbor marketplace. Specifically, the technology must be able to demonstrate that the required tipping fee for sediment dredged from harbor navigation channels does not exceed \$35/yd^3. The following discussion provides an evaluation and assessment of the economics of processing dredged sediment through a commercial-scale (500,000 yd^3/year capacity) Cement-Lock plant.

As Cement-Lock is a high-temperature thermal technology, it is energy intensive and its economics are sensitive to the cost of fuel. When the Cement-Lock Technology was proposed for the NJ Sediment Decontamination Demonstration Project, the natural gas cost was \$4/million Btu. For this economic evaluation, the cost of natural gas of \$9/million Btu was based on the average cost of natural gas during a recent 24-month span in Public Service Electric & Gas' (PSE&G) service area. An extended average for natural gas cost was taken rather than a "snapshot" cost from the period following the devastation of the U.S. Gulf Coast by Hurricanes Katrina and Rita, which sent local PSE&G natural gas prices to near \$17/million Btu.

The Cement-Lock Technology is flexible regarding co-processing of other materials with sediment, some of which have significant calorific value. For example, supplemental or alternate fuels, such as waste petroleum oils and sludges, tanker bottoms, municipal solid wastes, municipal sewage sludges, medical wastes, and shredded tires can be used to reduce energy-related costs. Further, some of these materials have tipping fees associated with their use, which increase revenues and enhance the Cement-Lock economics. However, all economic projections shown here assume no benefits from side stream materials and therefore can be considered conservative.

The economic evaluation includes the base case, basis of design, plant description, equipment summary, equipment cost estimate, total installed cost, and estimated operating cost. Costs for on-site sediment storage, screening, and handling have been included as an operation expense. The sensitivity of sediment treatment cost to several process and economic parameters was also assessed.

Base Case

The Base Case is a preliminary design and cost estimate of a commercial-scale Cement-Lock plant to decontaminate and convert 500,000 yd^3/year of dredged sediment to 243,000 ton/year of dry and pulverized Ecomelt product. The Ecomelt is shipped to an off-site location, blended with Portland cement, and used as construction-grade cement. The plant also generates 9.55 MW of electricity for export.

The estimated purchased major equipment cost and the total installed cost are $28,175,000 and $81,626,000, respectively, which includes 8 acres of on-site sediment storage. A natural gas cost of $9/million Btu is based on the averaged natural gas cost for a recent 24-month span in PSE&G' service area. Using these conditions and assumptions, the break-even tipping fee for the dredged sediment is $34.97/$yd^3$ of dredged sediment.

The capital and operating costs can be reduced by further optimizing the design and operations including but not limited to co-processing of waste materials containing calorific value such as waste petroleum oils and sludges, tanker bottoms, municipal solid wastes, municipal sewage sludges, medical wastes, and shredded tires; mechanical dewatering combined with thermal drying for dredged sediment; combustion of oxygen-enriched-air or oxygen with natural gas/other fuels in the kilns; and improved process and equipment design and costing.

Basis of Design

The basis of design and assumptions used in design calculations are summarized below:

1. The proposed plant is an "n^{th}" plant operating on a 24 hour/day and 7 day/week basis with an on-line factor of 90 percent.
2. The plant consists of multiple operating trains with no spare equipment.
3. The proximate, ultimate, and ash analyses of "as-dredged" sediment are given below. The sediment is screened to a particle size of less than 2 inches.
4. Dredged sediment is unloaded from barges or supply trucks, screened to remove oversized debris and stored in the on-site sediment storage area. For the base case, the sediment storage area is 8 acres. The sediment is then transferred to the sediment dryers by crane unloaders equipped with clamshell buckets.
5. Dredged sediment is dried in indirect-contact, rotary steam-tube dryers where the sediment moisture content is reduced from 60 to 15 percent. The sediment solids in the dryers are maintained at a temperature of < 220°F to prevent volatilization of contaminants during

drying. Effluent gases from the sediment dryers are fed to the Gas Cleanup Section for treatment before being discharged to the atmosphere. Superheated low-pressure steam generated from the heat recovery boilers is used for sediment drying.

6. Dried sediment is blended with a predetermined amount of modifier solids in the mixers before being fed to the Ecomelt Generators. The sediment storage pit, sediment dryers and mixers are located inside of the sediment receiving building.

7. The feed materials are melted in the rotary kiln Ecomelt Generators at 2400°F in the presence of excess oxygen. Superficial gas velocity in the kiln and oxygen concentration at the kiln outlet are maintained at less than 15 ft/s and greater than 2 volume percent (dry basis), respectively, to ensure complete destruction of contaminants and to minimize the carryover of fly ash.

Proximate Analysis, wt %			**Ash Analysis, wt % (dry)**	
Moisture	60.00		SiO_2	66.67
Ash	36.52		Al_2O_3	13.71
Volatile Matter	3.43		TiO_2	0.87
Fixed Carbon	0.05		Fe_2O_3	6.83
Total	100.00		CaO	1.78
			MgO	2.15
Ultimate Analysis, wt % (dry)			K_2O	2.59
Ash	91.31		Na_2O	2.24
Carbon	3.53		SO_3	1.06
Hydrogen	0.66		P_2O_5	0.48
Nitrogen	0.33		SrO	0.02
Sulfur	0.83		BaO	0.06
Oxygen (by diff.)	3.34		Mn_3O_4	0.12
Total	100.00		Others (by diff.)	1.42
			Total	100.00

Sediment Calorific Value (HHV), Btu/lb (dry)	700
Dredged Sediment Bulk Density, lb/ft^3 (wet)	77

8. The temperature and gas residence time in the secondary combustion chambers (SCC) are maintained at > 2200°F and 2 seconds, respectively. Oversized vertical SCCs are used to facilitate the settling of fly ash carried over from the Ecomelt Generators and to minimize the entrainment of fly ash to the heat recovery boilers.

9. Hot off-gases from the SCCs are cooled to 300°F in the heat recovery boilers where superheated, high-pressure steam at 600 psia and 900°F is generated. A slip stream of the steam generated is depressurized and fed to the sediment and Ecomelt dryers for drying of dredged sediment and Ecomelt. The remaining steam is fed to steam turbine generators to generate electric power.

10. Powdered lime and activated carbon sorbents are injected separately into the cooled off-gases exiting the heat recovery boilers where acid gases and volatile metal species are removed. Spent lime and carbon sorbents are then removed from the off-gas stream in separate lime and carbon baghouses. Spent sorbents are collected for disposal.

Conventional dosage rates are used for the sorbents. Cleaned off-gas is then vented to the atmosphere through the exhaust fans and an exhaust stack.

11. Ecomelt is dewatered by inclined conveyors of the Ecomelt granulators and then dried in the Ecomelt dryer by indirect contact with superheated, low-pressure steam generated from the heat recovery boilers. As there are no contaminants in the wet Ecomelt granulates, the off-gas from the Ecomelt dryer is discharged directly to the atmosphere. Dried Ecomelt is pulverized in a pulverizer system. Dried and pulverized Ecomelt product is stored in a hopper.
12. Ecomelt is shipped to an off-site location for blending with Portland cement to yield construction-grade blended cement. The Ecomelt could also be sent to ready-mix plants where it would be used as a partial replacement for Portland cement in the manufacture of concrete. The off-site processing is outside the battery limits of the Cement-Lock plant.

Plant Description

A schematic flow diagram of the proposed plant is shown in Figure 7. The plant consists of Feed Handling, Sediment Treatment, Gas Cleanup, and Power Generation sections. A brief description of each section is given below.

Section 100: Feed Handling

Dredged sediment is received at the plant site, screened to remove oversized debris, and off-loaded from barges or trucks into the on-site (long-term) sediment storage area. From the long-term storage, sediment is delivered to the process plant by trucks and weighed by truck scales near the receiving building (RB-101). The trucks are lined with membranes to prevent spilling and dripping during shipping. The truck scales can weigh the largest supply trucks allowed on the road. Sediment is then dumped into a storage pit inside the receiving building. The receiving building is under a slight negative pressure and has a large floor area to allow quick and easy maneuvering of several supply trucks unloading at the same time.

The sediment storage pit consists of two compartments: one for wet sediment and one for dried sediment. Each compartment provides two days of plant capacity. Wet sediment is transferred from the storage pit to Sediment Dryers (SD-101) by Crane Unloaders (CU-101) equipped with clamshell buckets. Two 100 percent capacity crane unloaders are used to ensure continuous operation. Wet sediment is dried in two 50 percent capacity Sediment Dryers (SD-101). The Sediment Dryers are indirect-contact, rotary steam-tube dryers. Dried sediment is returned to the storage pit by Dried Sediment Conveyors (BC-101). The temperature of sediment solids in the

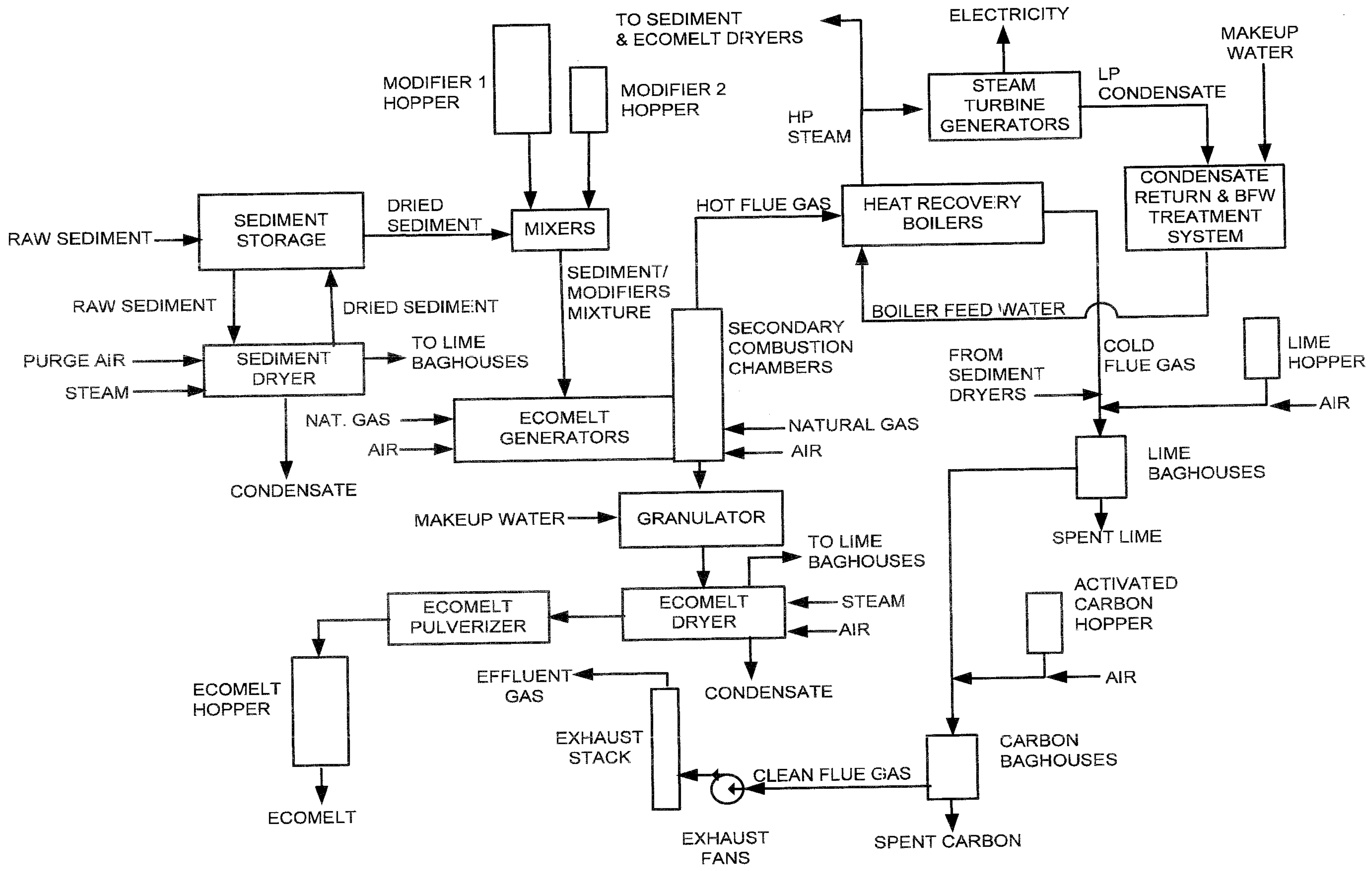

Figure 7. Schematic Flow Diagram of a Commercial-Scale Cement-Lock Plant (Base Case)

dryers is maintained at < 220°F to prevent volatilization of contaminants from dredged sediment during drying. Superheated low-pressure steam generated in the Heat Recovery Boilers (HR-301) is used for drying. Condensate from the sediment dryers is collected and returned to the Heat Recovery Boilers by Condensate Pumps (CP-401) and Boiler Feed Water Pumps (WP-401). Off-gas from the sediment dryers is fed to the Gas Cleanup Section for treatment before discharge to the atmosphere.

Modifier solids are pneumatically transferred from supply trucks to Modifier 1 and Modifier 2 Hoppers (TK-101 and TK-102). The hoppers are equipped with discharge cones, rotary feeders and discharge conveyors. Modifier solids are fed from the hoppers to two 50 percent capacity Mixers (MX-101) by Modifier Conveyors (SC-101 and SC-102). Dried sediment is fed from the storage pit to the mixers by Dried Sediment Conveyors (BC-102).

The sediment storage pit, sediment dryers and mixers are located inside the receiving building.

Section 200: Sediment Treatment

The dried sediment and modifiers mixture is fed from the Mixers (MX-101) to four 25 percent capacity Ecomelt Generators (EG-201). The Ecomelt Generators are rotary kilns where the feed solids are melted at 2400°F in the presence of excess oxygen with sufficient solids and gas residence time so that the organic contaminants contained in the sediment are destroyed and converted to carbon dioxide and water. Superficial gas velocity in the kilns and oxygen concentration at the kiln outlets are maintained at < 15 ft/s and > 2 volume percent (dry basis), respectively, to ensure complete destruction of contaminant species and to minimize the carry over of fly ash.

The molten slag discharged from the Ecomelt Generators (EG-201) is quenched with water, solidified and converted to Ecomelt granules in four 25 percent capacity Granulators (GR-202). Any non-volatile inorganic contaminants contained in the sediment are immobilized in the matrix of the resultant Ecomelt granules. Ecomelt granules are then dewatered in the granulators and conveyed to the Ecomelt Dryer (ED-201). The Ecomelt dryer is a rotary steam-tube dryer where the Ecomelt granules are indirectly dried with low-pressure steam generated from the Heat Recovery Boilers (HR-301). Dry Ecomelt is pulverized in the Ecomelt Pulverizer (EP-201), stored in the Ecomelt Hopper (TK-201), and then hauled away by trucks for off-site processing.

Flue gases from the Ecomelt Generators are fed to four 25 percent capacity Secondary Combustion Chambers (SCC, SC-202) where the flue gases are further combusted with natural gas and air, if necessary, to ensure complete destruction of contaminants contained in the flue gases.

Section 300: Gas Clean-Up

Hot flue gas from the SCCs is cooled to 300°F in four 25 percent capacity Heat Recovery Boilers (HR-301) where superheated high pressure steam is generated at 600 psia and 900°F. A slip stream of steam is depressurized to 150 psia and fed to the sediment dryers and Ecomelt dryer. The remaining steam is fed to four 25 percent capacity Steam Turbine Generators (ST-401) where electricity is generated.

Cooled flue gases exiting the Heat Recovery Boilers is combined with the off-gases from the Sediment Dryers (SD-101) and Ecomelt dryer and fed to two 50 percent capacity gas clean-up systems. Powdered lime sorbent is injected into the cooled flue gases where acid gases are removed. The flue gases are then fed to Lime Baghouses (BH-301) where spent lime sorbent is collected for disposal. Powdered activated carbon sorbent is then injected into the flue gases exiting the lime baghouses where volatile metal species are removed. The flue gases are then fed to Carbon Baghouses (BH-302) where the spent carbon sorbent is collected for disposal.

Cleaned flue gases from the Carbon Baghouses are fed to two 100 percent capacity Exhaust Fans (B-301) and discharged to the atmosphere through one 100 percent Exhaust Stack (ST-301).

Section 400: Power Generation

Superheated high-pressure steam generated in Heat Recovery Boilers (HR-301) is fed to four 25 percent capacity Steam Turbine Generators (ST-401) where electricity is generated. A portion of the generated electricity is used to supply the power required to operate the entire plant equipment. The remaining power is exported to the grid.

The exhaust steam from the steam turbine generators is condensed and recycled to the heat recovery boilers through four 25 percent capacity condensate return system trains. The condensate return system consists of Condensers (CD-401), Condensate Pumps (CP-401), and Boiler Feed Water Pumps (WP-401). The Boiler Feed Water Pumps raise the pressure of the returned condensate and makeup boiler feed water to the operating pressure level of the heat recovery boilers. Makeup water is treated in one 100 percent capacity Boiler Feed Water Treatment System (WT-401) before it is fed to the condensate return system.

Cooling water to Condensers (CD-401) is provided by one 100 percent capacity Cooling Tower (CT-401) and four 25 percent capacity Cooling Water Pumps (CP-402).

Mass Balance

The plant-wide mass balance is given below.

Input Streams	lb/hr	**Output Streams**	lb/hr
Dredged sediment	131,849	Dry Ecomelt	61,613
Modifier 1	21,600	Exhaust gas	562,150
Modifier 2	1,360	Spent lime	2,403
Purged air to sediment dryers	111,839	Spent carbon	124
Natural gas to Ecomelt generators	14,124	Ecomelt dryer off-gas	17,814
Air to Ecomelt generators	286,707		
Makeup water to granulators	60,003		
Lime sorbent	1,529		
Activated carbon sorbent	124		
Convey air for lime	2,000		
Convey air for activated carbon	2,000		
Purged air to Ecomelt dryer	10,969		
Total In	644,104	**Total Out**	644,104

Utility Requirements

The estimated requirements for electricity, natural gas and water for the plant are given below. A total of 12.25 MW is generated in Steam Turbine Generators (ST-401). The electric power requirement for the plant is 2.7 MW. The net power generated for export is 9.55 MW.

Electricity, kW-hr/day	64,895
kW-hr/ton Dredged Sediment	41.02
Plant Electrical Requirement, MW	2.70
Natural Gas, Btu/day	7,815,723,787
Btu/ton Dredged Sediment	4,939,808
Water, gal/day	397,654
gal/ton Dredged Sediment	251

Equipment Summary

A brief summary of the major process equipment items for the Feed Handling, Sediment Treatment, Gas Cleanup, and Power Generation sections including key design and operating parameters follows.

Section 100: Feed Handling			
Equip. No.	**Equipment Name**	**Qty**	**Equipment Description**
RB-101	Sediment Receiving Building	1	Enclosed building houses a Sediment Storage Pit with two compartments – one for dredged sediment and one for dried sediment, Crane Unloaders (CU-101), Sediment Dryers (SD-101) and Mixers (MX-101). Equipped with multiple bay doors to allow easy maneuvering of sediment supply trucks and unloading operation.
CU-101	Crane Unloader	2	Overhead bridge crane equipped with clamshell bucket rated to transfer 70 ton/hr of dredged sediment from Sediment Storage Pit to Sediment Dryer (SD-101). Equipped with 350 HP motor.
SD-101	Sediment Dryer	2	Rotary steam-tube dryer rated to dry 33 ton/hr dredged sediment from 60 to 15% water content by condensing 150 psig supersaturated steam. Sediment temperature is maintained below 220°F. Equipped with carbon steel shell, internal steam tubes, and 125 HP motor and drive.
SF-101	Sediment Dryer Fan	2	Induced draft exhaust fan rated to discharge 25,000 SCFM off gas from Sediment Dryers (SD-101) at 220°F and negative 6" w.g. into atmosphere. Carbon steel structure, complete with damper, 40 HP motor and drive.
TK-101	Modifier 1 Hopper	1	Storage hopper rated for 1000 tons granulated Modifier 1 solids. Equipped with multiple discharge cones, rotary feeders and discharge screw conveyors.
TK-102	Modifier 2 Hopper	1	Storage hopper rated for 130 tons granulated Modifier 2 solids. Equipped with multiple discharge cones, rotary feeders and discharge screw conveyors.
BC-101	Dried Sediment Conveyor	2	Enclosed belt conveyor rated to convey 20 ton/hr dried sediment containing 15% water and 85% solids from Sediment Dryers (SD-101) to Storage Pit. Carbon steel construction, complete with motor and drive.
BC-102	Dried Sediment Conveyor	2	Enclosed belt conveyor rated to convey 20 ton/hr dried sediment containing 15% water and 85% solids from Storage Pit to Mixers (MX-101). Carbon steel construction, complete with motor and drive.
SC-101	Modifier 1 Conveyor	2	Screw conveyor rated to convey 6 ton/hr granulated Modifier 1 solids from Modifier 1 Hopper (TK-101) to Mixers (MX-101). Carbon steel construction, complete with motor and drive.

Section 100: Feed Handling			
Equip. No.	**Equipment Name**	**Qty**	**Equipment Description**
SC-102	Modifier 2 Conveyor	2	Screw conveyor rated to convey 2 ton/hr granulated Modifier 2 solids from Modifier 2 Hopper (TK-102) to Mixers (MX-101). Carbon steel construction, complete with motor and drive.
MX-101	Sediment-Modifier Mixer	2	Continuous horizontal solids mixer rated to mix 16 ton/hr dried sediment and 6 ton/hr granulated modifier solids. Carbon steel construction, complete with 100 HP motor and drive.
BC-103	Mixed Feed Conveyor	4	Enclosed belt conveyor rated to convey 11 ton/hr mixture of dried sediment and modifier solids from Mixers (MX-101) to Ecomelt Generators (EG-201). Carbon steel construction, complete with 15 HP motor and drive.

Section 200: Sediment Treatment			
Equip. No.	**Equipment Name**	**Qty**	**Equipment Description**
EG-201	Ecomelt Generator	4	Direct gas-fired, slagging rotary kiln system rated to melt 8 ton/hr dried sediment and 4 ton/hr modifier solids at a nominal temperature of 2400°F with excess air at over one hour solids residence time. Equipped with refractory-lined carbon steel shell, dropout box, gas-fired burner systems located on both ends, combustion and cooling air blowers, riding assemblies, and variable speed 100 HP motor and drive.
SC-201	Secondary Combustion Chamber	4	Vertical combustion chamber to provide 2 seconds gas residence time at 2200°F for 19,000 SCFM flue gas exiting Ecomelt Generators (EG-201). Includes refractory-lined carbon steel vessel and gas-fired burner system.
GR-201	Granulator	4	Wet slag drag conveyor system rated to quench 8 ton/hr molten slag discharged from Ecomelt Generators (EG-201) at a nominal temperature of 2400°F with water. Equipped with water-filled tank, dewatering drag conveyor, and motor and drive.
BC-201	Ecomelt Conveyor	4	Enclosed belt conveyor rated to discharge 8 ton/hr wet Ecomelt granules containing 90% solids and 10% water from Granulators (GR-201). Carbon steel, complete with variable speed motor and drive.
ED-201	Ecomelt Dryer	1	Rotary steam-tube dryer rated to dry 34 ton/hr granulated solids containing 10% water by condensing 150 psia supersaturated steam. Equipped with carbon steel shell, internal steam tubes, and 125 HP motor and drive.
EP-201	Ecomelt Pulverizer	1	Complete pulverizer system rated to pulverize 31 ton/hr dry granulated Ecomelt solids from minus ¼ inch to 95% minus 20 µm. Complete with grinding mill and motor, classifier system, cyclone separator, bag filter, product conveyor, exhaust fan and motor.
TK-201	Ecomelt Hopper	1	Storage hopper rated for 1000 tons dry and pulverized Ecomelt solids. Equipped with discharge cone, rotary feeder and discharge screw conveyor.

Section 300: Gas Cleanup			
Equip. No.	**Equipment Name**	**Qty**	**Equipment Description**
HR-301	Heat Recovery Boiler	4	Packaged waste heat recovery boiler system rated to generate 38,000 lb/hr superheated high pressure steam at 600 psia and 900°F by cooling 19,000 SCFM hot flue gas exiting Secondary Combustion Chambers (SC-201) from 2400° to 300°F at 14.7 psia. Boiler system can handle dust laden flue gas with minimum fines buildup and gas pressure drop. Boiler is designed to allow easy cleaning of tube bundles and removal of fines.
TK-301	Lime Hopper	1	Carbon steel storage hopper rated for 130 tons pulverized lime sorbent. Equipped with multiple aerated discharge cones and rotary feeders.
LB-301	Lime Air Blower	2	Packaged air blower system rated to compress 300 SCFM ambient air to 25 psia, all carbon steel, complete with motor and drive.
BH-301	Lime Baghouse	2	Baghouse rated to remove and collect ½ ton/hr pulverized spent lime from 110,000 ACFM flue gas at 300°F and negative 14" w.g. Equipped with fabric filters, support structure, insulation, platform and ladder, rotary feeder, discharge screw feeder, and motors and drives.
SC-301	Spent Lime Conveyor	2	Screw conveyor rated to convey 1 ton/hr pulverized spent lime from Lime Baghouse (BH-301) to dumpster. All carbon steel, complete with motor and drive.
TK-302	Activated Carbon Hopper	1	Carbon steel storage hopper rated for 20 tons pulverized activated carbon sorbent. Equipped with aerated discharge cone and rotary feeder.
CB-301	Carbon Air Blower	2	Packaged air blower system rated to compress 300 SCFM ambient air to 25 psia, all carbon steel, complete with motor and drive.
BH-302	Carbon Baghouse	2	Baghouse rated to remove and collect 200 lb/hr pulverized spent carbon from 110,000 ACFM flue gas at 350°F and negative 20" w.g. Equipped with fabric filters, support structure, insulation, platform and ladder, rotary feeder, discharge screw feeder, and motors and drives.
SC-302	Spent Carbon Conveyor	2	Screw conveyor rated to convey 200 lb/hr pulverized spent carbon from Carbon Baghouse (BH-302) to dumpster. Carbon steel, complete with motor and drive.
EF-301	Exhaust Fan	2	Induced draft exhaust fan rated to discharge 150,000 SCFM effluent gas from Carbon Baghouses (BH-302) at 300°F and negative 20" w.g. to atmosphere. All carbon steel structure, complete with damper, 400 HP motor and drive.
ST-301	Exhaust Stack	1	Carbon steel vent stack rated to discharge 210,000 ACFM cleaned effluent gas at 300°F to atmosphere.

Section 400: Power Generation			
Equip. No.	**Equipment Name**	**Qty**	**Equipment Description**
WT-401	Boiler Feed Water Treatment	1	Packaged boiler feed water treatment system rated to deliver 310 gpm feed water for heat recovery boilers to generate superheated high-pressure steam at 600 psia and 900°F. Equipped with storage tank, water softener system, deaerator system and feed water pump.
ST-401	Steam Turbine Generator	4	High-efficient steam turbine generator rated to generate 3 MW electricity from 21,100 lb/hr superheated high pressure steam generated from Heat Recovery Boilers (HR-301), fed to turbine generator at 600 psia and 900°F.
CD-401	Condenser	4	Tube and shell heat exchanger rated to condense exhaust steam from Steam Turbine Generators (ST-401) at 90°F and 1½ in. Hg by contacting with cooling water. 20 x 10^6 Btu/hr heat duty. Carbon steel construction.
CP-401	Condensate Pump	4	Centrifugal pump rated for 80 gpm condensate at 90°F and 10 psi differential pressure. Carbon steel, complete with motor and drive.
WP-401	Boiler Feed Water Pump	4	Reciprocating pump rated for 80 gpm boiler feed water and 635 psi differential pressure. All carbon steel, complete with 50 HP motor and drive.
CT-401	Cooling Tower	1	Conventional cooling tower rated for 1,300 gpm cooling water.
CP-401	Cooling Water Pump	4	Centrifugal pump rated for 1,300 gpm cooling water and 30 psi differential pressure. Carbon steel, complete with 25 HP motor and drive.

Base Case Cost Estimate

The estimated capital and operating costs are given below. The purchased cost for major process equipment items totals $28,175,000. The equipment costs are based on previous vendor quotations for similar equipment, published cost estimating correlations and charts, and standard engineering estimates.

The total installed cost of the plant is $81,626,000. The total installed cost is estimated using a factored method based on purchased equipment costs. Conventional cost estimating factors commonly used for preliminary designs are used for this design. Costs of building and services, installed utilities and service facilities, and working capital are not included, but allowance is made for home office, field, and contingency. The accuracy of the cost estimate is ±30 percent.

It should be noted that the capital and operating costs can be further reduced by design and operational optimizations, including but not limited to co-processing of waste materials containing heating value such as shredded tires, industrial, municipal solid and medical wastes;

mechanical dewatering combined with thermal drying for dredged sediment; combustion of oxygen-enriched-air or oxygen with natural gas in the Ecomelt Generators, and improved process and equipment design and costing.

Purchased Equipment Costs

Section 100: Feed Handling			
Item No.	**Item Name**	**Qty**	**Purchased Cost, 2005$**
SS-100	On-Site Sediment Storage (8 acres)	1	2,400,000
RB-101	Sediment Receiving Building	1	1,000,000
CU-101	Crane Unloader	2	700,000
SD-101	Sediment Dryer	2	1,510,000
SF-401	Sediment Dryer Fan	2	86,000
TK-101	Modifier 1 Silo	1	200,000
TK-102	Modifier 2 Silo	1	40,000
BC-101	Dried Sediment Conveyor	2	72,000
BC-102	Dried Sediment Conveyor	2	72,000
SC-101	Modifier 1 Conveyor	2	20,000
SC-102	Modifier 2 Conveyor	2	20,000
MX-101	Mixer	2	200,000
BC-103	Mixed Feed Conveyor	4	150,000
	Subtotal		**6,470,000**

Section 200: Sediment Treatment			
Item No.	**Item Name**	**Qty**	**Purchased Cost, 2005$**
EG-201	Ecomelt Generator	4	6,000,000
SC-201	Secondary Combustion Chamber	4	2,800,000
GR-201	Granulator	4	691,000
BC-201	Ecomelt Conveyor	4	154,000
ED-201	Ecomelt Dryer	1	421,000
EP-201	Ecomelt Pulverizer	1	2,000,000
TK-201	Ecomelt Hopper	1	200,000
	Subtotal		**12,266,000**

Section 300: Gas Cleanup			
Item No.	**Item Name**	**Qty**	**Purchased Cost, 2005$**
HR-301	Heat Recovery Boiler	4	3,044,000
TK-301	Lime Hopper	1	30,000
LB-301	Lime Blower	2	30,000
BH-301	Lime Baghouse	2	504,000
SC-301	Spent Lime Conveyor	2	20,000
TK-302	Activated Carbon Hopper	1	20,000
CB-301	Activated Carbon blower	2	20,000
BH-302	Carbon Baghouse	2	504,000
SC-302	Spent Carbon Conveyor	2	20,000
EF-301	Exhaust Fan	2	349,000
ST-301	Stack	1	100,000
	Subtotal		**4,641,000**

Section 400: Power Generation			
Item No.	**Item Name**	**Qty**	**Purchased Cost, 2005$**
WT-401	Boiler Feed Water Treatment	1	253,000
ST-401	Steam Turbine Generator	4	3,696,000
CD-401	Condenser	4	529,000
CP-401	Condensate Pump	4	20,000
WP-401	Boiler Feed Water Pump	4	178,000
CT-401	Cooling Tower	1	72,000
CP-402	Cooling Water Pump	4	50,000
	Subtotal		**4,798,000**

Summary of Equipment Costs by Section	
Section 100: Feed Handling	**6,470,000**
Section 200: Sediment Treatment	**12,266,000**
Section 300: Gas Clean-Up	**4,641,000**
Section 400: Power Generation	**4,798,000**
Total	**28,175,000**

Total Installed Costs	
Direct Costs	**2005 $**
Purchased Equipment	28,175,000
Equipment Installation	5,635,000
Installed Instrumentation & Controls	5,635,000
Installed Electrical	2,817,500
Installed Piping	8,452,500
Site Development/Yard Improvement	2,817,500
Foundations/Concrete	2,817,500
Structural Steel	2,817,500
Insulation	1,408,500
Total Direct Cost	**60,576,000**
Indirect Costs	
Home Office	9,086,400
Field	4,543,100
Contingency	7,420,500
Total Indirect Cost	**21,050,000**
Total Installed Cost (Direct + Indirect)	**81,626,000**

Sediment Treatment Cost

The estimated treatment cost for sediment dredged from navigational channels is presented below. Revenue streams include the sale of finely ground Ecomelt as a component of construction-grade cement and the sale of export electric power to the grid. The Ecomelt can be mixed with Portland cement yielding construction-grade blended cement or utilized directly in the manufacture of concrete (as a partial replacement for Portland cement). For the present evaluation, the selling price for dry, pulverized Ecomelt has been assigned a value of $80 per ton. Per the Engineering News Record website (www.enr.com), Portland cement was being sold on the open market for about $93 per ton in (August 2006).[6] The revenue for electric power generation is estimated at $100/MW-hr, which is the same cost for in-plant electricity use.

A 20-year period for depreciation was assumed for the commercial plant in a sustainable industry. The raw materials required by the plant are shown in Table 27. The utilities required by the plant are shown in Table 28. The costs for all utilities and consumables are based on current prevailing rates or estimates. In Table 29, labor costs cover the man-power required for plant operation and plant management only. Labor costs include benefits to the workers. Maintenance and interest expenses are assumed to be 1.5 and 6.75 percent, respectively. A debt-to-equity ratio of 75:25 was assumed for amortizing the borrowed capital over a 20-year period. Land required for the plant is estimated at 25 acres, which will be leased at a rate of $50,000 per acre per year.

Table 27. Raw Material Input and Material Output for a 500,000 yd^3/year Capacity Cement-Lock Plant Using Dredged Sediment as Feed Material

Raw Material Input	ton/day
Dredged Sediment	1,582
Modifier 1	260.4
Modifier 2	16.5
Lime	18.4
Activated Carbon	2.52
Material Output	
Ecomelt	822.4
Spent Lime	28.9
Spent Activated Carbon	2.52

Table 28. Utility Requirements and Costs (Credits) for a 500,000 yd^3/year Capacity Cement-Lock Plant Using Dredged Sediment as Feed Material

Component	**Unit Cost (Credit)**
Modifier 1	$50/ton
Modifier 2	$200/ton
Lime	$100/ton
Activated Carbon	$2,000/ton
Natural Gas	$9/million Btu
Electricity, purchase	$100/MW-hr
Electricity, sale to grid	($100/MW-hr)
Water	$4/1000 gallons
Ecomelt	($80/ton)

Table 29. Labor Requirements and Costs and Other Expenses for a 500,000 yd^3/year Capacity Cement-Lock Plant Using Dredged Sediment as Feed Material

Labor Requirements & Costs

Labor Category	Daytime or Shift	Number of Personnel	Salary (including benefits)
Plant Manager	Day	1	$87,750
Plant Supervisors	Shift	5	$337,500
Plant Operators	Shift	20	$945,000
Accountant	Day	1	$60,750
Clerk	Day	1	$47,250
Secretary	Day	1	$33,750

Maintenance Expense, Depreciation, Interest, and Financing

Maintenance	1.5% of Total Installed Cost
Depreciation	20 year, Straight-line
Interest rate	6.75%
Financing	75:25 debt / equity ratio

Subtracting the total expenses from the total revenues gives the revenue shortfall that must be made up by the "break-even" tipping fee from the sediment. In this scenario, the required tipping fee is $34.97/$yd^3$ of sediment. The overall treatment cost estimates are summarized in Table 30.

Co-processing of other wastes with dredged sediment offers a significant benefit for reducing the cost of sediment treatment. Depending upon the availability of these other wastes (e.g., fly ash, petroleum sludges, tank bottoms, municipal solid wastes, and scrap tires), the cost for processing sediment by the Cement-Lock Technology can be reduced even further. Additional revenues can be generated by substituting alternate materials for modifiers.

It should be noted that the natural gas consumption can be significantly reduced by thermal drying or mechanical dewatering the sediment prior to processing. Also, using oxygen enrichment in the rotary kiln will also reduce natural gas consumption.

Table 30. Economics of 500,000 yd^3/year Capacity Commercial-Scale Cement-Lock Plant Using Dredged Sediment as Feed Material

Sediment Processed, yd^3/yr	500,000
Annual Revenues	
Sale of Ecomelt ($80/ton)	$19,430,276
Electric Power Generation ($100/MW-hr)	$9,657,900
Total Revenues	$29,088,176
Annual Expenses	
Labor	$1,512,000
On-Site Sediment Handling, Screening ($0.50/$yd^3$)	$250,000
Raw Materials	
Modifier 1	$4,257,360
Modifier 2	$1,072,224
Lime	$602,732
Activated Carbon	$977,616
Utilities	
Natural Gas	$23,107,187
Electricity	$2,131,801
Water	$522,517
Maintenance Expenses (1.5% of TIC)	$1,224,390
	==========
Total Expenses	$35,657,827
Provision for Lease	$1,250,000
Depreciation (straight-line)	$4,081,300
Capital Recovery Charges	$5,585,893
	==========
Total Operating Expenses	$46,575,020
Revenues – Expenses	-$17,486,844
Break-Even Tipping Fee, $/$yd^3$	**$34.97**

Sensitivity

The sensitivity of the break-even tipping fee to variations in natural gas cost ($9/million Btu base case), plant throughput capacity (500,000 yd^3/year base case), processing rate (100% base case), and Ecomelt product selling price ($80/ton base case) were also estimated. Not unexpectedly, the break-even tipping fee increases with increasing natural gas cost, decreasing sediment processing rate (% of rated plant capacity), decreasing plant throughput capacity, and decreasing Ecomelt selling price. The results of the sensitivity study are presented in graphical form in Figure 8 below.

To understand Figure 8, consider the case in which the value of Ecomelt were to increase by 25 percent (from \$80 to \$100/ton). Follow the green curve for "Ecomelt Selling Price) from the Base Case (\$34.97/yd^3) to the 25 percent value on the abscissa. The break-even tipping for that case would decrease to \$26/yd^3. If, on the other hand, the value of Ecomelt were to decrease by 25 percent (from \$80 to \$60/ton), the break-even tipping fee would increase to \$46/yd^3. As another example, if the cost of natural gas were to increase by 33 percent (from \$9 to \$12/million Btu), the break-even tipping fee would increase to \$51/yd^3.

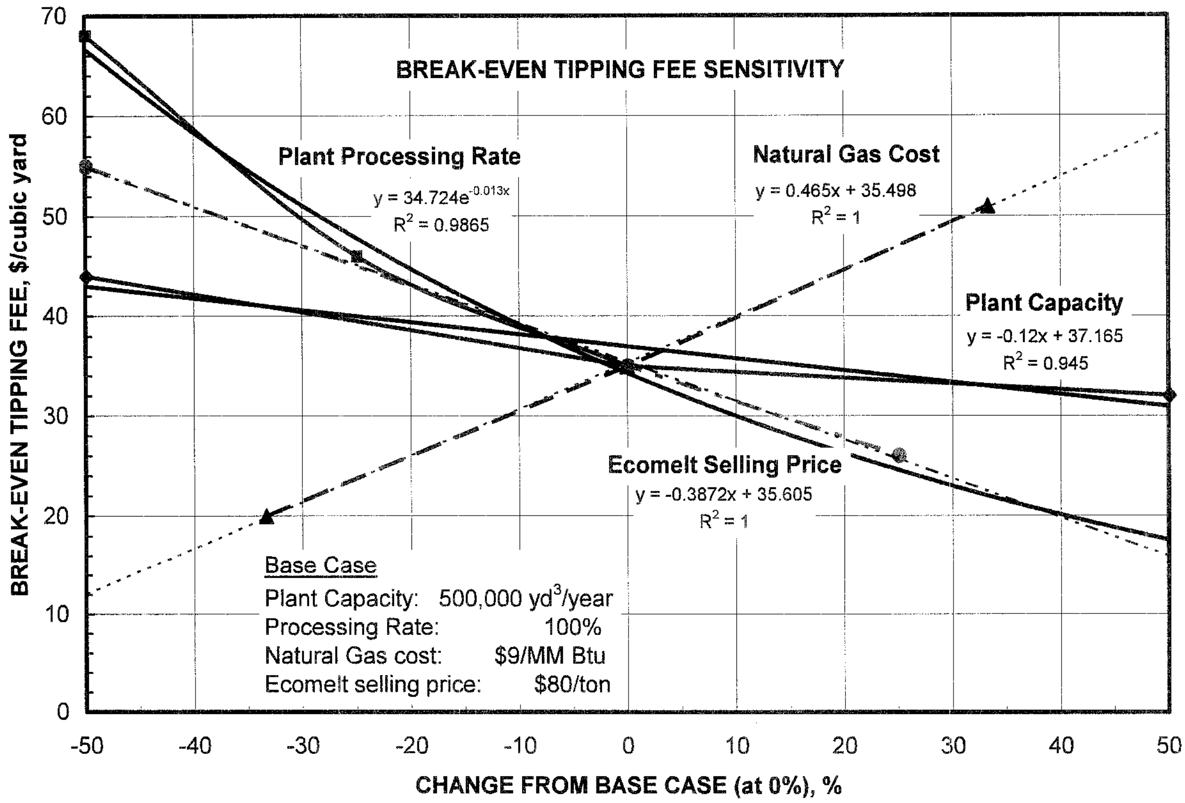

Figure 8. Sensitivity of Required Break-Even Tipping Fee to Process Economic Parameters for a Commercial-Scale Cement-Lock Plant

VI. RESOLUTION OF OUTSTANDING ISSUES

The primary issues remaining to be resolved for the Cement-Lock demo plant are whether or not the recommended modifications to the sediment and modifier feeding systems and the slag discharge system of the kiln are effective. To be effective, the modifications should enable the feeding systems to consistently feed the desired amount of sediment and modifiers to the Ecomelt Generator without accumulating on walls or other surfaces. Similarly, the modifications to the drop-out box should enable the free flow of molten slag from the kiln directly to the granulator water below without encountering any interfering surfaces.

Steps Taken to Resolve the Issues: Under a contract modification from the NJ-DOT/OMR (Task 6. Equipment Modification Design Study), ECH contracted with CEntry Constructors & Engineers (Sandy, UT) to provide consulting services in the areas of slagging kiln discharge systems and the sediment and modifier feeding systems. CEntry is a manufacturer of slagging rotary kiln thermal processing units and has designed and built some 20 slagging kilns in the U.S. and Canada over the past 20 years. According to CEntry, eight of those slagging kilns are still in operation today.

CEntry provided consulting services to ECH during which time they critiqued the current system configuration, provided substantial suggestions on retrofit modifications to remedy the slag accumulation problem, and provided additional suggestions on modifications to the sediment feeding system. RPMS Consulting Engineers also participated in the Task 6 effort and developed costs and a preliminary schedule to implement the modifications.

The complete results of Task 6 were submitted to NJ-DOT/OMR in July 2006.[5] The Task 6 report includes descriptions of the suggested modifications, engineering drawings of the suggested modifications, estimated costs to implement the modifications based on the drawings, and a schedule to implement the modifications.

VII. BENEFICIAL USE OF PRODUCT

EcoAggMat: The approximately 53 tons of EcoAggMat generated during the March 2005 non-slagging campaign were beneficially used as clean fill at a site remediation project in Kearny, NJ for BASF Corporation. Based on the chemical and leaching analysis of the material, the NJ DEP approved its placement at the BASF site. Therefore, the demonstration of the beneficial use of EcoAggMat has been completed.

Ecomelt: The Ecomelt produced during the several slagging-mode tests will be used in another demonstration of beneficial use. The Ecomelt will be dried and ground to cement fineness (< 50 μm). Grinding companies have been identified for this activity. Once the Ecomelt has been ground, a sample will be sent to CTLGroup (Skokie, IL) to develop a mix design for its ultimate use. The mix design will specify the amounts of Ecomelt, Portland cement, sand, gravel, and water that must be mixed together to achieve the desired properties for concrete for beneficial use. Once the mix design is complete, the bulk sample of ground Ecomelt will be shipped to a local (NJ) ready-mix company. The ground Ecomelt will then be used as a partial replacement for Portland cement in the manufacture of concrete for a length of sidewalk at Montclair State University (Montclair, NJ). Results of this demonstration, once complete, will be submitted to NJ-DOT/OMR as an addendum to this report.

When preparing Cement-Lock construction-grade cement for testing, typically 25 or 40 percent of the required amount of Portland cement has been replaced with Ecomelt.

Stratus Petroleum Sediment: The sediment and sediment mixed with modifiers remaining from the Phase I project is planned to be processed through the Cement-Lock demonstration plant as part of the Phase II Demonstration Project. The sediment will be used in a Confirmation Test to evaluate if the plant modifications to the feeding and slag discharging systems have been successful in enabling extended operation.

If any unprocessed sediment remains after the Phase II project, it will be beneficially used at a local NJ site that is permitted to accept harbor dredged material.

VIII. CONCLUSIONS AND RECOMMENDATIONS

The Cement-Lock demonstration plant is a "first-of-a-kind" large-scale solids-and-fluid-processing plant. The following conclusions are based on the experience gained and results achieved during the Sediment Decontamination Demonstration Pilot Test Project. Recommendations for future work follow.

Conclusions

- The Ecomelt Generator can operate at elevated temperatures required for slagging operation.
- The plant can be operated in non-slagging mode for an extended period of time; however, even under those conditions the plant began to show signs of fatigue and wear.
- The existing sediment and modifier conveying and blending systems are inadequate for sustained and consistent feeding of wet sediment or dry modifiers.
- The drop-out box system is inadequate for sustained slagging operation.
- The pollution control equipment (including SCC, flue gas quencher, baghouse, and activated carbon bed) performed as designed to reduce air emissions to required low levels.
- On a mass flow basis, emissions of dioxins and furans from the vent stack were 0.35 ng/dscm (at 7% O_2). For comparison, EPA's New Source Performance Standard (40 CFR 60.52b) limits emissions of dioxins and furans from large municipal waste incinerator facilities to 30 ng/dscm (at 7% O_2.)
- On a TEQ (Toxicity Equivalency) basis, 99.02 percent of the PCDD, PCDF, and PCB congeners in the sediment-modifier mixture fed to the plant were destroyed. The measured emission of PCDD and PCDF congeners in the stack amounted to 2.86×10^{-9} lb/hr.
- Of the PCBs fed to the plant in the sediment-modifier mixture (2.94×10^{-4} lb/hr), 99.49 percent was destroyed and converted to products of complete combustion. About 0.03 percent (9.54×10^{-8} lb/hr) of the PCBs appeared in the EcoAggMat. About 0.48 percent (1.42×10^{-6} lb/hr) appeared in the stack flue gas.
- The activated carbon adsorber bed achieved 99.2% mercury capture efficiency compared with 70 percent required in the demo plant operating permit.
- Emission of mercury from the vent stack was very low, amounting to 5.6×10^{-6} lb/hr (or 0.049 lb/year).
- The EcoAggMat produced under non-slagging conditions was essentially non-leachable under the conditions of the TCLP and SPLP protocols. Low levels of arsenic and lead were detected in the leachate from the NJ Protocol MEP test.
- Based on its overall analysis, EcoAggMat was determined to be suitable for fill in NJ residential applications.

- The EcoAggMat is suitable for use as a partial replacement (up to 50 percent by volume) for sand in mortar mixtures.
- The Cement-Lock construction-grade cement (from Ecomelt) exhibited compressive strength that exceeded ASTM requirements for Portland as well as blended cements.
- The Ecomelt produced did not leach any priority elements above the analytical detection limits of the TCLP test.
- Based on stated assumptions for a 500,000 yd^3/year commercial-scale Cement-Lock plant, the required tipping fee for processing sediment dredged from navigation channels was estimated to be \$34.97/yd^3.
- Sensitivity of processing costs have been evaluated.

Recommendations

- The existing feed system, including mechanical dewatering and/or thermal drying of sediment, slurry pumping, kiln discharge system, and drop-out box system should be thoroughly evaluated by a company with significant material handling design, slagging kiln design, construction, and operating experience.
- The winterization of the plant should also be re-evaluated from the standpoint of long-term continuous operation during inclement weather.
- Based on the evaluation, the necessary modifications needed to ensure successful and prolonged operation of the Cement-Lock demo plant under slagging conditions should be developed. The modifications should include detailed designs and a firm cost estimate to implement the modifications.
- Upon completion of the modifications to the plant, a test should be conducted with some of the unprocessed Stratus Petroleum sediment to confirm that the modifications are effective.
- Upon successful completion of the Confirmation Test of the demo plant, the Phase II project should be initiated with Passaic River sediment. ECH's parent company, GTI, is planning to contract directly with U.S. EPA to complete this work.

IX. REFERENCES

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Appendix A

DEMO PLANT SITE, CONSTRUCTION, INSTALLATION, START-UP, AND OPERATIONS

DEMO PLANT SITE, CONSTRUCTION, INSTALLATION, START-UP, AND OPERATIONS

This section includes details of the demo plant site selection, construction, installation, start-up, and operation.

Site Selection – International Matex Tank Terminal (Bayonne, NJ)

The Cement-Lock sediment decontamination demonstration facility is located on a 2-acre parcel leased by ECH within the 700-acre facilities of the International Matex Tank Terminal (IMTT) in the City of Bayonne, Hudson County, New Jersey. On this site, ECH constructed and operated a nominal 13,000 yd^3 per year Cement-Lock Demonstration plant to process dredged materials. By using oxygen enrichment in the primary combustion air and/or predrying the sediment feed, the capacity of the plant can be increased to 30,000 yd^3 per year.

The 2-acre project site is located at the southeastern tip of the Bayonne peninsula and is entirely surrounded by the IMTT property. The property is bounded by a railroad yard to the north, a pipe rack and a 60-foot diameter tank in a containment area to the east, a pipe rack and service road to the south, and a pipe rack and one-story building to the west. About 1,900 feet to the south of the site is the Kill Van Kull waterway and 500 feet west of New Hook Road. About 2,000 feet to the east and southeast is New York Bay. The IMTT property line lies about 6,000 feet to the west of the project site. The following two aerial photographs (Figures A-1 and A-2) show the location of the Cement-Lock demonstration plant within the IMTT facility

The site has topography with a gradual slope of about 3 feet over 250 feet from west to east. There are several underground utilities on the site, including a city water line, a fire water line, and a storm sewer. There are no residential areas adjacent to the project site. The nearest residential area is approximately one mile to the north-northwest. The site is essentially a flat, vacant lot, covered with dirt and gravel within a heavily industrialized tankage complex. There is no vegetation present.

The 2-acre project site for the Cement-Lock Demonstration Plant consists of the following elements:

- A 4,800-ft^2 (60 x 80 feet) raw material containment area to store the dredged material. The containment area is constructed of concrete "Jersey" barriers with an impervious 40-mil thick polyethylene liner and a 4-inch thick concrete base.
- The Cement-Lock equipment, consisting of storage bins and hoppers for feedstock materials, natural gas fired rotary kiln and rotary drum dryer, material handling conveyors, and gas clean-up equipment, including a natural gas-fired secondary combustion chamber, quencher, dust collector baghouse, activated carbon bed, I.D. (induced draft) fan, and stack with continuous emissions monitoring equipment.
- An employee facilities trailer and administration office/control trailer.
- Parking area for visitors, plant manager, shift supervisors, and laborers.

Figure A-1. Photograph of the IMTT Site Showing the Cement-Lock Demonstration Plant Location (Scale: 1 inch = 1,260 feet)

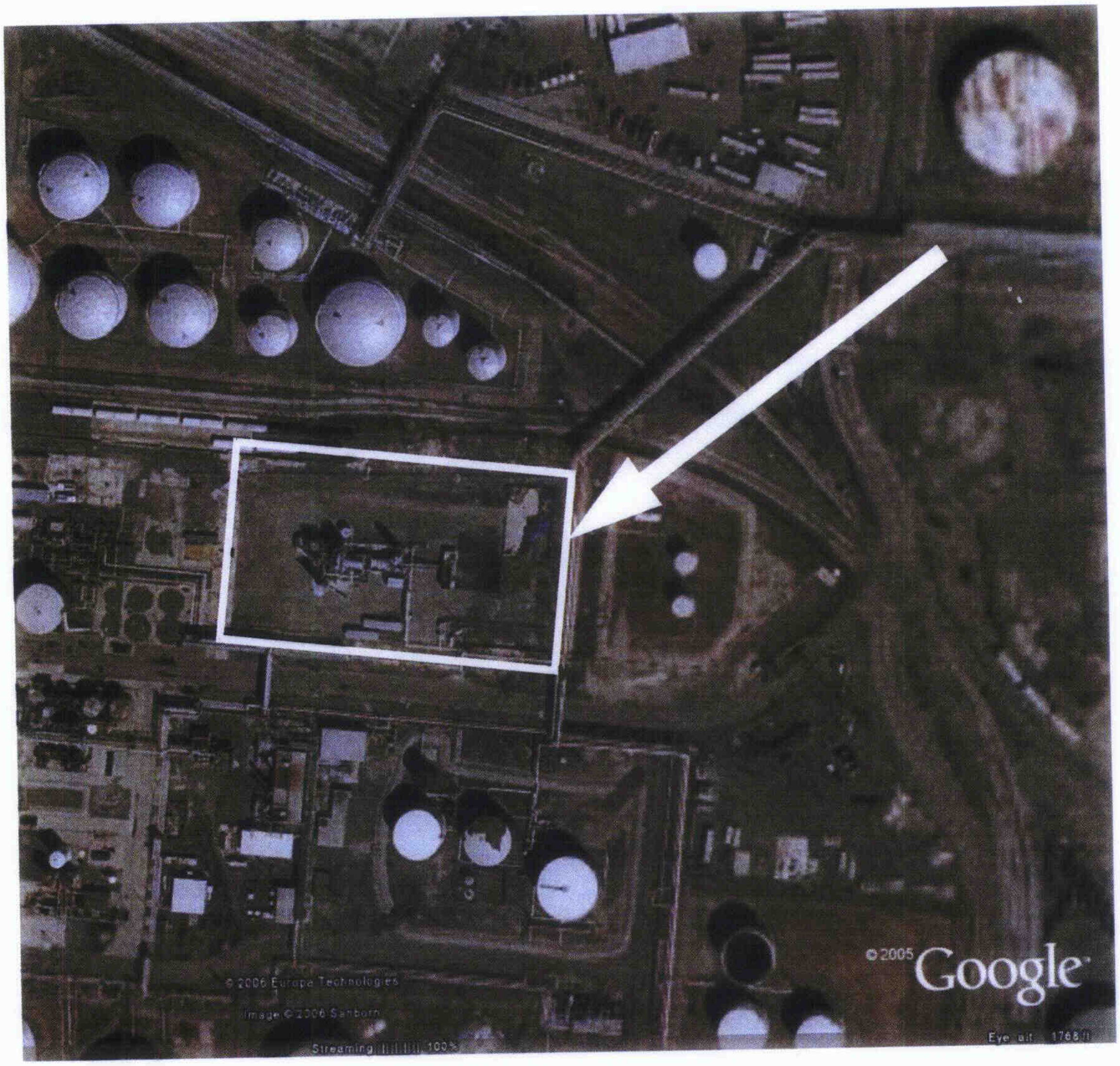


Figure A-2. Close-Up Photograph of the IMTT Site Showing the Cement-Lock Demonstration Plant Installed (Scale: 1 inch = 225 feet)

Equipment Construction and Installation

The equipment for the Cement-Lock demonstration plant was originally fabricated for the specific application of medical waste incineration in non-slagging or ashing mode. The rotary kiln system was subsequently obtained by Andersen 2000 (A2K) during an acquisition. A2K modified the equipment for the Cement-Lock Technology, which included means for maintaining the molten slag exiting the rotary kiln in a fluid state.

Infrastructure

Actual construction activities were initiated in June 2002 with the installation of a 10-foot high, chain-link fence around the leased property perimeter on the IMTT facility. Other construction-related activities included:

1) Preparing the subsurface ground for the several monolithic concrete slabs
2) Excavating the soil where the foundation pads would be poured
3) Installing framing and pouring concrete for the foundation pads
4) Receiving equipment deliveries, including structural steel, vessels, motors, piping, ductwork, etc. for the plant.
5) Installing and connecting each piece of equipment as designed
6) Installing the needed utility infrastructure
7) Installing the electrical power and instrumentation.

The infrastructure items above are discussed in more detail below.

The preliminary layout for the equipment, the sediment storage area, roads, accesses, and trailers for Operation Control and Staff, the Motor Control Center building, and the equipment storage building road access around the plant was prepared by RPMS Consulting Engineers (RPMS, Monroe Township, NJ). The drawing prepared by RPMS is included as Figure A-3 (Drawing No. 3337-C2). The six major features of the plant layout are described below

1. Immediate plant equipment site: The Cement-Lock plant equipment has been located in the central area of the leased property, which allows for ready access around the whole plant. The plant is oriented along its major length in an east-west direction. Movement of sediment through the plant during processing is from east to west. Ultimately, the Ecomelt product will be unloaded from the Ecomelt storage hopper via a screw conveyor on the southwest corner of the plant. Around the physical plant concrete foundations support each major equipment piece. The plant design does not include an enclosing building.

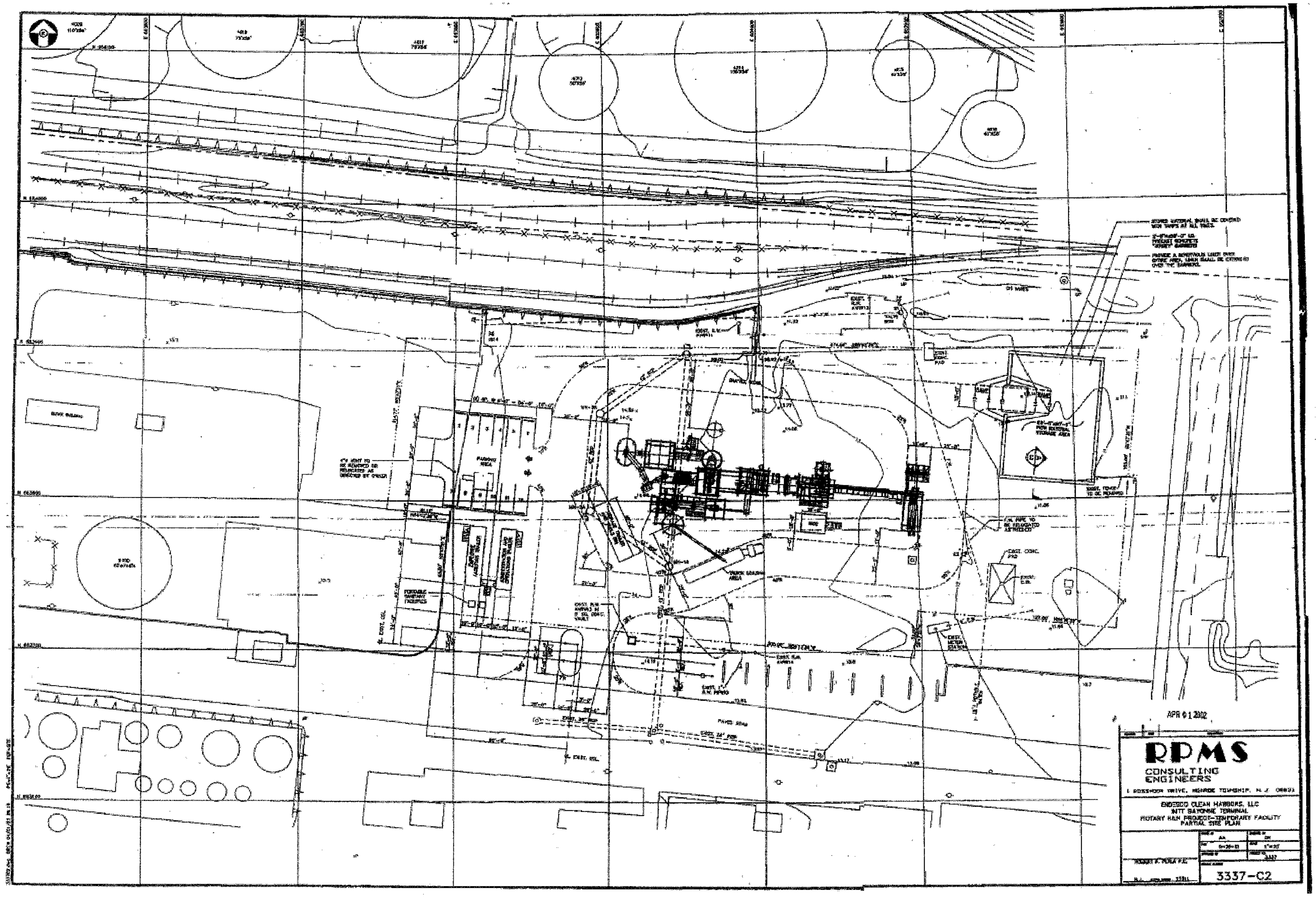


Figure A-3. Cement-Lock Demonstration Plant Layout at IMTT (RPMS Drawing No. 3337-C2)

2. Surrounding area: The 2-acre site is nominally 400 feet long (east-west) and 200 feet wide (north-south). This geometry accommodates the nominal plant equipment dimensions of 200 feet long and about 100 feet wide (excluding the sediment storage area). Within the confines of the security fenced area, the ground level was brought to a uniform elevation using crushed stone. The crushed stone allows for heavy equipment and truck traffic to move unhindered throughout the enclosed area. The plant equipment is located essentially in the middle of the property.

3. Security fencing: As mentioned above, security fencing was specified by IMTT to be 10 feet tall, chain-link fencing and to include three strands of barbed wire at the top.

4. Connection with local utilities: Local utility service (natural gas and electricity) for the IMTT facility is provided by Public Service Gas & Electric Company (PSE&G). IMTT obtains the individual commodities (natural gas and electricity) from third-party suppliers, for example, Amerada Hess Corporation for natural gas. ECH also had the option of obtaining natural gas from third-party suppliers; however, because of its intermittent operating schedule, ECH chose PSE&G for natural gas delivery and commodity. For electric power, ECH installed a meter on the plant transformer for metering power to the plant from the IMTT feeder.

The nearest source of natural gas for connection is a natural gas spud about 400 feet directly to the east of the plant outside of the leased property boundary. According to PSE&G, the supply of natural gas at this location is sufficient for up to 40 million Btu per hour maximum demand from the plant and 30 million Btu per hour average (per the plant design throughput) demand. PSE&G also informed ECH that because the plant location is at the end of the natural gas supply pipeline, the natural gas supply pressure will vary depending upon upstream demand from 4 to 15 psig. Therefore, it was necessary to install a natural gas booster compressor on the natural gas supply line to ensure that the pressure of the natural gas supply to the plant is uniform and consistent as required for proper operation of the natural gas burners. The booster compressor was manufactured by Scale Compressor and was located on the north side of the plant equipment in proximity to the primary and secondary natural gas burner trains to minimize the distance of the natural gas line run.

The nearest source of electricity is immediately to the south of the plant site and in high-voltage lines running along the pipe rack. Andersen 2000 specified that the power consumption for the plant during nominal operation (all the motors connected to the conveyors, pumps, and controls) totals 1200 amps at 480 volts or 576 kilowatts. The supply of electricity available from the IMTT feeder was sufficient for the Cement-Lock demo plant needs. A 1,000-kW transformer was specified by RPMS electrical engineering staff, procured, and installed for the plant.

An existing water main runs through the plant site area on a north-south orientation about halfway across the site. There is also a storm sewer that runs through the plant site, which was relocated so that the foundation for the plant can be installed without interference. As the Cement-Lock plant is a net consumer of water, there is no need for a wastewater disposal/ discharge connection.

5. Roads and accesses for the plant: One of the main access roads for the IMTT property runs along the lower (southern) edge of the plant site in an east-west direction. The plant site was once the site of an asphalt plant. Access to the plant site is afforded on the south edge of the property through two areas: The first is located at the far southwest corner of the property; the second is located on the south edge of the property about 100 feet east of the western boundary. Around the plant equipment itself, roads and accesses were designed for bringing modifiers, lime, and sediment to the site. The traffic pattern for removing Cement-Lock Ecomelt product from the site were also planned, designed and implemented.

6. Location and installation of other infrastructure: Other infrastructure includes the equipment storage building, the process control and staff trailers, and the motor control center (MCC), temporary emergency generator, and sediment storage area.

The construction progressed, the site layout and configuration were altered somewhat to improve access to the modifier hoppers, to make the whole site more convenient, and to reduce overall costs of installing the plant itself.

Foundations and Foundation Design

The objectives of this task were to design and install foundations for the Cement-Lock demonstration plant equipment, the sediment storage hopper, modifier hoppers, Cement-Lock product storage hopper, and other ancillary equipment items (screw conveyors, compressor, bins, motor control center, etc) to accommodate the larger-size plant. The throughput capacity of the plant was increased to accommodate up to 30,000 yd^3 per year of sediment when the EPA Region 2/BNL and NJ-DOT/OMR project objectives were both accommodated.

The design of the foundations and road access included traffic patterns for bringing modifiers, lime, oxygen (potentially for Phase II), and sediment to the site as well as removing Cement-Lock Ecomelt product from the site.

The increase in throughput capacity of the unit increased the size of many of the individual equipment items including the baghouse and the drop-out box. The size of the kiln did not change as this was not directly impacted by the increase in throughput capacity. However, the overall weight of the new Cement-Lock equipment did require special foundation design for support. Installing piles was considered mandatory by A2K to support the mass of the rotary kiln and its refractory load. However, as described below, the use of pilings was not permitted by IMTT due to ongoing environmental remediation at the plant site. There was concern that driving piles to bedrock would puncture the clay layer beneath the surface of the property. This would provide a pathway for organic contaminants in the upper soil strata to migrate down through the clay layer and contaminate the aquifer below. Therefore, another method of supporting the plant that does not utilize pilings needed to be designed depending upon the load-bearing characteristics of the soil and subsoil.

Increasing the overall plant throughput capacity is achieved by increasing the sizes of certain equipment as well as using oxygen-enriched air for combustion. Using oxygen-enriched air significantly reduces the quantity of flue gases that must be heated to Ecomelt Generator temperature (2400° to 2600°F) thereby saving fuel costs. Also, using oxygen-enriched air reduces the quantity of flue gases that must be handled by the downstream air pollution control equipment. If oxygen-enriched air is used for Cement-Lock plant operation, a new oxygen supply pad will need to be installed. Liquid oxygen will be brought to the plant site periodically during continuous operations. The liquid oxygen will be pumped into manufacturer-supplied vessels and vaporized as needed during operation. As the project developed, it was decided for economic reasons, that oxygen enrichment would not be included in the Phase I effort.

The development of additional site infrastructure entailed the selection of a more specialized general contractor as well as the necessary subcontractors to carry out the entire installation of the plant. This also necessarily involved getting the plant equipment tested and readied for operation (commissioning and shakedown testing).

Subsurface Soil Data

The Schoor DePalma (Manalapan, NJ), a local soil testing and geotechnical firm was enlisted to perform a subsurface investigation and geotechnical evaluation in the proposed area of the demonstration plant to provide recommendations for foundation type, pavement design, and general earthwork construction.

The report by Schoor DePalma is included in its entirety in Appendix D. A diagram showing the locations of the boring holes in relation to the proposed plant location is presented in Figure A-4 (Preliminary RPMS Drawing).

Based on the results of the subsurface soil investigation, Schoor DePalma proposed a foundation design to support all of the Cement-Lock demonstration plant components. First, across the expanse of the plant footprint (about 200 by 100 feet), about 3 feet would be excavated from the west end and brought to the east end and leveled. The subgrade would then be compacted. Next, a layer of geotextile fabric (Geogrid "Tensar 1200BX") would be spread across the area. Then a 10½ inch layer of compacted fill would be spread, followed by another layer of geotextile fabric, followed by another layer of compacted fill, and followed finally by a third layer of geotextile fabric. This would serve the purpose of establishing a solid foundation for the concrete pads to follow.

The main pad, which supports the charging platform, the rotary kiln plus refractory and motor drive, the secondary combustion chamber, the drop-out box, and the water spray quencher is a monolith 2 feet 9 inches thick. It is 88 feet long and 32 feet wide.

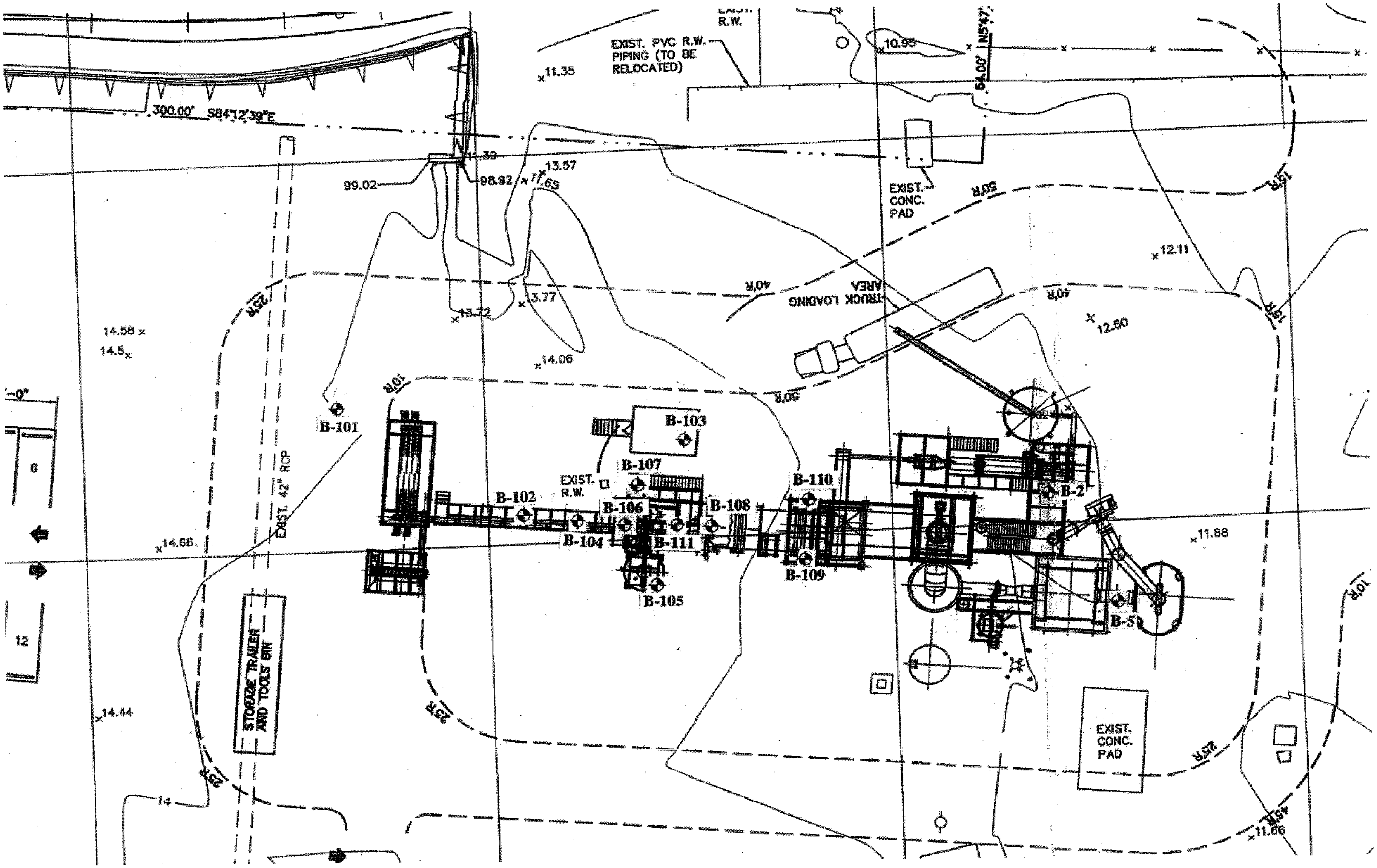


Figure A-4. Location of Soil Core Sampling Points (Preliminary RPMS Drawing)
The Cement-Lock demo plant orientation was later rotated 180°.

Utility Requirements

The utility requirements for the Cement-Lock demonstration plant were estimated by A2K for the plant operating at its full design capacity of about 2931 pounds of sediment (containing 60 weight percent water) per hour plus appropriate amounts of Modifier 1 and 2. The electrical requirements are 1200 amps at 480 volts (576 kilowatts). The natural gas requirements are 40 million Btu/hour (maximum) and 30 million Btu/hr (nominal)

The water requirements were estimated as

Ecomelt Granulator evaporation	7 gpm
Flue Gas Quencher water	35 gpm
Fire protection for Activated Carbon bed	75 gpm

The total estimated water requirement was 117 gpm. A2K recommended a nominal water supply of 200 gpm for the plant. This was the value that was used for establishing the water utility for the plant. All of the needed utilities (except for oxygen) were availability at the site.

Installing Refractory and Insulation

Because of weight and durability concerns associated with the high-temperature refractory, most of the refractory was installed at the site after the equipment had been installed. The primary equipment for which refractory is needed includes the Ecomelt Generator, the secondary combustion chamber (SCC), and the interconnecting piping between the SCC and the flue gas quencher. The refractory work was completed by Lynn Whitsett Company (GA).

Two major equipment items were delivered to the plant site with some refractory already installed: The drop-out box, which had been "gunned" on-site at A2K. The nose and head of the rotary kiln, which had been cast on-site at A2K.

For cold weather-related reasons, it was necessary to insulate some of the equipment and piping to prevent freezing as well as condensation. The primary piece of equipment requiring insulation is the baghouse. Similarly, pipes handling water-bearing gases or liquids were insulated.

Plant Standard Operating Procedures

The operating and maintenance (O&M) procedures developed by A2K were reviewed by GTI staff. Comments and suggestions were incorporated into the final O&M document. Also, per the recommendation of RPMS and A2K, a series of Standard Operating Procedures (SOPs) were developed for the Cement-Lock demonstration plant. The SOPs include the following: Start-up and shut-down procedures, plant operations management, general start-up and operations procedure, solids feed systems operating procedures, fuel gas system operating procedures, Ecomelt system operating procedures, Ecomelt flue gas systems operating procedures, Ecomelt dryer flue gas systems operating procedures, plant support systems operating procedures, overall plant maintenance procedures. The SOPs are included in Appendix E.

Temporary Buildings

Several temporary buildings or trailers were required for the Cement-Lock demonstration plant facility. These include office space, locker room, motor control center, and storage locker.

During construction, the general contractor (RPMS) and its subcontractors require office space and working space. Typically, subcontractors bring their own trailers and equipment to work from. During operations, the shift supervisors and plant manager require office space, computer, internet access, and a space devoted to process control. Similarly, the operating staff (laborers) requires a separate locker room.

The motor control center (MCC) must also be housed in a building that has controlled temperature and atmosphere so that the PLC (Programmable Logic Controller) does not get overheated or under cooled, or endures severe fluctuations in humidity.

The following includes information on the temporary buildings required at the Cement-Lock demonstration plant facility.

Office Space: One trailer was rented from Williams Scotsman to serve as the main control office. This is a mobile office 50 feet long by 10 feet wide. It has two entrances, and two offices with a large central conference room. It has running water (non-potable) and is equipped with a restroom. Bottled water is provided for the supervisory staff.

Locker Room: One trailer was rented from Williams Scotsman to serve as the locker room for the operating staff (laborers). This is a mobile office 40 feet long by 10 feet wide. It has two entrances and one office with a large central conference-type room. It has running water (non-potable) and is equipped with a restroom. Bottled water is provided for the operating staff.

Motor Control Center: A prefabricated structure 11 feet wide and 19 feet long was provided for the Motor Control Center (MCC) from Eagle Companies (Peoria, IL). It includes two access doors with stairways down to ground level. It also has a heater and air conditioning unit installed. The PLC and connecting wiring are located at the north central part of the building. The motor controls themselves are located in the center of the building. The building is elevated about 3 feet off the ground to provide bottom entry of the electrical leads from the main transformer and exit of the power cables to the field.

Storage Box: One storage box was rented from Williams Scotsman for on-site storage. This storage box is constructed of steel and is 40 feet by 8 by 8 feet.

Equipment Installation and Deficiencies

Deliveries of equipment began after the concrete for the pads had been poured and cured. Deliveries were made over the course of four months. The first deliveries – a truckload of structural steel, the rotary kiln, and the sediment storage bin – were made on September 18, 2002. The kiln could not be set on its trunnions that day due to a misalignment between the twenty 1½-inch diameter bolts set in each of the trunnion pedestals and the corresponding 1⅝-inch diameter holes in the trunnion baseplate. The twenty holes in each trunnion baseplate were enlarged to accommodate the tight bolt pattern. The drum of the rotary kiln was set on its trunnions, two days later on September 20 (see photo below). The bottom section of the flue gas quencher (shown behind the rotary kiln drum) was erected on September 23. The last delivery of a major equipment item was the motor control center (MCC) building, which was delivered to the plant site on January 24, 2003.

During the course of equipment installation, deficiencies in fabrication and manufacture were noted by the installing contractor. The first deficiency was the misalignment in the bolts and holes for the trunnion pedestal and baseplates mentioned above. Later as equipment deliveries and installation progressed, many of deficiencies were noted in structural steel, several inoperative motors, rusted or broken parts, and other items. In total, 117 deficiencies were documented during construction. Per prior agreement, these deficiencies were noted and brought to A2K's attention. Correcting these deficiencies caused delays and extra costs to the overall project.

Electrical and Instrumentation

Bid packages for the electrical and instrumentation work required for the plant were prepared and submitted by RPMS to several local contractors. Bids were received and evaluated and the subcontract for the work was let. The contractor began installing the electrical conduit and trays in late April 2003. Part of the delay in beginning this work was due to delays in getting electrical drawings from A2K.

Haz-Op Review Sessions

Prior to completing plant construction and installation, representatives from GTI, A2K, RPMS, and Hazen Research met at the offices of RPMS to anticipate potential hazards and assess the overall operability of the plant. The Haz-Op review sessions focused on the Piping & Instrument Drawings prepared by A2K and modified by RPMS to include additional needed instrumentation. The sessions were conducted April 1 and 2 with a follow-up demo plant site visit on April 3, 2003.

The results of the Haz-Op review were summarized in two documents (Haz-Op Action Items Report and Haz-Op Summary Report, Appendix F). Input on the final implementation of specific Haz-Op recommended items was received from all of the original participants of the Haz-Op review sessions. The final list of items implemented is presented in Table A-1. Table A-2 summarizes the recommended actions.

Table A-1. List of Items Implemented from the Haz-Op Review Sessions

Item No.*	Action / Description
11.	Add Cover to Bucket Elevator Inlet Hopper (C-104)
14.	Add Flow Indicating Transmitters to Inlet and Outlet of Water-Cooled Auger/Screw Feeder (C-151
16.	Add Discharge Chute to Conveyor (C-205) Below the Discharge of Conveyor (C-203)
22.	Add Backup Pump to Granulator Recirculation Pump (P-203)
31.	Add Backup thermocouple for Melt Burners
33.	Install Back-up Pressure Regulators on Major Compressed Air Consumer Lines
37.	Add Level Switch Low to Granulator Recirculating Water Tank (T-203)
38.	Add Flow Indicating Transmitter to Seal Flush of Granulator Recirculation Pump (P-203)
39.	Add Temperature Indicating Transmitter to Granulator Recirculating Water Tank (T-203)
42.	Add Pressure Safety Valve to Natural Gas Booster
43.	Move Valve at Outlet of Water-Cooled Auger/Screw Feeder (C-151) Jacket Piping to Downstream of Pressure Safety Valve (PSV-151)
Misc.	Add 1 Analog and 1 Digital Input Card to PLC

*See Table 2 for references for each *Item No.*

Table A-2. Summary of Potential Problems and Solutions from Haz-Op Review Sessions for the Cement-Lock Demo Plant

NODE #	DEVIATION	CAUSES	CONSEQUENCES	RISK FACTOR	RECOMMENDATION	PRIORITY	ACTION & ESTIMATED COST	ACTION ITEM #	ECH / GTI RECOMMENDATIONS & RATIONALE
1 SEDIMENT FEED SYSTEM	No Flow	bridging in bin due to overfill	no feed, loss of heat sink in dryer	8	mirror, platform, lights at bin	B	Purchase & Install Mirror $1,000	1	Not needed.
		bin empty					Design, Fab & Erect Platform $15,000	2	No. Rent manlift to access hopper (if needed for long-term operation, add platform at that time)
	Less Flow	bridging in bin	loss of heat sink in dryer	6	alarm mass flow	A	Programming Change	3	A2K programming change (add FAH & FAL to FIC-102)
	Lower Temperature	Freezing weather	large chunks causing plug or bridging	9	provide heat to sediment storage & bin	C			No. If needed for extended operation during Phase II, add at that time
	Higher Level	overfilling by bucket loader	bridging, low or no flow	8	mirror, platform, lights at bin	B			No. Area lighting is included in the Electrical / Instrumentation work
					charge from south end of bin	C	Incorporate In SOP	4	Yes. SOP Addition
3 MODIFIER #1 FEED	No Flow	bin empty	improper melting or viscosity high forming clinkers in kiln, possible steam explosion	3	flow indication with high & low alarm on outlet of C-103	A	A2K To Recommend Flow Sensor Suitable For Application	5	No. Need alternate solution (to load cells or deflector plate)
		bridging in bin		2					
		HV-103 closed		4					
		V-103 fails		4					
		F-103 fails		4					
		C-103 fails		4					
		clumping due to water		4	plan receipt of mat'l in dry weather and include in raw material spec	C	Incorporate In SOP	6	Yes. SOP Addition
	Less Flow	same as no flow	same as no flow	2	flow indication with high & low alarm on outlet of C-103	A	See Above	7	No. Same as #5
	More Flow	operator error		4					
		calibration							
	Higher Pressure	vent plugged by clumped lime dust	fill T-104 with lime dust which causes error in ratio of materials	2	remove cross connection between vessels and install vent on T-104	A	ECH/GTI To Advise If Permissible With NJ-DEP Air Permit	8	No. Overfilling of T-103 will be detected by existing LSH & LAH. Note: Connecting pieces have been removed from T-103 and T-104. Pressure/vacuum vent has been installed on T-104.
	No Level	operator error	improper melting or viscosity high forming clinkers in kiln, possible steam explosion	4	flow indicator with high & low alarm on outlet of C-103	A	See Above	9	No. Same as #5
		Bindicator failure							
4 MOD #2 FEED	No Flow	bin empty	improper melting or viscosity high forming clinkers in kiln, possible steam	3	flow indicator with high & low alarm on outlet of F-104	A	A2K To Recommend Flow Sensor Suitable For Application	10	No. Need alternate solution (to load cells or deflector plate)
		bridging in bin		2					
		HV-104 closed		4					

Table A-2. Summary of Potential Problems and Solutions from Haz-Op Review Sessions for the Cement-Lock Demo Plant

NODE #	DEVIATION	CAUSES	CONSEQUENCES	RISK FACTOR	RECOMMENDATION	PRIORITY	ACTION & ESTIMATED COST	ACTION ITEM #	ECH / GTI RECOMMENDATIONS & RATIONALE
		V-104 fails	explosion						
		F-104 fails							
	Less Flow	same as no flow		2					
	More Flow	operator error		4					
		calibration							
	Water in Bin	rainwater	wet alumina affects lime	7	put cover over bag chute	B	Purchase Cover $100	11	Yes. Needed for dust minimization.
					store palletized alumina dry		Incorporate In SOP	12	Yes. SOP Addition
	No Level	operator error	improper melting or viscosity high forming clinkers in kiln, possible steam explosion	4	flow indicator with high & low alarm on outlet of F-104	A	See Above	13	No. Same as #10
		Bindicator failure							
5 BLENDED FEED SYSTEM	Higher Temperature	loss of water flow	water leak into kiln	4	relocate water flow meter to outlet	A	Piping Not Installed Yet. No Cost If Decision Made Before Installation.	14	Yes. Add FIT to C-151 inlet and FIT to C-151 outlet. A2K programming change (Flow alarm if Water in > water out = leak)
6 ECOMELT GENERATION	No Flow	drag conveyor fails	kiln overfills dropout box	8	consider manual cleanout of drop out box	C	A2K To Make Design Modification	15	No. Drop-out box and granulator can be accessed from Secondary Combustion Chamber manway
		C-205 fails	material backs up		add diverter on outlet of C-203		Design, Fab & Install Flange With Hinged Cover $10,000	16	Yes. Need diverter on outlet of C-203 to dispose off-spec product.
		F-205 fails							
	Less Flow	build up a dam in kiln	steam explosion in dropout box	2	add another sight glass to kiln	A	For Port Similar To The One On Dropout Box $3000.	17	No. Existing sight port at end of kiln on drop-out box views internals of kiln.
					provide method of adding flux quickly		Design & Install Air Cannon $10,000.	18	No. For initial testing, blend flux (CaF_2) with alumina and then charge T-104. For future operations, add flux loading bin & feeder to M-131
					consider water cooled camera		A2K To Recommend	19	No. Water-cooled, optical camera not recommended. GTI/ECH to procure hand-held IR gun for temperature sensing internally through sight ports
					consider IR skin temperature monitor			20	No. Indirect approach w/ slow response time (See #19)
	Higher Temperature	loss of quench water flow from P-203	molten material flashes water in granulator	6	add city water back-up to water sprays with auto actuation	A	Design Piping, Valving, Controls & Install - $15,000	21	No. Not feasible due to IMTT concerns about existing drain and capacities
					consider back-up pump		$30,000	22	Yes. Add second pump system in

Table A-2. Summary of Potential Problems and Solutions from Haz-Op Review Sessions for the Cement-Lock Demo Plant

NODE #	DEVIATION	CAUSES	CONSEQUENCES	RISK FACTOR	RECOMMENDATION	PRIORITY	ACTION & ESTIMATED COST	ACTION ITEM #	ECH / GTI RECOMMENDATIONS & RATIONALE
									parallel with existing pump (Duplicate P-203)
					consider head tank			23	No. Not recommended. See #22.
7 ECOMELT FINISHING	No Flow	upstream node failures	heat damage to vapor side equipment	7	have ID fan increase on high temperature	B	Programming Change	24	A2K programming change
		ID fan failure	plant shut down	9	add diverter on outlet of C-203, see also Node 6	C	See Above	25	See #16
10 VENT GAS	Lime in gas stream to Carbon Bed	bag break in baghouse	plugging carbon bed	9	consider bag break indicator	C	A2K To Recommend Indicator	26	No. Use existing ΔP's of S-303 (baghouse) and A-304 (activated carbon bed) for indication of broken bags. Opacity meter will also signal breakthrough of CaO. Include in SOP
11 LIME ADDITIVE	No Flow	bin empty	no acid gas removal	9	add low flow switch just ahead of venturi	C		27	No. Need alternate solution (to load cells or deflector plate)
12 PRIMARY BURNER TRAIN	No Flow of Natural Gas to Burner	no gas supply	plant shut down	7	add alarms set lower/higher than trips	B	Programming Change	28	A2K programming change (add PAL & PAH)
13 AFTER BURNER TRAIN	No Flow of Natural Gas to Burner	no gas supply	environmental emissions violation, shut down feed	9	add alarms set lower/higher than trips	C	Programming Change	29	A2K programming change (add PAL & PAH)
14 MELT BURNERS TRAIN	No Flow of Natural Gas to Burner	no gas supply	slag solidifies on tiles and could dump molten slag into granulator water causing steam explosion	6	add low temp alarm and trip should cut off feed	A	Programming Change	30	A2K programming change (add PAL & PAH)
		thermocouple failure			research alternatives to control by thermocouple		A2K To Investigate & Recommend	31	Yes. Provide backup T.C. installation & connection cost. A2K programming change.
15 DRYER BURNER TRAIN	No Flow of Natural Gas to Burner	no gas supply	wet product	9	add alarms set lower/higher than trips	C	Programming Change	32	A2K programming change (add PAL & PAH)

Table A-2. Summary of Potential Problems and Solutions from Haz-Op Review Sessions for the Cement-Lock Demo Plant

NODE #	DEVIATION	CAUSES	CONSEQUENCES	RISK FACTOR	RECOMMENDATION	PRIORITY	ACTION & ESTIMATED COST	ACTION ITEM #	ECH / GTI RECOMMENDATIONS & RATIONALE
16 INSTRUMENT AIR DRYER	Less Flow	air compressor failure	automatic valves go to fail position shutting down the plant	4	add instrument air compressor for back up or N2 for back up	A	Compressor $9,100 Installation $5,000 Power $10,000 Total $24100 Alternate Solution: Use Backpressure Regulators To Major Process Users & To Save Receiver Volume For Instrument Air For Valves If Compressor Fails: 2" Air Line To Z-301 Sprays, 1-1/2" Air Line To S-303 Baghouse, 1" Air Line To S-402 Baghouse, 1" To CEMS: $8000	33	Yes. Install backpressure regulators on major air consumer lines to conserve instrument air during power outage (rent back-up compressor).
17 ECOMELT QUENCH WATER CIRCUIT	No Flow	pump P-203 fails	mechanical damage due to steam explosion	3	add city water back-up to water sprays with auto actuation	A	See Node #6	34	No. Not feasible due to lack of capacity in existing IMTT drain system
					consider back-up pump			35	Same as #22
					consider head tank			36	No. See #22
		tank empty			add low level switch		$2,000	37	Yes. Add LSL & remote LAL to T-203
	No Flow of Pump Seal Water	control valve fail	rapid pump seal failure	4	add high/low flow switch	A	$3,000	38	Yes. Add FSL & remote FAL to water seal flush of P-203.
	Less flow of Pump Seal Water	control valve fail	pump seal failure spraying hot water in area	6		B			
	Higher Water Temperature	quenching process an loss of make-up water	npsh problem at pump causing low flow	10	add high temp alarm to TI set at 190F	C		39	Yes. Add TI, TSH & remote TAH for control room alarm to C-203 to monitor water temp & prevent steam formation.
18 NATURAL GAS BOOSTER	Less Flow	plugging of strainer	low burner firing	7	provide low pressure & temperature alarms, run indication to main control room	A	Programming Change	40	A2K programming change
	Higher Temperature	large compression ratio on hot feed gas	excess temperature affects burner regulators		provide temperature alarm set at 150°F	B	Programming Change	41	A2K programming change
	Higher Pressure	failure of 3" recycle	overpressure of gas supply	6	install PSV and high pressure alarm	A	Install PSV, Alarm Requires Only Programming Change	42	Yes. Add PSV. A2K programming change (add PAH - Set point @ 40 psig?)
5 BLENDED FEED SYSTEM	Higher Pressure	Accidental closure of downstream valve					Additional Comment Outside Of Haz-Op Meeting	43	Yes. Move valve at outlet of C-151 water-cooled jacket piping to downstream of PSV-151.

Equipment Rental

ECH opted to rent several equipment items rather than incur the capital costs associated with each, including:

- Two trailers for control room and staff, storage container (Williams Scotsman, South Kearny, NJ)
- Sanitary facilities (Mr. John, Keasbey, NJ)
- Emergency Generator and Automatic Transfer Switch (Foley Inc., Piscataway, NJ)
- Man-lift, front-end loader, skidsteer, and fork lift (Foley Inc., Piscataway, NJ)

The equipment was rented as needed and then returned to the rental agency when not needed. The only items continuing to be rented are the control room trailer and the storage container.

Completion of construction of the Cement-Lock demonstration plant was marked on July 26, 2003. Shakedown and commissioning activities commenced on Monday July 29, 2003.

Plant Shakedown and Commissioning

The objective of shakedown and commissioning activities was to ensure that all of the individual equipment items associated with the Cement-Lock demonstration facility are in proper working order. Another objective is to ensure that each subsystem (designated collection of individual equipment items) is also working in concert with the other subsystems. A third objective is to insure that all data acquisition and control equipment (instruments, wiring, PLC, etc.) is working properly and is communicating with the computers in the control room.

Shakedown and Commissioning Team

Plant shakedown and commissioning activities were performed under the guidance of A2K. The initial shakedown team included Doug East and James Dunn from GreenTree Services, Inc. (Exton, PA) and later, A2K Commissioning Engineer, Nelson Carswell. RPMS and their subcontractors provided labor for welding, cutting, rewiring, adjusting, monitoring, etc. during the shakedown and commissioning activities. Also, to serve as site monitors on behalf of ECH as well as GTI interests, Steve Calderone and Todd Harvey (Unitel Technologies, Mount Prospect, IL) were at the plant site from May 8 through September 4, 2003, which was concurrent with equipment installation as well as the initial shakedown and commissioning activities, and A2K manager and supervisor training. GTI staff, including Project Manager Robert Sheng, Mike Mensinger, and Dave Bowen, also served stints on-site during the remainder of the shakedown and commissioning activities.

Subsystem Testing

Each equipment subsystem was checked for proper connection and operation by the shakedown and commissioning team in a systematic manner. The Cement-Lock demonstration facility subsystems include:

- Sediment hoppers, augers, feed systems, motors, conveyors, instrumentation
- Modifiers 1 and 2 hoppers, feed systems, rotary valves, motors, conveyors, instrumentation
- Rotary kiln melter (Ecomelt generator), drive motor, burner, natural gas supply, combustion air blowers, refractory, alignment, instrumentation
- Secondary combustion chamber system, burner, natural gas supply, combustion air blower, refractory, instrumentation
- Natural gas burner systems (main, secondary, melt, and Ecomelt dryer)
- Ecomelt granulator and conveyor system, water sprays, drag conveyor motor, instrumentation.
- Ecomelt conveyor, dryer, and storage system, conveyors, motors, instrumentation
- Flue gas quench system, water sprays, water storage tank, pumps, instrumentation
- Lime injection system, lime hopper, blower and motor, rotary valve, instrumentation
- Baghouse dust collection, compressed air system, rotary valve, dust collection, instrumentation
- Activated carbon adsorber bed system, carbon, fire suppression system, instrumentation
- Induced draft (I.D.) fan, motor, damper, instrumentation
- Computer data acquisition and control system, PLC (Programmable Logic Controller)
- Safety interlocks
- Natural gas supply system, natural gas compressor, instrumentation.

The results of shakedown testing of the major system components are discussed below and include any problems as well as solutions that may have arisen during the shakedown.

At a minimum all electrical connections were checked for continuity and accuracy. All electrical connections were checked for proper polarity. Electric motors were checked for proper voltage, wiring, and rotation. Pumps (and associated motors) were checked for proper wiring, rotation, and lose connections, leaks, etc. Connecting lines and nozzles were checked for blockages, obstructions, leaks, etc. Safety switches were checked for proper operation. All conveyors were checked for proper rotation, correct installation of keys, obstructions, etc. Natural gas lines were checked for leaks, proper connection to safety controls. Natural gas burners were checked for operability, safety controls. Computer signals from the field were checked for proper connection to the PLC, and for communication with the computer control system.

Refractory Curing: Concurrent with the equipment calibrations, the refractory bricks in the kiln, the gunned refractory in the secondary combustion chamber, and the ductwork were cured in the manner specified by the manufacturer. A2K took the lead in the refractory curing operation. The curing operation involves heating the refractory in stages to specified higher temperatures and maintaining those temperatures for specific time periods. Curing is necessary to drive off surface moisture as well as moisture that is variously combined with the refractory components. The refractory curing requires slow and steady heating over a period of several days.

Once the refractory has been maintained at temperature for the specified time, it was planned to continue with actual operations to save time. Originally, A2K had recommended that the kiln temperature be brought back down to ambient so that the refractory could be examined for problems and/or defects.

Electrical Components

All of the electrical installation work was completed prior to commissioning. Cable trays and conduit were installed. All electric motors in the demo plant were wired to appropriate motor starters in the Motor Control Center (MCC). During shakedown, each motor was tested for proper wiring and "bumped" for proper rotation. Motors that were found to be wired incorrectly were rewired. Four Brooks-Hansen motors were found to be inoperative upon testing. These four motors were removed and new motors were installed and connected.

Instrumentation

All instruments were checked for proper polarity, connection, continuity, and operation at the instrument itself, at the PLC (Programmable Logic Controller), and at the HMI (Human Machine Interface otherwise known as a PC). Some instrument loops were checked from the PLC directly.

Instruments (thermometers, thermocouples, and temperature indicating transmitters, pressure indicators, gauges, pressure indicating transmitters, flow meters, flow indicating transmitters, and digital inputs and digital outputs) were checked for proper connection and calibrations and limits as needed. Several instruments and transmitters were found to be inoperative during the calibrations. These instruments and transmitters were repaired or replaced.

Instrument calibrations were performed by Omni Instruments as part of the electrical and instrumentation installation work under subcontract to RPMS. Also, supplementary calibrations were performed by KGB Controls and A2K on selected instruments. Joe Grable (KGB Controls formerly with A2K) had originally designed the piping and instrumentation diagrams for the Cement-Lock demo plant when he was with A2K. The results of KGB Controls instrument calibration efforts are summarized in Appendix G.

The HMI (human-machine interface, or computer) was delivered to the plant site and set up. A second (backup) computer and its data acquisition and collection system were installed and tested. Either computer can be used for process control as well as data acquisition.

Five computer screens were developed by A2K and KGB Controls with GTI input that are used to control the function and operation of the demo plant. These include:

1) Feed System,
2) Ecomelt Generator,
3) Flue Gas Quencher (spray cooler),
4) Flue Gas Clean Up (lime feed system, baghouse, activated carbon bed, I.D. fan), and
5) Ecomelt Dryer and Storage.

The screens are shown in Figures A-5 through A-9.

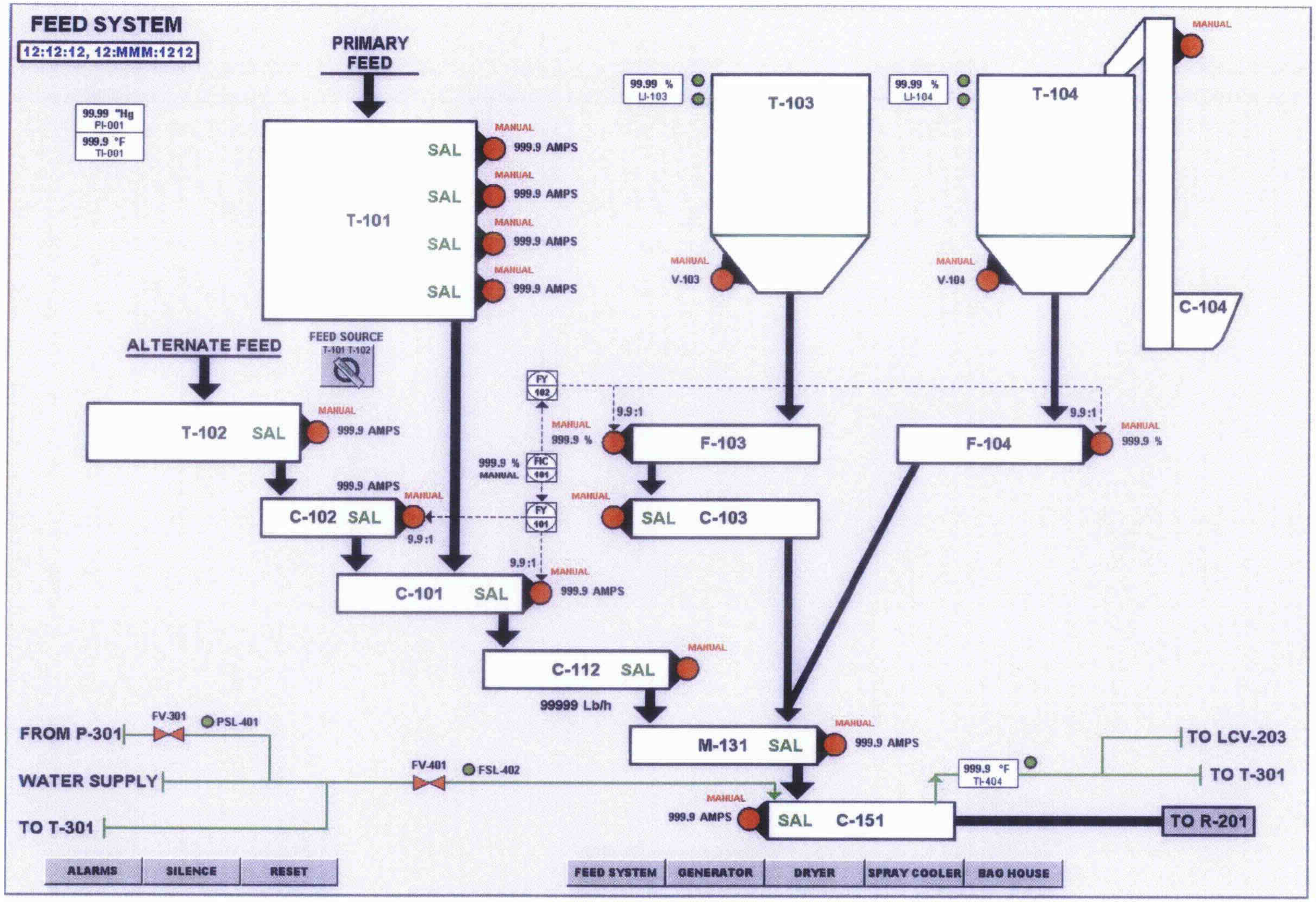


Figure A-5. Cement-Lock Demo Plant Computer Screen – Feed System

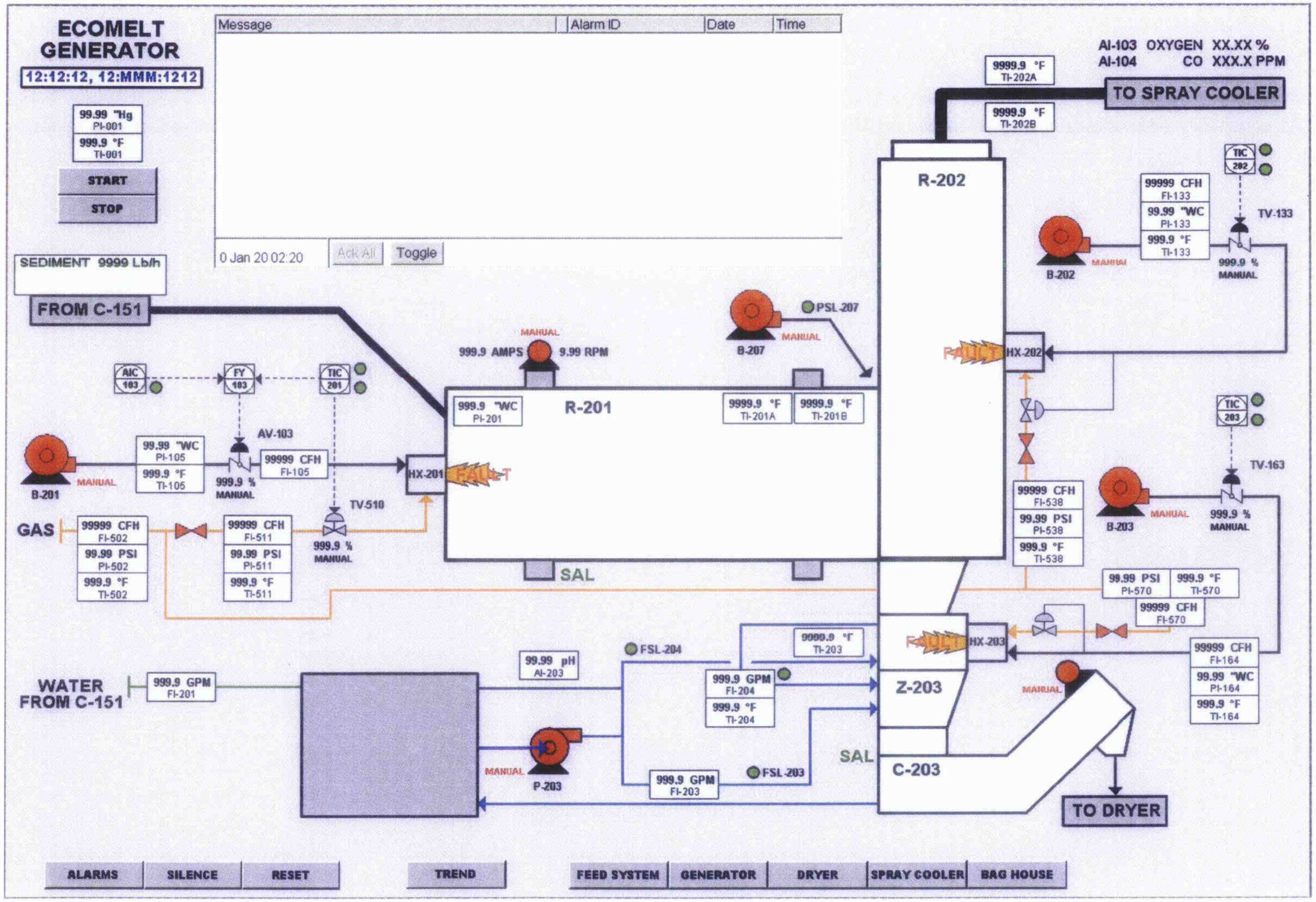


Figure A-6. Cement-Lock Demo Plant Computer Screen – Ecomelt Generator

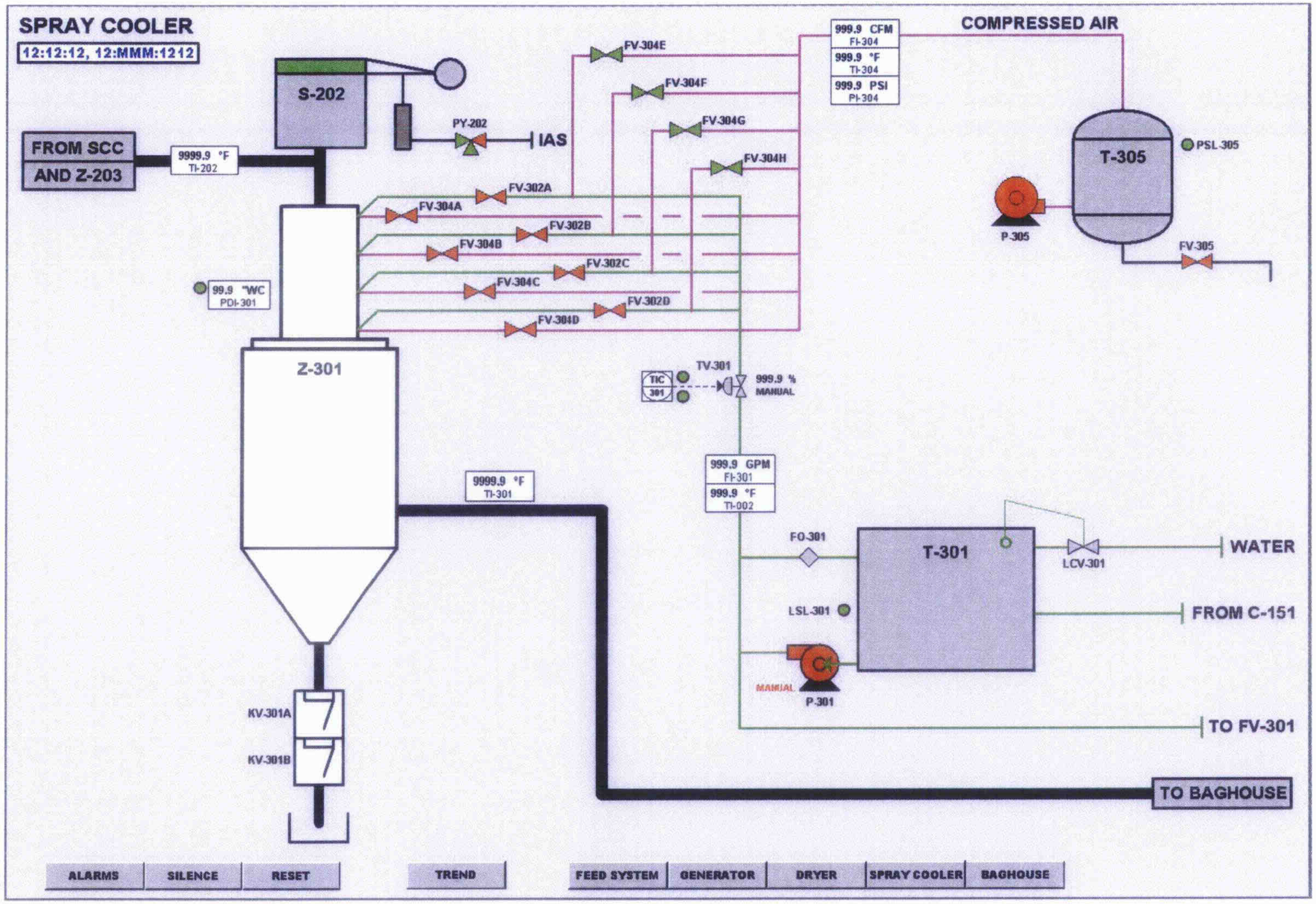


Figure A-7. Cement-Lock Demo Plant Computer Screen – Flue Gas Quencher

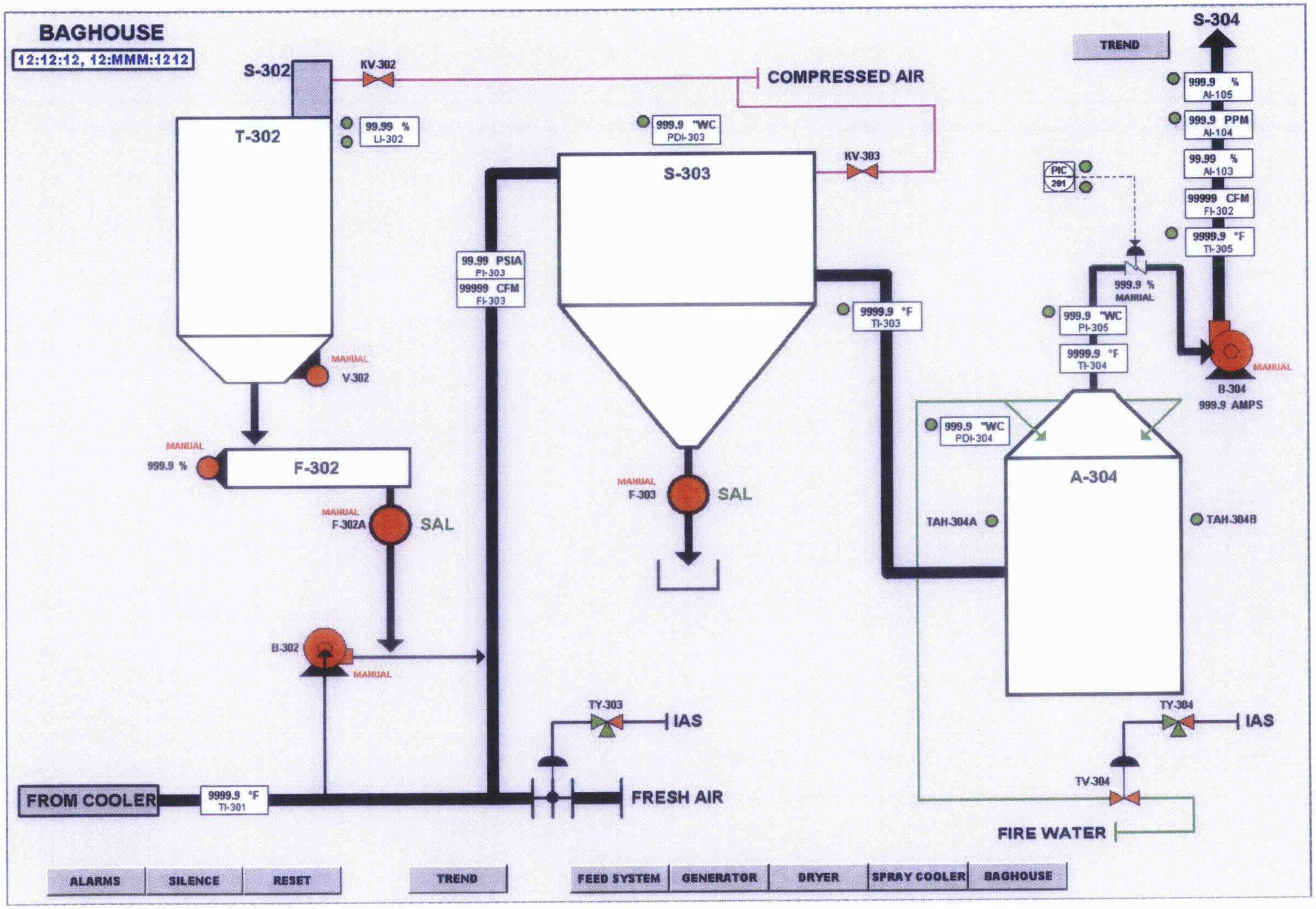


Figure A-8. Cement-Lock Demo Plant Computer Screen – Flue-Gas Clean Up

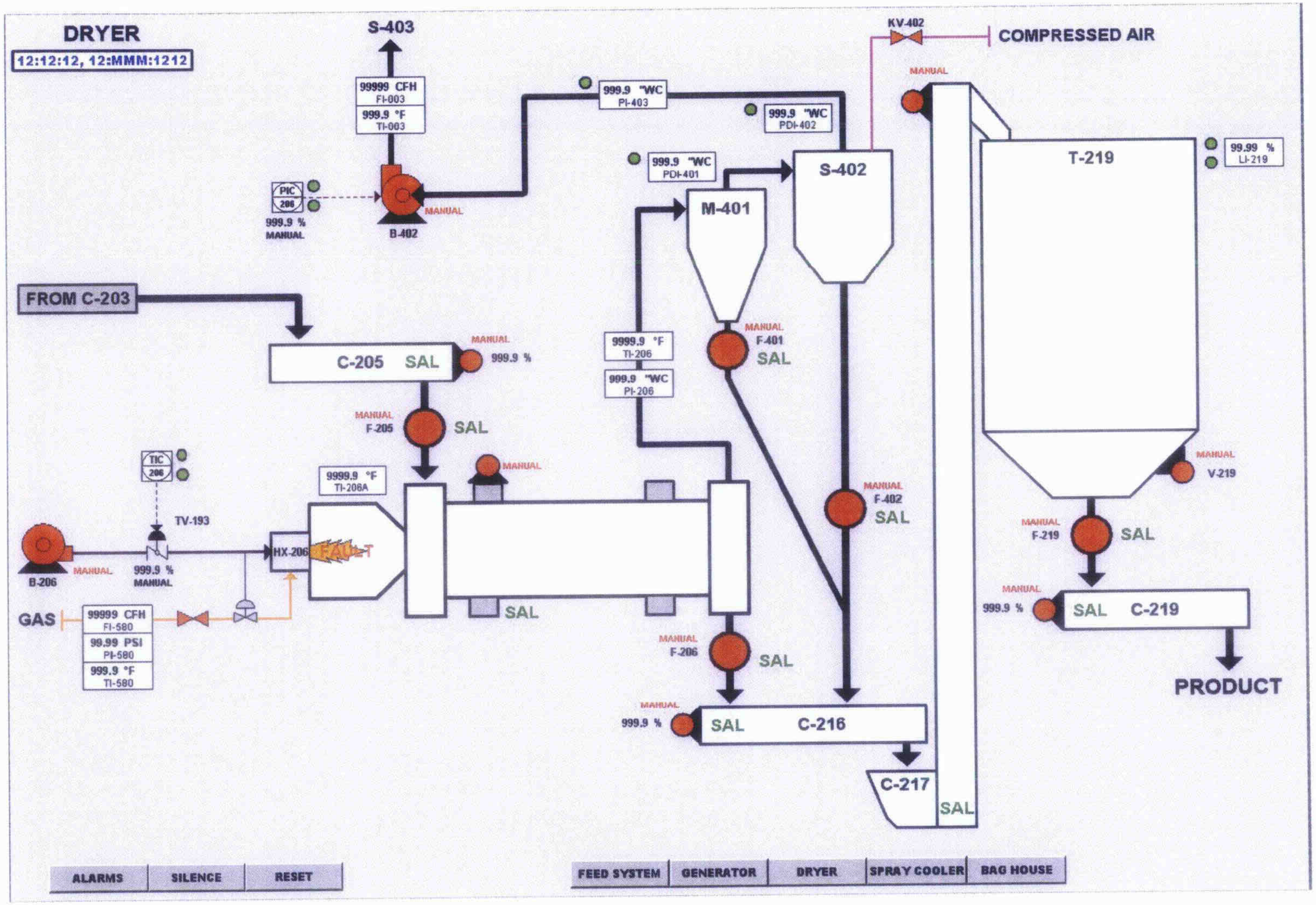


Figure A-9. Cement-Lock Demo Plant Computer Screen – Ecomelt Dryer and Storage

Sediment Preparation

The sediment for the project had been dredged from the Stratus Petroleum site (Newark, NJ) in Upper Newark Bay. About 5,000 yd^3 of sediment was dredged out of which about 500 yd^3 were set aside for the Cement-Lock demonstration project. This quantity of as-dredged sediment was mixed with water and then screened to remove debris greater than ½ inch. The debris was discarded in an ordinary landfill. The sediment-water slurry was then subjected to dewatering and pelletizing apparatus operated by JCI/Upcycle. The objective of this pretreatment step was to facilitate the initial operation of the Cement-Lock demo plant by providing uniformly sized pellets of feed. However, the sediment-water slurry did not readily dewater, nor did it pelletize.

Nevertheless, JCI/Upcycle treated the bulk of the sediment through the equipment and placed the material in twenty 20-yd^3 capacity roll-off containers for interim storage. The roll-offs were lined with polyethylene liners and covered with tarps. The quantity of sediment collected from this operation was estimated to be about 350 yd^3 or a total of about 362.9 tons (based on a bulk density of 76.8 lb/ft^3). The sediment was unloaded into a specially constructed sediment storage area at the Cement-Lock demonstration plant site at IMTT, which was part of the NJ-DEP AUD. The tarps had been removed from each of the twenty roll-offs before unloading, however, it was not possible to remove the polyethylene liners at that time.

During the shakedown and commissioning activities, the RPMS operators systematically combed through the sediment in storage using a bobcat-type front-end loader and shovels to remove the polyethylene liners and any other oversized material (Figure A-10). This debris was discarded in an ordinary landfill.

Figure A-10. Oversize Debris Being Separated from Sediment in Storage Area

The screened sediment was then covered with tarps to reduce dusting as well as rainwater infiltration. Several samples were collected from different areas of the pile to determine the average moisture content of the sediment. This information was needed to properly combine the proper amounts of modifiers to the sediment prior to feeding into the Ecomelt Generator. The water content of the sediment in storage was determined to be in the range of 40 to 45 weight percent.

Sediment Feed System

The sediment feed system consists of the following equipment items: 100-yd^3 capacity main Storage Hopper (T-101), alternate Storage Hopper (T-102), sediment conveyors C-101, C-102, the Pug Mill Mixer (C-131), sediment Weigh Feeder (C-112), and water-cooled Auger/Screw Feeder (C-151). Conveyor C-101 is a metering conveyor that controls the flow of sediment to the Weigh Feeder (C-112). Based on the Weigh Feeder indication of sediment flow, the proper quantities of Modifier 1 and Modifier 2 are fed from their respective feed systems.

All of these equipment items in this subsystem were tested and their operation confirmed. During testing and calibration of the load cells on the Weigh Feeder (C-112), it was found that one of the four load cells was inoperative and needed to be replaced. The load cells were serviced by Industrial Scales (Linden, NJ).

Even though the load cells were calibrated, the sediment feeding tests through the weigh feeder yielded inconsistent results. It was concluded that the sticky nature of the sediment caused it to accumulate within the Weigh Conveyor rather than pass readily through. The load cell output (on the HMI) could not be correlated with the quantity of sediment that actually was discharged from the weigh conveyor to the pug mill. This prompted the sediment and modifier premixing approach (see following).

The main sediment feed system was calibrated according to the calibration procedure prepared by A2K (Appendix H). The initial attempts to calibrate the main sediment feed conveyor (C-101) resulted in completely plugging and jamming the conveyor. With all four of the augers turning in the main Sediment Hopper (T-101), it appeared that too much sediment was being fed to the main feed conveyor. Also, the consistency of the sediment was such that it stuck to the flights of the screw conveyor. Very little material actually made it out of the screw conveyor and into the pug mill (M-131). The operators had to remove the segmented covers to the conveyor and manually removed the sediment from the flights.

In later calibration efforts, it was found that by operating only one or two of the four augers in the Sediment Hopper, the rate of sediment being fed to the main conveyor could be managed. However, the consistency of the sediment still posed a problem.

Two approaches to remedying the feeding problem were investigated: The first involved adding water to the sediment to render it more pumpable / flowable. Some small-scale batch mixing tests were conducted to evaluate this approach using a portable Pulsair system. The results showed promise; however, the ambient temperature had declined to the mid 20°F's by that time and the sediment had begun to freeze.

The second approach involved premixing the sediment and modifiers solids together in measured batches. In this manner, the composition of the sediment-modifier mixture could be better controlled. Also, adding the dry modifier solids reduced the overall moisture content of the mixture sufficiently to render it less sticky. The use of the alternate feed hopper (T-102) for the premixed material was considered. Several batches of premixed sediment-modifiers were manually prepared in the sediment storage area using a rototiller. The premixed batches were stored and covered with tarps.

During the refractory-curing activities, a leak developed in the swivel union joint that supplies water to the water-cooled auger/screw (C-151). The swivel union joint had failed at the threaded end. Part of the threaded pipe was stuck in the auger inlet connection. Once this threaded pipe was removed, the replacement swivel joint was installed.

It was also found during shakedown and commissioning that the twin mixers inside the alternate Feed Hopper (T-102) were wired in reverse. When the wires were properly connected and the system was tested, it was observed that the two mixers had been switched when installed. In other words, the north mixer was in the south mixer's position and vice versa. The mixers were removed and installed correctly.

One concern with using the alternate Feed Hopper for the initial testing of the Cement-Lock system was that another conveyor (C-102) was needed to feed the main sediment feed conveyor (C-101). This added step introduces other potential material handling problems.

Modifier Feed System

The modifier feed systems include the Modifier 1 Hopper (T-103), Feeder (F-103), Conveyor (C-103), Modifier 2 Hopper (T-104), and Feeder (F-104).

During the initial shakedown testing, the motor that drives the Modifier 1 metering screw was found to be a direct current (DC) motor rather than an AC motor. A2K ordered an AC motor replacement that was later installed.

The modifier feed systems were calibrated according to the calibration procedure prepared by A2K (see Appendix I). At first, the Modifier 1 feed system appeared to be undersized for the load of limestone. However, upon disassembling the equipment, wet limestone was found to have clogged discharge chute from the hopper. Rainwater had apparently infiltrated the lower section of the hopper. The flanged connection was re-sealed with caulk and retightened. The problem did not recur.

When the Modifier 1 and 2 feeding systems were initially tested, it was found that neither was in the proper range for the demo project. Both were feeding much more modifier than expected or appropriate for the demo.

Modifications needed to achieve the proper range for each feed system were installed. For the Modifier 1 feed system, this involved installing a reducing sleeve on the exit screw to limit slippage of material through the annular space. For the Modifier 2 feed system, the opening onto the belt conveyor was mechanically reduced to expose only about ⅛ inch for material to pass through. After these modifications were made, each feed system was successfully calibrated.

Lime Feed System

The lime feed system includes the Lime Hopper (T-302), Feeder (F-302), Lime Feeder Airlock (F-302A), and Lime Eduction Blower (B-302).

The lime feed system was calibrated according to the calibration procedure prepared by A2K (see Appendix J). To convey the lime into the flue gas upstream of the baghouse, a slipstream of hot flue gas was used as motive gas. As the demo plant system was being commissioned, it was discovered that the high water vapor content of the flue gas slip stream was causing the lime to plug in the screw feeder mechanism. As a means of eliminating this problem, the inlet to the lime feeder blower was disconnected from the hot flue gas line and opened to ambient air. Ambient air has much lower water vapor content than the flue gas. It will be heated to operating temperature upon mixing with the bulk flue gas stream.

Flue Gas Quencher

The flue gas quencher system includes the Flue Gas Quencher (Z-301), double tipping valves (KV-301 and KV-302), the Quencher Water Tank (T-301), Quencher Water Pump (P-301), air compressor (P-305), and Water Flow Control Valve (TV-301).

This system was tested for operability during the refractory curing activities. It is critical that the Flue Gas Quencher operate properly to protect the downstream air pollution control equipment, specifically the baghouse and activated carbon bed, from temperature excursions. The bags in the baghouse are capable of operating at temperatures up to 500°F (Huyglas®); however the design temperature (per A2K) is 400°F. The carbon in the activated carbon bed is specified to operate at 350°F.

As the temperature of the flue gases increased to about 350°F, the Flue Gas Quencher system was made operational. Prior to achieving that temperature, no flue gas cooling was needed. The system works by sensing the temperature of the flue gases in the duct exiting the Flue Gas Quencher. If the temperature exceeds the set point (about 350° to 375°F), the controls open one or more (there are four) water spray nozzles at the top of the quencher. If the temperature falls below the set point, then one or more nozzles are closed. Too much water flow to the flue gas quencher results in dumping of condensate through the double tipping valves at the bottom of the quencher. The objective of Flue Gas Quencher operation is to minimize the quantity of water dumping – it should be a "dry" quencher.

It was found that the system that controls the rate of water flowing to the flue gas quencher had failed. All of the equipment for the water flow control (TV-301) had to be replaced. After the control valve was replaced, the flow of water was more controllable. There were other concerns about the efficiency of the spray nozzles in atomizing the cooling water in the Flue Gas

Quencher chamber. Pressure indicators were added to the air and water lines to monitor these parameters. Additional instrumentation is needed to insure proper atomization.

Baghouse

The particulate filtration/collection subsystem consists of the Baghouse (S-303), the dust discharge Rotary Feeder (F-303), and a collection bin. The system also incorporates a reverse pulse compressed air system to clean the accumulated dust from the bags when the pressure drop exceeds the manufacturer's recommendation.

Initial inspection of the baghouse showed that 4 of the 324 bags could not be properly installed due to interference with internal structural bracing. This interference needed to be corrected as the Air Quality permit issued by the NJ-DEP specifically states the number and total surface area of the bags. The manufacturer (Griffin Environmental, Syracuse, NY) was contacted to repair the problem. The interference was corrected and the four bags were properly installed.

Activated Carbon Adsorber Bed

The Activated Carbon Adsorber bed (A-304) is an air pollution control device designed to capture volatilized heavy metals, such as mercury, that may be present in dredged sediment. The activated carbon adsorber bed consists of two 2-foot thick beds of activated carbon pellets within a single steel vessel. The total quantity of activated carbon pellets in the two beds was about 24,000 pounds. This unit is designed to operate at temperatures in the range of 350° to 400°F.

Temperature Excursion

The following incident occurred during the shakedown and commissioning, specifically refractory curing, which was initiated in October 2003.

On October 15, at about 11:10 pm, the shift supervisor was making his rounds through the plant and noted that the top of the activated carbon bed vessel was "red" and that the external insulation on the activated carbon bed vessel was on fire. He turned on the emergency fire water supply to the activated carbon bed, shut down the rotary kiln and secondary combustion chamber burners, opened the emergency stack cap, and put out the external fire using a fire extinguisher.

He also notified the commissioning engineer from A2K. Employees of IMTT were in the vicinity of the demo plant at that time and also noted the temperature excursion.

No dredged sediment or any other type of waste material was in the system or had been fed to the system at any time prior to or during this unplanned event.

It was concluded that the main cause of the temperature excursion (and the resulting air emission) was the improper use of a sulfur-impregnated activated carbon in the activated carbon bed. As the temperature exceeded about 180°F, the elemental sulfur began to sublime from the carbon pellets. The vapor-phase elemental sulfur then reacted with oxygen in the flue gas releasing heat of combustion. Bed temperatures began to rise locally due to flue gas short-circuiting and eventually ignited some of the carbon pellets.

The incident was reported to the NJ-DEP as required by the Air Quality permit issued to ECH. A letter report on the incident was prepared and submitted to the NJ-DEP for an affirmative defense per statute.

After the temperature excursion, the plant was allowed to cool. The next morning, the four hatches on the carbon bed were opened so that the condition of the internal structure of the activated carbon bed could be assessed. Upon opening the hatch covers, the carbon began smoldering. Additional water was sprayed on the carbon directly to quench the hot spots. When all the hot spots had been quenched, the activated carbon was removed from the two beds using a vacuum truck. The carbon was then relocated and sequestered in the northeastern end of the sediment storage area pending final disposition.

The damage to the equipment was assessed (see Figures A-11 through A-14). The steel support grating for the upper bed had bowed under the temperature, allowing some of the upper carbon bed to migrate to the lower bed. The #6 mesh screen that held the carbon pellets also failed in several spots. The fire suppression systems above each bed were damaged and required replacement. Four of the eight high-temperature switches in the beds were damaged. The upper portion of the external insulation also required replacement. Finally, the entire load of activated carbon pellets required replacement. A lump-sum price to repair the activated carbon bed damage was provided by RPMS using FMW Piping (Carteret, NJ) as the mechanical contractor.

Also a supply of activated carbon (RB-4C) was ordered from Norit Americas to replace the sulfur-impregnated carbon. Although sulfur-impregnated activated carbon is not suitable for this application, activated carbon (without sulfur) has been determined to be suitable. Activated carbon has an auto-ignition temperature of about 750°F, which is significantly higher than the normal operating temperature of the activated carbon bed (range of 350° to 400°F).

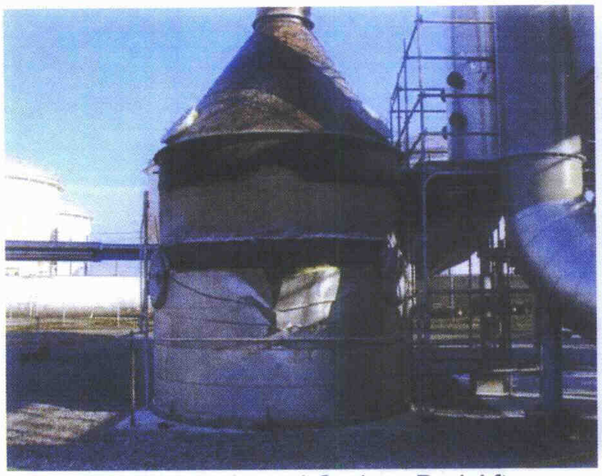


Figure A-11. Activated Carbon Bed After Temperature Excursion (Note paint discoloration and fire damage to insulation)

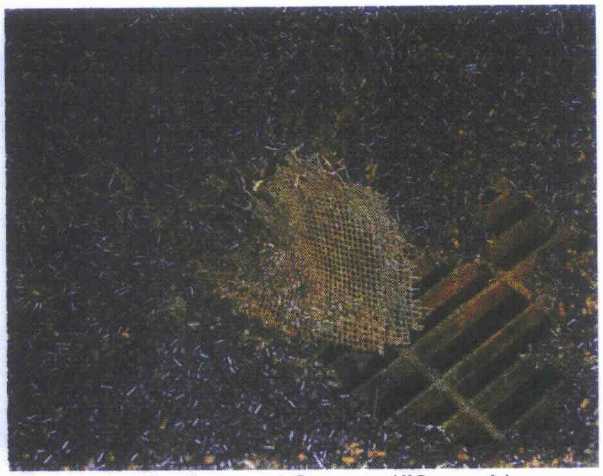


Figure A-12. Support Screen (#6 mesh) Failure (Note orange color on surface of some carbon pellets)

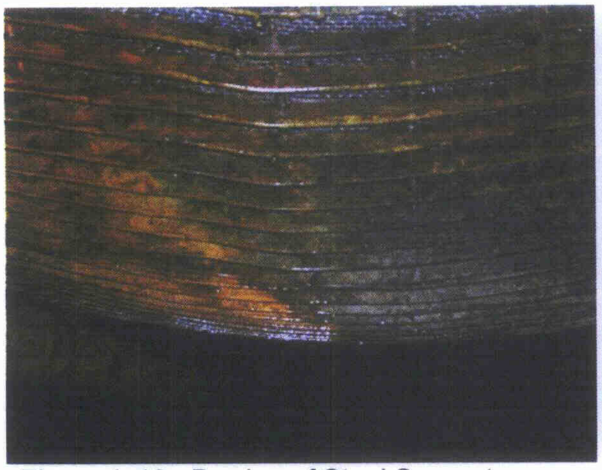


Figure A-13. Bowing of Steel Support Grating of Upper Bed

Figure A-14. Fire Suppression System Damage

The activated carbon (AC) bed repair work began on November 5. The entire load of sulfur-impregnated activated carbon had to be removed from the AC bed. This was done by the RPMS operators. The sulfur-impregnated activated carbon was relocated to the sediment storage area for later disposition.

Proceeding with the mechanical repairs, the mechanical subcontractor first removed the 36-inch diameter duct connecting the I.D. fan inlet to the AC bed outlet. Then they removed the conical upper portion of the AC bed to expose the damaged upper carbon support screen and grating. The damaged screen and grating supports were removed. Both upper and lower damaged fire suppression systems were removed. The lower support grating sustained little damage and was retained in place (Figure A-15). A new layer of #10 mesh steel screen was installed on top of the steel grating in the lower bed.

Figure A-15. Inside of Activated Carbon Bed and Central Flue Gas Chimney (The lower grating without screen is also shown)

The supply of activated carbon (about 21,000 pounds of RB-4C) ordered from Norit Americas (Dallas, TX) to replace the sulfur-impregnated carbon was delivered to the plant on November 8. The lower bed was filled with carbon first, then a new layer of #10 mesh screen and grating was placed on top of the carbon in the lower bed. This was done to prevent the formation of peaks and valleys of carbon that may lead to hot spots due to uneven flue gas flow distribution. The lower fire suppression piping was installed. After the lower bed was completed, the new upper bed grating and screen were installed. The carbon was loaded and then a layer of screen and grating was installed on top of the carbon. The upper fire suppression piping was installed.

To provide a seal between the conical top and the lower section of the AC bed, a layer of drop warp fiberglass tape (2½ by ¼ inch) was used. The conical top was repositioned and installed on November 8. The connecting duct was then reinstalled and the mechanical work was completed on November 10. Two of the four operating temperature switches were relocated to the upper bed to provide coverage.

Induced Draft (I.D.) Fan

While commissioning the I.D. fan and motor, the pneumatic actuator for the air damper failed to respond properly. Investigation showed that the actuator had been incorrectly connected to the high-pressure air line from the compressor rather than the low-pressure instrument signal line. The diaphragm had been irreparably damaged. A replacement actuator was ordered and installed. However, further testing showed that the new actuator was not strong enough to adjust the air damper under the full load of the I.D. fan. A larger replacement was obtained by A2K, installed, and tested for proper function.

The temperature excursion that occurred on October 15 also affected the I.D. fan. The expansion joint that connects the ductwork from the Activated Carbon bed to the I.D. fan inlet was overheated and the flexible boot developed some cracks. These cracks could allow air to infiltrate the I.D. fan and reduce its capacity. Because of this, the expansion joint requires some maintenance; however, it is functional.

An associated part of the flue gas handling system is the emergency stack cap. The emergency stack cap is located at the top of the refractory-lined duct leading from the Secondary Combustion Chamber into the Flue Gas Quencher. The stack cap opens in situations that may result in excessively high-temperature flue gas passing into the baghouse or into the activated carbon bed. Both air pollution control units have upper temperature limits, which must be maintained to prevent fires.

When initially tested, the stack cap would not open sufficiently. The chain (which reaches from the stack cap all the way to ground level) needed to be reduced in length. This was done. Also, a personnel guard rail was installed around the counterweight at ground level to prevent accidents. Similarly, on the top level, the grating interfered with the movement of the chain. The grating was adjusted to allow free movement of the chain.

Natural Gas Supply System

The natural gas supply system consists of the natural gas booster compressor and the supply lines to the different process burners. During commissioning, a check valve required for the natural gas line was installed to complete the natural gas service. The natural gas line was successfully leak / pressure tested from the spud up to the natural gas booster (the test gas was nitrogen). The natural gas compressor was commissioned and, after some adjustment of its internal PLC programming parameters, operated as designed. The booster compressor supplies natural gas to the piping at a pressure of 15 psig.

Natural Gas Burners

There are four main burner systems in the Cement-Lock demo facility: 1) Primary Burner (30-million Btu/hour – HX-201) for the Ecomelt Generator, 2) Secondary combustion chamber burner (6-million Btu/hour – HX-202), 3) Melt burners (three nominal 500,000-Btu/hour – HX-203A, B, C), and 4) Ecomelt dryer burner (0.9-million Btu/hour – HX-206). Each burner system is equipped with its own safety, flow control, and flame detection systems.

Primary Burner

During shakedown and commissioning, the primary burner pilot light was lit and operated for a sustained period. The primary burner (HX-201) was initially operated for brief periods with only its central jets firing, while other process adjustments were made. Similarly, the secondary combustion chamber burner (HX-202) was also ignited and burned for a short period. Initial attempts made to ignite the three melt burners (HX-203A, B, and C) were not successful. The motor on the air blower modulator motor failed and the burners could not be tested. As the modulator on the Ecomelt Dryer has the same motor, it was "borrowed" and installed so that the melt burners could be tested. The safety fire eye (purple peeper) also did not function properly. A replacement was found locally and installed.

Also, the capacity of the main burner seemed to have been reached at a much lower firing rate than expected. It was discovered that the pilot regulator on the main burner was undersized. A larger pilot regulator was ordered by A2K. Even after this regulator was installed, the flow of natural gas to the main burner appeared to have reached a maximum of about 21 million Btu/hour. As this was significantly less than the 40 million Btu/hour maximum design rate, attempts to remedy this situation were made.

The output from the natural gas booster was increased from 15 to 20 psig, thereby increasing the flow to the main burner somewhat. However, this still did not provide the proper flow of natural gas. The restricting orifice on the natural gas supply line to the main burner was removed to improve the flow volume of natural gas. Also, the size of the supply piping to the main burner was increased from 3 to 4 inches in diameter to reduce pressure drop and improve the flow of natural gas. These changes had the desired effect of improving the flow to the main burner.

Secondary Combustion Chamber Burner

While commissioning the air blower (B-202) for the Secondary Combustion Chamber, debris in the blower housing became entrained causing damage to the blower. The motor also failed during this event. A2K fortunately had a spare blower at their facilities. A2K also ordered a replacement motor which was delivered and installed.

Melt burners

The melt burners were commissioned without having the main burner firing, which may have biased the observed performance of these burners. The fuel train to each burner needs additional instrumentation so that natural gas pressure can be properly monitored to each burner.

Ecomelt Dryer Burner

The Dryer burner was successfully commissioned and fired, but not yet fully tuned.

Ecomelt Generator

The Ecomelt Generator subsystem consists of the Ecomelt Generator (R-201), Secondary Combustion Chamber (R-202), and the refractory, motor drive, and combustion air blowers.

Refractory curing is a critical operation prior to actual operation of the kiln system. The refractory must be heated slowly to drive off moisture without cracking the refractory.

Kiln Alignment

During the initial stages of refractory curing it was observed that the kiln was riding uphill against the bumpers. The kiln had been aligned previous when it was not under load or rotating. A2K suggested that the kiln be re-aligned to minimize wear on the bumpers. This was done on November 10 by Evans & Daniels (Plymouth, PA). Also, the motor drive for the kiln vibrated severely when the kiln was operated above 0.4 RPM. Additional support for the motor drive was installed by the mechanical contractor, but this did not alleviate the problem. The motor drive was realigned by the Longo Company on November 13. It was also recommended that the rotary kiln dryer also be realigned prior to extended operation.

As the refractory was being heated up, water vapor was observed emanating from the welded joint between the Secondary Combustion Chamber and the Drop-Out Box. The refractory installer had originally welded this section together, but the seal was not complete. Operators were enlisted to caulk this joint to minimize any air infiltration during operation.

Refractory Curing

The refractory curing was initiated on October 13. The temperature in the rotary kiln was to be brought up slowly according to the curing schedule recommended by A2K. However, while attempting to light the burners, it was determined that the ultraviolet flame detectors were inoperative (had failed). The UV flame detectors had to be replaced. On October 15, heat-up was resumed and by early evening, temperatures in the kiln and secondary combustion chamber had reached about 600°F. Late on the same evening, there was an unplanned and unforeseen temperature excursion in the activated carbon bed (see section above on Activated Carbon Adsorber Bed).

Once the activated carbon bed repairs were completed, refractory curing continued. Shortly after the kiln was started up on November 13 visual observation of the kiln internals revealed that several bricks had dislodged from the kiln. As the kiln rotated, the bricks tumbled down its length and fell into the granulator. The bricks were from one area in the second course near the entrance to the kiln. The kiln was immediately stopped and allowed to cool. A2K was contacted to bring in the refractory installer, Lynn Whitsett, to install new bricks and repair any other damage that was detected. A representative from Lynn Whitsett arrived at the plant site on November 16 (Sunday) and installed the new bricks. Galvanized washers were inserted between the newly installed bricks as wedges.

Power Outages

The Cement-Lock demo facility sustained two major power outages during shakedown and commissioning activities. The first occurred on November 22; the second on December 7.

November 22: On Saturday, November 22, the temperature of the Ecomelt Generator had reached about 2150°F. Shortly after 6:00 pm, there was a plant-wide power outage. The power outage occurred when the motor mount for the water-cooled Auger/Screw Feeder (C-151) came loose. Two bolts welded to screw's base hold the motor in place. One of these bolts sheared off when the screw auger inside the water-cooled shell started to jam. The motor mount consequently turned counter-clockwise and pinched its electrical feed wires against the structural steel. The pinched wires shorted out the motor and grounded the electrical power to the plant. This was an electrical ground fault.

Power to the plant was restored by flipping the main breaker in the MCC back on. This however did not restore power to the plant motors and instruments as the PLC had been overloaded.

At about 8:45 pm, the kiln motor was restarted by increasing the frequency to the motor and overriding the PLC through a remote start. The reason the PLC would not start when the power was restored was because there was a faulty scaling factor in the program for the melt burners. Joe Grable (KGB Controls) assisted in remotely reprogramming the faulty code in the PLC. The scale factor for the burners was set higher than the value set in the PLC. This false value kept the PLC from being able to restart.

There was no apparent damage done to the kiln from this incident. No bricks fell, nor did the kiln shell warp. The activated carbon bed filled up with water due to an interlock that immediately opens the fire suppression system when the power is cut off. The carbon bed was drained manually the next day. It was dried out as hot flue gas flowed through it during subsequent operation.

It was originally thought that the motor overloaded due to heavy amounts of sediment sitting on the C-151 inlet due to sediment feed calibration testing earlier in the day. However, it appears that the auger/screw stopped turning in the shell, while the motor continued to rotate. The force of the forward and reverse motion of the motor during the feed testing was responsible for the failure of the weld at the motor mount.

The motor was rewired by SM Electric on November 24. It was tested on November 25 and found to be fully functional. Also, the water-cooled auger/screw can be turned by hand.

The heat-up of the kiln was resumed on Friday, November 28. However, a problem arose in closing the emergency stack cap. One of the two support chains that facilitate opening the stack cap broke. This piston in the pneumatic cylinder jammed. The operators disconnected the other supporting chain and closed the stack cap manually. This occurred during a strong rain/thunder storm. Also, the flue gas quencher also experienced control problems. The kiln temperature was reduced to about 1000°F until the stack cap could be repaired.

December 7: The second major power outage occurred at the plant site on December 7. On December 5 and 6 about 15 inches of snow fell across the area. The shakedown and commissioning team continued heating the Cement-Lock demo plant during that time. The kiln temperature had reached about 2300°F. At about 2:20 pm, power was lost across the entire IMTT terminal facility. This outage was the result of a downed PSE&G power line outside of the IMTT facility. The downed power line resulted in a fire at the IMTT substation which shut off power completely. The emergency generator was able to keep the kiln rotating; however power was not restored until about 12:00 midnight (December 8).

Ecomelt Granulator

The Ecomelt Granulator subsystem consists of the Ecomelt Granulator (C-203), granulator water recirculation Tank (T-203), Ecomelt drag conveyor, and Granulator recirculation pump (P-203).

During the shakedown and commissioning, the backup granulator water recirculation pump (P-203A) was mechanically and electrically installed. When the motor was "bumped" to test shaft rotation, it was found to be reversed. After the motor was rewired, during the retest the motor jammed and could not be restarted. The impeller had apparently become unscrewed when the pump was originally bumped. This fault has since been corrected.

Ecomelt Dryer and Storage

The Ecomelt Dryer and Storage subsystem consists of the Ecomelt Dryer (D-206), Rotary Feeder (F-206), Dried Ecomelt Conveyor (C-216), Bucket Elevator (C-217), Ecomelt Hopper (T-219), Rotary Feeder (F-219), Dried Ecomelt Product Conveyor (C-219), Dryer Cyclone Separator (M-401), Bag Filter (S-402), and Ecomelt Dryer I.D. Fan (B-402).

The individual components have been tested. The refractory in the Ecomelt Dryer has not yet been cured since a heat sink is required to prevent overheating the dryer chamber. Refractory curing must wait until the flow of Ecomelt from the granulator is sufficient to serve as a heat sink. Also, the rotary dryer itself needs to be aligned prior to extended operation.

Continuous Emissions Monitoring System (CEMS) Testing

The Continuous Emissions Monitor System (CEMS, Figure A-16) is capable of measuring the oxygen (O_2) and carbon monoxide (CO) contents of the flue gas as well as opacity. All three of these parameters are required to be measured and recorded as stipulated by the Air Quality permit issued by the NJ-DEP.

Figure A-16. Continuous Emissions Monitoring System

The CEMS was successfully activated and calibrated with special protocol calibration gases. Protocol gases are used for regulatory compliance testing of stack gases. To obtain the protocol designation, certified gases are reanalyzed after one week to determine component composition. For each component of interest, the arithmetic average of the two analyses is used as the calibration gas value. The protocol calibrations for the CO and O_2 and the analysis of the nitrogen (zero gas) are included in Appendix K.

Summary of Shakedown and Commissioning

During shakedown and commissioning, numerous equipment failures and problems were encountered that delayed the project, including a temperature excursion in the activated carbon bed, two power outages, and the deleterious effects of inclement weather.

Some problems are expected during start-up and commissioning. However, the Cement-Lock demo plant start-up encountered numerous unexpected and unanticipated equipment problems and failures that delayed the project. A summary of the major equipment problems, failures and the resulting delays is presented in Table A-3.

Table A-3. Summary of Delays During Commissioning of the Cement-Lock Demo Plant

Item	Date	Description	Delay, Days
1	10/6	Main ID fan damper actuator was damaged on start-up because instrument air impulse lines were connected incorrectly. Commissioning terminated. A replacement unit was ordered, delivered and installed. Correct air impulse line connections were installed. Commissioning resumed.	4
2	10/13	Replacement ID fan damper actuator was found to be undersized, which resulted in problems of maintaining adequate pressures and flow rates in kiln, secondary combustion chamber, and flue gas cleanup equipment. Commissioning terminated. Sizing of damper actuator was reviewed. Larger-size replacement unit was ordered, delivered and installed. Commissioning resumed.	4
3	10/15	Encountered operating problems with kiln and secondary combustion burners including frequent flame-out and difficulty of re-ignition. Design and operation of air and fuel trains, flame control panels, and burners were reviewed and tested. UV scanners on burners were found to be faulty / inoperative. Commissioning terminated. Replacement UV scanners were located and installed. Commissioning resumed.	2
4	10/15	Activated carbon bed temperature excursion. Carbon bed was shut down and flooded with fire water. Commissioning terminated. Carbon bed was cooled, opened and drained. External vessel insulation was damaged, carbon adsorbent was deactivated, and internal bed support structure was severely damaged. Design and operation of carbon bed were reviewed. Replacement activated carbon was identified, ordered, delivered and installed. Modified internal bed support structure was installed. Carbon bed operating procedure was modified. Commissioning resumed.	15
5	10/21	Unable to feed modifier 1 (limestone) solids from storage hopper to mixer. Commissioning terminated. Design and operation of modifier 1 feed system were reviewed. Modifier 1 feeder was first thought to be undersized and methods to increase feeder capacity were reviewed. Investigation showed that water has gotten into the feeder leading to limestone clumps. Flange joints were sealed, wet solids were drained, and feeder was recalibrated. Commissioning resumed.	2

Table A-3 (cont.). Summary of Delays During Commissioning of the Cement-Lock Demo Plant

Item	Date	Description	Delay, Days
6	10/21	Unable to control feed rate of modifier 2 (alumina) feeder from storage hopper to mixer. Commissioning terminated. Design and operation of modifier 2 feeder was reviewed and modified. Modifier 2 feeder recalibrated. Commissioning resumed.	2
7	10/21	Unable to raise kiln temperatures. Commissioning terminated. Design and operation of air and fuel trains, flame control panel, and kiln main burner were reviewed and tested. Natural gas pressure regulator was undersized. Larger-size replacement regulator was ordered, delivered and installed. Commissioning resumed.	4
8	10/22	Rotary joint on water-cooled auger/screw failed leading to leakage of cooling water. Shut down water-cooler auger/screw and commissioning terminated. Dismantled water-cooled auger and identified failed component. Replacement parts were ordered, delivered and installed. Commissioning resumed.	4
9	11/4	Readings of key instruments were found to be inaccurate. Commissioning terminated. Instruments were recalibrated. Commissioning resumed.	3
10	11/10	Kiln was found to be out of alignment. Commissioning terminated. Kiln was realigned. Commissioning resumed.	1
11	11/11	Computer malfunctioned. Commissioning terminated. Computer was replaced. Commissioning resumed.	2
12	11/12	Support of kiln drive motor was found to be inadequate. Commissioning terminated. Additional motor support was installed. Motor was re-aligned. Commissioning resumed.	1
13	11/13	Refractory bricks fell out of kiln. Commissioning terminated. Original refractory installer was notified, arrived on site, and installed replacement refractory bricks. Commissioning resumed.	4
14	11/19	Unable to control temperature at outlet of flue gas quencher. Hot flue gas would result in fire in the baghouse and activated carbon bed. Commissioning terminated. Temperature controller for water to gas quencher malfunctioned. Replacement controller was ordered, delivered and installed. Commissioning resumed.	4

Table a-3 (cont.). Summary of Delays During Commissioning of the Cement-Lock Demo Plant

Item	Date	Description	Delay, Days
14	11/19	Unable to control temperature at outlet of flue gas quencher. Hot flue gas would result in fire in the baghouse and activated carbon bed. Commissioning terminated. Temperature controller for water to gas quencher malfunctioned. Replacement controller was ordered, delivered and installed. Commissioning resumed.	4
15	11/20	Unable to obtain consistent and reproducible calibration results of sediment weigh feeder. Commissioning terminated. Design and operation of sediment and modifier feed systems were reviewed. Existing sediment weigh feeder was determined to be not suitable for sticky materials. Alternatively, feed materials were mixed in sediment storage area. Commissioning resumed.	2
16	11/20	Encountered frequent plugging and jamming problems in sediment feed system. Commissioning terminated. Design and operation of sediment feed system were reviewed. Different feed injection arrangements, moisture contents of feed mixture, and rotational speeds of conveyor and live bottom hopper were evaluated experimentally. Commissioning resumed.	9
17	11/22	Water-cooled auger/screw was jammed and mounting bracket of auger motor failed leading to emergent power outage. Activated carbon bed was flooded due to power outage. Commissioning terminated. Damaged water-cooled auger/screw and motor mounting bracket were repaired. Carbon bed was opened, drained and dried. Commissioning resumed.	4
18	11/25	Unable to raise kiln temperatures to desired operating levels. Commissioning terminated. Design and operation of natural gas supply line to kiln main burner were reviewed. Calculations showed existing natural gas header was undersized. Undersized line was replaced by larger-size gas supply line. Commissioning resumed.	4
19	11/25	Unable to control temperatures at outlet of flue gas quencher. Design and operation of atomizing spray nozzles and air/water supply systems were reviewed. Spray nozzles were removed, inspected and tested. Pressure indicators on air and water supply lines were installed. Commissioning resumed.	3

Table A-3 (cont.). Summary of Delays During Commissioning of the Cement-Lock Demo Plant

Item	Date	Description	Delay, Days
20	11/25	Unable to discharge solids from alternate feed hopper. Commissioning terminated. Twin-auger mixers and motor wiring of alternate feed hopper were installed incorrectly. Reinstalled augers and reversed motor wiring. Commissioning resumed.	3
21	11/28	Unable to close stack cap due to broken linkage. Commissioning terminated. Adjusted chain linkage, adjusted length and weight of counterweight, repaired obstructing grating, and repaired actuator cylinder. Commissioning resumed.	3
22	12/4	Refractory bricks in kiln came loose. Commissioning terminated. Repaired loose bricks. Commissioning resumed.	2
23	12/3	Unable to convey lime adsorbent with quenched flue gas. Commissioning terminated. Modified lime blower piping and installed new suction line. Commissioning resumed.	3
		Total Delay Days	**85**

Operator Training and Safety

The plant operators underwent both classroom as well as hands-on training in the proper function of the demo plant equipment. Also, as part of the overall focus on safety at the plant during construction as well as operations, the plant manager and all shift supervisors as well as GTI project staff underwent health and safety training to enable them to safely assist RPMS staff in the operation of the plant on an "as needed" basis. Training and safety-related activities are described below.

A2K Classroom Training

On September 3 and 4, 2003, A2K conducted classroom training for the Cement-Lock demonstration plant at IMTT facilities. Tom Van Remmen, A2K Vice President of Sales and Marketing presented the training material, which was abstracted from the Cement-Lock demo plant Operations & Maintenance Manual. Attending the training were the RPMS plant manager, 4 shift supervisors, 1 alternate shift supervisor, 2 site managers from Unitel Technologies, and 4 GTI staff. Also attending the classroom training were sponsors Scott Douglas (NJ-DOT/OMR), Eric Stern (U.S. EPA Region 2), and Keith Jones (Brookhaven National Laboratory). Safe operation of the plant was stressed during the training session as being of paramount importance. The complete handout discussed by A2K during the training is included in Appendix L.

The A2K Commissioning Engineer, Nelson Carswell, provided hands-on plant operations training of the plant manager, shift supervisors, and laborers.

IMTT Safety Orientation

On September 17, the RPMS plant manager, shift supervisors, and GTI staff attended safety orientation training and awareness seminar presented by the Safety Department of IMTT. Attendance at the safety seminar is required by IMTT for anyone who will be working on the IMTT property.

Scaffolding Training

On October 15, the supervisory staff and operators underwent scaffolding use and safety awareness training. The 4-hour session was conducted by a representative from Emilcott Associates. Each attendee received a diploma certifying that they had attended the session.

Health and Safety Plan

A detailed, site-specific Health and Safety Plan (HASP) was prepared as a deliverable for the project (see Appendix M).

As part of the on-going emphasis on health and safety, GTI and ECH staff provided weekly review sessions of the safety requirements and expectations at the plant.

Overall, during the construction, installation, and shakedown and commissioning activities at the plant, there were no significant or lost time injuries.

Start-Up and Initial Operation

The start-up and initial operation of the Cement-Lock demo plant are described below. In preparation for the initial start-up and processing of sediment through the plant, the operating staff preparing batches of premixed sediment, modifiers, and flux during the day shift. The nominal makeup of each batch consisted of about 1650 pounds of wet sediment and the prescribed amounts of limestone, alumina, and flux (fluorspar). The batches were prepared using an electronic drum scale. A rototiller was used to mix the materials together.

Test No. 1 (December 9-10, 2003)

On the morning of December 9, the kiln temperature had been brought up to 2425°F. The Secondary Combustion Chamber (SCC) temperature was 2290°F. At 9:15 a.m. the decision was made to begin feeding the premixed sediment-modifier mixture to the kiln through an opening in the main conveyor (C-101). The sediment-modifier mixture was manually fed at a rate estimated to be about 600 pounds per hour. The readings obtained from the weigh conveyer (C-112) were judged unreliable due to the sticky nature of the sediment. Several batches of premixed feed material were fed manually during the day.

That night, due to safety concerns, feeding was halted. The operators prepared additional batches of premixed feed materials under rented tower lights. Other operating parameters were maintained at steady conditions.

Although molten slag was observed to be dripping from the "ceiling" of the rotary kiln (Figure A-17), no Ecomelt was discharged from the Cement-Lock demo plant on December 9. It was estimated that several batches of premixed feed material would be required to coat the refractory with a layer of slag.

On December 10, feeding resumed around 9:00 a.m.. Shortly thereafter, the water-cooled auger/screw (C-151) jammed. This auger runs at a fixed speed and was being fed more material than it could effectively convey into the rotary kiln. This imbalance resulted in "flooding or choking" in the pug mill discharge (the connecting plenum between the pug mill and the auger/screw).

Operating conditions in the Cement-Lock demo plant were steady when the material was fed into the C-101 conveyor. Natural gas flows to the main kiln burner averaged 20.7 million Btu/hour during the operating period. The flow of combustion air to the main burner averaged 230,535 SCFH. Temperature in the Secondary Combustion Chamber averaged 2390°F and the natural gas flow averaged 833,000 Btu/hour. Combustion air to the SCC averaged 9338 SCFH. The temperature at the melt burner averaged 1924°F. Natural gas flow to the melt burners was not recorded. Other conditions were steady. The temperature of flue gases flowing into the activated carbon bed was 350°F. The time-temperature history of the initial start-up of the Cement-Lock demo plant is presented in Figure A-18. Temperatures for the Ecomelt Generator, SCC, Flue Gas Quencher outlet, Activated Carbon bed outlet, and Main Flue Gas Vent (stack) are presented.

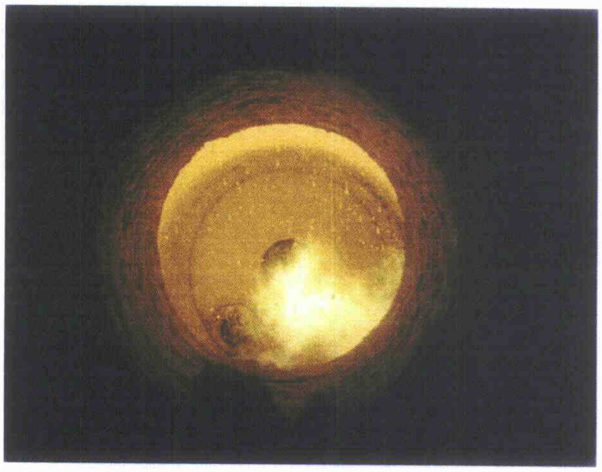


Figure A-17. Molten Slag Dripping from the Kiln "Ceiling" During December 2003 Campaign

The presence of rocks in the feed material caused the inclined screw conveyor (C-101) to jam several times. Although the operators had removed oversized materials by hand, some tramp materials were missed. The conveyor system had to be stopped, the motors locked out, and the lids to the conveyor removed so that the blockage could be cleared.

Feeding resumed at 2:00 p.m. At this point, the kiln temperature had been increased to 2515°F. By visual observation, the molten slag in the kiln appeared to be less viscous than that from the pilot-scale testing at Hazen Research.

At 3:10 p.m., the first sample of Ecomelt from Stratus Petroleum sediment was conveyed out of the granulator (Figure A-19). Samples were taken for visual and microscopic examination. Under cross-polarized light, the desired non-crystalline (glassy) phases appear dark (Figure A-20). The undesired crystalline phases appear as bright spots. The estimated desired glassy composition of the Ecomelt sample was over 90 percent.

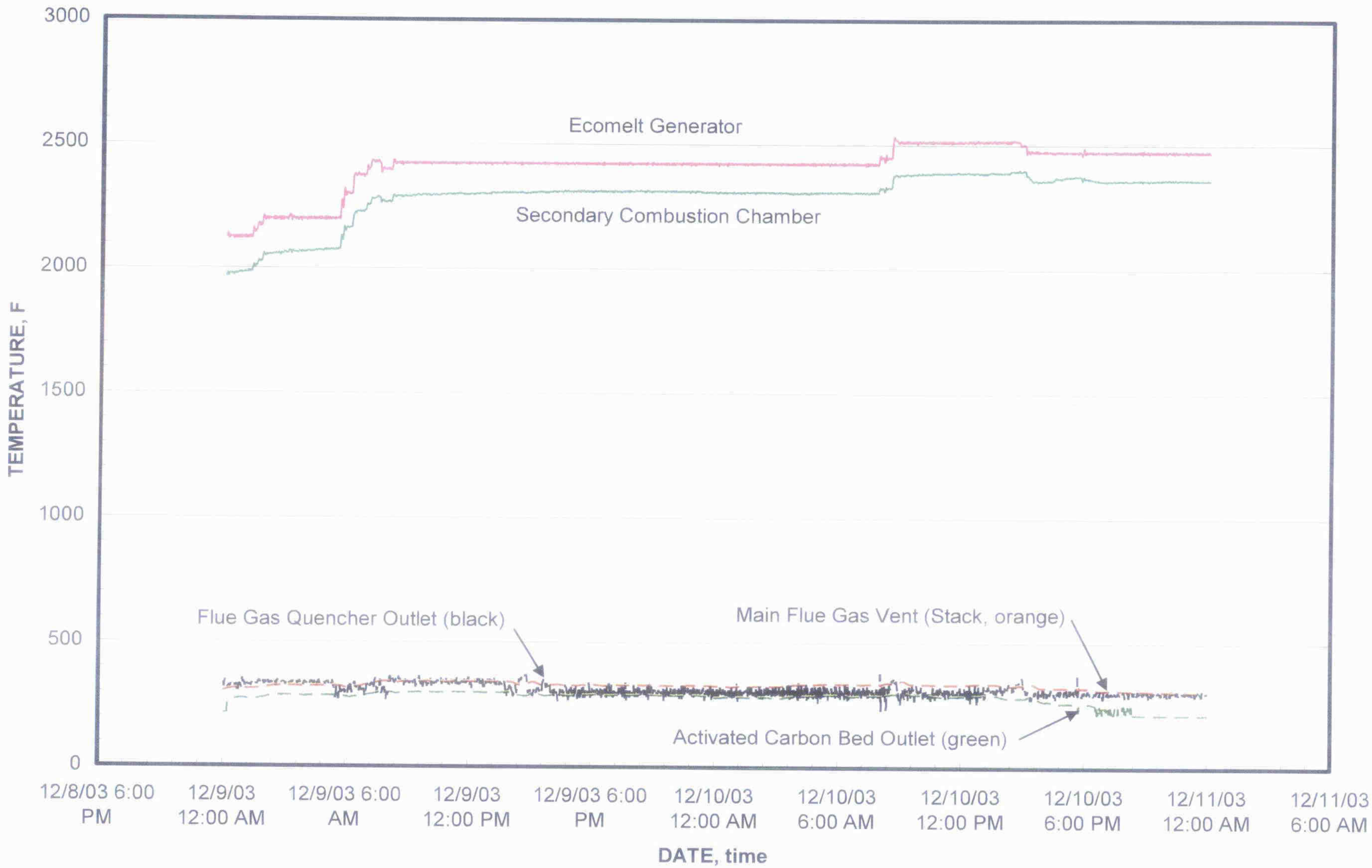


Figure A-18. Time-Temperature History of the Initial Startup (Test No. 1, December 9-10, 2003) of the Cement-Lock Demo Plant

Figure A-19. Initial Ecomelt Produced from Stratus Petroleum Sediment – Collected December 10, 2003.

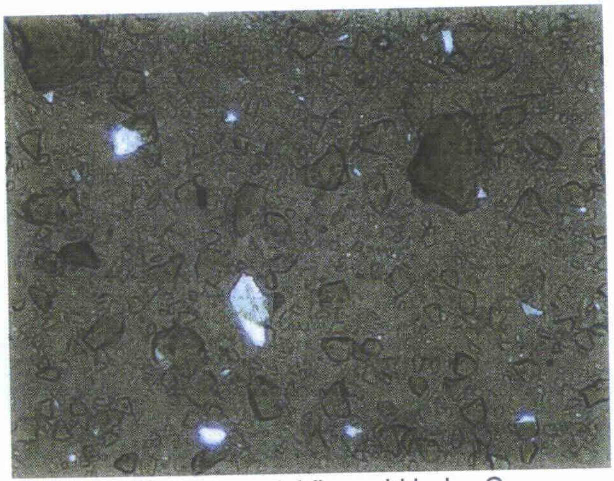


Figure A-20. Ecomelt Viewed Under Cross-Polarized Light, the Desired Glassy (Dark) Phase Predominates. Bright Spots are Undesired Crystalline Phases.

Manual feeding was halted just after 3:00 p.m. as the operators changed shifts. Feeding was resumed at 4:00 p.m.

When viewed through the two view ports on the drop-out box, the molten slag appeared to be more viscous around the kiln discharge than in the main part of the rotary kiln. Slag buildup on the ceramic pusher tiles and drop-out box section was also observed. The three melt burners were constantly fired at their maximum output. However, there is speculation that the melt burners were under-fired due to insufficient natural gas pressure to the burners. The length of the main burner flame was increased to convey more heat toward the drop-out box and possibly clear the slag buildup. This was not effective and the slag continued to accumulate. By 6:00 p.m., the slag buildup had blocked the entire south view port and half of the north view port. At this point, solids feeding was halted.

At about 12:00 midnight, the shift supervisor reported that the drag conveyor in the Ecomelt granulator had jammed. Attempts to clear the jam were not successful. The kiln was maintained at about 2500°F overnight.

The next day, the kiln temperature was reduced according to the prescribed rate. After the system had cooled sufficiently, the tiles were withdrawn so that the condition of the drop-out box could be evaluated. The granulator and drop-out box were filled with accumulated slag. The operators removed the slag from the drop-out box and granulator using a pneumatic jackhammer until the vessel was cleared on December 24. The slag was collected in five 55-gallon drums. The initial Ecomelt produced was collected in two partially filled 55-gallon drums.

A debriefing meeting was held at the plant site to discuss the possible causes of the slag accumulation in the drop-out box area and to recommend possible solutions. Other aspects of plant operation were discussed as well. The major recommendations from the debriefing were to 1) repair the kiln seals to minimize the influx of cool air into the drop-out box, 2) add additional burners to the drop-out box area (either as movable lances or permanently installed equipment), 3) add additional view ports to the drop-out box, 4) increase the rotational speed of the C-151 screw/auger, 5) enable forward/reverse operation for the sediment feed conveyors, and 6) add a condensate collection tank and recirculation pump to the Flue Gas Quencher bottom.

A sample of Ecomelt from the initial operation of the Cement-Lock demo plant was submitted to CTLGroup (formerly Construction Technology Laboratories, Skokie, IL) for testing. CTLGroup conducted x-ray diffraction (XRD) on samples of raw sediment and Ecomelt. The results of the XRD analysis on the sample of sediment (Figure A-21) show the presence of numerous peaks of undesired crystal phases (typically quartz). The results of the XRD analysis on the sample of Ecomelt (Figure A-22) show the smooth characteristic hill indicating the desired glassy (amorphous) nature of Ecomelt.

CTLGroup performed the ASTM test for slag hydraulic activity (C-1073) on the Ecomelt sample. In this test, a sample of pozzolanic material (Ecomelt) is mixed with prescribed amounts of sand and a 20 weight percent solution of sodium hydroxide (NaOH). The mixture is formed into 2-inch cubes and the cubes of mortar are then cured at 55°C for 24 hours. After the curing period, the samples are tested for compressive strength. The results of this test showed that the Ecomelt was hydraulically active and achieved a compressive strength of 4,380 psi. Please note that the original laboratory-scale sample of Ecomelt achieved a 1-day compressive strength of 3100 psi.

CTLGroup also conducted tests to determine the compressive strength per ASTM Standard C-109 for comparison with the requirements for Portland cement of ASTM C-150. The results of these tests showed compressive strengths after 3, 7, and 28 days of curing of 1765, 2910, and 5190 psi, respectively, which compares very favorably with previous results.

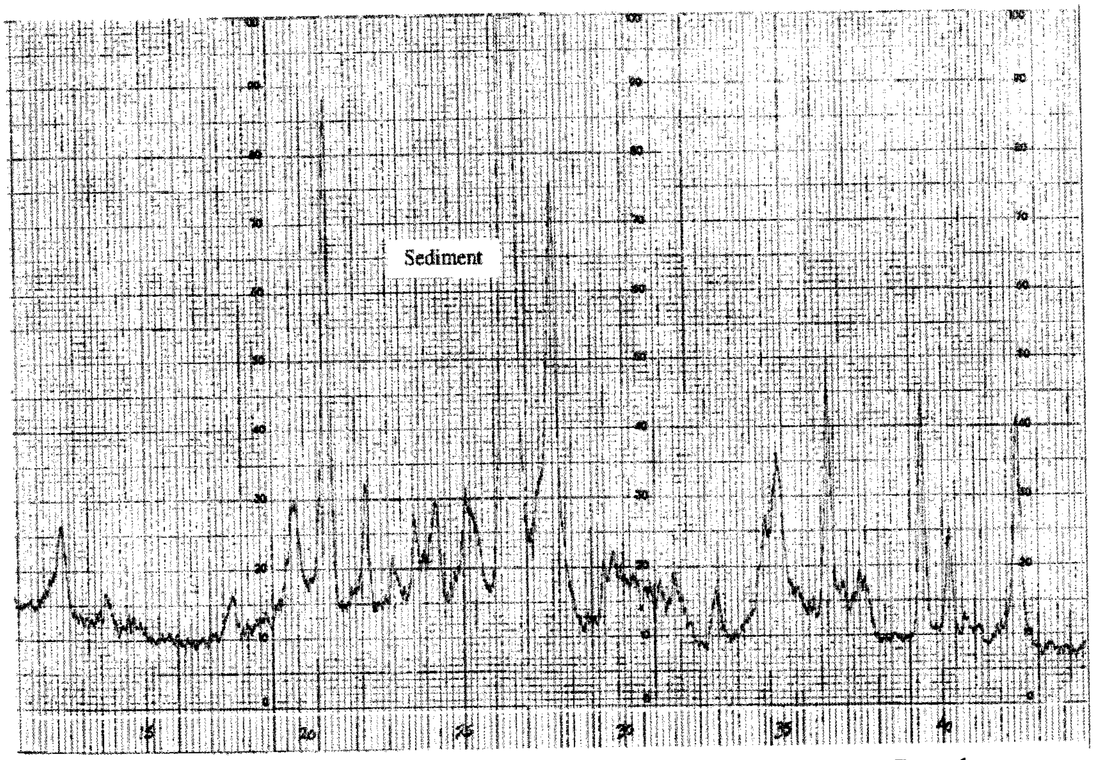


Figure A-21. X-Ray Diffraction of Dredged Sediment from Stratus Petroleum –
Peaks Indicate Crystalline Phases of Mineral Matter

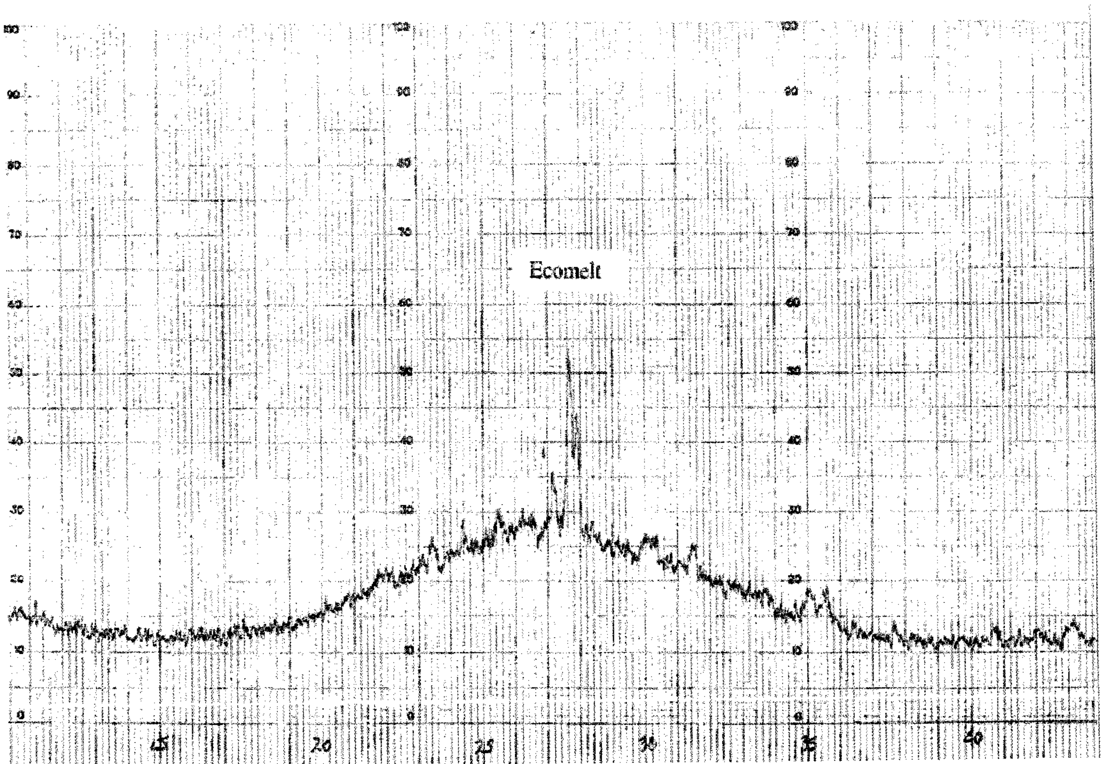


Figure A-22. X-Ray Diffraction of Ecomelt from Stratus Petroleum Sediment –
Lack of Peaks Indicates Desired Glassy Nature

IMPROVING PLANT OPERABILITY

The problems encountered during the initial start-up of the Cement-Lock demonstration plant in December 2003 led to the involuntary shutdown of the Cement-Lock demo plant. The implementation of the following mechanical or operational solutions was expected to enhance the overall operability of the demo plant.

Several equipment-related problems contributed to the involuntary shutdown during initial start-up in December 2003. These problems are categorized into four major sections:

1. Feed Solids Handling
2. Ecomelt Generator and Drop-Out Box
3. Gas Cleanup, and
4. Miscellaneous Repairs / Retrofits

Among the problems identified were the inability to consistently and uniformly feed sediment into the system, inadequate air seal around the rotary kiln at the drop-out box, insufficient thermal energy input to the drop-out box, and insufficient real-time information on the situation developing in the drop-out box. Other problems related to sediment handling and feeding included sticking of sediment to and jamming of the sediment feed screw (C-101). Problems related to gas cleanup included inadequate atomization of the flue gas quencher water and excessive production of condensate from the flue gas quencher.

Process Improvements and Enhancements

The proposed solutions to problems identified after the December 2003 campaign and the actions taken are listed below. Please note that some of the proposed solutions were not instituted. After careful consideration, these were judged to be not cost-effective for the benefit that was originally conceived. Those proposed solutions are marked "not done" and are followed with a brief explanation.

Feed Solids Handling

- Install a tent to cover the raw sediment storage area – Complete

- Spread the raw sediment over the ground (under the tent) to reduce its moisture content by air drying – Complete
- Blend predetermined amounts of modifier solids with air-dried sediment – Complete
- Install a removable cover on top of main sediment storage hopper (T-101) – Complete
- Install variable speed drive on the four conveyor motors of the main sediment storage hopper (T-101) – Complete
- Install forward/reverse switches on sediment feed conveyors (C-101 and C-112) – Complete
- Increase the speed of water-cooled screw/auger (C-151) – Complete
- Install a discharge chute on the main sediment feed conveyor (C-101) – Complete
- Install removable covers on the sediment feed conveyor (C-101) – Complete

These modifications will enable the sediment or sediment-modifier mixture to be fed more consistently and uniformly into the system via the existing screw conveyors.

Installing a tent over the sediment storage area significantly improved the feed preparation activities. The tent was 90 feet long and 60 feet wide. It was 24 feet tall at its highest point. The tent has 6 support poles located within the covered sediment storage area.

The removable cover on the main sediment hopper (T-101) consists of plastic tarps draped over a central horizontal pole and tied down with guy lines. When the hopper is being loaded, the guy lines are used to retract a portion of the tarp exposing the material in the hopper below.

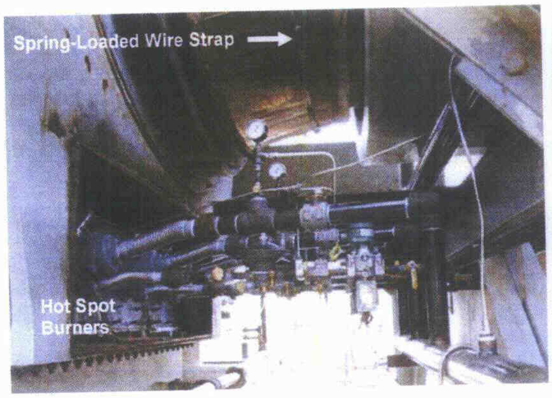
Air drying of raw sediment and premixing of dried sediment with modifier solids will greatly improve the operability of the feed handling system. Adding forward/reverse motor switches to the conveyors will also improve the operability of the conveyors.

The fixed-speed drive of the water-cooled screw/auger C-151 was converted to a variable-speed drive. The original specification for screw/auger C-151 called for it to deliver 117 cubic feet ($4\frac{1}{3}$ yd^3) per hour of sediment and modifier mixture. This relates to a throughput capacity of 30,000 yd^3/year of sediment, which is significantly higher than the target feed rate for demo plant testing. The variable-speed drive allows the conveyor to be set at a specified feed rate. If material begins to accumulate in the plenum above the C-151 screw/auger, the speed can be increased.

Ecomelt Generation and Drop-Out Box

- Repair air seal (overlapping leaf seals) assembly at kiln discharge – Complete
- Seal weld gaps in seal frame around kiln discharge – Complete
- Repair and retune existing melt burners and air/fuel trains as needed – Complete
- Remove pusher plate/tile assembly and its cooling water supply and return system – Complete
- Install refractory lined wall to replace pusher plate/tile – Complete
- Install 5 melt burners at strategic locations around the kiln discharge – Complete
- Install air and fuel gas trains and control panel for new melt burners – Complete
- Install combustion air blower system for new melt burners (including motor control center switch addition) – Complete
- Install flue gas sampling nozzles at kiln discharge (for CO & O_2 measurement) – Complete
- Install 2 sight ports at kiln discharge including safety blast gates and air purge – Complete
- Install TV camera and monitor system at kiln discharge – Not done
- Replace damaged thermocouples at kiln discharge – Complete
- Install forward/reverse switch on granulator conveyor (C-203) – Complete
- Verify settings of all existing and new burners (North American Manufacturing Co., Ltd.) – Complete
- Install operator access port (manway) at kiln discharge – Complete

These modifications and retrofits will minimize the heat loss from the kiln discharge and provide additional thermal input so that the slag discharged from the kiln can be kept in a fluid molten state. The photograph (below left) shows the three new North American Manufacturing Co. Hot Spot burners installed at the drop-out box and connected to the natural gas and air supplies. The photograph (below right) shows the high-velocity Tempest burner installed on the north wall of the drop-out box (a second burner is installed on the south wall).



The air seal was improved by the simple addition of a wire strap wrapped circumferentially around the individual steel leaves connected with a spring (photograph above left). The spring keeps the wire taut and the leaves from flapping.

The new nozzle on the west side of the drop-out box enables the concentrations of O_2 and CO of the flue gases exiting the rotary kiln to be measured to facilitate the settings of natural gas and air inputs and to improve combustion efficiency and reduce excess air (which saves fuel).

The two new sight ports were installed on the west wall of the drop-out box. These will enable operators to visually note conditions where the slag exits the kiln and enters the drop-out box.

After considerable discussion, it was decided that a camera would add only limited benefit to the operation of the rotary kiln melter system during this phase of testing. In addition to its initial acquisition cost, costs would be incurred to install and connect the camera to electrical and water utilities (it needs to be water cooled because of the local temperature) and lead the video feed to the monitor in the trailer. Additional manpower would be needed to maintain the camera and to monitor its output, which would detract from other staff duties. Another view port would be required for direct viewing if a camera were to be mounted on an existing view port. Taken together, these costs were considered too much for this phase of the project. For the extended operation of the Phase II effort, which will process up to 2,500 yd^3 of sediment, a camera could be useful.

The new operator access door (manway) was installed on the west wall of the drop-out box just below the level of the two new sight ports. The access is 27 inches wide and 24 inches tall.

Gas Clean-Up

- Remove the double tipping valves at the bottom of the flue gas quencher – Complete
- Install condensate surge tank and recirculating pump on the exit of flue gas quencher (Z-301) – Not done
- Relocate spray nozzles in throat of flue gas quencher – Complete
- Install pressure indicators on air / water lines to spray nozzles of gas quencher – Complete
- Repipe air and water to the spray nozzles eliminating all of the solenoid valves and the by-pass air lines – Complete
- Install backup thermocouple at outlet of flue gas quencher – Not done
- Locate and repair air leakage in I.D. fan expansion joint – Complete
- Repair the Continuous Emissions Monitoring System – Complete
- Replace/repair ID fan expansion joint – Not done

These modifications will enhance the performance of the flue gas quenching system, reduce pressure fluctuations, and reduce the amount of excess air leaking into the system.

The double tipping valves were removed. A simple flange was fabricated to cover the opening left by removing the double-tipping valves. Instead of installing a condensate surge tank with recirculating pump as originally proposed, we decided to route any condensate from the bottom of the flue gas quencher directly to the granulator recirculation tank (T-203). Both water sources are "contact" water, meaning that they have been in contact with process gases and, as such, cannot be disposed of without treatment. This was a logical and less expensive solution to this particular problem.

The four spray nozzles in the throat of the flue gas quencher generated a considerable amount of condensate during operation. To reduce or eliminate this unwanted situation, the spray nozzles were completely disconnected from the nozzle header and were then rewelded so that they extended about 3 inches farther into the spray plenum than before. This was sufficient to insure that the spray would not come into contact with the walls. Also, pressure gages were installed on each water header so that the water pressure as well as the air pressure could be monitored and adjusted according to the manufacturer's specifications for proper spray development. During subsequent operation, the quantity of condensate generated as well as the pressure and temperature fluctuations in the flue gas quencher were significantly reduced.

The damage to the I.D. fan expansion joint due to the temperature excursion that occurred October 2003 was determined to be superficial. No leakage was detected and not further action was taken.

Miscellaneous Repairs / Retrofits

- Recalibrate all flow transmitters – Complete
- Repair water supply leaks at the hot box, trailers, safety shower, and conveyor C-151 – Complete
- Repair Continuous Emission Monitoring System – Complete

These modifications will ensure that the flow measurement devices are properly working and providing accurate information to the computer data acquisition and control system. A total of 18 instruments were recalibrated by KGB Controls (Tyrone, GA). These instruments are listed below.

FIT-203	Flow transmitter for water to granulator sprays (C-203)
FIT-502	Flow transmitter for natural gas to plant
FIT-511	Flow transmitter for natural gas to primary burner
FIT-570	Flow transmitter for natural gas to melt burners
FIT-164	Flow transmitter for air to melt burners
FIT-105	Flow transmitter for air to primary burner
TT-303	Temperature transmitter for baghouse outlet
TT-301	Temperature transmitter for flue gas quencher outlet
TT-206	Temperature transmitter for dryer outlet
TT-304	Temperature transmitter for activated carbon bed outlet
TT-305	Temperature transmitter for flue gas at stack outlet
TT-404	Temperature transmitter for water from C-151 (water-cooled screw)
TT-202B	Temperature transmitter for secondary combustion chamber (backup)
TT-202A	Temperature transmitter for secondary combustion chamber (primary)
TT-201B	Temperature transmitter for rotary kiln (backup)
TT-206A	Temperature transmitter for dryer combustion chamber
TT-203	Temperature transmitter for drop-out box (Z-203)
TT-201A	Temperature transmitter for rotary kiln (primary)

The report prepared by KGB for the calibration work is presented in Appendix G.

Information collected by the CEMS is crucial to the operation of the plant as the oxygen and carbon monoxide contents in the flue gas are limited by the NJ-DEP Air Quality Permit. While the CO monitor was being repaired by Rosemount Analytical, we rented another unit from Clean Air Rentals (Palatine, IL). The repaired CO monitor was returned and reinstalled in the CEMS cabinet and is fully functional.

CONTINUING SLAGGING OPERATIONS

After the equipment retrofits and process enhancements were in place, ECH and its operating team prepared the system for start-up.

Preparations for Plant Operations

Prior to the first demo plant test, GTI conducted laboratory-scale tests to determine how much drying was required to improve the flowability and conveyability of sediment feed material. The test results showed that an air-dried sediment and modifier mixture with a net moisture content of about 20 weight percent (or lower) would be conveyable. Based on these results, the operating crew prepared several large batches of air-dried sediment blended with specific quantities of modifier solids. The bobcat was used to scoop up a known volume of sediment (about 1000 pounds), and then a rototiller was used to blend the modifiers into the sediment. The individual modifiers were weighed using an electronic scale. The batches of air-dried sediment and modifiers were stored under the tent.

North American Manufacturing Co., Ltd. dispatched their service technician to the plant to tune the new burner system and check the operation of the other existing burners. Mr. Tamas Nemeth spent four days at the plant site (July 7-10, 2004) troubleshooting and tuning the burners. He found several items that needed to be rewired and control piping that needed to be installed. His report (included in Appendix N) indicated that the natural gas supply to the original melt burners was restricted by an undersized regulator. Thus, these burners could only be fired at about 240,000 Btu/hr instead of the design rate of 500,000 Btu/hr each. To overcome this limiting restriction, RPMS installed a manual bypass around the limiting regulator.

Trace Environmental Systems (TES) set up and confirmed the operation of the Continuous Emissions Monitoring System (CEMS). The original CO analyzer did not function properly and was removed and taken back to TES's shop for evaluation. In the meantime, GTI rented a CO analyzer from Clean Air Rentals (Palatine, IL). On July 13 TES's service technician returned to the plant to install and calibrate the rented CO monitor.

The emergency diesel generator was reconnected to the plant power system and successfully tested. It had been disconnected and removed after the December 2003 campaign.

The rotary discharge feeder on the baghouse had rusted solid and could not be freed up. FMW removed the rotary feeder and replaced it with another 6-inch rotary feeder borrowed from the Ecomelt dryer baghouse that was not being used.

On July 13, we began calibrating the four augers in the main sediment hopper (T-101). The augers are driven by new variable-speed motors that can be adjusted to deliver the desired amount of material to the main sediment conveyor (C-101). C-101 is operated at a constant speed to deliver the feed material to the weigh conveyor (C-112) and then to the pug mill (M-131). Two loads of pre-blended feedstock were charged to the main sediment storage hopper (T-101) for the calibrations. During the calibration, it was observed that the four augers were not turning in the proper direction to propel the feed material toward the discharge end. This wiring problem was subsequently corrected by SM Electric.

The pre-blended feed material could be conveyed much more readily than the raw, wet sediment tested in December 2003. The calibration showed that at 33 percent (20 Hz), the nominal feed rate was 330 pounds per hour. At 100 percent (60 Hz), the nominal feed rate averaged about 1500 pounds per hour.

To keep rainwater out of the main sediment hopper (T-101), water-proof tarps were draped over the hopper over a central pipe in a tent-like structure. The tarps are held in place by guy ropes. When material is charged to the hopper, the tarps were pulled back.

The operators devised a high-pressure air lance to disrupt "rat-holing" and bridging in the T-101 sediment hopper. This was to facilitate consistent feeding from the hopper. The operator directed the high-pressure air stream at material in the hopper that had bridged.

Refractory curing was initiated at a low heat-up rate for the new refractory "lip" and new refractory around the new Hot Spot and Tempest burners. The curing rate was specified by Harbison-Walker Refractories Co. The primary burner on low fire was used for this operation.

Ecomelt Generation (Slagging) Tests

The following tests were conducted in the Cement-Lock demo plant with equipment retrofits and process enhancements in place under slagging conditions.

- Test No. 2 (July 16-17, 2004)
- Test No. 3 (July 22-23, 2004)
- Test No. 4 (September 22, 2004)
- Test No. 5 (October 27-28, 2004)

The operating conditions and results of each test are described in detail below.

Test No. 2 (July 16-17, 2004)

The objective of this test was to operate the Cement-Lock demo plant with the newly installed process enhancements and equipment retrofits in place and begin processing the pre-blended sediment-modifiers mixture.

Prior to test initiation, the temperatures in the rotary kiln (TIC-201) and secondary combustion chamber (SCC) (TIC-202) were measured at 2400° and 2250°F, respectively.

Temperatures of the refractory lining at various locations in the rotary kiln and drop-out box were also measured by hand-held pyrometer. These temperature readings showed that the fire bricks near the rotary kiln discharge were about 150°F higher than the reading indicated by TIC-201, which was measured by a thermocouple (TE-201) located on the ceiling of the drop-out box. The refractory "lip" in the drop-out box was about 100°F hotter than the TE-203 readings measured by a thermocouple located on the west wall of the drop-out box.

The flow of natural gas to the primary burner averaged 13,338 SCFH (or about 13.3 million Btu/hr). The flow of combustion air averaged 123,983 SCFH. The SCC burner was not fired during the test. As the temperature of the SCC was significantly higher than the minimum permitted level of 2100°F, it was not considered necessary.

The water flow to the granulator sprays was reduced from 55 to 40 gpm and the flow of water to the weir was reduced to 60 gpm. As a result of these flow reductions, the drop-out box temperature (TIC-203) increased from 1780° to 1845°F.

The test was initiated at 10:00 am when the four augers in T-101 were started at 67 percent (40 Hz) or a nominal feed rate of about 1000 pounds per hour.

During the initial part of the test, the oxygen concentration in the flue gas exiting the system through the vent stack averaged 7 mole percent (dry basis) By the end of the test, the O_2 concentration had been brought down to about 5.5 mole percent by adjusting excess air. At that point, the excess air was 32 percent above the stoichiometric requirement. The carbon monoxide concentration in the flue gas averaged 2.8 ppm during the initial part of the test and then increased to about 3.5 ppm for the remainder of the test.

As in Test No. 1 (December 2003), it took several hours of feeding before molten slag completely coated the surface of the rotary kiln and Ecomelt began to flow out of the Ecomelt granulator. The Ecomelt was black and granular with numerous -¼-inch spherical pieces. It resembled the Ecomelt generated during the pilot test at Hazen Research.

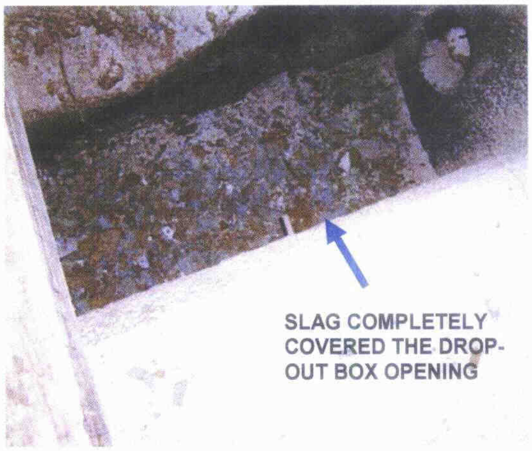
During the test, slag "rain" was observed to continuously fall from the ceiling of the kiln as it rotated. The presence of "rain" indicates that the viscosity of the slag was too high. Under the desired conditions, molten slag would form a rivulet flowing down the middle of the kiln floor. Slag "rain" was also observed during Test No. 1.

At about 2:30 pm, we increased the kiln temperature to 2450°F. Also, we took a feed rate measurement using the newly installed chute in C-101. The feed rate was determined to be about 1800 pounds per hour. The operator's air-lancing technique in the feed hopper was more efficient than expected. The auger speed rate was reduced to compensate.

Within about 15 minutes, the drop-out box temperature (TIC-203) began to increase. After about one hour (3:30 pm), the drop-out box temperature had reached 2200°F. Achieving a higher drop-out box temperature was one of the test objectives; however, it appeared to coincide with the accumulation of slag in the drop-out box.

At about 4:30 pm, we experienced a jam in the conveyor (C-205) that feeds the Ecomelt dryer as oversized slag material was being brought up by the Ecomelt granulator conveyor (C-203). As the conveyor jammed, the drive belt connecting its motor to the C-205 conveyor failed. Still hot slag material had to be extracted manually from the 6-inch diameter sample port on the C-205 granulator conveyor.

Feed was discontinued shortly thereafter (at 4:30 pm). Kiln rotation was reduced from 0.4 to 0.3 rpm to reduce the flow rate of slag to the drop-out box. The melt burners were fired continuously and the temperature of the drop-out box increased from 2200° to over 2600°F by 7:30 pm. The kiln temperature was maintained overnight at 2450°F in hope that the blockage would clear; however, it did not. On July 17, the test was terminated and the temperature in the rotary kiln was brought down per the prescribed rate of about 100°F per hour.



On July 20, the system had cooled sufficiently for personnel to enter and make a photographic record of the slag accumulation in the drop-out box. The photo (above left) shows that the top level of the slag was uniformly flat. It had completely covered over the granulator opening just below the new Hot Spot melt burners. The photo (above right) shows slag had begun to fill the nozzle of the Hot Spot burner under the new refractory “lip”. As mentioned above, the drop-out box had been heated by the melt burners overnight at about 2600°F and the slag had flowed to a uniformly flat level. Thin layers of slag also flaked from the walls and kiln as shown in the photo.

Operating staff entered the drop-out box with a jackhammer and began chipping away at the slag. Within two hours, the slag had been completely broken up. Shards of slag were removed from the granulator through the sample port at the entrance to the C-205 conveyor. Later, to facilitate removal of any oversize slag in future tests, FMW installed an access/clean out port on the upper end of the C-203 conveyor. Figure A-23 shows the time-temperature history of Test No. 2 of the Cement-Lock demo plant from July 16 to 17, 2004 with retrofits and enhancements in place.

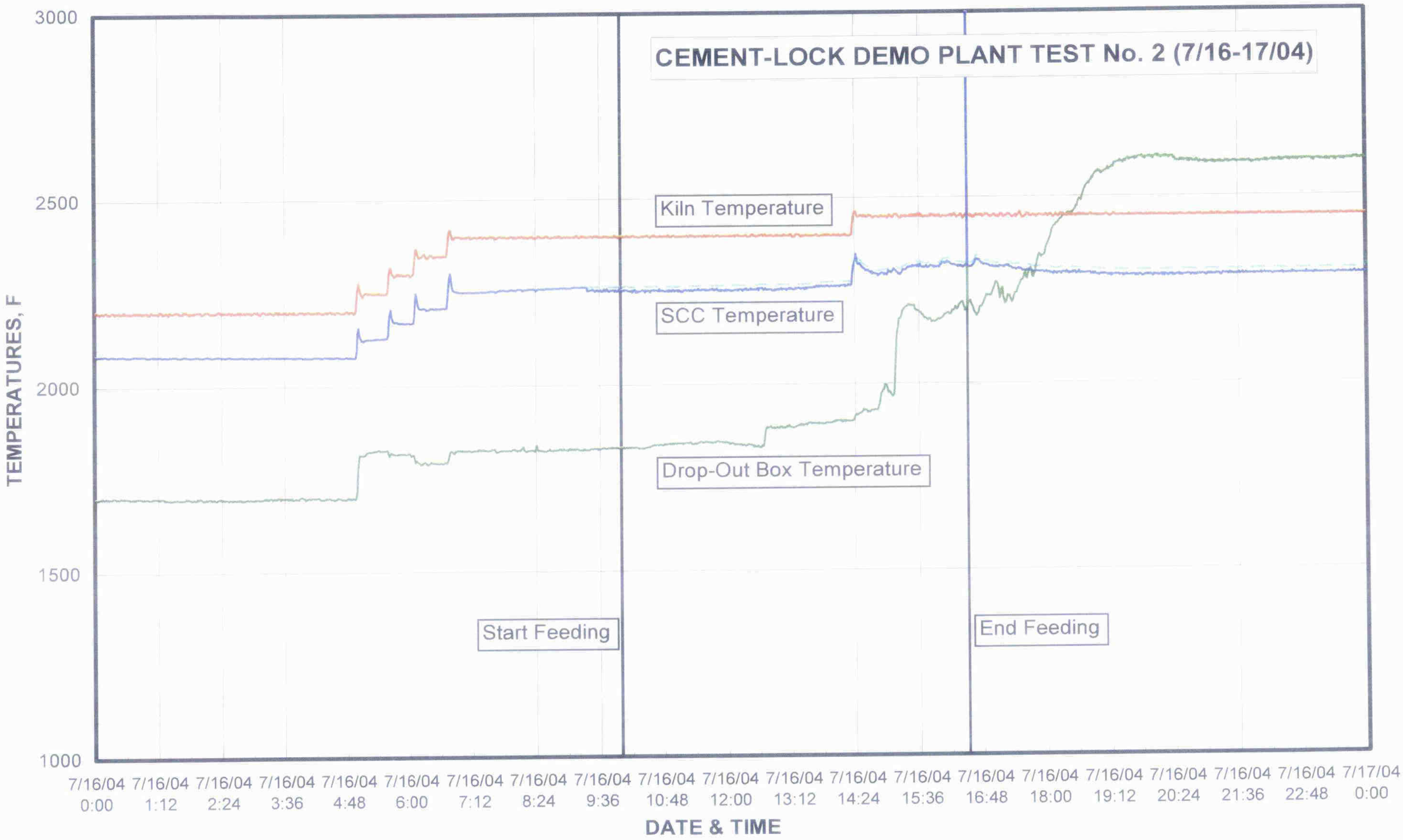


Figure A-23. Time-Temperature History of Cement-Lock Demo Plant Test No. 2 with Retrofits and Enhancements (July 16-17, 2004)

Test No. 3 (July 21-22, 2004)

The objective of this test was to operate the Cement-Lock demo plant at conditions that would minimize slag accumulation including increasing the temperature of the drop-out box and adding additional modifiers and flux to the feed. The combined effects were to improve slag fluidity.

Prior to test initiation, the temperatures in the rotary kiln (TIC-201) and secondary combustion chamber (SCC) (TIC-202) were measured at 2450° and 2285°F, respectively. The flow of natural gas to the primary burner averaged 14,513 SCFH (or about 14.5 million Btu/hr). The flow of combustion air averaged 142,446 SCFH. The SCC burner was also not fired during this test.

The water flow to the granulator sprays was reduced from 40 to 8 gpm and the flow of water to the weir was reduced from 60 to 15 gpm. Reducing the water flows was expected to reduce the amount of steam generated in the drop-out box area. As a result of these flow reductions, the drop-out box temperature (TIC-203) increased from 1845° to 2210°F.

Test No. 3 was initiated at 3:30 pm when the four augers in T-101 were started at 33 percent (20 Hz) or a nominal feed rate of about 500 pounds per hour. Additional modifier (limestone) and flux (fluorspar) were added to the feed material to decrease its viscosity when molten.

During the test, the oxygen concentration in the flue gas exiting the system through the vent stack averaged 7 mole percent (dry basis). The carbon monoxide concentration in the flue gas averaged 3 ppm during the test.

After several hours of feeding, Ecomelt began to flow out of the Ecomelt granulator. As in Test No. 2, the Ecomelt was black and granular with numerous minus ¼-inch spherical pieces.

Slag "rain" was also observed to fall from the ceiling of the kiln as it rotated during this test. Figure A-24 shows the time-temperature history of Test No. 3 of the Cement-Lock demo plant from July 21 to 22, 2004 with retrofits and enhancements in place.

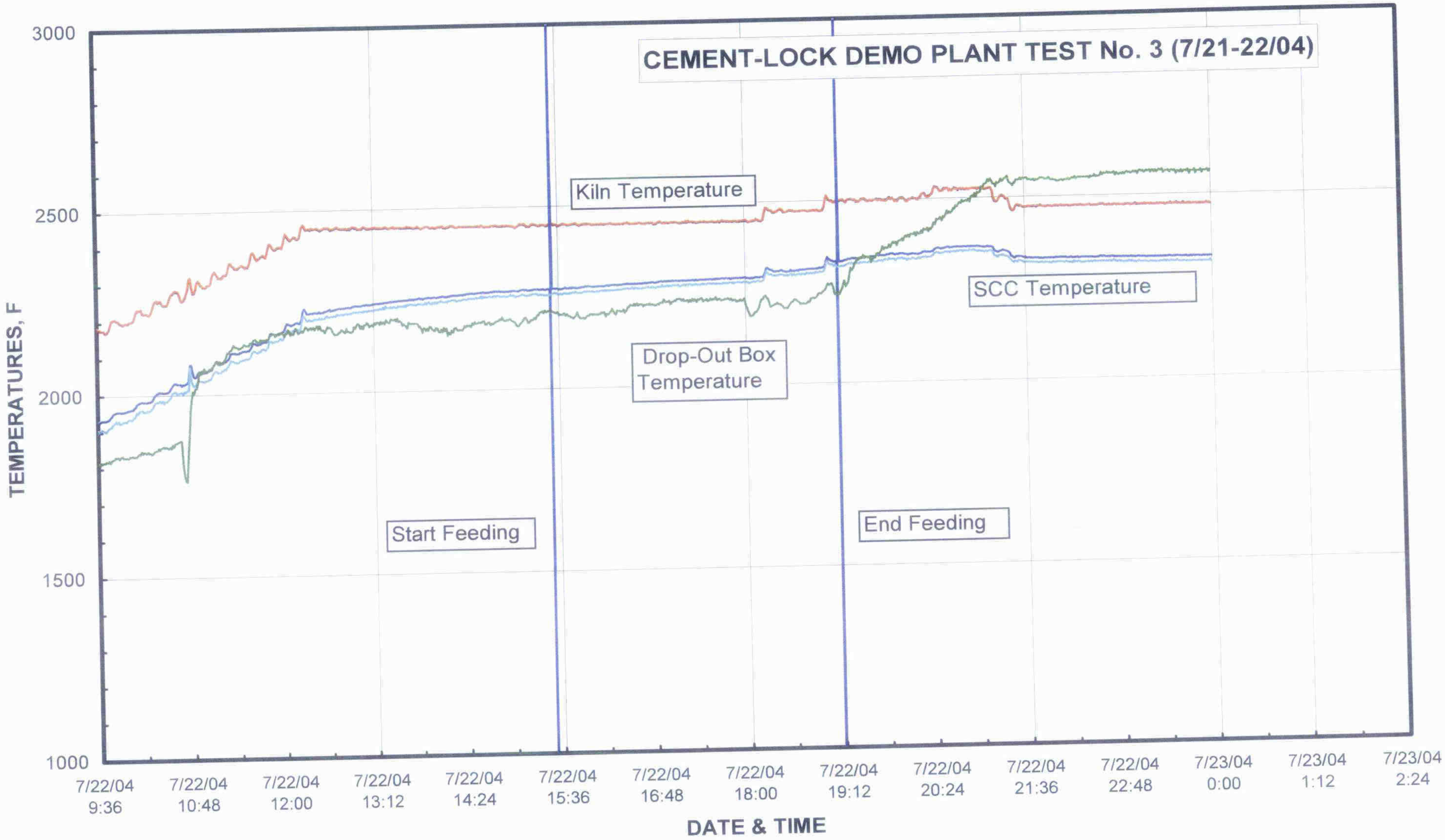


Figure A-24. Time-Temperature History of Cement-Lock Demo Plant Test No. 3 with Retrofits and Enhancements (July 21-22, 2004)

We increased the kiln temperature (TIC-201) to 2475°F at about 6:15 pm and then to 2500°F at about 7:00 pm. The objective of these operating changes was to decrease the slag viscosity in the kiln. Over the same time period, the drop-out box temperature (TIC-203) increased from about 2235° to about 2275°F.

At about 7:10 pm, we experienced a jam in the granulator conveyor (C-205) as oversized slag material was being brought up the granulator. The C-205 conveyor was halted. Hot slag had to be extracted manually from the port cut in the C-203 granulator conveyor plenum. Feed was discontinued at about 7:15 pm.

At about 8:30 pm, we increased the kiln temperature to 2550°F in an attempt to disrupt the drop-out box blockage; however, there was no effect. By 9:15 pm, the drop-out box temperature had reached 2550°F and the kiln temperature was reduced to 2475°F. These conditions were held constant overnight.

The next morning (July 23), the temperature of the drop-out box had risen to 2620°F and the granulator water temperature had cooled to 180°F. In an effort to break the slag blockage, we momentarily opened the weir and spray water valves full in an attempt to fracture the blockage with cold water/steam impingement. There was no apparent effect of this action and the valves were closed. It was decided to terminate the test so that the slag in the drop-out box could be cleared. The demo plant system was cooled per the prescribed procedure.

Post-Test Evaluation (Tests No. 2 & 3)

On July 26, the slag blocking the exit was removed using a jackhammer as before. Before the slag was broken, two adjacent 1-foot diameter holes were observed in the slag covering the drop-out box. These could have resulted from the water weir/spray action described above.

During inspection of the rotary kiln refractory, we noticed that part of the cast refractory of the kiln "nose" at the discharge end of the kiln had cracked and spalled. The refractory contractor was brought back on-site to repair the damaged area and to touch up" two other problem areas in the kiln.

Even though process operating conditions were adjusted from the first test to minimize slag accumulation, the second test was terminated for essentially the same reason. The drop-out box was too cool to allow the molten slag to readily flow into the granulator.

For the next test, we had planned to increase both the kiln and drop-out box temperatures to 2500°F to further reduce the viscosity of the melt in the kiln and improve the fluidity of the slag flowing through the drop-out box. However, it was apparent that merely changing the operating conditions (e.g., increasing the kiln temperature and/or adding more flux) would not provide a positive means of clearing accumulated slag and ensuring sustained operation. More aggressive actions were needed to assure a successful test. Specifically, a mechanical means of breaking or disrupting slag was needed before another test would be attempted.

Slag Breakers – Several approaches to slag breaking were considered. For example, one suggestion was to use pneumatic or electrically operated chisels inserted into the dropout box through the water-cooled transition section between the drop-out box and the granulator. The chisels would be activated when slag began to accumulate on the drop-out box walls. It was concluded that the angle of chisel insertion and the maneuvering space were limited which would reduce the effectiveness of this approach.

Another approach was a "see-saw" slag breaker. This approach was determined to be feasible and several conceptual configurations were prepared. One slag breaker arm each would be installed at the north and south end of the granulator just under the weir trough. The breaker arms would be attached to pivot pipes that could be pushed in or pulled out to access the entire width of the drop-out box opening. The breaker arms would be long enough to reach the edge of the kiln nose when rotated. When not in use, the breaker arms would be retracted up against the east and west walls of the overflow weir. The pivot pipes and breaker arms would be cooled in part by the existing water sprays. External handles would be used to activate the breaker arms individually. Two mechanical slag breakers each consist of a 2-inch-diameter stainless steel pipe, 4½ feet long were fabricated and installed.

View Port Installation – A new view port was installed on the upper north side of the drop-out box for observing the discharge of slag from the kiln into the granulator (the photo below was taken from the new view port).

Granulator Discharge Modifications – A GTI consultant proffered that excessive steam generation from the Ecomelt quencher was cooling the slag. He suggested that the cross-sectional area of the drop-out box opening be reduced to limit radiation heat transfer to the quench water below. Reducing the radiation heat transfer would reduce steam formation. Therefore, we blocked off a portion of the drop-out box discharge area to limit heat loss to the granulator water due to radiation. To accomplish this, ⅜- and ¼-inch thick steel plates were installed lengthwise across the drop-out box discharge. Refractory bricks left over from the rotary kiln refractory repair were layered on top of the steel plates for insulation. The open area was reduced by about 50 percent from 72 x 21 inches to 72 x 10½ inches. The water spray nozzles and water header on the west wall of the drop-out box were removed to accommodate the bricks. The photo at right (Figure A-25) shows the reduced area at the discharge of the drop-out box. The rotary kiln nose and extended lip are indicated with arrows. The two drop-out box thermocouples (T.C.) can also be seen at right. The slag breakers (not visible) are operable within this reduced open area.

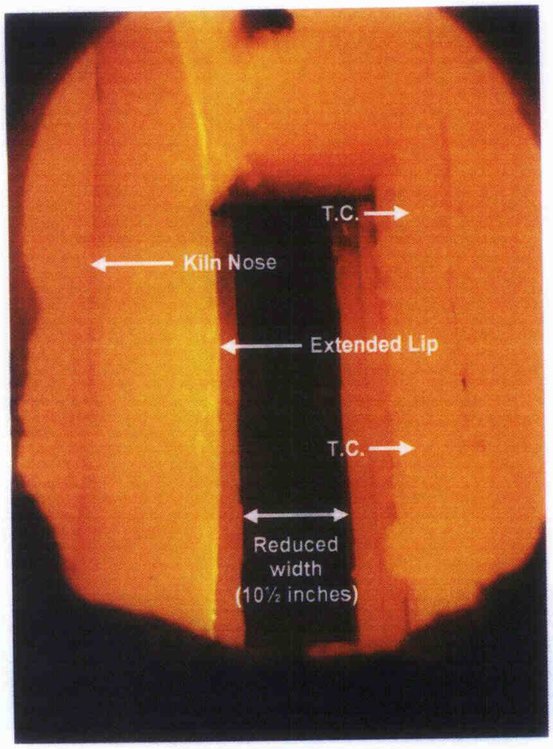


Figure A-25. View of Kiln Nose, Extended Lip, and Reduced Drop-Out Box Area.

The lower screw section of conveyor C-205 was removed and the opening under the discharge of the granulator drag conveyor was enlarged to accommodate Ecomelt and chunks of oversized slag.

Miscellaneous Equipment-Related Repairs – The timer on the baghouse back-pulsing system had been set with a 0-second delay at the factory. As a result, all six banks (with 3 rows per bank) of air headers back-pulsed simultaneously. This caused wide pressure fluctuations in the downstream air pollution control equipment. The timer was reset for a 30-second delay between back-pulsing for each of the six banks to reduce the magnitude of back-pulsing pressure fluctuations.

Also, by-pass piping was installed around an undersized pressure regulator that limited the amount of natural gas that could be fed to the original melt burners. These melt burners were adjusted using the by-pass to increase the gas supply. As a result, each burner produced a high-velocity flame that extended completely across the drop-out box and impinged on the east wall.

Test No. 4 (September 22, 2004)

Another recommendation made following Tests No. 2 and 3 was to operate the kiln with less excess air to the primary burner. Reducing excess air to the primary kiln burner has the benefit of reducing fuel consumption, thereby improving process efficiency. Prior to conducting Test No. 4, we conducted the following test to determine the effect of excess-air minimization tests.

Excess-Air Minimization Tests – Previous CEMS readings had shown that the kiln had been operating with significant excess air. To measure the excess air content in the flue gas exiting the kiln, we employed a portable $CO/CO_2/O_2$ monitor. The hot flue gas sample was taken using a 2-inch diameter and 12-foot long water-cooled stainless steel sample probe. The sample probe was inserted into a 2½-inch nozzle at the west end of the kiln (upper drop-out box) and extended into the drop-out box plenum about 6 feet.

The excess-air minimization tests were conducted when the system was operating at a kiln temperature of 2500°F. No sediment was fed to the system during these tests. The initial O_2 content of the flue gas exiting the kiln was measured at 12.0 mole percent (dry basis) with a CO content of 20 ppm. For combustion of natural gas (methane) with air, this value represents 120 percent excess air. The excess air ratio was reduced in steps using the computer control system until the O_2 concentration measured at the kiln exit had reached 4.0 mole percent. This represents about 20 percent excess air. At these conditions, the CO content in the kiln exit increased to 130 ppm. At the same time, the O_2 and CO contents in the vent stack measured 6.4 mole percent and 6.6 ppm, respectively. Thus, the overall excess air in the Cement-Lock system was about 40 percent.

As expected, as the ratio of excess air to natural gas was reduced, the concentration of O_2 in the flue gas exiting the rotary kiln decreased and the concentration of CO in the flue gas increased. Flue gases passing from the kiln into the secondary combustion chamber encounter additional fuel and air that provide an additional 2 seconds of residence time at temperature to complete the burnout of products of incomplete combustion (PICs).

The results of these tests show that the system can be operated at an O_2 content exiting the kiln as low as 4.0 percent without experiencing flame instability or elevated CO levels in the vent stack.

CO Excursion and Visible Flame – After the excess air minimization tests were completed, the kiln temperature was reduced at the prescribed rate of 100°F per hour to the overnight "idling" temperature of 1800°F.

At about 2:00 a.m. (morning of September 22) per instructions, the shift supervisor began to increase the temperature of the rotary kiln from its idling temperature of 1800°F at a rate of 100°F per hour. At this rate of heating, the kiln temperature would be 2500°F by about 9:00 a.m.. Each time the shift supervisor increased the temperature setting on the controller (TIC-201), the valve controlling the flow of natural gas opened and a surge of natural gas was admitted to the primary kiln burner. At the same time, the flow of combustion air to the system was increased proportionately as well. As the temperature reached its new set point, the natural gas flow to the burner was reduced and the ratio of air-to-natural gas was balanced.

However, because the ratio of air-to-natural gas had been reduced during the earlier excess air minimization experiments, each time the shift supervisor increased the temperature there was a momentary episode of incomplete combustion of the natural gas. This led to transient CO increases that were recorded by the CEMS. During the early stages of heat up, the CO excursions were small; however at about 6:30 a.m. on September 22, flames were visible around the periphery of the emergency stack cap. At that time, the kiln temperature was about 2200°F.

Within a few minutes, IMTT's Safety Manager arrived at the plant and instructed the shift supervisor to immediately shut down the kiln and melt burners. The shift supervisor proceeded accordingly. The flame emanating from in the emergency stack cap was extinguished immediately when the natural gas supply to the system was shut off.

The unburned CO in the flue gas was apparently ignited by the hot refractory lining in the emergency stack cap located at the outlet of the secondary combustion chamber. The spontaneous ignition temperature of CO is 1128°F (Perry's Chemical Engineers' Handbook).

Safety and Oversight Proposal: Because there was a visible flame, IMTT requested a detailed plan from ECH to ensure that this would not happen again. Therefore, a safety and oversight proposal was developed by GTI and ECH and submitted to IMTT for review on October 12. On October 21, Mr. Jamie Coleman, President, IMTT – Bayonne informed us that the safety and oversight proposal had been accepted. With the acceptance of the plan, we had the approval of IMTT to proceed with the next test. The safety and oversight plan specifies that during operation of the Cement-Lock demo plant, the operation must be monitored by GTI staff knowledgeable in the process and equipment (a copy of the incident report and the safety and oversight plan is included in Appended O).

As part of the requirements in the safety and oversight plan, during the next startup, we provided refresher training and safety reviews for the shift supervisors and laborers. This included rules and regulations on personal protective equipment (PPE), no smoking regulations, prohibition on cell phone use on IMTT property, confined space procedures, fire extinguisher use, emergency marshaling and evacuation planning, and plant shut-down procedures.

Sediment Feeding Test: After a review and diagnostic of the system following the CO excursion, we restarted and began reheating the system (September 22). The target temperature of 2500°F was reached in the rotary kiln. The temperature of the drop-out box reached 2450°F. In previous tests, the drop-out box temperature lagged below the kiln temperature by as much as several hundred degrees.

At 6:30 pm, sediment feeding was initiated at a rate of 500 pounds per hour. The objective of this test was to operate the Cement-Lock demo plant with the new auxiliary burner system and other mechanical improvements – including slag breakers – in place. The preblended mixture of sediment began to enter the kiln a short while later.

However, at 8:00 p.m. the computer control system indicated a slow speed on the granulator drag conveyor – it had jammed. Attempts to unjam the conveyor and restart the motor were unsuccessful. Also, the torque arm support for the motor and gear reducers that drive the drag conveyor had bent 90°. As the torque arm bent, the motor mounting bracket rotated and the motor impacted the granulator housing. The motor casing separated from the gear reducer housing. The run was terminated involuntarily. No Ecomelt® was produced. As it was unclear where the jam occurred, the temperature of the kiln was brought down at the prescribed rate and allowed to cool so that repairs could be implemented.

Upon opening the granulator on September 27, RPMS observed that no large chunks of slag or refractory were responsible for jamming drag conveyor. The jam had apparently been caused by slack in the chain links of the drag conveyor that jammed the downstream (compression) side of the circuit. RPMS had previously eliminated slack in the drag conveyor chain by removing several links. The drag conveyor chain had been re-tensioned; however, chain wear and/or possible loosening of the motor support bracket resulted in enough slack to cause the jam. The motor and its gear reducer were dismantled and sent to a motor repair shop for evaluation and repair.

Equipment Repairs: The damaged gear reducer and motor that drives the granulator drag chain conveyor (C-203) were replaced. As the delivery time for replacement parts for the original gear reducer and motor was about six weeks, we opted to obtain a comparably specified gear reducer and motor. These items were delivered, installed, and tested for proper operability. A new torsion bar was installed to replace the one that was bent during the previous test. The tension in the granulator drag chain conveyor was adjusted and the conveyor was operated for several hours to run it in. The refractory contractor repaired two loose refractory rings in the main section of the rotary kiln and repaired some damage to the nose ring refractory. Also, the rotary feeder that discharges spent lime from baghouse was repaired and reinstalled. It had become jammed.

Test No. 5 (October 27-28, 2004)

For this test, the drop-out box was in the same configuration as that for Test No. 4 (September 22). The open area of the drop-out box was about one-half its original size with refractory bricks layered on steel platforms. Mechanical slag breakers were installed – one on the south and one on the north side of the drop-out box.

The primary objectives of the test were to evaluate 1) the impact of the reduced open area of the drop-out box bottom on its temperatures, 2) the effectiveness of the slag breakers, and 3) the impact of the tuned melt burners on drop-out box temperature.

System Start-Up: We initiated system start-up with around-the-clock operation on October 26. The temperature of the rotary kiln was brought up to operating temperature at the prescribed rate of 100°F per hour. Overnight, we maintained the rotary kiln at its "idling" temperature of 1800°F to conserve fuel and equipment.

The target temperature of 2450°F was reached in the rotary kiln at about 10:00 a.m. on October 27. At that time, the temperature of the drop-out box was 2420°F. The temperature in the drop-out box was higher than that of the previous tests. The temperature increase resulted from one or a combination of the following actions: 1) The open area of drop-out box bottom was decreased by 50 percent (reducing radiation heat loss), 2) three melt burners on the west wall were repaired and tuned, and the thermal input to the dropout box was increased, and 3) water spray to the drop-out box was removed.

The kiln temperature was selected to conserve the equipment and refractory while providing a relatively low viscosity melt. At this temperature, the slag viscosity would be close to the targeted viscosity (< 100 poise) according to the study performed by Hazen Research for ECH. The temperatures in the kiln and dropout box could be increased if slag began to accumulate.

At 11:00 a.m., we began feeding the premixed blend of air-dried sediment and modifiers at a rate of 500 pounds per hour. The premixed blend of sediment began to enter the kiln a short while later. We monitored the progression of the molten slag through the kiln thereafter. Slag slowly progressed through the kiln as it first coated the refractory walls. The slag "rain" phenomenon was again observed indicating that the viscosity of the melt was still too high to enable it to roll down the kiln wall. The pressure in the kiln was maintained at a slight vacuum of -0.3 inches (water gauge). The oxygen content of the flue gas exiting the stack was about 8 mole percent (dry basis).

At about 3:20 p.m. the first samples of Ecomelt began to exit from the granulator. The Ecomelt was in the shape of small (less than ¼ inch) irregularly shaped particles, dark brown to black in color. At about 3:45 p.m. slag was observed to be flowing over the bricks on the reduced open area and the slag breakers were activated. The slag breaker on the south side was operated almost continuously as directed by the observer at the upper view port. The action of the south slag breaker caused some bricks on the southeast wall to move away from the platform. By 4:00 p.m. slag began accumulating in the bottom of the drop-out box and on top of the south slag breaker. The north side slag breaker was moved from under the bricks on the west side of the drop-out box. However, as the slag breaker was moved toward the east, it caused the bricks above to migrate toward the east as well reducing the throat area even more. This rendered the north slag breaker ineffective and it was returned under the bricks on the west wall (Figure A-26).

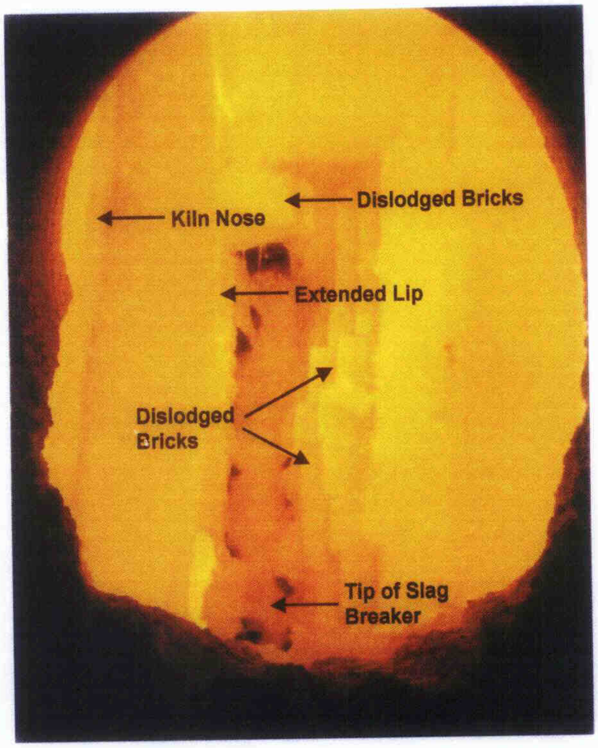


Figure A-26. View of Slag Accumulated on Bricks and Slag Breaker after Test No. 5 (lighter colors are relatively hotter than darker colors)

At 4:15 p.m. feed to the kiln was discontinued. At 5:00 p.m. the kiln temperature (TIC-201) was increased to 2500°F. At about 5:30 p.m. the throat had become almost completed filled with slag. By 7:00 p.m. slag was covering almost the entire drop-out box. The south slag breaker became ineffective as it was covered with slag and could not be freed up. As the test could not be continued under these conditions, we began to cool the system at about 11:00 p.m.

The molten slag flowing over the bricks at the throat of the drop-out box appeared to be much more viscous than the molten slag flowing in the kiln and over the nose and lip. Observations also confirmed that the more viscous molten slag over and down from the bricks precipitated the slag accumulation and the eventual plug up.

A total of 849 pounds of Ecomelt was produced during the test. The time-temperature history of this test is presented in Figure A-27.

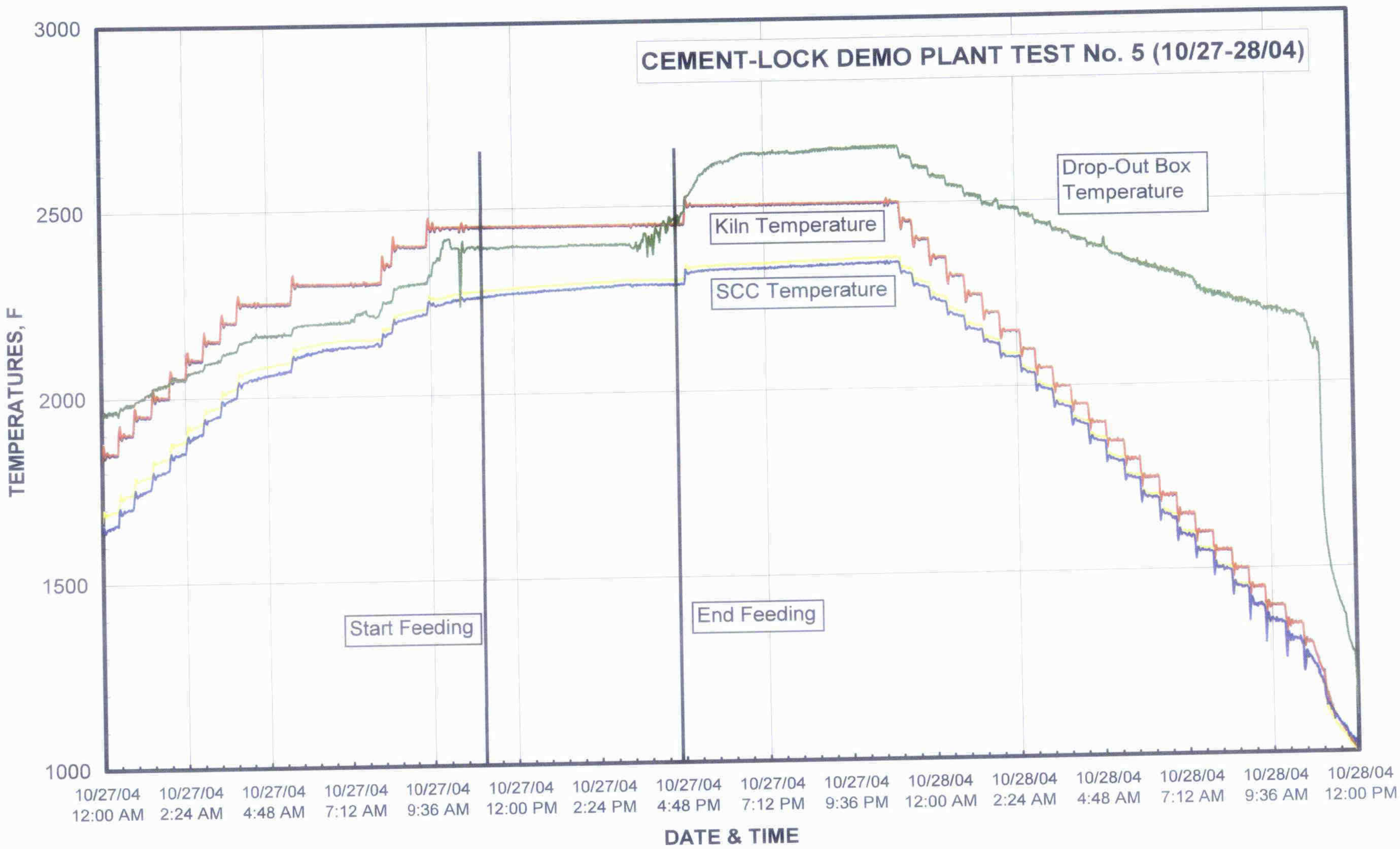


Figure A-27. Time-Temperature History of Cement-Lock Demo Plant Test No. 5 (October 27-28, 2004)

Post-Test Evaluation

When the system was cool enough to open, the following observations were made. The opening of the drop-out box just above the granulator was completely covered with slag. The location, shape and appearance of the slag were similar to those of previous tests. There were numerous cracks noted in the refractory lining. The burner tile of the south Hot Spot burner on the east wall was cracked. The burner tile of the center Hot Spot burner was also cracked and protruded slightly. However, both burner nozzles appear to be intact. The south slag breaker was severely warped and concaved (crescent-shaped).

The following recommendations were made based on the above observations:

Remove the bricks added to the water trough: The bricks were added to decrease the opening area of the drop-out box and reduce the radiation heat loss to the water. The drop-out box temperatures did increase; however, the heat input of the original melt burners was also increased and the water spray to the drop-out box was deleted. Therefore, the precise impact of the bricks can not be determined. The lower bricks were less than 9 inches above the granulator water. As measured by pyrometer, these bricks were 300°F lower in temperature than the drop-out box temperature. Molten slag adhered, cooled and solidified over these bricks, precipitating slag accumulation.

Reconsider effectiveness of slag breakers: As the slag cools, its viscosity increases significantly. The slag has the consistency of taffy and does not shatter upon impact. The slag breakers must be operated almost continuously, otherwise they will become ineffective as slag freezes on top of them. As the slag was accumulating, the breakers were more difficult to move and less effective. They are also labor intensive.

Extend the weir: The height of the existing overflow weir should be raised to just under the bottom of the drop-out box such that the overflow water will continuously cover these vertical walls. Based on experience from the Hazen pilot plant test and all the demo plant tests, slag does not accumulate on water-covered walls. With this arrangement, the molten slag would fall directly into the water, and minimize the chances of sticking to the walls or bricks, thereby minimize slag accumulation.

Increase kiln and dropout box temperatures to 2600°F or higher: Increasing temperature will reduce slag viscosity, minimize slag rain, and improve slag discharging from the kiln. The key issue is whether the temperature at the bottom of the drop-out box can be increased to over 2450°F where the slag viscosity would be about 100 poise.

Extend the kiln lip well over the throat of the drop-out box: The accumulation of slag occurs primarily from the south and east walls of the drop-out box. By extending the lip to the midpoint of the open area will minimize slag sticking on the walls of the drop-out box. The lip can be kept clear (and hot) by the north and south Tempest burners.

Equipment Turnaround: After Test No. 5 was completed, the drop-out box was cleared of accumulated slag, which took about two hours. Other work performed included removal of the refractory bricks that had been installed in the drop-out box to reduce the area of the throat. The steel plate supports as well as the south slag breaker were also removed.

The refractory contractor (Duddy Contracting) repaired loose bricks near the primary burner and filled various cracks that had developed in the rotary kiln after Test No. 5. The refractory supplier (Harbison-Walker Refractories) evaluated the kiln bricks and castable. His opinion was that the kiln bricks were in fairly good shape. He noted that the castable kiln nose ring had deteriorated and would eventually fail. An indication of failure would be spalling of a large chunk of castable from the nose ring. It would require replacement at that time.

The granulator drag conveyor chain was tightened. Also, the 60 x 90 foot Century tent that had been used to cover the sediment storage area since June 2004 was removed by the rental company. Plastic tarps were used to keep the piles of sediment and sediment modifier mixtures covered in lieu of the tent.

Revised drop-out box configuration and implementation: After considerable additional discussion about the slag accumulation problem, it was decided to extend the lip of the kiln past the midpoint of the granulator opening. This concept had been discussed previously, but was rejected in favor of reducing the open area and installing mechanical slag breakers. There had been concerns in the past about the potential for the extended lip to fail with large chunks of refractory falling into the granulator. When this approach was revisited with the refractory installer, he said that the kiln lip could be extended about 8 inches past the existing lip and it would be self-supporting. This would put the edge of the lip about one-half the way across the open throat of the drop-out box. The southern-most part of the lip would extend upward in an arc about four feet above the lowest point of the lip. This arc would include a trough-like depression that would allow slag to flow downward toward the central part of the extended lip and then overflow.

The existing refractory was demolished and forms for the new "extended lip" were installed. The new refractory, Novacon 95, was poured on November 19 and electric heaters were installed in the kiln to maintain the temperature at about 65°F to facilitate curing. The forms were removed on November 24. Testing of the revised configuration was planned to be initiated on November 29 just after the Thanksgiving holidays.

Plant Assessment and Reconfiguration Plan with Volcano Partners

Representatives from the NJ-DOT Office of Maritime Resources, EPA Region 2, Brookhaven National Laboratory, and ECH/GTI met at NJ-DOT/OMR offices on November 18, 2004 for a project review meeting. The objective of the meeting was to discuss project progress and achievements including the persistent problem of slag accumulation in the drop-out box and to develop a plan for completing the Phase I project successfully and in a cost-effective timely manner. A schedule proposed by NJ-DOT/OMR called for project participants to complete an overall evaluation of the Cement-Lock demo plant with problem resolution recommendations by December 15. These recommendations were to ensure a high probability of success and were to be implemented immediately so that operations could resume by January 5, 2005. The Phase I testing could possibly be completed by January 17, 2005 with Phase II operations following shortly thereafter.

After the November 18 meeting, GTI and Volcano Partners, L.L.C. (Volcano, Key Biscayne, FL) agreed to work together to develop the overall plan to complete the Phase I project. The primary goals of the ECH/Volcano Study were to 1) evaluate the current status of the Cement-Lock demo plant, 2) advise on actions that would enable the plant to operate successfully for the Phase I testing and, 3) advise on actions for successful treatment of dredged sediment for Phase II of the project.

This effort was cost-shared by ECH and Volcano and was initiated on November 29, 2004. As part of the study, participants met at the demo plant on December 7 for a site tour and to discuss equipment modification options. The overall project was completed on December 15, 2004 as scheduled. The final report was transmitted to project sponsors for consideration and action.

Recommendations for major equipment modifications (including nose ring refractory, drop-out box, granulator, lime feeding system, sediment feeding system, plant winterization, and operational changes (e.g., kiln operating temperature) as determined by the Volcano Study are summarized below.

Kiln Nose Ring Refractory – As mentioned above, the kiln nose ring refractory exhibits cracking that will eventually result in its failure during operation. The refractory supplier recommended that no action be taken at the present time. He did recommend that during operations the nose ring should be frequently inspected for signs of impending failure. Depending upon availability of materials, replacement of the nose ring refractory could require up to 4 months.

Drop-Out Box (DOB) – The study recommended that any surface that slag could impinge below the rotary kiln should be eliminated. Several alternate DOB configurations were proposed during the study. The study concluded that the granulator should be moved under the nose of the kiln so that slag would flow directly into the water below. This modification would entail considerable metal and refractory re-working. However, it was considered to have a high probability of performing as designed.

Granulator Modifications – The study noted that a sizable piece of refractory could become dislodged from the kiln nose ring and fall into the granulator. If this were to happen, it could jam the drag conveyor in the granulator resulting in an involuntary shut-down. A solution would be to install a grizzly screen under the water in the granulator above the drag conveyor blades. Should a piece of refractory break loose, it would be caught by the grizzly. Ecomelt would continue to fall through the grizzly screen into the granulator below.

Lime Feeding System – The lime feeding system has not consistently fed lime to the duct upstream of the baghouse. It was suggested that air sparging taps be installed around the live bottom of the hopper, which would permit the lime to be “fluffed” to provide more consistent flow. Also, a partial load of limestone was mistakenly unloaded into the lime hopper, which must be removed and replaced prior to the next test.

Sediment Feeding System – To facilitate feeding possibly frozen sediment-modifier mixture, an ALLU SML screening bucket would be procured. This device can crush and size frozen material as well as wet material. A conveyor belt would be rented that extended from the sediment storage area to the feed system so that frozen material could be metered and fed.

Plant Winterization – Equipment winterization will be necessary regardless of the modifications.

Operation of the West Wall Melt Burners – The melt burners on the west wall of the DOB would continue to be operated to make up, at least in part, the loss of the heat from the 3 Hot-Spot burners that were to be removed from the east wall. These burners would be operated under fuel-rich conditions to minimize flow of excess air into the system.

Kiln Operating Temperature – Increasing the kiln temperature (as indicated and controlled by TIC-201) to 2600°F was recommended for the next test. This would reduce slag viscosity to a honey-like flowability.

Path Forward for the Demo Project

The results of the ECH/Volcano Study were presented to the project sponsors. All agreed that the results presented a viable short-term solution to the problem of slag accumulation in the DOB. However, funding for the recommended equipment modifications was not available. Therefore, alternatives for the path forward needed to be developed. The alternatives were discussed at a meeting held on December 28, 2004 in Newark, NJ with NJ-DOT/OMR, U.S. EPA Region 2, Brookhaven National Laboratory, and ECH/GTI. The consensus of the meeting was that to complete the current project, the Cement-Lock demo plant would be operated in non-slagging (or ashing) mode. Project participants agreed that this would be the favored approach given the lack of funds for implementing the equipment modifications recommended in the ECH/Volcano Study. Steps were immediately initiated to implement this approach.

NON-SLAGGING OPERATION

Non-Slagging Demo Plant Operations

Beginning in early January 2005, RPMS Consulting Engineers (RPMS) and their mechanical, electrical, and insulating contractors worked to prepare the Cement-Lock demo plant for non-slagging operations. The work included repair of frozen/cracked piping, addition of insulation and heat tracing, installation of a conveyor belt system and electrical hookup, recalibration of selected instruments, and preparation of EcoAggMat collection stands.

Around-the-clock plant operation was initiated on March 5. Plant operations continued until March 21, when it was decided to stop feeding and begin to cool the system. These activities are described in more detail below.

Plant winterization: Winterization of the plant equipment included repairing the damage to the water supply system that resulted in a leak in December 2004. FMW repaired the broken pipe and damage to the backflow preventer in the hot box. They also installed water drain valves on strategic water lines in the plant. These valves will enable each line to be readily drained in the event of freezing weather. The water supply line was successfully tested up to the main header.

SM Electric checked out the circuitry for the heaters on the Flue Gas Quencher water storage tank. This heating system had never been connected. They connected the control panel to power and confirmed the operation of the system. SM Electric also confirmed the operation of the other heat tracing systems or repaired and ran additional heat tracing as required.

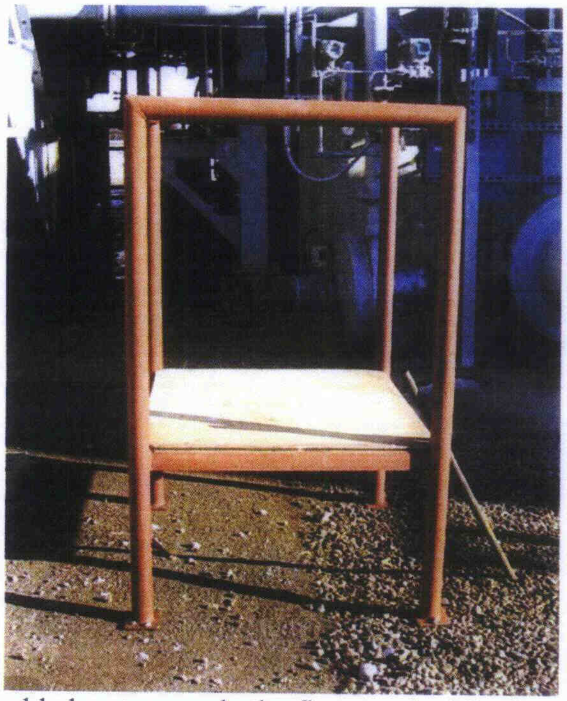
The air receiver tank from the compressor, air control piping, and the exposed air and water piping on the top of the Flue Gas Quencher were insulated. The plant experienced a major snow event the weekend of January 22, 2005. Several days of work were devoted to snow removal around the plant so that contractors could continue their work. A skidsteer (bobcat) was rented to facilitate snow removal.

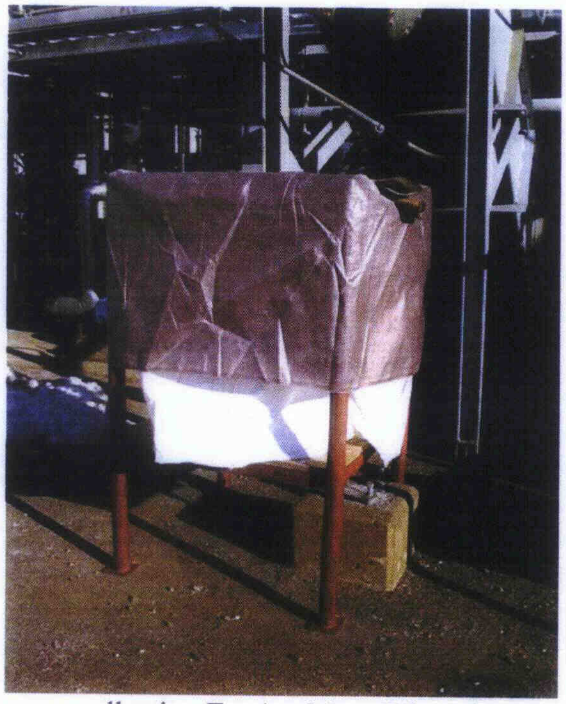
Sediment feed system: For feeding the frozen sediment-modifier mixture to the plant during cold weather, a hydraulically operated crushing, sizing, and screening bucket – ALLU SML – was procured. According to the manufacturer, the ALLU bucket can perform as a conventional bucket to load sediment. It can also crush and size frozen material. If needed, it can also feed and size wet material. The ALLU bucket will be used to meter the sediment-modifier mixture onto a rented belt conveyor. The belt conveyor will extend 80 feet from the sediment storage area to the alternate feed hopper (T-102). The speed of the ribbon blenders in the alternate feed hopper will be reduced by installation of a variable-speed drive to match the feed rate.

Originally, we had considered discharging the belt conveyor directly above the main sediment conveyor (C-101); however, the structural steel and close quarters in the vicinity rendered this approach infeasible.

Lime hopper feed system: The lime feeding system has not consistently fed lime to the duct upstream of the baghouse in recent tests. One explanation is that the lime may have absorbed moisture from the air and partially caked in the hopper. One approach would be to install air spargers around the bottom of the hopper to dry out the lime. However, for the non-slagging campaign it was decided to clean the flights and recalibrate the lime feeder system.

EcoAggMat Collection: We designed and FMW fabricated two stands to collect EcoAggMat as it was discharged from the inclined drag conveyor (C-203) discharge chute. Having two stands





enabled us to recycle the first stand while the other was collecting EcoAggMat. When the Super sack was filled, the drag conveyor would be momentarily shut down. The photo above left shows one stand as built. The photo above right shows the stand with Super sack in place in position under the C-203 discharge chute. The Super Sacks were 39 inches by 39 inches by 36 inches tall with duffle top openings. Each Super sack had a plastic liner to prevent any excess moisture from leaking out of the Super sack onto the ground. This arrangement worked very well during the non-slagging campaign.

Around-the-Clock Operations: Staffing for around-the-clock operations included a plant manager, and a shift supervisor and 3 laborers each shift. Supervisor shifts were 12 hours. Laborers worked an 8-hour shift. The required safety and oversight staffing was provided around the clock by GTI.

The primary and SCC burners were initially ignited on March 3. A problem with the low-gas pressure switch prevented the system from being heated to temperature. This problem was corrected and the system was heated to 1800°F at the prescribed rate of 100°F per hour. Although the rotary kiln temperature was readily achieved, the SCC temperature could not be readily increased above 1800°F. Numerous approaches to increasing the SCC temperature were tried, but did not work. A restriction orifice in the natural gas feed line to the SCC burner was limiting the flow. It was removed after consultation with North American Manufacturing Company. Also, we increased the rotary kiln temperature to 1835°F to reduce the load on the SCC burner. Together these changes enabled the SCC temperature to reach 2115°F. The time-temperature history of the campaign is presented in Figure 28.

On the morning of March 6, when the rotary kiln temperature was about 1200°F, chunks of the new extended lip (refer to discussion on page 95) detached from the drop-out box and plunged into the granulator quencher. The chunks were dragged out of the granulator by the drag conveyor. A total of 475 pounds of refractory was collected. Fortunately, no other damage to the internals of the kiln or the drop-out box was sustained. It was decided that this would not prevent the operation of the system in non-slagging mode so operations continued. A piece of wood (5 feet x 2 inches x 8 inches) that had been installed by the refractory installed to support the extended lip also fell into the granulator on top of the slag breakers. By reducing the water level in the granulator, enough ambient air was drawn into the granulator to burn the wood piece. It eventually broke up and was removed from the back (north side) of the granulator.

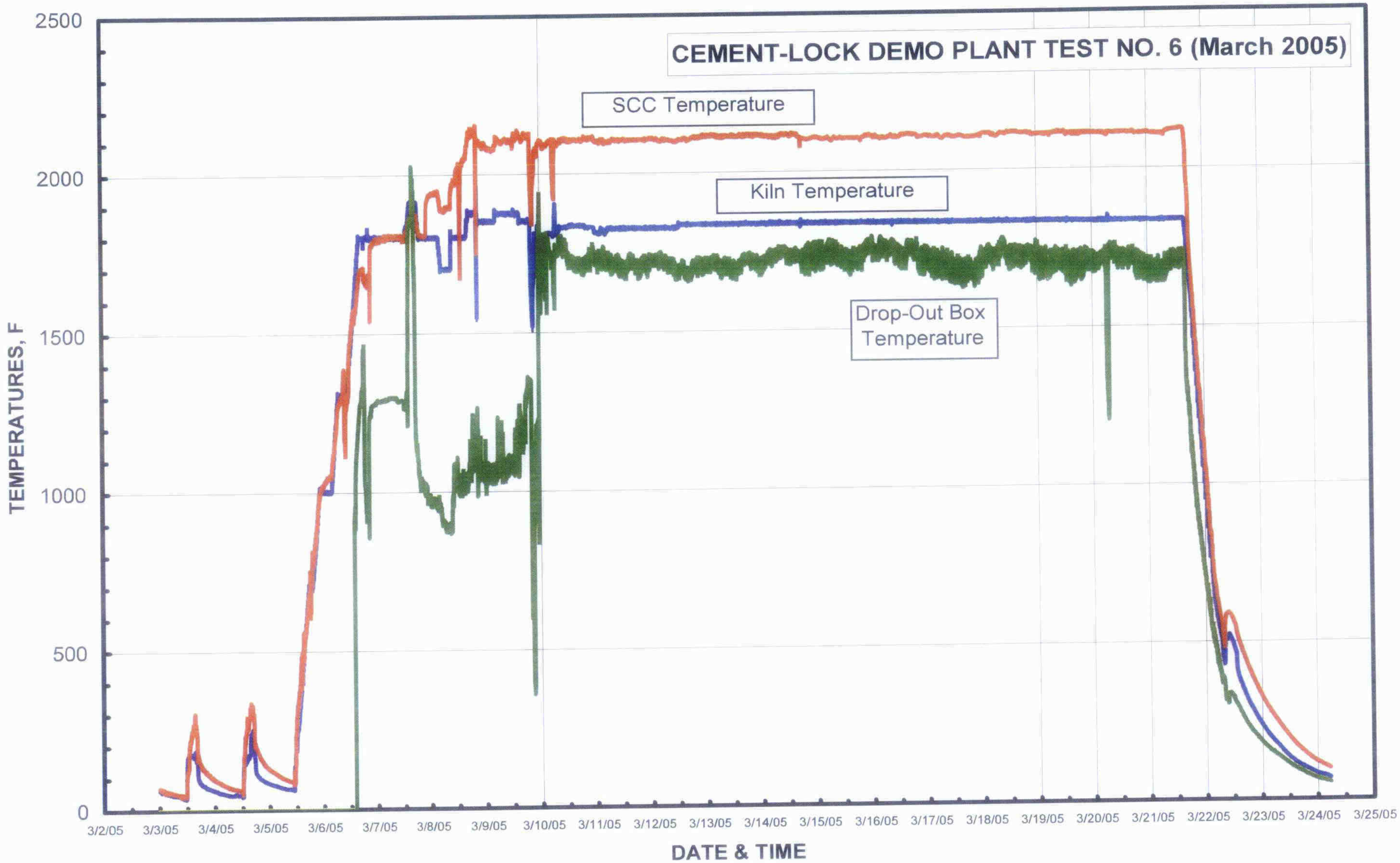


Figure 28. Time-Temperature History of Cement-Lock Demo Plant Test No. 6 – Non-Slagging Mode (March 2005)

A problem occurred during the initial operation of the ALLU SML mechanical bucket that precluded its being used for the duration of the non-slagging campaign. Later, it was decided to return the ALLU to the manufacturer.

Some preliminary sediment-modifier mixture feeding tests were conducted to determine appropriate feeding techniques for the air-dried, but frozen material. Frozen material became caked around the main feed conveyor (C-101), which needed to be opened and cleared by hand.

Overnight the temperatures in the area fell below freezing during the campaign. This required the operating staff to check the condition of the compressor air receiver drain/discharge as well as several key equipment items every 5-10 minutes to ensure that they did not freeze up. A protocol and check list was prepared and followed during freezing conditions.

Thermally treated material flowing from the kiln was generally in the shape of small irregularly shaped particles, spheres, or oblate spheroids. The size ranged from sand to about 1 inch in size (Photo at right shows EcoAggMat collected in a Super Sack). On several occasions, material tumbling in the kiln agglomerated into larger chunks that resemble logs or pancakes. These were described as being typical of non-slagging kiln operation by Dr. Paul Queneau (consultant). One log about 4 feet long and 8 inches in diameter successfully passed through the kiln and broke up as it dropped into the granulator. On another occasion, a pancake about 2½ feet in diameter and 8 inches thick dropped into the granulator and caused the drag conveyor to jam. Fortunately, the pancake was accessible from the back of the granulator and it readily broke up when manipulated with a poker. Pieces of the pancake were withdrawn from the granulator by the drag conveyor.

EPA SITE Program Sampling: Beginning on March 10, 2005 at about 10:15 a.m. the EPA SITE program sampling team began their sampling work. The sampling team had arrived at the plant site a few days earlier so that they could attend IMTT Safety Orientation training. Operating conditions during the sampling were a feed rate of 500 pounds per hour, a kiln temperature of 1835°F (T-201), a SCC temperature of 2115°F (T-202), and kiln rotation rate of 0.4 rpm. These conditions were maintained consistently during the sampling activities.

Consistent feeding of the sediment-modifier mixture was achieved by manually loading the material into the C-151 access/view port from a 5-gallon pail. Manual feeding was selected over mechanical feeding (i.e., using the T-102 hopper, the C-102 and C-101 conveyors) to ensure consistent conditions during EPA sampling.

EPA SITE Program sampling continued on March 11, beginning about 8:00 a.m. They finished sampling about 6:00 p.m. They then packed their equipment and departed.

Continuing Non-Slagging Operation: After the EPA SITE sampling was completed, we continued feeding the sediment-modifier mixture to the system. However, we increased the feed rate to 1,000 pounds per hour, which was equivalent to one Bobcat bucket of sediment-modifier mixture per hour. The EcoAggMat product was collected in 1-yd^3 capacity Super Sacks and as each sack was filled it was logged, weighed, and relocated to storage in the west part of the property.

Three 5-gallon pails of EcoAggMat were delivered to BASF Company for beneficial use evaluation.

Freezing temperature continued to plague operations during the late evening and overnight hours. Some evenings, it was all the operating staff could do but keep the equipment from freezing up. Also, the alternate feed hopper (T-102), which had been used as the surge hopper for material being fed from the sediment storage area onto the belt conveyor began to experience packing of sediment-modifier mixture in its discharge conveyor (C-102). When this small conveyor plugged, it took several hours to unplug. As the material from the conveyor belt continued to fill the alternate feed hopper until the plug was detected, the extra material then backed up into the alternate feed hopper and plugged it. Later we decided to bypass the alternate feed hopper (T-102) and deposit feed material directly into the C-101 conveyor. This simplified the operation somewhat, but made the operation more labor intensive.

Sediment-modifier mixture also plugged the water-cooled screw conveyor (C-151) several times during the campaign. This was usually the result of overfeeding material into the C-101 conveyor, which in turn fed the C-112 Weigh Hopper, which fed the M-131 Pug Mill.

We took precautions to avoid overfeeding this conveyor, including taking preventive maintenance steps once per shift to clear C-151, run it forward and reverse for 10 to 15 minutes then close it up. Nevertheless, the water-cooled screw auger continued to plug.

Material continued to accumulate around the water-cooled auger shaft as well as on the interior of the feeding tube. Material became caked on the bottom of the feed tube and displaced the rotating auger up against the top of the feed tube. The added friction of the rotating screw against the feed tube surface caused the water-cooled screw auger motor to overheat. We tried reducing the caking in the bottom of the feed tube using water sprays as well as water dumped directly into the C-151 access/view port. These steps were moderately successful in reducing the motor load; however, within a short time, the motor would again begin to heat up.

The diaphragm in the vacuum pump in the CEMS cabinet also failed during the campaign. Trace Environmental Systems came out to the plant and repaired the pump and did maintenance work on the stack sampling lines. A few lines had become overheated during the campaign and had developed a leak. The CEMS was repaired and put back into service.

The filter screens that protect the granulator recirculation water pump began to accumulate fine particles of lime over time. We would switch from one duplex screen to the other at least once per shift. The filter screen not in use would be cleaned of lime and replaced. The source of the lime was limestone that had been premixed into the sediment prior to feeding. When subjected to the temperature in the kiln, the limestone would calcine into lime. At least a portion of the lime would dissolve into the granulator water.

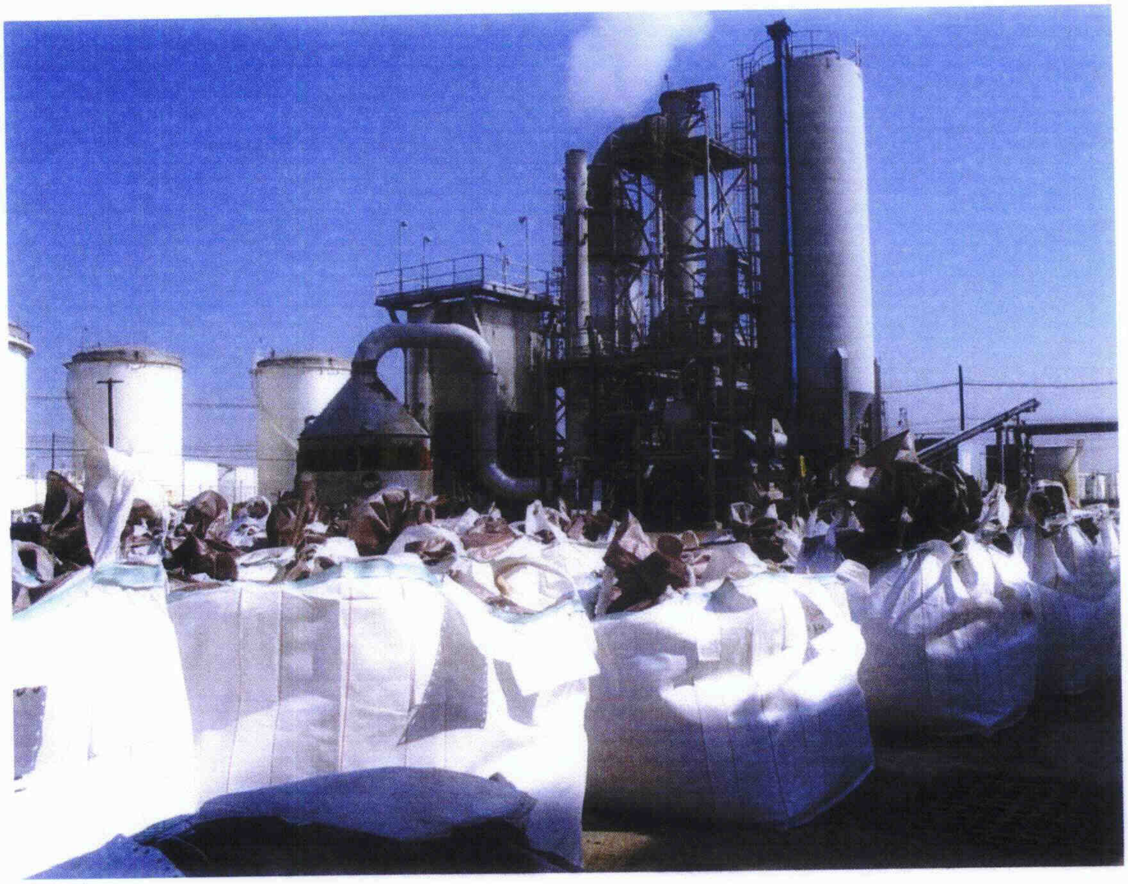
By March 20, the motor overheating experienced with water-cooled screw auger C-151 continued to worsen. Adding water to the C-151 access/view port did not relieve the overheating. Running the auger in reverse also had limited effect. The screw auger needed to be pulled out of the kiln feed tube so that it could be thoroughly cleaned and evaluated. This would necessitate shutting down the plant.

At 3:30 p.m. on March 21, after discussing the situation with ECH/GTI management and project sponsors, we decided to discontinue attempts to feed and begin cooling the system.

On March 22, the system had cooled sufficiently that FMW could pull the water-cooled screw auger out of its feed tube for inspection. The auger showed signs of friction-induced deformation that progressively worsened closer to the discharge end.

As the major objective of the non-slagging campaign had been achieved, we decided to begin returning the rental equipment and begin planning for Phase II of the overall project.

Overall, we estimate that about 80 yd^3 of sediment-modifier mixture was processed through the Cement-Lock demo plant system from March 5 through 21, 2005. The EcoAggMat was collected in 107 Super Sacks (see photo below).



Subsequently, the rental equipment was returned and the EcoAggMat as well as the remainder of untreated sediment and sediment-modifier mixture is awaiting beneficial use disposition.

Appendix B

NEW JERSEY PERMITTING

NJ Acceptable Use Determination

NJ Air Quality Permit

Appendix C

QUALITY ASSURANCE PROJECT PLANT FOR NON-SLAGGING CEMENT-LOCK DEMO PLANT TEST

U.S. Environmental Protection Agency SITE Program

Appendix D

SOIL BORING TEST RESULTS

(Schoor Depalma)

Appendix E

STANDARD OPERATING PROCEDURES (S.O.P.s)

(RPMS Consulting Engineers, Monroe Township, NJ)

Appendix F

HAZ-OP ACTION ITEMS REPORT

HAZ-OP SUMMARY REPORT

HAZ-OP ACTION ITEMS REPORT

Index

Action Items - Cover Page

Printed:April 08, 2003, 2:38 p.m.
Company: Endesco Clean Harbors LLC
Location: Bayonne, NJ
Facility: Cement-Lock Demonstration Plant

PHA Method:HAZOP
PHA Type: Initial

Process:	Cement-Lock
File Description:	Initial HAZOP PHA for new demonstration plant.
Date:	April 1, 2003
Process Description:	Contaminated soil is mixed with additives and fed into a rotary kiln. Volatile components are driven off into the vapor phase and combusted in a secondary combustion chamber. The resulting gas is cooled and passed through a baghouse and carbon bed to remove particulates and harmful chemical emissions before venting to the atmosphere. Solids in the kiln are heated to the melting point and poured into a quench system and granulator to form a material called Ecomelt. This material is further processed in a drier and stored as finished product. This material can then be sold and used as the cement basis for concrete.
Chemicals:	
Purpose:	Review the design of the Cement-Lock demonstration plant from a hazard and operability (HAZOP) point of view.
Scope:	The entire cement-lock demonstration plant will be reviewed.
Objectives:	The objective of the sessions is to identify potential hazards and operability problems that could be caused by deviations from the current plant design.
Project Notes:	This plant is a scale up of technology developed on the lab bench and pilot plant operations. It is intended to be a continuously operating demonstration of the developing technology. Most of the unit operations within the plant are commonly used in various other types of production facilities. S: Severity L: Likelihood R: Risk Factor REF#: Recommendation number P: Priority A: High B: Medium C: Low

Filters: None

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Action Items

Session: (1) 4/1/2003

Revision:
Node: (1) Sediment Feed System
Drawings: 1148-3100-6
Parameter: Flow
Intention: feed 2931 pph

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
	bridging in bin due to overfill	no feed, loss of heat sink in dryer	8	need mirror and platform & lights	B
	bin empty	no feed, loss of heat sink in dryer	8	need mirror and platform & lights	B
Less Flow	bridging	loss of heat sink	6	alarm mass flow	A

Session: (1) 4/1/2003
Revision:
Node: (1) Sediment Feed System
Drawings: 1148-3100-6
Parameter: Temperature
Intention: ambient temp warm enough for sediment to be flowing

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
Lower Temperature	freezing weather	large chunks of mat'l causing bridge or plug	9	provide heat if plan to run during cold weather	C

Session: (1) 4/1/2003
Revision:
Node: (1) Sediment Feed System
Drawings: 1148-3100-6
Parameter: Level
Intention: keep level below 1/3 until experience indicates higher allowable

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
Higher Level	overfilling by bucket loader	bridging, low or no flow	8	need mirror and platform & lights	B
				charge from end opposite outlet	C

Session: (2) 4/1/2003
Revision:
Node: (3) Modifier # 1 Feed
Drawings: 1148-3100-6
Parameter: Flow
Intention: Flow of modifier # 1 (limestone) shall be 470 pph automatically ratioed from sediment feed

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
No Flow	bin is empty	feed material may not melt or viscosity may be very high forming clinkers in kiln and possibly steam explosion in quencher.	3	flow indicator with high and low alarm on outlet of C-103	A
	bin is bridged	improper melting, clinkers in kiln and potential steam explosion	2	ditto	A
	HV-103 closed	improper melting, clinkers in kiln and potential steam explosion	4	ditto	A
	V-103 fails	improper melting, clinkers in kiln and potential steam explosion	4	ditto	A

	F-103 fails	improper melting, clinkers in kiln and potential steam explosion	4	ditto	A
	C-103 fails	improper melting, clinkers in kiln and potential steam explosion	4	ditto	A
	clumping due to water	improper melting, clinkers in kiln and potential steam explosion	4	plan receipt of material in dry weather and include in raw material spec	C
Less Flow	same as no flow	same as no flow	2	flow indicator with high and low alarm on outlet of C-103	A
More Flow	operator error	improper melting, clinkers in kiln and potential steam explosion	4	flow indicator with high and low alarm on outlet of C-103	
	calibration	improper melting, clinkers in kiln and potential steam explosion	4	ditto	

Session: (2) 4/1/2003
Revision:
Node: (3) Modifier # 1 Feed
Drawings: 1148-3100-6
Parameter: Pressure
Intention: intent is to keep vessel at atm when filling or using material

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
Higher Pressure	vent plugged by clumped lime dust	fill T-104 with lime dust which cause error in ratio of materials	2	remove cross connection between vessels and install vent on T-104	A

Session: (2) 4/1/2003
Revision:
Node: (3) Modifier # 1 Feed
Drawings: 1148-3100-6
Parameter: Level
Intention: maintain operating level

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
No Level	operator error	no flow with improper melting, clinkers in kiln and potential steam explosion	4	flow indicator with high and low alarm on outlet of C-103	A
	bindicator failure	no flow with improper melting, clinkers in kiln and potential steam explosion	4	ditto	A

Session: (2) 4/1/2003
Revision:
Node: (4) Modifier # 2 Feed
Drawings: 1148-3100-6
Parameter: Flow
Intention: flow 29 pph of alumina

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
No Flow	bin is empty	feed material may not melt or viscosity may be very high forming clinkers in kiln and possibly steam explosion in quencher.	3	flow indicator with high and low alarm on outlet of F-104	A
	bin is bridged	improper melting, clinkers in kiln and potential steam explosion	2	ditto	A

	HV-104 closed	improper melting, clinkers in kiln and potential steam explosion	4	ditto	A
	V-104 fails	improper melting, clinkers in kiln and potential steam explosion	4	ditto	A
	F-104 fails	improper melting, clinkers in kiln and potential steam explosion	4	ditto	A
Less Flow	same	same	2	same	A
More Flow	operator error	improper melting, clinkers in kiln and potential steam explosion	4	flow indicator with high and low alarm on outlet of F-104	A
	calibration	improper melting, clinkers in kiln and potential steam explosion	4	ditto	A

Session: (2) 4/1/2003
Revision:
Node: (4) Modifier # 2 Feed
Drawings: 1148-3100-6
Parameter: Composition
Intention: minus 1/16 alumina pellets

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
water in bin	rainwater	wet alumina affects lime	7	put cover over bag shoot	B
				store alumina dry	B

Session: (2) 4/1/2003
Revision:
Node: (4) Modifier # 2 Feed
Drawings: 1148-3100-6
Parameter: Level
Intention: maintain operating level in bin

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
No Level	operator error	no flow with improper melting, clinkers in kiln and potential steam explosion	4	flow indicator with high and low alarm on outlet of F-104	A
	indicator failure	no flow with improper melting, clinkers in kiln and potential steam explosion	4	ditto	A

Session: (3) 4/1/2003
Revision:
Node: (5) Blended Feed System
Drawings: 1148-3100-6
Parameter: Temperature
Intention: keep c-151 equipment less than 200 deg F

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
Higher Temperature	loss of water flow	water leak into kiln	4	relocate water flow to outlet	A

Session: (3) 4/1/2003
Revision:
Node: (6) Ecomelt Generation
Drawings: 1148-3105-6
Parameter: Flow

Intention: produce 1148 pph of molten slag

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
No Flow	drag conveyor fails	Kiln overfills drop out box	8	consider manual clean out of drop out box	C
	C-205 fails	material backs up	8	add diverter on outlet of C-203	C
	F-205 fails	material backs up	8	ditto	C
Less Flow	building up a dam in kiln	steam explosion in drop out box	2	add another sight glass	A
				provide method of adding flux rapidly	A
				consider water cooled camera	A
				consider IR skin temperature monitor	A

Session: (4) 4/1/2003
Revision:
Node: (6) Ecomelt Generation
Drawings: 1148-3105-6
Parameter: Temperature
Intention: maintain adequate temperature to keep molten material flowing

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
Higher Temperature	loss of quench water	molten material flashes water in granulator	6	add city water back-up to water sprays with auto actuation	A
				consider back-up water pump	A
				consider head tank	A

Session: (4) 4/1/2003
Revision:
Node: (7) Ecomelt Finishing
Drawings: 1148-3106-4
Parameter: Flow
Intention: flow 1136 pph of Ecomelt product

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
No Flow	upstream node failures	heat damage to vapor side equipment	7	have ID fan increase on high temp	B
	ID fan failure	plant shut down	9	add diverter on outlet of C-203, see also node 6	C

Session: (6) 4/2/2003
Revision:
Node: (10) Vent Gas
Drawings: 1148-3107-12
Parameter: Phase
Intention: vapor phase

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
lime in gas stream to carbon bed	bag break in baghouse	plugging of carbon bed	9	consider broken bag detector	C

Session: (6) 4/2/2003

Revision:
Node: (11) Lime Additive
Drawings: 1148-3107-12
Parameter: Flow
Intention: maintain flow of 90 pph of lime to coat bags

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
No Flow	bin empty	no acid gas removal	9	add low flow switch just ahead of venturi	C

Session: (7) 4/2/2003
Revision:
Node: (12) Primary Burner Train
Drawings: 1148-3101-7
Parameter: Flow
Intention: maintain sufficient flow to meet required temperature while maintaining the proper ratio

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
No Flow of NG to main burner	No gas supply	plant shut down waste feed	7	add alarms set lower/higher than trips	B

Session: (7) 4/2/2003
Revision:
Node: (13) Afterburner Train
Drawings: 1148-3102-3
Parameter: Flow
Intention: maintain temp

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
No Flow of NG to main burner	No gas supply	environmental emissions violation, shut down feed	9	add alarms set lower/higher than trips	C

Session: (7) 4/2/2003
Revision:
Node: (14) Melt Burners Train
Drawings: 1148-3003-0 1148-3108-2
Parameter: Flow
Intention: maintain flow to control temp in melt area

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
No Flow of NG to main burner	No gas supply	slag solidifies on tiles and could dump molten slag into granulator water	6	add low temp alarm and trip should cut of waste feed	A
	thermocouple failure			research alternatives to control by thermocouple	A

Session: (7) 4/2/2003
Revision:
Node: (15) Dryer Burner Train
Drawings: 1148-3104-6
Parameter: Flow
Intention: maintain dryer outlet temperature by adjusting flow

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
No Flow of NG to main burner	No gas supply	wet product	9	add alarms set lower/higher than trips	C

Session: (7) 4/2/2003
Revision:
Node: (16) Instrument Air Dryers
Drawings: 1148-3109-4
Parameter: Flow
Intention: provide dry air as demanded by instruments

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
Less Flow	air compressor failure	automatic valves go to fail position shutting down the plant	4	add instrument air compressor for back-up or N2 for back-up	A

Session: (5) 4/2/2003
Revision:
Node: (17) Ecomelt Quench Water Circuit
Drawings: 1148-3105-6
Parameter: Flow
Intention: provide 31 to 62 gpm of water to quench Ecomelt and 120 gpm to water seal weir

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
No Flow	pump fail	mechanical damage due to steam explosion	3	add city water back-up to water sprays with auto actuation	A
				consider back-up water pump	A
				consider head tank	A
	tank empty	same	3	add low level switch	A
no flow of seal water	control valve fail	rapid pump seal failure	4	add high/low flow switch	A
less flow of seal flush	control valve fail	pump seal failure spraying hot water in area	6	see above	B

Session: (5) 4/2/2003
Revision:
Node: (17) Ecomelt Quench Water Circuit
Drawings: 1148-3105-6
Parameter: Temperature
Intention: keep water temperature less than 190 deg F

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
Higher Temperature	quenching process and loss of make-up water	npsh problem at pump causing low flow	10	add high alarm to TI	C

Session: (7) 4/2/2003
Revision:
Node: (18) Natural Gas Booster
Drawings: NG Booster
Parameter: Flow
Intention: provide sufficient gas to burners

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
Less Flow	plugging of strainer	low burner firing	7	provide low pres & temp alarms, run indication to main control room	A

Session: (7) 4/2/2003
Revision:

Node: (18) Natural Gas Booster
Drawings: NG Booster
Parameter: Temperature
Intention: provide gas below 150 deg F

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
Higher Temperature	large compression ratio on hot feed gas	excess temp affects burner regulators	7	provide temp alarm	B

Session: (7) 4/2/2003
Revision:
Node: (18) Natural Gas Booster
Drawings: NG Booster
Parameter: Pressure
Intention: deliver gas at 15 psig

DEVIATION	CAUSES	CONSEQUENCES	R	RECOMMENDATIONS	P
Higher Pressure	failure of 3" recycle	overpressure of gas supply	6	install psv and high pres alarm	A

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HAZ-OP SUMMARY REPORT

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<u>Node 14: Melt Burners Train, Parameter: Flow</u>
<u>Node 14: Melt Burners Train, Parameter: Temperature</u>
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<u>Node 15: Dryer Burner Train, Parameter: Composition</u>
<u>Node 16: Instrument Air Dryers, Parameter: Flow</u>
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<u>Node 19: Continuous Emissions Monitoring, Parameter: Composition</u>

Worksheet - Cover Page

Printed:April 08, 2003, 2:51 p.m.
Company: Endesco Clean Harbors LLC
Location: Bayonne, NJ
Facility: Cement-Lock Demonstration Plant

PHA Method:HAZOP
PHA Type: Initial

Process:	Cement-Lock
File Description:	Initial HAZOP PHA for new demonstration plant.
Date:	April 1, 2003
Process Description:	Contaminated soil is mixed with additives and fed into a rotary kiln. Volatile components are driven off into the vapor phase and combusted in a secondary combustion chamber. The resulting gas is cooled and passed through a baghouse and carbon bed to remove particulates and harmful chemical emissions before venting to the atmosphere. Solids in the kiln are heated to the melting point and poured into a quench system and granulator to form a material called Ecomelt. This material is further processed in a drier and stored as finished product. This material can then be sold and used as the cement basis for concrete.
Chemicals:	
Purpose:	Review the design of the Cement-Lock demonstration plant from a hazard and operability (HAZOP) point of view.
Scope:	The entire cement-lock demonstration plant will be reviewed.
Objectives:	The objective of the sessions is to identify potential hazards and operability problems that could be caused by deviations from the current plant design.
Project Notes:	This plant is a scale up of technology developed on the lab bench and pilot plant operations. It is intended to be a continuously operating demonstration of the developing technology. Most of the unit operations within the plant are commonly used in various other types of production facilities. S: Severity L: Likelihood R: Risk Factor REF#: Recommendation number P: Priority A: High B: Medium C: Low

Filters: None

Worksheet

Page: 1
Company:Endesco Clean Harbors LLC
Facility: Cement-Lock Demonstration Plant

Session: (1) 4/1/2003
Revision:
Node: (1) Sediment Feed System
Drawings: 1148-3100-6
Parameter: Flow
Intention: feed 2931 pph

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Flow	motors lose power	no feed, loss of heat sink in dryer	speed alarms	3	4	8		
			temperature sensor in dryer lowers fuel rate					
	interlock trips system	no feed, loss of heat sink in dryer		3	1	3		
	augers jammed by large chunks in feed	no feed, loss of heat sink in dryer	screen feed	3	4	8		
	bridging in bin due to overfill	no feed, loss of heat sink in dryer	SOP on fill level	3	4	8	1	need mirror and platform & lights
	bridging due to composition	no feed, loss of heat sink in dryer	screening	3	4	8		
			water available					
			operator trained to proper condition					
	bin empty	no feed, loss of heat sink in dryer	SOP	3	4	8	1	need mirror and platform & lights
	can't fill due to loader out of service	no feed, loss of heat sink in dryer	maintenance & fuel supply, good operating procedures	3	4	8		
More Flow	operator error increases speed	exceed reg limit	SOP, mass flow indicator	4	4	9		
		may not be able to maintain temp in kiln	SOP, mass flow indicator, temp control of burner	4	4	9		
Less Flow	bridging	loss of heat sink	temp control of burner	3	2	6	2	alarm mass flow
			mass flow indicator					
	operator error	loss of heat sink	SOP	3	4	8		
	ringing of augers	loss of heat sink		3	4	8		

Session: (1) 4/1/2003
Revision:
Node: (1) Sediment Feed System
Drawings: 1148-3100-6
Parameter: Temperature
Intention: ambient temp warm enough for sediment to be flowing

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Lower Temperature	freezing weather	large chunks of mat'l causing bridge or plug	operate in warm weather	3	5	9	3	provide heat if plan to run during cold weather

Session: (1) 4/1/2003
Revision:
Node: (1) Sediment Feed System
Drawings: 1148-3100-6
Parameter: Composition
Intention: consistent uniform size uniform composition, no clay, < 2" stone, no metal, >damp

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Contains stones or metal	poor screening	see low or no flow		3	4	8		
	broken equipment pieces	see low or no flow		3	5	9		
Missing water	dried out in bin	see low or no flow	water is available via hose	3	3	7		

Session: (1) 4/1/2003
Revision:
Node: (1) Sediment Feed System
Drawings: 1148-3100-6
Parameter: Level
Intention: keep level below 1/3 until experience indicates higher allowable

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Level	overfilling by bucket loader	bridging, low or no flow	operator training	3	4	8	1	need mirror and platform & lights
							4	charge from end opposite outlet

Session: (2) 4/1/2003
Revision:
Node: (2) Alternate Feed System
Drawings: 1148-3100-6
Parameter: Flow
Intention: Flow alternate feed at 2931 PPH

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Flow	HV-102 closed by operator	no feed, loss of heat sink in dryer	operator training, mass flow indicator	3	4	8		
	stem indicator misread	no feed, loss of heat sink in dryer	mass flow indicator	3	5	9		
Less Flow	HV-102 closed by operator	loss of heat sink in dryer	operator training, mass flow indicator	3	4	8		

Session: (2) 4/1/2003

Revision:
Node: (3) Modifier # 1 Feed
Drawings: 1148-3100-6
Parameter: Flow
Intention: Flow of modifier # 1 (limestone) shall be 470 pph automatically ratioed from sediment feed

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Flow	bin is empty	feed material may not melt or viscosity may be very high forming clinkers in kiln and possibly steam explosion in quencher.	level indication and low level alarm	1	3	3	5	flow indicator with high and low alarm on outlet of C-103
	bin is bridged	improper melting, clinkers in kiln and potential steam explosion	none	1	2	2	5	ditto
	HV-103 closed	improper melting, clinkers in kiln and potential steam explosion	operator training	1	4	4	5	ditto
	V-103 fails	improper melting, clinkers in kiln and potential steam explosion	none	1	4	4	5	ditto
	F-103 fails	improper melting, clinkers in kiln and potential steam explosion	speed indicator	1	4	4	5	ditto
	C-103 fails	improper melting, clinkers in kiln and potential steam explosion	speed indicator	1	4	4	5	ditto
	clumping due to water	improper melting, clinkers in kiln and potential steam explosion	SOP	1	4	4	6	plan receipt of material in dry weather and include in raw material spec
Less Flow	same as no flow	same as no flow	same as no flow	1	2	2	5	flow indicator with high and low alarm on outlet of C-103
More Flow	operator error	improper melting, clinkers in kiln and potential steam explosion	none	1	4	4		flow indicator with high and low alarm on outlet of C-103
	calibration	improper melting, clinkers in kiln and potential steam explosion	none	1	4	4		ditto

Session: (2) 4/1/2003
Revision:
Node: (3) Modifier # 1 Feed
Drawings: 1148-3100-6
Parameter: Pressure

Intention: intent is to keep vessel at atm when filling or using material

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Pressure	vent plugged by clumped lime dust	exceed design pressure of vessel T-103	PSV-103	2	5	8		
		fill T-104 with lime dust which cause error in ratio of materials	none	2	1	2	7	remove cross connection between vessels and install vent on T-104
	plugged baghouse	exceed design pressure of vessel T-103	PSV-103	2	4	7		
	excess air from truck blowing in	exceed design pressure of vessel T-103	system is sized for vent capacity to exceed truck capacity, PSV-103	2	5	8		
	overfill hopper	exceed design pressure of vessel T-103	two high level alarms	2	5	8		
Lower Pressure	vent plugged by clumped lime dust	collapse the hopper	PSV-103	2	4	7		

Session: (2) 4/1/2003
Revision:
Node: (3) Modifier # 1 Feed
Drawings: 1148-3100-6
Parameter: Composition
Intention: the material shall be 1/4" or smaller dry limestone

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Contamination	delivered material off spec	could be same as no flow	written spec and require certificate of analysis with each load	1	5	5		
water in bin	rainwater	exothermic reaction	sealed vessel	4	4	9		
			operator training					
		bridging, see no flow	operator training	1	4	4		
	water in instrument air	same	air dryer	1	5	5		

Session: (2) 4/1/2003
Revision:
Node: (3) Modifier # 1 Feed
Drawings: 1148-3100-6
Parameter: Level
Intention: maintain operating level

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS

No Level	operator error	no flow with improper melting, clinkers in kiln and potential steam explosion	level indication and alarm	1	4	4	5	flow indicator with high and low alarm on outlet of C-103
	bindicator failure	no flow with improper melting, clinkers in kiln and potential steam explosion	separate high level alarm	1	4	4	5	ditto
Higher Level	overfilling	exceed design pressure of vessel T-103	two high level alarms	2	5	8		

Session: (2) 4/1/2003
Revision:
Node: (4) Modifier # 2 Feed
Drawings: 1148-3100-6
Parameter: Flow
Intention: flow 29 pph of alumina

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Flow	bin is empty	feed material may not melt or viscosity may be very high forming clinkers in kiln and possibly steam explosion in quencher.	level indication and low level alarm	1	3	3	8	flow indicator with high and low alarm on outlet of F-104
	bin is bridged	improper melting, clinkers in kiln and potential steam explosion	none	1	2	2	8	ditto
	HV-104 closed	improper melting, clinkers in kiln and potential steam explosion	operator training	1	4	4	8	ditto
	V-104 fails	improper melting, clinkers in kiln and potential steam explosion	none	1	4	4	8	ditto
	F-104 fails	improper melting, clinkers in kiln and potential steam explosion	speed indicator	1	4	4	8	ditto
Less Flow	same	same	none	1	2	2	8	same
More Flow	operator error	improper melting, clinkers in kiln and potential steam explosion	none	1	4	4	8	flow indicator with high and low alarm on outlet of F-104
	calibration	improper melting, clinkers in kiln and potential steam explosion	none	1	4	4	8	ditto

Session: (2) 4/1/2003
Revision:
Node: (4) Modifier # 2 Feed
Drawings: 1148-3100-6
Parameter: Composition
Intention: minus 1/16 alumina pellets

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS

Contamination	wrong material delivered	could be same as no flow	material spec and C of A	1	5	5		
	material falling into bucket elevator	ditto	SOP	1	5	5		
water in bin	rainwater	wet alumina affects lime	none	2	4	7	9	put cover over bag shoot
							10	store alumina dry

Session: (2) 4/1/2003
Revision:
Node: (4) Modifier # 2 Feed
Drawings: 1148-3100-6
Parameter: Level
Intention: maintain operating level in bin

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Level	operator error	no flow with improper melting, clinkers in kiln and potential steam explosion	level indication and alarm	1	4	4	8	flow indicator with high and low alarm on outlet of F-104
	indicator failure	no flow with improper melting, clinkers in kiln and potential steam explosion	separate high level alarm	1	4	4	8	ditto
Higher Level	overfilling	exceed design pressure of vessel T-104	two high level alarms	2	5	8		

Session: (3) 4/1/2003
Revision:
Node: (5) Blended Feed System
Drawings: 1148-3100-6
Parameter: Flow
Intention: flow 3431 pph of mixed material to the kiln

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Flow	feed equipment failure see previous nodes							
	M-131 motor fail	loss of heat sink in dryer	low speed alarm	3	4	8		
	C-151 motor failure	loss of heat sink in dryer	low speed alarm	3	4	8		
	blockage of mixer M-131	loss of heat sink in dryer		3	4	8		
	accumulation of melting (sticky) feed	loss of heat sink in dryer	cooled conveyer see temperature parameter	3	5	9		
Less Flow	operator error	loss of heat sink in dryer, feed system backs up	SOP	3	4	8		

	ringing of augers	loss of heat sink in dryer, feed system backs up		3	4	8		
Reverse Flow	operator error	loss of heat sink in dryer, feed system backs up	SOP, speed alarm	3	4	8		

Session: (3) 4/1/2003
Revision:
Node: (5) Blended Feed System
Drawings: 1148-3100-6
Parameter: Temperature
Intention: keep c-151 equipment less than 200 deg F

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Temperature	loss of water flow	damage to mechanical equipment	low flow alarm on water supply	2	3	6		
			high temp alarm on outlet water					
			make-up water available					
		water leak into kiln	same	1	4	4	11	relocate water flow to outlet

Session: (3) 4/1/2003
Revision:
Node: (6) Ecomelt Generation
Drawings: 1148-3105-6
Parameter: Flow
Intention: produce 1148 pph of molten slag

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Flow	see previous feed nodes							
	kiln stops rotating due to trunnion failure	mechanical damage to generator	speed indicator	2	4	7		
			interlocks to shut down burners & feed					
		loss of heat sink to dryer						
	operator error stops kiln	loss of heat sink to dryer		2	4	7		
	chain breaks	loss of heat sink to dryer		2	5	8		
	motor fail	loss of heat sink to dryer		2	4	7		
	drag conveyor fails	Kiln overfills drop out box	speed indicator with S/D interlocks	3	4	8	12	consider manual clean out of drop out box

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
	C-205 fails	material backs up	speed indicator with S/D interlock	3	4	8	13	add diverter on outlet of C-203
	F-205 fails	material backs up	speed indicator with S/D interlock	3	4	8	13	ditto
Less Flow	building up a dam in kiln	steam explosion in drop out box	look in view port	1	2	2	14	add another sight glass
							15	provide method of adding flux rapidly
							16	consider water cooled camera
							17	consider IR skin temperature monitor

Session: (4) 4/1/2003
Revision:
Node: (6) Ecomelt Generation
Drawings: 1148-3105-6
Parameter: Temperature
Intention: maintain adequate temperature to keep molten material flowing

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Temperature	volatiles in sediment	mechanical damage	temp control of burner, high temp alarm, high high S/D	2	4	7		
	over fire burner	mechanical damage	ditto	2	4	7		
	loss of nose cooling	mechanical damage	PSL-207 and blower is on emergency power	3	4	8		
	loss of quench water	molten material flashes water in granulator	low flow alarm	2	3	6	18	add city water back-up to water sprays with auto actuation
							19	consider back-up water pump
							20	consider head tank
Lower Temperature	low pressure of NG supply	slag dams with subsequent steam explosions	booster compressor, low pressure alarm, low temp alarm, low low temp S/D	1	4	4		
	excess flow	ditto	low temp alarm, low low temp S/D	1	4	4		
	excess air flow	ditto	low temp alarm, low low temp S/D	1	4	4		

Session: (4) 4/1/2003
Revision:
Node: (6) Ecomelt Generation
Drawings: 1148-3105-6
Parameter: Pressure

Intention: maintain slight vacuum condition in Ecomelt generator

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Pressure	volatile or water in feed	melting seals	prescreen feed for uniformity	2	4	7		
	ID fan failure	melting seals	interlock to burner shutdown	2	4	7		
			stack cap opens					
	carbon bed plug	melting seals	pdit-304 with alarm, stack cap opens	2	4	7		
	damper failure	melting seals	pdit 305 with alarm, stack cap opens	2	4	7		
	baghouse plug	melting seals	pdit-303 with alarm, stack cap opens	2	4	7		
	gas quencher plugs	melting seals	pdit-301 with alarm, stack cap opens	2	5	8		
	TV-303 open	melting seals	pdit-303 with alarm, stack cap opens	2	4	7		
	overspeed on blower	melting seals	pic-201 adjusts damper	2	4	7		
Lower Pressure	damper fails open	excess air lower temp	low pres alarm	2	4	7		
		trip ID fan						

Session: (4) 4/1/2003
Revision:
Node: (6) Ecomelt Generation
Drawings: 1148-3105-6
Parameter: Phase
Intention: liquefy the material to uniform viscosity to flow through generator to drop out

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
solid material remains	lower temperature	see lower temperature parameter						

Session: (4) 4/1/2003
Revision:
Node: (7) Ecomelt Finishing
Drawings: 1148-3106-4
Parameter: Flow
Intention: flow 1136 pph of Ecomelt product

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Flow	upstream node failures	heat damage to vapor side equipment	temp control on outlet gas	2	4	7	21	have ID fan increase on high temp
			high temp alarm					
	ID fan failure	plant shut down	high pressure alarm	4	4	9	13	add diverter on outlet of C-203, see also node 6

Session: (4) 4/1/2003

Revision:
Node: (7) Ecomelt Finishing
Drawings: 1148-3106-4
Parameter: Temperature
Intention: maintain 250 deg out of dryer

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Temperature	lower Ecomelt flow	overheat baghouse	temp control of burner & alarm	3	4	8		
		overheat bucket elevator	temp control of burner & alarm					
Lower Temperature	low NG pressure	wet product in hopper	temp control of burner & alarm	4	4	9		
	excess moisture in feed							

Session: (4) 4/1/2003
Revision:
Node: (7) Ecomelt Finishing
Drawings: 1148-3106-4
Parameter: Pressure
Intention: maintain slight vacuum in dryer

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Pressure	cyclone plug	thermal damage to dryer	pressure control & alarm	4	4	9		
	baghouse plug	thermal damage to dryer	pressure control & alarm	4	4	9		
	ID fan failure	thermal damage to dryer	pressure control & alarm	4	4	9		

Session: (4) 4/1/2003
Revision:
Node: (7) Ecomelt Finishing
Drawings: 1148-3106-4
Parameter: Composition
Intention: feed product shall be moist and final product dry

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
water carry over	drag conveyor running too fast	lower temp and moisture in product	SOP	4	4	9		

Session: (4) 4/1/2003
Revision:
Node: (7) Ecomelt Finishing
Drawings: 1148-3106-4
Parameter: Level
Intention: don't overfill hopper

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher	not loading a	back up elevator	level detection and	4	5	10		

Level	truck		alarm					

Session: (5) 4/2/2003
Revision:
Node: (8) Secondary Combustion
Drawings: 1148-3105-6
Parameter: Temperature
Intention: maintain gas temp at 2350 deg F

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Temperature	high volatiles	over 2600 deg F causes equipment damage	high temp alarm & shutdown	2	5	8		
	secondary burner control failure	over 2600 deg F causes equipment damage	high temp alarm & shutdown	2	4	7		
Lower Temperature	burner failure	environmental compliance issue	low temp alarm & shutdown	3	4	8		
	seal failure	environmental compliance issue	low temp alarm & shutdown	3	4	8		
	kiln temp low	environmental compliance issue	low temp alarm & shutdown					

Session: (5) 4/2/2003
Revision:
Node: (8) Secondary Combustion
Drawings: 1148-3105-6
Parameter: Pressure
Intention: operate at slight vacuum

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Pressure	see Ecomelt generator	none	stack cap					
Lower Pressure	see Ecomelt generator							

Session: (6) 4/2/2003
Revision:
Node: (9) Quencher
Drawings: 1148-3107-12
Parameter: Flow
Intention: cool 30000 pph of exhaust gas with 35 gpm of quench water

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Flow of quench water	P-301 fails due to power	equipment damage in baghouse & carbon bed	high temp alarms, high temp trip of stack cap, pump on emergency power	2	4	7		
	P-301 fails due to mechanical	equipment damage in baghouse & carbon bed	high temp alarms, high temp trip of stack cap	2	4	7		
	control valve	equipment damage in	high temp alarms,	2	4	7		

	TV-301 fail	baghouse & carbon bed	high temp trip of stack cap				
	FV-302 fail close	equipment damage in baghouse & carbon bed	high temp alarms, high temp trip of stack cap	2	4	7	
	operator error close manual valve	equipment damage in baghouse & carbon bed	high temp alarms, high temp trip of stack cap	2	4	7	
No flow of exhaust gas	see previous nodes						
No flow of air	solenoid valve fail	equipment damage in baghouse & carbon bed	high temp alarms, high temp trip of stack cap	3	4	8	
	pressure regulator fail	equipment damage in baghouse & carbon bed	high temp alarms, high temp trip of stack cap	3	4	8	
	loss of air supply	equipment damage in baghouse & carbon bed	see node on air compressor				
Less Flow of quench water	plugging of nozzles	equipment damage in baghouse & carbon bed	high temp alarm, trip open air to baghouse	3	4	8	
	some solenoid valve closed	equipment damage in baghouse & carbon bed	high temp alarm, trip open air to baghouse	3	4	8	
	TV-301 closing	equipment damage in baghouse & carbon bed	high temp alarm, trip open air to baghouse	3	4	8	
	cavitation of pump	equipment damage in baghouse & carbon bed	high temp alarm, trip open air to baghouse	3	4	8	
less flow of air	solenoid and regulator	equipment damage in baghouse & carbon bed	high temp alarm, trip open air to baghouse	3	4	8	
More Flow of quench water	TV-301 fail open	low overhead temp with possible acid gas formation in baghouse	temp low alarm	4	4	9	
		wet bottom	temp low alarm	4	4	9	
	Low air supply						
more flow of air	pressure reg fail	higher outlet temp could damage bags & carbon	high temp alarms & trips	3	4	8	

Session: (6) 4/2/2003
Revision:
Node: (9) Quencher
Drawings: 1148-3107-12
Parameter: Level

Intention: maintain water level in tank

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Level	LCV-301 fail closed	no flow see previous node	low level alarm					
	loss of water supply	no flow see previous node	low level alarm					

Session: (6) 4/2/2003
Revision:
Node: (10) Vent Gas
Drawings: 1148-3107-12
Parameter: Temperature
Intention: maintain temperature of 350 deg F

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Temperature	low flow in quencher	equipment damage in baghouse & carbon bed	high temp alarm & S/D	2	4	7		
Lower Temperature	high flow in quencher	condensation plugging bags	low temp alarm & del P alarm	2	4	7		
		moisture in dust could cause bridging	low temp alarm & del P alarm	4	4	9		

Session: (6) 4/2/2003
Revision:
Node: (10) Vent Gas
Drawings: 1148-3107-12
Parameter: Pressure
Intention: maintain slight vacuum

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Pressure	volatile or water in Ecomelt generation node	prescreen feed for uniformity		2	4	7		
	ID fan failure	see Ecomelt generation node	interlock to burner shutdown	2	4	7		
			stack cap opens					
	carbon bed plug	see Ecomelt generation node	pdit-304 with alarm, stack cap opens	2	4	7		
	damper failure	see Ecomelt generation node	pdit 305 with alarm, stack cap opens	2	4	7		
	baghouse plug	see Ecomelt generation node	pdit-303 with alarm, stack cap opens	2	4	7		
	gas quencher plugs	see Ecomelt generation node	pdit-301 with alarm, stack cap opens	2	5	8		
	TV-303 open	see Ecomelt generation node	pdit-303 with alarm, stack cap opens	2	4	7		
	overspeed on blower	see Ecomelt generation node	pic-201 adjusts damper	2	4	7		

Session: (6) 4/2/2003
Revision:
Node: (10) Vent Gas
Drawings: 1148-3107-12
Parameter: Composition
Intention: gas is composed of combustion products with low oxygen level

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS

High Concentration of oxygen	TV-303 opens on trip	carbon bed fire	high temp alarm & opens fire water supply (city water)	1	4	4		

Session: (6) 4/2/2003
Revision:
Node: (10) Vent Gas
Drawings: 1148-3107-12
Parameter: Phase
Intention: vapor phase

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
condensation of water	low temp see previous nodes	plugging of baghouse bags		4	4	9		
		plugging of carbon bed						
lime in gas stream to carbon bed	bag break in baghouse	plugging of carbon bed	del p alarm	4	4	9	22	consider broken bag detector

Session: (6) 4/2/2003
Revision:
Node: (11) Lime Additive
Drawings: 1148-3107-12
Parameter: Flow
Intention: maintain flow of 90 pph of lime to coat bags

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Flow	bin empty	no acid gas removal	level trans	3	5	9	23	add low flow switch just ahead of venturi
	bin bridged	no acid gas removal		3	4	8		
	HV-302 closed	no acid gas removal	operator train	3	5	9		
	F-302 fails	no acid gas removal	speed indicator	3	4	8		
	F-302A fails	no acid gas removal	low speed alarm	3	4	8		
	clumping	no acid gas removal		3	4	8		
	B-302 fails	no acid gas removal		3	4	8		
	blocked eductor	no acid gas removal		3	4	8		
Less Flow	same as no flow							

Session: (6) 4/2/2003
Revision:
Node: (11) Lime Additive
Drawings: 1148-3107-12

Parameter: Pressure
Intention: atm

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Pressure	vent plugged by clumped lime dust	exceed design pressure of vessel T-302	PSV-302	2	5	8		
	excess air from truck blowing in	exceed design pressure of vessel T-302	system is sized for vent capacity to exceed truck capacity, PSV-302	2	5	8		
	overfill hopper	exceed design pressure of vessel T-302	two high level alarms	2	5	8		
Lower Pressure	vent plugged by clumped lime dust	collapse the hopper	PSV-302	2	4	7		

Session: (6) 4/2/2003
Revision:
Node: (11) Lime Additive
Drawings: 1148-3107-12
Parameter: Composition
Intention: see node 3

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Contamination	delivered material off spec	could be same as no flow	written spec and require certificate of analysis with each load	1	5	5		
Liquid Carryover	rainwater	exothermic reaction	sealed vessel	4	4	9		
			operator training					
		bridging, see no flow	operator training	1	4	4		
	water in instrument air	same	air dryer	1	5	5		

Session: (6) 4/2/2003
Revision:
Node: (11) Lime Additive
Drawings: 1148-3107-12
Parameter: Level
Intention: maintain hopper level

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Level	operator error	see no flow	independent indicator and switch					

Session: (7) 4/2/2003
Revision:

Node: (12) Primary Burner Train
Drawings: 1148-3101-7
Parameter: Flow
Intention: maintain sufficient flow to meet required temperature while maintaining the proper ratio

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Flow of NG to main burner	No gas supply	plant shut down waste feed	pressure trip UV scanner	2	4	7	24	add alarms set lower/higher than trips
	valves closed							
	unit trip							
	regulator fail							
	control fail							
No flow of NG to pilot	same	none because plant won't be started						
No flow of air to main	blower failure due to power	plant shut down, minimal raw gas admitted	pressure switch, UV scanner	2	4	7		
	blower fails mechanically	plant shut down, minimal raw gas admitted	pressure switch, UV scanner	2	4	7		
	control fail	plant shut down, minimal raw gas admitted	pressure switch, UV scanner	2	4	7		
	blocked intake	plant shut down, minimal raw gas admitted	pressure switch, UV scanner	2	4	7		
No flow of air to pilot	same	none						
proper ratio	failure of O2 trim	excess O2 low temp	temp alarms	4	4	9		
		Low excess air low temp high CO	temp alarms	4	4	9		

Session: (7) 4/2/2003
Revision:
Node: (12) Primary Burner Train
Drawings: 1148-3101-7
Parameter: Temperature
Intention: maintain NG below 150 deg F

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Temperature	NG hot from booster compressor	failure of seals in regulators	see node 18	3	4	8		

Session: (7) 4/2/2003
Revision:
Node: (12) Primary Burner Train
Drawings: 1148-3101-7
Parameter: Pressure
Intention: maintain pressure to controls at greater than 11 and regulate to 10 psig

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Pressure	regulator fails open	over fire	high pressure switch & temp control will cut back flow	3	4	8		
Lower Pressure	booster failure	loss of flame	low pressure switch, UV detector	2	4	7		
	strainer plugged							
	regulator failed							

Session: (7) 4/2/2003
Revision:
Node: (12) Primary Burner Train
Drawings: 1148-3101-7
Parameter: Composition
Intention: natural gas heating value will remain constant

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
heating value changed by propane spike	city spikes with propane due to high demand	firing varies as heating value changes	temp control adjust firing	4	4	9		

Session: (7) 4/2/2003
Revision:
Node: (13) Afterburner Train
Drawings: 1148-3102-3
Parameter: Flow
Intention: maintain temp

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Flow of NG to main burner	No gas supply	environmental emissions violation, shut down feed	low pressure trip, UV scanner	4	4	9	25	add alarms set lower/higher than trips
	valves closed							
	unit trip							
	regulator fail							
	control fail							
No flow of NG to pilot	same	none because plant won't be started						
No flow of air to main	blower failure due to power	plant shut down, minimal raw gas admitted	pressure switch, UV scanner	4	4	9		
	blower fails mechanically	plant shut down, minimal raw gas admitted	pressure switch, UV scanner	4	4	9		
	control fail	plant shut down, minimal raw gas admitted	pressure switch, UV scanner	4	4	9		

	blocked intake	plant shut down, minimal raw gas admitted	pressure switch, UV scanner	4	4	9		
No flow of air to pilot	same	none						
proper ratio	maloperation of TV-539	high CO		4	4	9		

Session: (7) 4/2/2003
Revision:
Node: (13) Afterburner Train
Drawings: 1148-3102-3
Parameter: Temperature
Intention: maintain NG below 150 deg F

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Temperature	NG hot from booster compressor	failure of seals in regulators	see node 18	3	4	8		

Session: (7) 4/2/2003
Revision:
Node: (13) Afterburner Train
Drawings: 1148-3102-3
Parameter: Pressure
Intention: maintain pressure to controls at greater than 11 and regulate to 10 psig

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Pressure	regulator fails open	over fire	high pressure switch & temp control will cut back flow	3	4	8		
Lower Pressure	booster failure	loss of flame	low pressure switch, UV detector	4	4	9		
	strainer plugged							
	regulator failed							

Session: (7) 4/2/2003
Revision:
Node: (13) Afterburner Train
Drawings: 1148-3102-3
Parameter: Composition
Intention: natural gas heating value will remain constant

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
heating value changed Btu propane spike	city spikes with propane due to high demand	firing varies as heating value changes	temp control adjust firing	4	4	9		

Session: (7) 4/2/2003
Revision:

Node: (14) Melt Burners Train
Drawings: 1148-3003-0 1148-3108-2
Parameter: Flow
Intention: maintain flow to control temp in melt area

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Flow of NG to main burner	No gas supply	slag solidifies on tiles and could dump molten slag into granulator water	low pressure trip, UV scanner	2	3	6	26	add low temp alarm and trip should cut of waste feed
	valves closed							
	unit trip							
	regulator fail							
	control fail							
	thermocouple failure						27	research alternatives to control by thermocouple
No flow of NG to pilot	same	none because plant won't be started						
No flow of air to main	blower failure due to power	plant shut down, minimal raw gas admitted	pressure switch, UV scanner	2	4	7		
	blower fails mechanically	plant shut down, minimal raw gas admitted	pressure switch, UV scanner	2	4	7		
	control fail	plant shut down, minimal raw gas admitted	pressure switch, UV scanner	2	4	7		
	blocked intake	plant shut down, minimal raw gas admitted	pressure switch, UV scanner	2	4	7		
No flow of air to pilot	same	none						

Session: (7) 4/2/2003
Revision:
Node: (14) Melt Burners Train
Drawings: 1148-3003-0 1148-3108-2
Parameter: Temperature
Intention: maintain NG below 150 deg F

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Temperature	NG hot from booster compressor	failure of seals in regulators	see node 18	3	4	8		

Session: (7) 4/2/2003
Revision:
Node: (14) Melt Burners Train
Drawings: 1148-3003-0 1148-3108-2
Parameter: Pressure
Intention: maintain pressure to controls at greater than 11 and regulate to 10 psig

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Pressure	regulator fails open	hotter material with subsequent more generation of steam	high pressure switch & temp control will cut back flow	3	4	8		
Lower Pressure	booster failure	slag solidifies on tiles and could dump molten slag into granulator water	low pressure switch, UV detector	2	4	7		
	strainer plugged							
	regulator failed							

Session: (7) 4/2/2003
Revision:
Node: (14) Melt Burners Train
Drawings: 1148-3003-0 1148-3108-2
Parameter: Composition
Intention: natural gas heating value will remain constant

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
heating value changed by propane spike	city spikes with propane due to high demand	firing varies as heating value changes	temp control adjust firing	4	4	9		

Session: (7) 4/2/2003
Revision:
Node: (15) Dryer Burner Train
Drawings: 1148-3104-6
Parameter: Flow
Intention: maintain dryer outlet temperature by adjusting flow

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Flow of NG to main burner	No gas supply	wet product	pressure trip, UV scanner	4	4	9	28	add alarms set lower/higher than trips
	valves closed							
	unit trip							
	regulator fail							
	control fail							
No flow of NG to pilot	same	none because plant won't be started						
No flow of air to main	blower failure due to power	plant shut down, minimal raw gas admitted	pressure switch, UV scanner	2	4	7		
	blower fails mechanically	plant shut down, minimal raw gas admitted	pressure switch, UV scanner	2	4	7		
	control fail	plant shut down,	pressure switch,	2	4	7		

		minimal raw gas admitted	UV scanner					
	blocked intake	plant shut down, minimal raw gas admitted	pressure switch, UV scanner	2	4	7		
No flow of air to pilot	same	none						

Session: (7) 4/2/2003
Revision:
Node: (15) Dryer Burner Train
Drawings: 1148-3104-6
Parameter: Temperature
Intention: maintain NG below 150 deg F

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Temperature	NG hot from booster compressor	failure of seals in regulators	see node 18	3	4	8		

Session: (7) 4/2/2003
Revision:
Node: (15) Dryer Burner Train
Drawings: 1148-3104-6
Parameter: Pressure
Intention: maintain pressure to controls at greater than 11 and regulate to 10 psig

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Pressure	regulator fails open	thermal damage to the dryer and baghouse	high pressure switch & temp control will cut back flow, also high temp alarm	3	4	8		
Lower Pressure	booster failure	wet product	low pressure switch, UV detector	4	4	9		
	strainer plugged							
	regulator failed							

Session: (7) 4/2/2003
Revision:
Node: (15) Dryer Burner Train
Drawings: 1148-3104-6
Parameter: Composition
Intention: natural gas heating value will remain constant

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
heating value changed by propane spike	city spikes with propane due to high demand	firing varies as heating value changes	temp control adjust firing	4	4	9		

Session: (7) 4/2/2003

Revision:
Node: (16) Instrument Air Dryers
Drawings: 1148-3109-4
Parameter: Flow
Intention: provide dry air as demanded by instruments

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Less Flow	air compressor failure	automatic valves go to fail position shutting down the plant	low pressure alarm	1	4	4	29	add instrument air compressor for back-up or N2 for back-up
	plugged filters around dryer unit							

Session: (5) 4/2/2003
Revision:
Node: (17) Ecomelt Quench Water Circuit
Drawings: 1148-3105-6
Parameter: Flow
Intention: provide 31 to 62 gpm of water to quench Ecomelt and 120 gpm to water seal weir

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Flow	pump fail	mechanical damage due to steam explosion	low flow alarms	1	3	3	18	add city water back-up to water sprays with auto actuation
							19	consider back-up water pump
							20	consider head tank
	strainer plugged	same	low flow alarm	1	4	4		
	tank empty	same	low flow alarm	1	3	3	30	add low level switch
	control valve failure	empties tank	low flow alarms	1	4	4		
no flow of seal water	control valve fail	rapid pump seal failure		2	2	4	31	add high/low flow switch
	loss of water supply							
Less Flow of quench water	strainer plugged	as water reduced Ecomelt particles become clinkers	low flow alarm	4	2	7		
	flow indication error	as water reduced Ecomelt particles become clinkers	redundant indicators	4	4	9		
less flow of seal flush	control valve fail	pump seal failure spraying hot water in area		3	2	6	31	see above
	loss of water supply							

	pressure							

Session: (5) 4/2/2003
Revision:
Node: (17) Ecomelt Quench Water Circuit
Drawings: 1148-3105-6
Parameter: Temperature
Intention: keep water temperature less than 190 deg F

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Temperature	quenching process and loss of make-up water	npsh problem at pump causing low flow	temp indicator	4	5	10	32	add high alarm to TI

Session: (5) 4/2/2003
Revision:
Node: (17) Ecomelt Quench Water Circuit
Drawings: 1148-3105-6
Parameter: Pressure
Intention: pump discharge pressure of approx 40 psig

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Lower Pressure	pump cavitation	lower flow see previous node	low flow alarm	4	4	9		

Session: (5) 4/2/2003
Revision:
Node: (17) Ecomelt Quench Water Circuit
Drawings: 1148-3105-6
Parameter: Composition
Intention: strain out solids leaving relatively solid free water

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
High Concentration	of solids caused by failure of strainer	plugging of rotameters	redundant low flow alarm	4	4	9		
		plugging of spray nozzles	low flow alarm	2	5	8		
		equipment erosion	none	4	4	9		
	of solids caused by fines build up over time	could rapidly plug strainer	low flow alarm	4	4	9		
	of acid drives pH down caused by high level of acid gas	mechanical damage to materials of construction	pH meter	4	4	9		

Session: (5) 4/2/2003
Revision:
Node: (17) Ecomelt Quench Water Circuit
Drawings: 1148-3105-6
Parameter: Level

Intention: keep water level in tank T-203

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Level	no flow make up fail	no flow see previous node						
Higher Level	overflow of tank due to level control valve failure	minimal	tank overflow nozzle	5	4	10		
Lower Level	make up control failure	pump cavitates see previous node						
	water supply fails	same						
	leak	same						

Session: (7) 4/2/2003
Revision:
Node: (18) Natural Gas Booster
Drawings: NG Booster
Parameter: Flow
Intention: provide sufficient gas to burners

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Less Flow	plugging of strainer	low burner firing		3	3	7	33	provide low pres & temp alarms, run indication to main control room
	failure of compressor							

Session: (7) 4/2/2003
Revision:
Node: (18) Natural Gas Booster
Drawings: NG Booster
Parameter: Temperature
Intention: provide gas below 150 deg F

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Temperature	large compression ratio on hot feed gas	excess temp affects burner regulators		2	4	7	34	provide temp alarm

Session: (7) 4/2/2003
Revision:
Node: (18) Natural Gas Booster
Drawings: NG Booster
Parameter: Pressure
Intention: deliver gas at 15 psig

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Higher Pressure	failure of 3" recycle	overpressure of gas supply		2	3	6	35	install psv and high pres alarm

Session: (7) 4/2/2003

Revision:
Node: (19) Continuous Emissions Monitoring
Drawings: 1148-3101-7
Parameter: Flow
Intention: draw sample gas

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
No Flow to oxygen analyzer	plugged filters	no control of O2 trim	SOP	2	4	7		
	sample pump fails	no control of O2 trim	SOP	2	4	7		
No Flow from opacity blower	blower fails	indicates low opacity		4	4	9		

Session: (7) 4/2/2003
Revision:
Node: (19) Continuous Emissions Monitoring
Drawings: 1148-3101-7
Parameter: Composition
Intention: Report composition of stack gas

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R	REF#	RECOMMENDATIONS
Misread Composition	failure of CEM system	lost opportunity to collect data	SOP	5	3	9		

PHAWorks by Primatech Inc.

Appendix G

INSTRUMENTATION CALIBRATION REPORTS

KGB Controls
Tyrone, GA
November 3-7, 2003

KGB Controls
Tyrone, GA
June 30, 2004

Omni Instrumentation Services, Inc.
Linden, NJ
February 28, 2005

ENDESCO Clean Harbors
Cement-Lock Project
Calibration report

While observing the operation of the system I noticed several instrument readings that did not make sense. Further examination revealed problems with these and several other instruments. Nelson Carswell and I began to try and identify these problems. We found loose tubing connections and incorrectly fitted tubing on several pressure transmitters, seized fittings on several pressure transmitters (the fitting could not be tightened but did not seal). We found three temperature transmitters out of place (exchanged with others) and two temperature transmitters incorrectly ranged. I had limited resources at the time to verify the accuracy of the instrumentation but based on what we found it was apparent that in order to be confident with the instrumentation a more thorough check had to be performed.

I arrived on Tuesday November 3 and began checking / calibrating the field instrumentation. I found three pressure and one temperature transmitters that were unserviceable and will have to be replaced (the temperature transmitter was replaced before I departed). There were many pressure transmitters that had square root output when the output should have been linear. These were corrected. There were several temperature transmitters (new instrumentation) that were incorrectly ranged, this was corrected by changing the range in the PLC or exchanging the transmitters.

Attached is a summary table outlining the pass / fail status of each instrument as well as a report on each instrument with as found / as left condition of each.

Notes:

1. Subtract 6 hours from the test time for the calibration reports (I forgot to reset the clock when I returned from Europe).
2. PIT-001 & PIT-303 are absolute pressure transmitters and could not be calibrated correctly without special equipment that I did not have.

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Appendix H

SEDIMENT FEED CALIBRATION PROCEDURE

SEDIMENT FEED CALIBRATION PROCEDURE

The following procedure was prepared by A2K to calibrate the sediment feed system. The sediment feed system includes the 100-yd^3 capacity main Sediment Storage Hopper (T-101), 25-yd^3 capacity alternate Storage Hopper (T-102), Conveyors C-101, C-102, the Pug Mill Mixer (M-131), Sediment Weigh Feeder (C-112), and Water-Cooled Auger/Screw Feeder (C-151).

Procedure to Calibrate the Sediment Feeding System

1. Lock and tag-out C-101. Remove all covers from C-101 and place all bolts in one box. Take off the lock and from this point on be extremely careful of moving equipment.
2. Fill T-101 with several buckets of sediment using the front-end loader. Monitor the level of T-101 to ensure there is enough feed through the calibration process.
3. Before calibrating the sediment feeding system, ensure all sediment is removed from C-101, C-112, the pug mill, and C-151. Before beginning this process, use a water hose to clear the contents of the pug mill outlet and the C-151 inlet, as this is believed to have caused the motor of C-151 to trip and eventually break free
4. After clearing out the area described in step 3, and with a barrel below the sampling chute, begin running C-101, C-112, the pug mill, and C-151, collecting the contents in the barrel below.
5. After 10 minutes of no sediment dropping into the barrel, visually inspect C-101 to ensure it is free of material. If material still exists, lock and tag-out C-101 and clean plugged areas of the screw by hand.
6. Now sediment calibration can begin. Start by collecting several drums, mark each drum numerically, and use the process scale to find the tare weight of each barrel. You will need a minimum of 3 barrels for one test. Use the table provided on the next page to record this information. Place a barrel under the sampling discharge of C-151 and when feeding begins, allow each barrel to fill to approximately 1/3 full (roughly 200 lbs). Once this barrel is 1/3 full, quickly move it out of the way and replace it with the next barrel.
7. The testing matrix for the sediment feed calibration is listed on the table on the following page. For all tests, monitor the flow of solids up C-101 and use a water hose to break-up any clumps that develop. Be careful not to flood C-101. If at any time the feed rate exceeds 200 lbs in five minutes (barrel roughly 1/3 full), stop testing and record results and time. Each testing period should be 15 minutes long due to the sporadic nature of the feeding system.
8. Use the following method for the tests listed in step 9 and on the attached table:
   - Start the specified T-101 auger.
   - Set the variable setting of C-101 to the desired set point and start the motor.
   - Start C-112, the pug mill, and C-151 (run in forward), respectively.
   - Have someone periodically check to ensure that sediment is not traveling into the kiln.

- Begin the 15-minute timer when the first drop of sediment falls into the barrel (following the barrel instruction in step 7). After 15 minutes, stop testing and remove the barrel, replacing it with another very quickly to clean out the feed system.
- Stop C-101 and allow the contents of C-112, the pug mill, and C-151 to drop into the empty barrel. When the contents have emptied, stop C-112, the pug mill, and C-151, respectively.
- Weigh the barrels and record on the table on the following sheet.
- Take a sample of the sediment for moisture analysis and record on the table as well.
- Remove and clean the three barrels

9. Test in the following order, repeating each "good test" (defined in step 10 below) three times:
   - Test 1A: Use only auger 'A' in T-101 (this is the auger that is closest to the extreme end of the C-101 inlet). Set the variable speed screw (C-101) to 100% output. Test as described in step 7.
   - Test 1B: Use only auger 'A' in T-101. Set the variable speed screw (C-101) to 50% output. Test as described in step 7.
   - Test 1C: Use only auger 'A' in T-101. Set the variable speed screw (C-101) to 10% output. Test as described in step 7.
   - Test 2A: Use only auger 'A' and 'C' in T-101. Set the variable speed screw (C-101) to 100% output. Test as described in step 7.
   - Test 2B: Use only auger 'A' and 'C' in T-101. Set the variable speed screw (C-101) to 50% output. Test as described in step 7.
   - Test 2C: Use only auger 'A' and 'C' in T-101. Set the variable speed screw (C-101) to 10% output. Test as described in step 7.
   - Test 3A: Use only auger 'A,' 'C,' and 'D' in T-101. Set the variable speed screw (C-101) to 100% output. Test as described in step 7.
   - Test 3B: Use only auger 'A,' 'C,' and 'D' in T-101. Set the variable speed screw (C-101) to 50% output. Test as described in step 7.
   - Test 3C: Use only auger 'A,' 'C,' and 'D' in T-101. Set the variable speed screw (C-101) to 10% output. Test as described in step 7.
10. "Good Test" Definition: Sediment flows up C-101 and eventually to the barrel (Good judgment must be used to determine if sediment is not flowing because of lack of mechanical output or because the material is struggling to feed up the conveyor [C-101]). The amount of sediment collected should not exceed 700 lbs in the 15 minute collection period. There should not be more than a 20% difference between the three repeated tests. Do not continue to add additional augers (Test 2 and 3) if the preceding test exceeded the 700 lbs per 15 minute criteria.
11. When all "good tests" have been completed, plot 3 calibration curves for the tests 1, 2, and 3. Use the data to plot the flow (lbs/hr) vs. the mechanical output of C-101. Take an average of the repeated tests to determine the flow for each test.

Test	Run	T-101 Augers	C-101 Output	Barrel No.	Barrel Tare Wt.	Final Barrel Wt.	15 min. Total	Notes
1A	1	A	100%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	2	A	100%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	3	A	100%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
1B	1	A	50%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	2	A	50%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	3	A	50%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
1C	1	A	10%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	2	A	10%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	3	A	10%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		

Test	Run	T-101 Augers	C-101 Output	Barrel No.	Barrel Tare Wt.	Final Barrel Wt.	15 min. Total	Notes
2A	1	A, C	100%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	2	A, C	100%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	3	A, C	100%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
2B	1	A, C	50%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	2	A, C	50%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	3	A, C	50%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
2C	1	A, C	10%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	2	A, C	10%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	3	A, C	10%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		

Test	Run	T-101 Augers	C-101 Output	Barrel No.	Barrel Tare Wt.	Final Barrel Wt.	15 min. Total	Notes
3A	1	A, C, D	100%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	2	A, C, D	100%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	3	A, C, D	100%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
3B	1	A, C, D	50%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	2	A, C, D	50%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	3	A, C, D	50%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
3C	1	A, C, D	10%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	2	A, C, D	10%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		
	3	A, C, D	10%		lbs.	lbs.	lbs.	
					lbs.	lbs.		
					lbs.	lbs.		
					lbs.	lbs.		

Appendix I

MODIFIERS FEED CALIBRATION PROCEDURE

MODIFIERS FEED CALIBRATION PROCEDURE

The following procedure was prepared by A2K to calibrate the modifier 1 and 2 feed systems. The modifier feed systems include the Modifier 1 Hopper (T-103), Feeder (F-103), Conveyor (C-103), Modifier 2 Hopper (T-104), and Feeder (F-104).

F-103 and F-104 Calibration Procedures

Reference Drawings:

1148-1006 REAR PLATFORM ELEVATION LIME FEED AREA SECTIONS F-F & A-A
1148-2110 LIMESTONE SILO T-103 DETAIL
1148-2120 MODIFIER #2 HOPPER T-104 (ALUMINA) DETAIL
1148-3100 FEED SYSTEM P&ID

Tool Requirements:

Lot	Combination wrenches
Lot	Ratchet and sockets
1	Box of heavy duty garbage bags
1	Roll of duct tape
1	4' square piece of ½" thick plywood
Lot	Baling wire
1	Electric drill with 3/16" diameter bit
1	Extension cord(s)
1	Access to a scale to measure 20 – 100 pounds
1	Stop watch

Design Data:

Tank Tag #	T-103	T-104
Powder	Limestone	Alumina
Design Feed Rate (#/h)	470.87	29.31
(#/ft³)	90	100
(ft³/h)	5.23	0.29

Feeder Tag #	F-103	F-104
Design Feed Rate (ft³/h)	4 - 14	0.25 – 0.80

F-103 Test Procedure:

1). Remove the double pant-leg duct and gaskets, which connects F-104 and C-103 to the pug mill (M-131).

2). Place the plywood on top of the pug mill. Drill holes in the plywood where appropriate and use the baling wire to secure the plywood.

3). Using the duct tape, secure a garbage bag to the discharge of C-103.

4). Open the slide gate HV-103.

5). Start the water-cooled auger/screw feeder (C-151).

6). Start the sediment/modifier mixer (M-131).

7). Start modifier #1 conveyor (C-103).

8). Start the vibratory feeder (F-103) by placing the speed controller FIC-103 in manual at 10% output.

9). Start the live bin bottom (V-103).

10). After a few minutes, product should be discharging from the feeder into the garbage bag.

11). Stop the vibratory feeder (F-103) by placing the speed controller FIC-103 in manual at 0% output.

12). Remove the garbage bag from the discharge of F-103 and empty it.

13). Using the duct tape, secure a garbage bag to the discharge of F-103.

14). Start the volumetric feeder (F-103) by placing the speed controller FIC-103 in manual at 10% output. Start the stopwatch at the same instant that the feeder is started.

15). At the end of five minutes, set the speed controller FIC-103 in manual at 0% output.

16). Remove the garbage bag from the bottom of F-103, seal it and mark it "F-103 – 10%.

17). Repeat steps 13 thru 16 for FIC-103 manual settings of 50% and 100%. The duration of these tests should be 2.5 minutes.

15). Close HV-103.

16). Stop modifier #1 conveyor (C-103).

17). Stop the sediment/modifier mixer (M-131).

18). Stop the water-cooled auger/screw feeder (C-151).

This should yield samples of 30 – 40 pounds each for the first two tests and a sample of 50 – 55 pounds for the third test.

<u>F-104 Test Procedure:</u>

1). Using the duct tape, secure a garbage bag to the discharge of C-104.

2). Open the slide gate HV-104.

3). Start the water-cooled auger/screw feeder (C-151).

4). Start the sediment/modifier mixer (M-131).

5). Start the vibe/belt feeder (F-104) by placing the speed controller FIC-104 in manual at 10% output.

6). Start the live bin bottom (V-104).

7). After a few minutes, product should be discharging from the feeder into the garbage bag.

8). Stop the vibe/belt feeder (F-104) by placing the speed controller FIC-104 in manual at 0% output.

9). Remove the garbage bag from the discharge of F-104 and empty it.

10). Using the duct tape, secure a garbage bag to the discharge of F-104.

11). Start the volumetric feeder (F-104) by placing the speed controller FIC-104 in manual at 10% output. Start the stopwatch at the same instant that the feeder is started.

12). At the end of one hour, set the speed controller FIC-104 in manual at 0% output.

13). Remove the garbage bag from the bottom of F-104, seal it and mark it "F-104 – 10%.

14). Repeat steps 10 thru 13 for FIC-104 manual settings of 50% and 100%. At the 50% setting, test for 45 minutes. At the 100% setting, test for 30 minutes.

12). Close HV-104.

13). Stop the sediment/modifier mixer (M-131).

14). Stop the water-cooled auger/screw feeder (C-151).

This should yield a sample of 30 – 35 pounds for the first test and samples of 35 – 40 pounds for each of the last two tests.

Weigh:

Take the bags and get them weighed. This data can then be used as a "look-up table" in the PC or it can be used to generate equations for use in the PC.

Reconnect:

1). Remove the plywood and baling wire from the top of the pug mill.

2). Insert the double pant-leg duct and gaskets, which connects F-104 and C-103 to the pug mill (M-131).

3). Bolt together each of the connecting flanges.

Appendix J

LIME FEED CALIBRATION PROCEDURE

LIME FEED CALIBRATION PROCEDURE

The following procedure was prepared by A2K to calibrate the Lime feed system. The lime feed system includes the Lime Hopper (T-302), Feeder (F-302), Lime Feeder Airlock (F-302A), and Lime Eduction Blower (B-302).

F-302 Calibration Procedures

Reference Drawings:

1148-2805 POWDERED LIME SILO T-302 DISCHARGE FEED EQUIPMENT ASSEMBLY
1148-2806 VOLUMETRIC FEEDER TO LIME FEEDER AIR LOCK TRANSITION DUCT DETAILS

Tool Requirements:

Lot	Combination wrenches
Lot	Ratchet and sockets
2	Box of heavy duty garbage bags
2	Roll of duct tape
2	4' square piece of ½" thick plywood
Lot	Baling wire
2	Electric drill with 3/16" diameter bit
2	Extension cord(s)
1	Access to a scale to measure 20 – 100 pounds
2	Stopwatch

Design Data:

Tank Tag #	T-302
Powder	Lime
Design Feed Rate (#/h)	90.04
(#/ft³)	50
(ft³/h)	1.81
Feeder Tag #	F-302
Design Feed Rate (ft³/h)	0.75 – 2.5

F-302 Test Procedure:

1). Remove the transition duct, flexible connector and gasket, which connect F-302 to the rotary feeder F-302A.

2). Place the plywood on top of the rotary feeder. Drill holes in the plywood where appropriate and use the baling wire to secure the plywood.

3). Using the duct tape, secure a garbage bag to the discharge of F-302.

4). Open the slide gate HV-302.

5). Start the volumetric feeder (F-302) by placing the speed controller HS-302 in manual at 10% output.

6). Start the live bin bottom (V-302).

7). After a few minutes, product should be discharging from the feeder into the garbage bag.

8). Stop the volumetric feeder (F-302) by placing the speed controller HS-302 in manual at 0% output.

9). Remove the garbage bag from the discharge of F-302 and empty it.

10). Using the duct tape, secure a garbage bag to the discharge of F-302.

11). Start the volumetric feeder (F-302) by placing the speed controller HS-302 in manual at 10% output. Start the stopwatch at the same instant that the feeder is started.

12). At the end of one hour, set the speed controller HS-302 in manual at 0% output.

13). Remove the garbage bag from the bottom of F-302, seal it and mark it "F-302 – 10%.

14). Repeat steps 10 thru 13 for HS-302 manual settings of 50% and 100%. At the 50% setting, test for 30 minutes. At the 100% setting, test for 20 minutes.

15). Close HV-302.

This should yield samples of 40 – 45 pounds each for the tests.

<u>Weigh:</u>

Take the bags and get them weighed. This data can then be used as a guide by the operators for determining powdered lime feed rate to the baghouse.

<u>Reconnect:</u>

1). Remove the plywood and baling wire from the top of the rotary feeder F-302A.

2). Install the transition duct, flexible connector and gasket between F-302 to the rotary feeder F-302A.

3). Bolt together the connecting flanges.

Appendix K

CERTIFIED PROTOCOL GAS CALIBRATIONS

(Spectra Gases, Inc., Branchburg, NJ)

SPECTRA GASES INC.

3434 Route 22 West • Branchburg, NJ 08876 USA Tel.: (908) 252-9300 • (800) 932-0624 • Fax: (908) 252-0811
Shipped From: 80 Industrial Drive • Alpha, NJ 08865 www.spectra-gases.com

CERTIFICATE OF ANALYSIS

EPA PROTOCOL MIXTURE

PROCEDURE # : G1

CUSTOMER: Gas Technology Institute
SGI ORDER # : 0041590
ITEM# : 2
P.O.# : W24054

CYLINDER # : CC-17723
CYLINDER PRES: 2000 PSIG
CGA OUTLET: 350

CERTIFICATION DATE: 9/5/2003
EXPIRATION DATE: 9/5/2006

CERTIFICATION HISTORY

COMPONENT	DATE OF ASSAY	MEAN CONCENTRATION	CERTIFIED CONCENTRATION	ANALYTICAL ACCURACY
Carbon Monoxide	8/21/2003 9/5/2003	162.0 ppm 162.1 ppm	162.1 ppm	+/- 1%

BALANCE Nitrogen

PREVIOUS CERTIFICATION DATES: None

REFERENCE STANDARDS

COMPONENT	SRM/NTRM#	CYLINDER#	CONCENTRATION
Carbon Monoxide	GMIS-1	CC-94868	505 ppm

INSTRUMENTATION

COMPONENT	MAKE/MODEL	SERIAL #	DETECTOR	CALIBRATION DATE(S)
Carbon Monoxide	Horiba VIA-510	570423011	NDIR	8/20/2003

THIS STANDARD IS NIST TRACEABLE. IT WAS CERTIFIED ACCORDING TO THE EPA PROTOCOL PROCEDURES. DO NOT USE THIS STANDARD IF THE CYLINDER PRESSURE IS LESS THAN 150 PSIG.

ANALYST: Cheryl Patino
CHERYL PATINO

DATE: 9/5/2003

SPECTRA GASES INC.

3434 Route 22 West • Branchburg, NJ 08876 USA Tel.: (908) 252-9300 • (800) 932-0624 • Fax: (908) 252-0811
Shipped From: 80 Industrial Drive • Alpha, NJ 08865 www.spectra-gases.com

CERTIFICATE OF ANALYSIS

EPA PROTOCOL MIXTURE
PROCEDURE # : G1

CUSTOMER:	Gas Technology Institute	**CYLINDER # :**	CC-126794
SGI ORDER # :	0041590	**CYLINDER PRES:**	2000 PSIG
ITEM# :	3	**CGA OUTLET:**	350
P.O.# :	W24054		

CERTIFICATION DATE: 9/5/2003
EXPIRATION DATE: 9/5/2006

CERTIFICATION HISTORY

COMPONENT	DATE OF ASSAY	MEAN CONCENTRATION	CERTIFIED CONCENTRATION	ANALYTICAL ACCURACY
Carbon Monoxide	8/27/2003 9/5/2003	2371 ppm 2379 ppm	2375 ppm	+/- 1%

BALANCE Nitrogen

PREVIOUS CERTIFICATION DATES: None

REFERENCE STANDARDS

COMPONENT	SRM/NTRM#	CYLINDER#	CONCENTRATION
Carbon Monoxide	SRM-2638a	FF23332	4866 ppm

INSTRUMENTATION

COMPONENT	MAKE/MODEL	SERIAL #	DETECTOR	CALIBRATION DATE(S)
Carbon Monoxide	Horiba VIA-510	42331960012	NDIR	8/27/2003

THIS STANDARD IS NIST TRACEABLE. IT WAS CERTIFIED ACCORDING TO THE EPA PROTOCOL PROCEDURES.
DO NOT USE THIS STANDARD IF THE CYLINDER PRESSURE IS LESS THAN 150 PSIG.

ANALYST: CHERYL PATINO

DATE: 9/5/2003

SPECTRA GASES

3434 Route 22 West • Branchburg, NJ 08876 USA   Tel: (908) 252-9300 • (800) 932-0624 • Fax: (908) 252-0811

Website: http://www.spectra-gases.com

SHIPPED FROM: 80 INDUSTRIAL DRIVE ALPHA, NJ. 08865 TEL: (908) 454-7455

SHIPPED TO: Gas Technology Institute
250 E. 22nd Street
Bayonne, NJ 07002

CERTIFICATE OF ANALYSIS

SGI ORDER # :	0041590		
ITEM# :	1	**CYLINDER # :**	CC-20231
CERTIFICATION DATE:	9/3/2003	**CYLINDER PRES:**	2000 psig
P.O.#:	W24054	**CYLINDER VALVE:**	CGA 580
GRADE:	CEM ZERO NITROGEN		

COMPONENT	REQUESTED GAS GRADE
NITROGEN	99.9995 %

CO	≤ 0.5 ppm
CO_2	≤ 1.0 ppm
H_2O	≤ 4.0 ppm
NOx	≤ 0.1 ppm
O_2	≤ 0.5 ppm
SO_2	≤ 0.1 ppm
THC	≤ 0.1 ppm

ANALYST: Cheryl Patino (signature)
Cheryl Patino

DATE: 9/3/2003

USA • United Kingdom • Germany • Japan
ISO 9001

Appendix L

ANDERSON 2000 CLASSROOM TRAINING HANDOUT

Appendix M

HEALTH & SAFETY PLAN

Appendix N

NORTH AMERICAN MANUFACTURING
BURNER TUNING REPORT

Appendix O

INCIDENT REPORT (SEPTEMBER 22, 2004)
AND SAFETY AND OVERSIGHT PROPOSAL

Appendix P

EPA SITE PROGRAM ENVIRONMENTAL SAMPLING REPORTS

TETRA TECH FLUE GAS SAMPLING RESULTS

G383-347

G220-36

G220-36_PAH

CEMENT-LOCK DVR_FINAL
(DATA VALIDATION REPORT)

Appendix Q

CTLGROUP (formerly Construction Technology Laboratories)
EVALUATION OF ECOAGGMAT PRODUCED FROM
NY/NJ HARBOR SEDIMENT