APPENDIX A.

EQUIPMENT MODIFICATION DESIGN STUDY SUMMARY
AND
IMPLEMENTATION OF EQUIPMENT MODIFICATIONS

EQUIPMENT MODIFICATION DESIGN STUDY SUMMARY AND IMPLEMENTATION OF EQUIPMENT MODIFICATIONS

This appendix section summarizes 1) equipment modification design study and 2) implementation of equipment modifications to the Cement-Lock demo plant sediment-modifier feeding system and the slag discharging system for the Phase II work.

EQUIPMENT MODIFICATION DESIGN STUDY SUMMARY

ECH worked with GTI staff and consultants and approached the equipment modification design task with considerable experience in operating the Cement-Lock demonstration plant in both slagging and non-slagging modes. Based on consultants' recommendations, ECH sought the participation of companies and individuals with specific capabilities and expertise for the equipment modification design.

For the sediment and modifier feeding system, ECH utilized the services of CEntry Constructors and Engineers (CEntry), RPMS Consulting Engineers (RPMS), and GTI. For the drop-out box (slag discharge) system, ECH utilized the services of CEntry, Paul Queneau (P. B. Queneau and Associates), FFE Minerals, and GTI.

Original Sediment and Modifier Feeding System

The Cement-Lock demo plant solids feeding system was originally designed to provide a continuous and consistent feed mixture of sediment and modifier solids to the rotary kiln melter (Ecomelt Generator). The design feed rate was 2,930 lb/hr of wet [60 weight percent (wt %) water] sediment plus 470 lb/hr of Modifier 1 and 30 lb/hr of Modifier 2. The modifiers are dry, granular solids that must be intimately blended with the sediment before being fed to the rotary kiln melter.

The sediment, dredged from the Stratus Petroleum site in Upper Newark Bay, consisted of 97 percent silt and clay and 3 percent sand. It was originally dewatered to about 55 wt % water with a belt press. During storage, the water content decreased to about 45 wt % by air drying.

Inconsistent feeding of sediment and modifier solids plagued demo plant operations since startup. The sediment was too wet and sticky to be mixed by the screws in the sediment feed hopper. The sediment also could not be readily conveyed out of the feed hopper via the four metering screws. The sediment stuck in the inclined screw conveyor as well as the weigh screw conveyor, and the pug mill. Sediment stuck to the surfaces of all rotating sediment handling equipment, which had to be periodically cleared by hand.

Since the sediment stuck and accumulated in the weigh screw conveyor, the modifier feeders did not supply the proper quantities of modifiers to the pug mill. It was concluded that a screw/auger type of conveyor was not suitable for this particular blend of feed materials.

Options for Sediment and Modifier Feeding System

Consideration of the options for the sediment and modifier feeding systems included the following assumptions regarding the initial processing of the sediment. About 5,000 yd^3 of Passaic River sediment containing about 60 wt % water were to be brought to Bayshore Recycling facility (Keasbey, NJ) in scows. Bayshore was to off-load the sediment from the scows by clamshell bucket and then screen the sediment to -¼-inch solids particle size. Bayshore was to store the screened sediment in the hold of the sediment storage vessel (Valgocen) until needed by either BioGenesis Enterprises for their soil washing project, or ECH for Cement-Lock.

For the sediment feed system modification designs, three different methods for feeding and/or preparing the sediment-modifiers mixture were considered so that it could be fed to the Cement-Lock demo plant: 1) Slurry feeding (pumping) from the slurry preparation area, 2) mechanical dewatering and belt conveying to the charging deck, and 3) thermal drying and screw or belt conveying. Mechanical dewatering and conveying the sediment using a belt conveyor was considered the most feasible approach.

ECH considered that in the overall scheme a mixer would be needed to blend the dewatered sediment with modifiers. This would insure intimate mixing of the components in the proper proportions. The sediment-modifiers mixture would then be conveyed via belt conveyor to the charging deck. Next, a ram or piston-type positive displacement feeder would be installed to consistently feed the material into the kiln. Brief discussion of each of these needed equipment items follows:

Mixer/Blender: We considered a batch mixer suitable for blending a total of 10,000 lb/hr or 120 ft^3/hr of sediment and modifiers, which is twice the estimated capacity of the rotary kiln for "dewatered" sediment containing 45 wt % moisture.

The mixer would be equipped with a charging funnel with a large opening to receive sediment and modifiers from a front-end loader. The mixer would be mounted on supporting legs such that the discharged materials could be collected and removed by a front-end loader.

Conveyor: The blended feed materials would be transferred from the sediment storage area to a new charging hopper located next to the kiln by an enclosed belt conveyor. The horizontal distance for the conveyor was about 140 feet, the vertical lift was about 20 feet, and therefore the conveyor length needed was about 141 feet. To convey 5,000 lb/hr or 60 ft^3/hr of feed materials (the estimated capacity of the kiln for dewatered sediment case), a 12-inch wide belt would be sufficient. The capacity of a 12-inch wide belt conveyor is about 900 ft^3/hr at a typical speed of 250 ft/min. ECH decided to rent a conveyor system from Smalis, Inc. (New Stanton, PA) as was done during the non-slagging campaign in March 2005.

Ram Feeder System: The ram feeder system would consist of a charging bin, an air lock (depending upon the supplier), and the ram feeder itself. Blended feed materials would be fed to the charging bin by belt conveyor. The charging bin would be designed to minimize "bridging" of feed solids inside the bin. The feed materials would fall by gravity from the charging bin to a plenum above the feeder. The feed materials would then be pushed by a ram feeder from the horizontal feed pipe into the kiln. The feeder will be placed inside the existing water-cooler feeder pipe to prevent overheating and caking of feed solids prior to entering the rotary kiln. The dimensions and cycle frequency of the air lock (if needed) will be based on the flow rate of feed materials and the volume of the feed pipe in order to provide a more steady feed into the kiln.

The V-Ram Solids (Albert Lea, MN) feeder has the capability to feed a wide variety of materials as evidenced by videos on their website (www.vram.com). The V-Ram feeder is a positive displacement feeder that does not require an air-lock or gate valve above or below to limit air intrusion. The V-Ram Solids Company provided delivery and cost for both an 11 and 16-inch feed system including hopper, feeder, motors, and control system. V-Ram also conducted a test using the sediment-modifiers mixture in a full size V-Ram pump test loop to confirm operability.

Existing Drop-Out Box (Slag Discharging) System

The original configuration of the Ecomelt Generator discharge and drop-out box is shown in Figure A-1. The purpose for the water-cooled ceramic tiles located just below the kiln's discharge was to divide the stream of molten slag discharged from the kiln into multiple rivulets to facilitate rapid quenching and granulation with water sprays.

Inspection of the system after the initial start-up test showed that most of the slag buildup was over the ceramic tiles and the vertical wall immediately above the tiles. Excessive air leakage through the air seal assembly at the kiln discharge end was also noted. A heat transfer analysis showed that the thermal input to the drop-out box was insufficient due to various radiation and convective heat losses.

During each of the slagging tests, as the molten slag discharged from the kiln, it solidified, accumulated, and plugged up the drop-out box before it could fall into the water in the granulator, which caused all involuntary shutdowns of the slagging tests. Numerous changes and modifications were implemented, but none were successful in remedying the slag accumulation problem.

Summary of Selected Sediment/Modifier Feeding and Drop-Out Box Modifications

The preferred equipment modifications for the sediment and modifier feeding systems and the slag discharging systems are summarized below.

Feeding System: The preferred feeding system for the sediment and modifiers includes a sediment-modifier mixer/blender in the sediment storage area, a covered belt conveyor to convey blended material to the charging deck, and a V-Ram feeder system with non-flowable charging hopper.

Slag Discharging System: The preferred configuration for the slag discharging (drop-out box) system includes replacing the kiln nose ring refractory, moving the granulator to the east under the rotary kiln discharge, angling the north and south walls of the drop-out box straight down, and adding view ports and access ports.

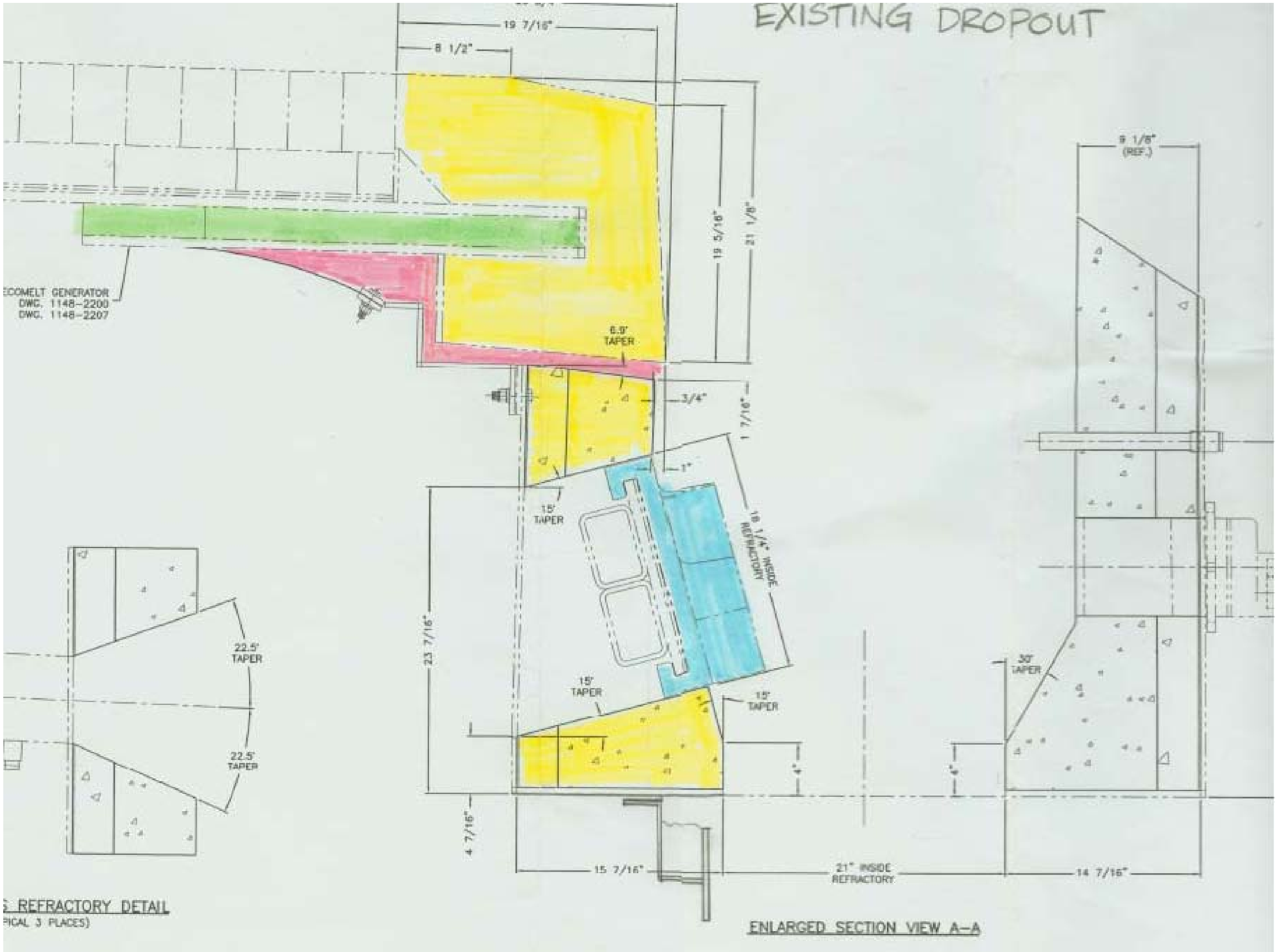

Figure A-1. Original Configuration of the Ecomelt Generator Rotary Kiln Nose and Drop-Out Box

Operating Protocol for Modified Cement-Lock Demo Plant

The operating protocol for the Cement-Lock demo plant with preferred equipment modifications is summarized below.

Screened sediment (-¼ inch) was mechanically dewatered at the facilities of Bayshore Recycling Corporation by BioGenesis Enterprises. The final moisture content of the dewatered sediment was 38.5 wt %. A total of 201.45 tons of dewatered Passaic River sediment was transported to the Cement-Lock demo plant in Bayonne.

The sediment was unloaded from the trucks into the sediment storage area and covered with tarps for rain protection. The sediment will be blended with modifiers using an ALLU-SML screening bucket. The screening bucket will mix the sediment-modifier mixture and then deposit the mixed material directly onto the covered conveyor belt. The quantities of sediment and modifiers being mixed together will be determined using an electronic weigh scale. The mixer/blender (described above) was not used during the Phase II work.

The rate of sediment-modifier mixture being fed to the belt conveyor via the ALLU screening bucket will set the overall system feed rate.

Feed materials will be transferred from the belt conveyor and dumped to the pug mill installed just above the charging bin for the V-Ram feeder. The V-Ram feeder will push the sediment-modifier mixture into the kiln.

The sediment-modifier mixture will become a flowing homogeneous molten mass as it traverses the Ecomelt Generator. Upon exiting the Ecomelt Generator, the slag will fall directly into the water in the quench granulator without touching any other surfaces. There are no water sprays and no supplemental burners in the drop-out box. The quenched and granulated material – Ecomelt – exits the granulator via a dewatering drag conveyor.

Implementation of Equipment Modifications

Implementation of Task 1 – Equipment Modifications is described in this section.

Task 1. Equipment Modifications

In this section, the work to design, procure, fabricate and install the modified slag discharging system, install the refractory work, V-Ram feeder, conveyor belt system, and other miscellaneous activities are described.

Discharging System: During the Task 6 Equipment Modification Design Study, RPMS prepared drop-out box design drawings based on CEntry Constructors and Engineers (CEntry, Sandy, UT) recommendations. CEntry then critiqued the drawings and RPMS followed up with further revisions. To circumvent this time-consuming and cumbersome procedure, for the current work, ECH wanted CEntry to complete both the final design and detailed design work.

ECH prepared the scope of work for the drop-out box final design and sent it to CEntry for a cost estimate in early June 2006. CEntry's estimated was accepted by ECH and ECH issued a P/O to CEntry for the work. CEntry's work on the final design of the drop-out box modifications was essentially completed by the end of June 2006. Further, CEntry had a designer available to do the detailed design work, so ECH executed a change order to CEntry's existing contract and CEntry commenced the detailed design work.

We reviewed the drawings prepared by CEntry for the design of the drop-out box and the detailed designs for the upper and lower discharge chutes. CEntry generated a total of four drawings: two plan drawings and two detailed design drawings. In the review process, CEntry concurred with the reduction in refractory thickness for the Phase II demo project as well as the overall changes in the ceramic and wire refractory anchor specifications.

Refractory Work: For the refractory work in the drop-out box and the rotary kiln nose ring, ECH contacted Duddy Contracting Inc. (DCI, Westfield, NJ) for a quotation. DCI had performed considerable work for ECH during the initial start-up of the plant as well as during continuing plant operations. DCI's quotation was consistent with the estimate provided for the Task 6 study. DCI works closely with the refractory manufacturer, Harbison-Walker Refractories.

RPMS and Duddy Contracting: A project "kick-off" meeting was held on July 25, 2006 at RPMS offices with Mr. Bob Perla and Mr. Steve Stetka (RPMS), Mr. Dan Chiaravallo and Mr.

Al Bond (Harbison-Walker Refractories), Mr. Kevin Duddy (DCI), and GTI. The objectives of the meeting were to get the mechanical and refractory work assignments clarified and to discuss the statement of work that had been prepared by GTI. We also discussed the design drawings that CEntry had prepared and made changes to the placement (orientation) of the ceramic and wire refractory anchors around the kiln nose ring.

During the discussion on refractory selection, it was suggested that instead of using 3-inch thick castable insulating refractory, a 1-inch thick insulating board could be used. This would facilitate installation and extend the clearance between the drop-out box walls and the rotating kiln by 2 inches on both sides of the kiln.

Since the mechanical and refractory work scopes are fairly interdependent upon each other, coherent work schedules needed to be established for RPMS and DCI tasks. For example, before DCI could go into the rotary kiln and demolish the drop-out box and nose ring refractory, the granulator (C-205) needed to be disconnected and removed. Before the granulator could be removed, the melt burners, some structural steel, and the electrical connections, natural gas piping, and air ductwork needed to be cleared and removed. Similarly, before FMW Piping could remove the old drop-out box, DCI needed to demolish the drop-out box refractory. The metal fabrication work also needed to be completed before the new refractory could be installed.

RPMS disconnected the electrical connections leading to the granulator (C-205) and cleared other utilities as required. FMW Piping (mechanical contractor) removed the melt burners from around the drop-out box including the Tempest and Hot Spots as well as the burners directed at the kiln nose. They also removed the structural steel around the drop-out box. FMW removed the granulator (C-205) from the system below the drop-out box so that DCI could begin demolition of the drop-out box refractory. DCI then demolished some 220 ft^3 of refractory from the drop-out box.

Next, FMW completed cutting the lower part of the drop-out box away. The nose ring gussets and nose ring shelf metal were also cut away. The kiln was rotated slowly to bring the parts to be cut away into reach. Figure A-2 shows the kiln nose after the cracked refractory was removed. Also the lower part of the drop-out box has been cut away in this view.

FMW also removed the front-end equipment in anticipation of receiving and installing the new V-Ram feeder. The front-end equipment removed includes the water-cooled screw auger (C-151), the pug mill mixer (M-131), and the weigh conveyor (C-112). Some interfering structural steel was also removed at the front end. The back end of the water-cooled housing that connects to the rotary kiln burner face plate was also cut back to accommodate the new V-Ram feeder.

Figure A-2. Lower Part of Drop-Out Box Cut Away. Old Refractory Anchors Visible in the Nose Ring and Drop-Out Box Wall

Using the detailed design drawings that had been prepared by CEntry, Casale Industries (Garwood, NJ) fabricated the main drop-out box section as well as the upper refractory-lined discharge chute and the lower stainless steel discharge chute. Fabrication was completed on October 13, 2006 and representatives from RPMS and GTI visited Casale to approve the fabrication and confirm key measurements. Threaded studs had been installed on a diamond-shaped pattern across the main drop-out box section as specified. All of the fabricated parts were delivered to the plant site on October 16, 2006.

FMW installed the main drop-out box section and welded the existing upper and new lower sections together (Figure A-3). The upper discharge chute (without refractory) and the stainless steel lower discharge chute are also shown in Figures A-4 and A-5 awaiting installation.

The anchors needed to support the wire anchors as well as the ceramic anchors around the nose of the kiln were also installed. The refractory anchors are positioned around the kiln nose ring alternating 45° up and 45° down. A ceramic refractory anchor is shown in place in the nose ring (Figure A-6).

Figure A-3. New Drop-Out Box Installed and Welded in Place

DCI installed the new refractory in the drop-out box and the kiln nose ring using a process called "guniting." In this process, a mixture of the refractory material and water is "gunited" onto the target surface using a high-pressure hose. The castable refractory (Harbison-Walker Refractories Versaflow 60) was also installed in the upper discharge chute.

Figure A-4. Upper Discharge Chute
(without refractory)

Figure A-5. Stainless Steel Lower
Discharge Chute

Figure A-6. Ceramic Refractory Anchor in Place on the Nose Ring.
Wire Anchors Shown Welded in Place

V-Ram Feeder: Based on the results of the Task 6 study, we contacted V-Ram Solids (Albert Lea, MN) to supply an appropriate feeder for the sediment-modifier mixture. To determine the proper size of the equipment, V-Ram requested that we send a bulk sample (three 55-gallon drums of sediment) for testing in their equipment. To simulate the addition of modifiers to the sediment, V-Ram suggested that the appropriate amount of sand be blended with the sediment. To that end, three 55-gallon drums loaded with Passaic River sediment (from the sediment storage area) were shipped to V-Ram Solids facilities.

GTI visited V-Ram Solids facilities on July 6, 2006 to witness the testing of the V-Ram solids feeder with Passaic River sediment. The V-Ram test equipment consisted of an 11-inch ram with flowable hopper (Figure A-7). At the outlet of the V-Ram feeder, lengths of 8-inch diameter pipe were connected to provide a suitable pumping distance for the feeder. Pressure transducers were located along the piping course to provide information on pressures generated during the pumping cycle. Data acquisition was by personal computer.

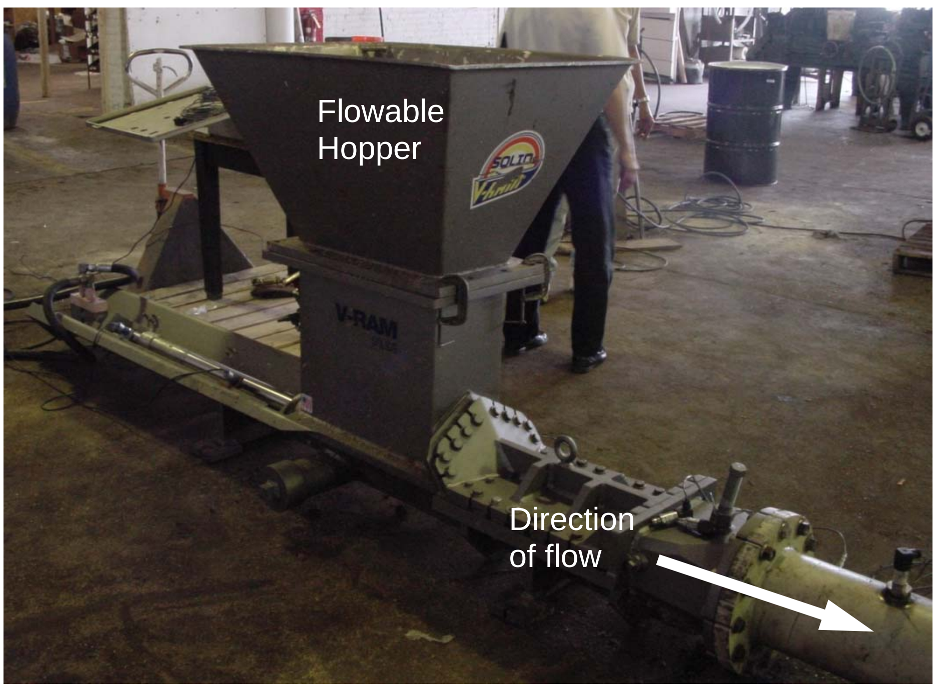

Figure A-7. V-Ram 11-inch Pump with Flowable Hopper
Connected to 8-inch Diameter Pipe

The first test of the V-Ram pump was with as-shipped Passaic River sediment. The sediment was shoveled into the flowable hopper and the pump was activated at a rate of about 18 strokes per minute. The V-Ram readily pumped the material through the pipe (Figure A-8).

Figure A-8. Passaic River Sediment Being Discharged through Straight 8-inch Diameter Pipe from V-Ram 11-inch Pump

The second test of the system was with Passaic River sediment blended with about 20 wt % dry fine silica sand. For this test, two 90° bends were also included in the piping (Figure A-9). The addition of sand was to simulate the addition of modifiers to the sediment. The sand and sediment were loaded into a mixer for blending and then into the feed hopper for the test. The V-Ram also readily pumped this mixture. The tests were recorded using a digital video camera. The data collected during the tests was recorded and transmitted to ECH on a CD.

Based on the test results, V-Ram prepared several proposals for ECH with different options of pump motor horsepower and materials of construction. For our application, V-Ram recommended the 16-inch V-Ram feeder. It was also noted that the sediment tended to stick on the sloped wall of the flowable hopper. Therefore, V-Ram Solids recommended a "non-flowable" hopper, which has vertical sides.

ECH evaluated the proposals and selected the 16-inch carbon steel system with non-flowable hopper. The purchase order was prepared and submitted to V-Ram in early August 2006. The complete V-Ram feeder system including control panel and hydraulic unit were delivered to the plant site on September 26, 2006 (Figure A-10). It was subsequently mechanically installed at the charging deck by FMW. SM Electric made the electrical connections. An end view of the V-Ram feeder installed is shown in Figure A-11. The high-pressure hydraulic lines are shown at lower right.


Figure A-9. Test Configuration for V-Ram Test with Passaic River Sediment Blended with Sand

Figure A-10. V-Ram Hydraulic Module Being Off-Loaded at the Cement-Lock Demo Plant Site (September 26, 2006)

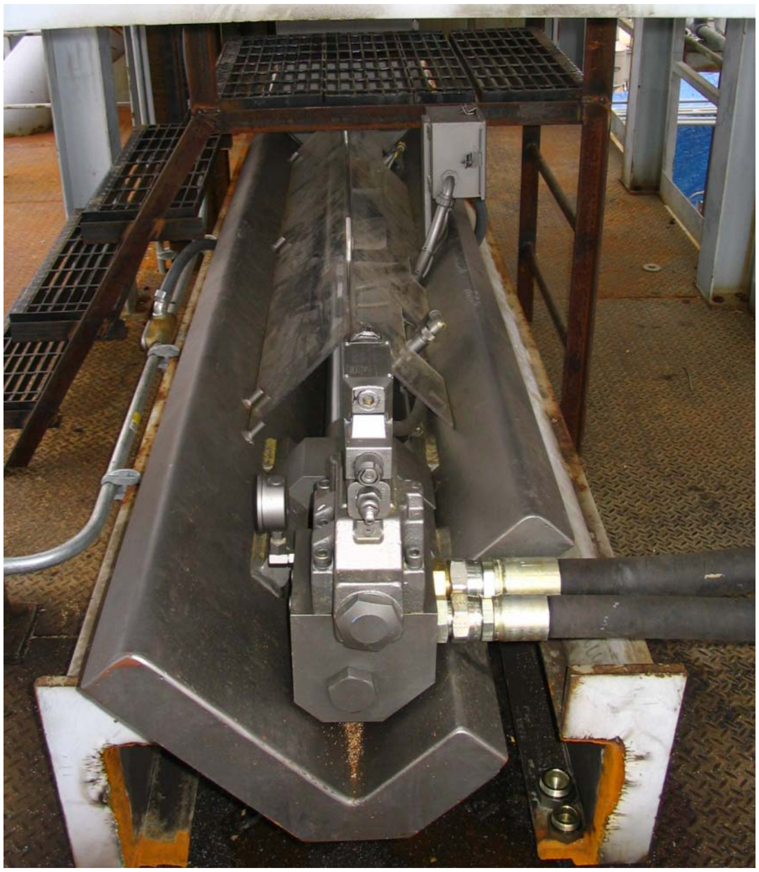

Figure A-11. End-View of V-Ram and Hydraulic Connections

Conveyor Belt system: The belt conveyor system would bring sediment-modifier mixture from the sediment storage area to the feed hopper of the V-Ram feeder on the charging deck. For this application, we contacted Smalis Inc. (New Stanton, PA). Smalis had provided the belt conveyor for the March 2005 non-slagging campaign.

RPMS developed detailed specifications for the belt conveyor system to feed the V-Ram feeder on the charging deck. The belt conveyor system included a 140-foot length of belt conveyor running from the sediment storage area parallel to the rotary kiln but at a shallow incline. Another 40-foot section of belt conveyor would run perpendicularly from the end of the 140-foot conveyor and be inclined up to the charging deck above the pug mill.

The existing pug mill (M-131, Figure A-12) was relocated and positioned just below the discharge of the inclined belt conveyor (Figure A-13).

Figure A-12. Pug Mill (M-131) to be Installed
Above the V-Ram Feeder

The conveyor system was originally scheduled for delivery in early November 2006. The conveyor parts were shipped to the plant site on November 13 and 15, 2006, which was later than scheduled thereby delaying plant start-up. FMW connected the parts of the conveyors and

Figure A-13. Pug Mill (M-131) Relocated to the Charging Deck
Above the V-Ram Feeder (V-Ram hopper shown at bottom)

lifted them up onto the stanchions. SM Electric Company connected power to the two conveyor motors and ran conduit and wire so that the long conveyor could be started or stopped at the inlet at the sediment storage area. The two-section belt conveyor system is shown in Figure A-14.

Figure A-14. Covered Belt Conveyors Running from the Sediment Storage Area to the Charging Deck (left: looking west from the sediment storage area; right: looking east from the SCC platform)

Once the V-Ram feeder was installed, the pug mill (M-131) was relocated and positioned above the V-Ram hopper (Figure A-15). The hydraulic connections between the V-Ram feeder and the hydraulic unit (at ground level) were connected.

Figure A-15. V-Ram Feeder Pump Installed at the Charging Deck. The Water-Cooled Screw Auger (C-151) Removed. Relocated Pug Mill (M-131) Above.

On November 6, 2006 the V-Ram service technician visited the plant to conduct shakedown testing and operator training. During initial shakedown testing, the V-Ram service technician determined that one of the valves on the hydraulic system was closed even though its actuator indicated it was open. This installation error was readily fixed. Also, the temperature sensor for the hydraulic oil reservoir was determined to be inoperative. V-Ram sent a replacement by overnight express, which was also installed.

Refractory Dryout: According to Harbison-Walker Refractories (HWR), the newly installed refractory needed to be carefully dried out to prevent cracking during subsequent operation. HWR specified a dryout schedule in which the refractory would be heated to specific temperatures and “soaked” at these temperatures for specific times. The refractory dryout was estimated to take about 67 hours and reach a maximum temperature of 1100°F.

Team Industrial Services (TEAM, Aston, PA) was selected to perform the refractory dryout. They had been highly recommended by DCI based on cost and experience. TEAM arrived at the demo plant site on November 3, 2006 (Friday) for IMTT Safety Orientation. On November 6, 2006 (Monday) they set up the equipment required for refractory drying. The equipment included a 10-million Btu/hour natural gas burner, blower, insulation, thermocouples for sensing temperature, and data acquisition equipment. The lower part of the drop-out box was closed off from the ambient using an insulating refractory blanket as shown below in Figure A-16.

The burner was inserted into the access hatchway on the north side of the drop-out box and insulated as shown in Figure A-17.

To limit the volume of air inside the rotary kiln and drop-out box that must be heated, bulkheads were installed by FMW in the kiln and the duct leading to the secondary combustion chamber (SCC). FMW also constructed a steel box-like structure to protect the data acquisition equipment from weather. The structure was covered with a tarp for rain protection.

TEAM began the prescribed heating schedule late Monday and completed the dryout on Thursday at which time they began dismantling and demobilizing their equipment. Overall, the decision to use a professional dryout company to cure the refractory was a good one even though it had not been included in the original work scope. The alternative was to have RPMS and GTI personnel attempt to maintain the prescribed dryout schedule using the primary (30-million

Btu/hour) kiln burner at low-fire initially, which would have required heating the entire kiln volume.

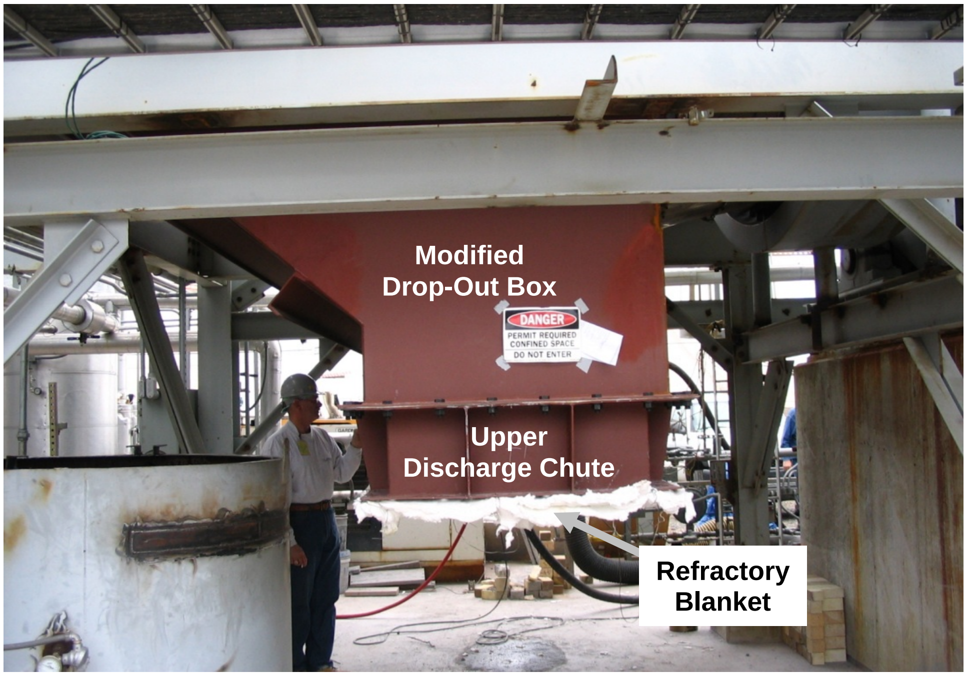

Figure A-16. New Drop-Out Box and Upper Discharge Chute
in Place with Refractory Blanket Shown at Bottom

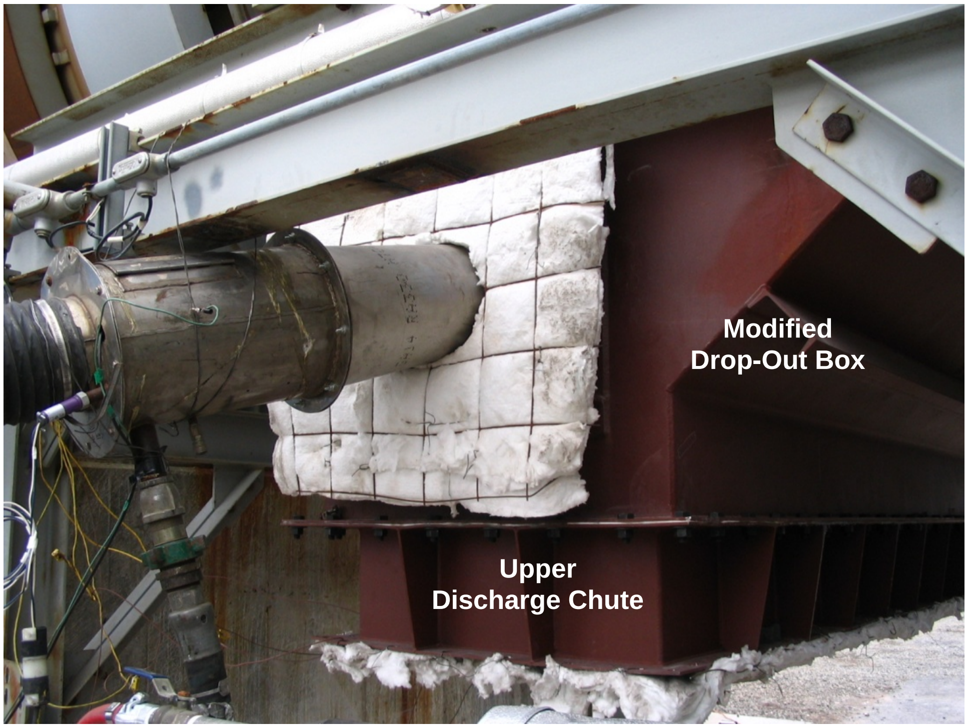

Figure A-17. TEAM's 10-Million Btu/hour Burner Installed and
Insulated in North Drop-Out Box Access Hatchway

Stack Cap: The stack cap was removed from its position on top of the emergency stack and placed on the ground (Figure A-18) in an inverted position. During previous tests, the overheated steel had warped the stack cap such that the cap did not close completely. Steel that had been damaged due to overheating was removed. The burned metal was removed from the stack cap. According to DCI, the refractory appeared to be sound. The stack cap was reinstalled and tested for proper function.

Figure A-18. Stack Cap (Removed From Emergency Stack) Showing Overheated Metal

Haz-Op Session: RPMS and GTI project personnel convened a Haz-Op session to discuss "hazards and operability" issues that could arise because of the new equipment installed in the demo plant. The discussion focused on the new two-section conveyor system and the V-Ram feeder. As a result of these discussions, new emergency stop switches were located near both the long conveyor inlet and the V-Ram feeder. The modified drop-out box was discussed, but did not elicit any Haz-Op suggestions.

Scaffolding: Safety Scaffolds (Branchville, NJ) visited the plant to assess the scaffolding needs at four locations: 1) the west end kiln view ports, 2) the north side drop-out box view port, 3) the activated carbon bed inlet, and 4) the main stack. Safety Scaffolds has provided scaffolding for the Cement-Lock demo plant in previous campaigns.

The scaffolding for the west end kiln view ports and the north side drop-out box view port are needed for proper operation of the plant. The scaffolding for the stack and activated carbon bed are required for the EPA SITE stack and environmental sampling teams.

Natural Gas Service: Natural gas service to the plant was resumed by the local utility (PSE&G) on November 1, 2006. Two gas meters are located about 450 feet to the east of the plant.

Miscellaneous Repairs: FMW corrected a leaking gasket in the main flue gas duct leading from the flue gas quencher to the bag house. The leak was detected during the refractory dryout operation when water was observed dripping from the duct connection. It turns out that the flue gas quencher water spray valve was inadvertently left on, which enabled the leaking gasket to be discovered.