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ONSITE RECYCLING OF ELECTRIC ARC FURNACE DUST: THE JORGENSEN STEEL FACILITY

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INTRODUCTION

The steel-making industry produces a large amount of Electric Arc Furnace (EAF) dust as part of normal production. This waste is listed as K061, defined as "emission control dust/sludge from the primary production of steel in electric arc furnaces" under 40 CFR 261.32. A glass making technology called Ek Glassification™ (hereafter called "the Process") has been developed by Roger B. Ek and Associates, Inc. (hereafter called "the Developer") to recycle EAF dust and convert it, along with other byproducts of the steel-making industry, into marketable commodities.

This Process was evaluated under the Waste Reduction Innovative Technology Evaluation (WRITE) Program. The project was designed and conducted in cooperation with the Washington State Department of Environmental Quality, the Process Developer and the host test site, the Earle M. Jorgensen (EMJ) Steel Company of Seattle, Washington. Test personnel for EPA were supplied by SAIC Inc., on contract to EPA.

The overall objectives of the project were to conduct a pilot scale evaluation of the Process, investigate if toxic metals are leached from the products (such as colored glass and glass-ceramics; ceramic glazes, colorants, and fillers; roofing granules and sand-blasting grit; and materials for Portland cement production). Three glass recipes (Glass I, II, and III) were designed by the developer for potential use at EMJ. The EPA portion was focused on determining the toxic metals concentrations of the Glass II recipe, evaluating the P2 impact of using this Process in comparison to traditional methods of waste treatment and disposal, and assessing the economics of both.

METHODOLOGY

For this project, a portable pilot-scale process furnace was utilized. The furnace was located in the steel-melting area of the EMJ plant so that fugitive emissions could be collected with the steel plant's dust collection system and routed to the baghouse. Natural gas burners were used for the initial melting of the glass and to heat the furnace to its operating temperature of approximately 2,500°F. The furnace was also equipped with molybdenum metal electrodes, which could be used for partial or complete electric heating of the furnace. For this test, the electrodes were also tested to provide criteria for designing a full scale system, including requirements for the electric power supply.

EMJ supplied samples of feed materials for the test. Chemical analyses were performed on the feed materials to serve as a basis for mixing the three recipes. The feed materials used for the production of the glass included EAF dust, spent steel slags, spent refractories, mill scale, and grinding swarf. Approximate batch size was 300 lbs.

The Developer's test program consisted of the sampling and analysis of all three glass recipes, and process monitoring throughout the test.

The Glass II recipe was sampled and analyzed as part of the EPA testing activities. This recipe was used to prepare glaze, iron silicate for Portland cement production and sandblasting grit.

Glass was dispensed either into molds to form castable products or into a granulator (water quench) to form granular products. Once ladling or pouring was complete, the furnace was refilled with glass batch and the process was repeated.

Samples obtained were split for analysis by both EPA's laboratory (NET Pacific, Inc.) and the Developer's laboratory (Sound Analytical Services, Inc.) and placed in 1-L glass jars. The primary granular, and a composite of the castable samples were subjected to the TCLP in accordance with SW-846 Method 1311 and subsequently analyzed for eight RCRA metals plus zinc. The TCLP analyses performed on Glasses I and III by the Developer's laboratory were reported to be within TCLP limits.

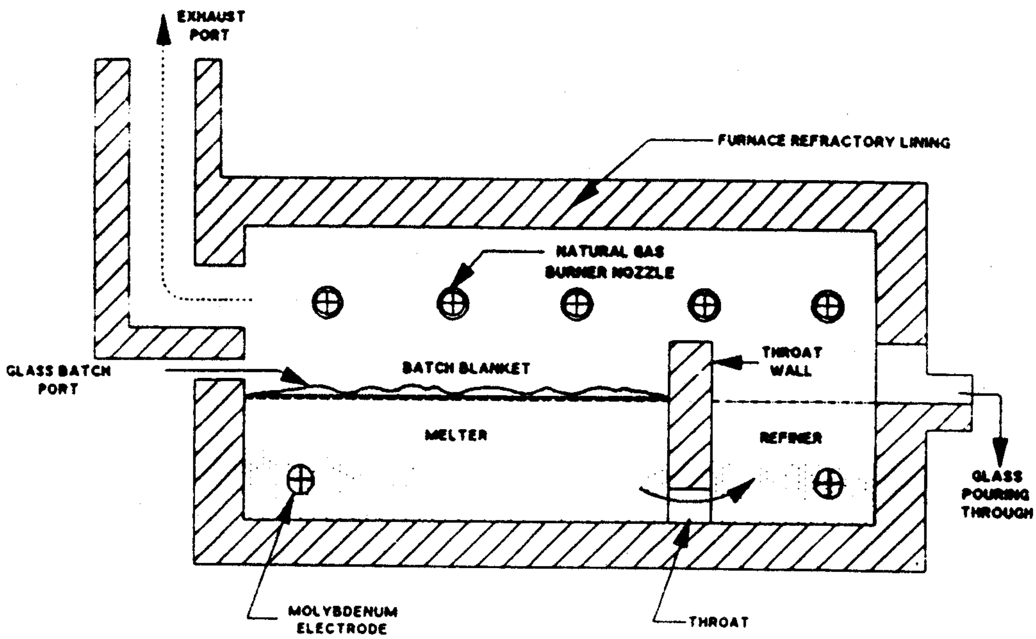

Figure 1. Ek Glassification™ Test Furnace for EAF Dust

RESULTS

Results from analyzing leachability characteristics for are shown in Table 1. The leachable metals concentrations, in both the castable and granular samples were within the TCLP limits for all compounds analyzed. Barium, chromium, lead, and zinc were the only compounds detected in either of the EPA samples. Comparison of these data to those obtained by the Developer produced similar results (for the granular product only).

TABLE 1. TCLP RESULTS AND COMPARISON TO REGULATORY LIMITS FOR SAMPLES FROM EMJ

EPA HW No.[1]	Contaminant	EPA Castable Sample[2] (mg/L)	EPA Granular Sample[2] (mg/L)	Developer Granular Sample (mg/L)	Regulatory Level[3] (mg/L)
D004	Arsenic	<0.0025	<0.0025	<0.2	5.0
D005	Barium	0.043	0.025	<0.1	100.0
D006	Cadmium	<0.0035	<0.0035	<0.1	1.0
D007	Chromium	0.050	0.13	0.1	5.0
D008	Lead	0.067	0.120	<0.1	5.0
D009	Mercury	<0.000086	<0.000086	<0.002	0.2
D010	Selenium	<0.001	<0.001	<0.3	1.0
D011	Silver	<0.0092	<0.0092	<0.1	5.0
----	Zinc	0.95	0.60	0.6	NR

1 Hazardous Waste Number
2 Average of duplicate samples
3 Regulatory levels taken from 40 CFR ch. 1 (7-1-90 Edition), Section 261.24, Table 1
NR Not Regulated

The major P2 impact of implementing this Process is the double effect of precluding the treatment and burial of the EAF dust in a hazardous landfill while negating the requirement of mining and processing virgin material for the purpose of making identical products. For this limited evaluation, the pollution involved in making glass products the traditional way, vs. recycling, the relative energy consumption, resource depletion, etc. were not quantified.

The recycling of other, non-hazardous wastes into the Process, is an added benefit.

The economic estimates indicate that a profitable operation is possible. Industrial product prices ranged from $2/ton (Portland cement materials) to $650/ton (glass ceramics/ architectural tiles feedstocks) based on 1991 information. Assuming that the average price of products sold is in the middle of the price range, and based on the Developer's projection of operating costs, in a ten-year period, the Process could produce a gross profit of $63,195,000. Avoiding disposal costs (at around $200/ton) could save another $43,040,000, for a total of $106 million. The capital costs for this facility would be $10,500,000 Additional benefits could be reduced liability, and avoidance of administrative costs for permits and managing of hazardous waste under the old system. The actual savings realized will depend heavily on the types and amounts of products sold.

Air emissions and process wastewater were not analyzed for this test. For full scale applications these may need to be investigated under actual operating conditions.

Stack gas sampling data were previously gathered during earlier, pilot-scale tests at the Oregon Steel Mill (OSM). Although these data suggest acceptable air emissions, the data do not satisfy EPA stack testing protocols and standards. Prior to this project, on the basis of historical and glassmaking data from other sources, the Developer was allowed to proceed in building a full-scale facility at OSM by the Oregon Department of Environmental Quality.

The full report and project summary, titled "Recycling of Electric Arc Furnace Dust: Jorgensen Steel Facility", by Trevor W. Jackson, et al., are being published as EPA reports.

CONCLUSIONS:

The glass product types which were prepared by the Process and tested as part of this study resulted in relatively non-leachable glasses. The concentrations measured were lower than those allowed under RCRA regulations for TCLP.

- The Process utilizes both listed and non-hazardous foundry wastes to replace constituents that would otherwise be mined and processed from virgin sources as additives for glass-making. Ideally this results in both a conservation of resources and reduction of hazardous and non-hazardous wastes for disposal.

- This project did not focus on investigating compliance issues in terms of air emissions and waste water generated during batch charging, melting, quenching and drying of the three glass products. Although there is historical evidence for glassmaking, for a rigorous evaluation of species and concentrations, this type of testing would need to be evaluated at full scale under actual operating procedures/conditions.