

**Materials Characterization Paper**  
*In Support of the*  
**Advanced Notice of Proposed Rulemaking –**  
**Identification of Nonhazardous Materials That Are Solid Waste**

**Foundry Sand - Used as ingredient in clinker manufacture**

*December 16, 2008*

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**1. *Definition of Foundry Sand***

Foundry sand is an industrial material generated by the metal-casting industry, which uses the sand to form a physical mold used in the production of metal products. Two general types of sand are used in metal casting: clay-bonded sand (green sand); and chemically-bonded sand:

- Green sand is composed of naturally occurring materials that are blended together: high quality silica sand; bentonite clay as a binder; a carbonaceous additive to improve the casting surface finish; and water. Due to the carbon content, green sand is actually black in color and adheres together due to the clay and water content. Green sand molds comprise about 90 percent of the casting volume in the United States.
- Chemically-bonded sand does not employ a clay binder. Instead, chemical binders are used to cause the sand to hold its shape during the introduction of the molten metal into the mold and the cooling of the casting. Chemically-bonded sand is generally light in color and coarser in texture than clay bonded sand, and accounts for only 10 percent of casting volume in the United States. Foundries use chemically-bonded sand in coremaking, where high strengths are necessary to withstand the heat of the molten metal (FIRSTb).

After multiple uses in castings, the sand becomes unsuitable for castings and is either disposed of in landfills or beneficially used in other applications, including use as an ingredient in the manufacture of portland cement.

**2. *Annual Quantities of Foundry Sand Generated and Trends in Generation***

**(1) Sectors that generate foundry sand:**

- The metal-casting industry, represented by NAICS code 3115, is the sole generator of spent foundry sand.

**(2) Quantities and prices of foundry sand generated:**

- According to the American Foundry Society (AFS), a metal casting industry group, the metal-casting process generates 9.4 million tons of foundry sand annually (AFS 2007).

**(3) Trends in generation of foundry sand:**

- The generation of foundry sand generally tracks with the manufacture of cast metal products. Despite increased foreign competition, the metal casting industry expects modest growth to continue. Sales of metal castings are expected to grow 14 percent over the next three years from \$33 billion in 2005 to \$37.7 billion in 2008 (Industrial Metalcasting).

**3. Uses of Foundry Sand**

**(1) Ingredient uses of foundry sand:**

- Spent foundry sand can be used in the manufacture of portland cement clinker. Most foundry sands are high in silica content and can serve as a potential alternative silica source in portland cement clinker production. In addition, portland cement clinker production requires certain minerals, such as iron and aluminum oxides, both of which are found in many spent foundry sands. Brass foundries create sands that can be hazardous under RCRA (if disposed of) due to metals content and, therefore, are outside the scope of this report.
- According to the portland cement industry, foundry sand can be beneficially reused in the manufacturing of portland cement when it possesses the following properties: silica content of 80 percent, low alkali levels, and uniform particle size. In addition, large quantities of foundry sands must be available for it to be used by Portland cement manufacturers (FIRST).

**(2) Non-combustion uses of foundry sand:**

- Spent foundry sand can be used as a substitute for virgin sand in road base, structural fill, flowable fill, soil amendment, or as the fine aggregate portion of concrete or hot-mix asphalt. In addition, some sand can be used as a high-end additive to industrial materials, such as plastics, to provide specific textures and colors.

**(3) Quantities of foundry sand landfilled:**

- AFS estimates that in 2006, 6.8 million tons of foundry sand were disposed in landfills. This quantity includes sand used as a landfill daily cover.

**(4) Quantities of foundry sand stockpiled/stored:**

- The sources consulted for this paper did not provide available information concerning whether significant quantities of foundry sand are stockpiled or stored.

**Exhibit 1: Overview of Generation and Use of Foundry Sand in 2007**

Commodity	Annual Quantity Generated	Annual Quantity Used as Ingredient		Annual Quantity Landfilled	Annual Quantity in Other Uses	Total Quantity Stockpiled
		Cement Kilns	Other			
----- Short Tons -----						
Foundry sand	9.4 million	Undetermined	None	6.8 million	2.6 million	Undetermined
<p><b>Sources:</b>            Oman, Alicia. American Foundry Society (AFS), personal communication, 12/21/07, and Foundry Industry Benchmarking Survey, August 2007, accessed at: <a href="http://www.strategicgoals.org/benchmarking/foundryresults8-7.pdf">http://www.strategicgoals.org/benchmarking/foundryresults8-7.pdf</a>.</p> <p><b>Notes:</b>            Detailed quantitative data on the various beneficial use applications of foundry sand have not been well documented in the past. In an attempt to address this issue, AFS recently conducted a benchmark survey to collect information from the foundry industry on the specific quantities of spent foundry sand being beneficially used in different applications. The survey results indicate that none of the respondents are currently using foundry sand in clinker manufacture. According to the Portland Cement Association, however, foundry sand is being used by a number of North American cement kilns (FIRSTb).</p>						

**4. Management and Combustion processes for Foundry Sand**

**(1) Types of units using foundry sand:**

- When used in clinker manufacture, foundry sand is fed into cement kilns with other raw material feed. No other combustion applications appear to use significant quantities of foundry sand as an input.

**(2) Sourcing of foundry sand:**

- In some cases, cement manufacturers obtain foundry sand through direct agreements with foundries, most of which are located in certain states, including Illinois, Wisconsin, Michigan, Ohio, and Pennsylvania. Some foundries market their spent sand through a third-party or a cooperative instead of selling directly to the end-user. The majority of foundries are small businesses that generate small quantities of spent foundry sand. Through arrangements with multiple foundries, cooperative brokers/third party processors may be able to provide sufficient and consistent amounts of spent foundry sand to support the need of cement kilns. If a cement kiln uses a third party broker, the broker will pay the foundry for the foundry sand, but in some cases the kiln purchases the sand directly from the foundry.

**(3) Processing of foundry sand:**

- Foundry sand used in portland cement manufacturing must be separated from other foundry by-products through a series of screens (FIRST). The oversized material that does not pass the screens is termed "raw core butt" and consists of

chunks and grains of coarse sand and scrap metal. Most portland cement plants also require that core butts be ground to a uniform grain size. Vibrating screens and a ball mill are used to further separate the components of this stream and to crush the oversized chunks of sand. Through use of a magnetic separator, metal in the stream is removed.

**(4) State status of foundry sand use as ingredient:**

- At this stage, we have not identified any states that have specifically given beneficial use designation to the use of foundry sand in clinker manufacture, or that prohibit use of foundry sand in clinker, but we have not performed an exhaustive investigation of state activities and regulations.

**5. Foundry Sand Composition and Impacts**

**(1) Composition of foundry sand:**

- Spent foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (bentonite, sea coal, resins) and dust (Turner Fairbank Highway Research Center). Spent foundry sand may also contain heavy metals and phenols that are absorbed by the sand during the molding process and casting operations. Phenols are formed through high-temperature thermal decomposition and rearrangement of organic binders during the metal pouring process. The presence of heavy metals is greater in foundry sands generated from nonferrous foundries. Spent foundry sand from brass or bronze foundries, in particular, may contain high concentrations of cadmium, lead, copper, nickel, and zinc (Turner Fairbank Highway Research Center).

**(2) Impacts of foundry sand use:**

- In clinker manufacture, foundry sand partially offsets the need for virgin silica, iron, and alumina sources. Thus, using foundry sand in the cement kiln can reduce the unit consumption of virgin feed stock materials and related emissions.
- The specific lifecycle impacts of foundry sand use as a raw material in clinker production are not evaluated here because of uncertainties in lifecycle scenario development. For example, it is difficult to determine the replacement ratio between foundry sand and other raw feed materials in clinker production. Thus, the correct quantity of material to be modeled is unclear. In addition, foundry sand may substitute for a variety of virgin raw materials as well as other secondary materials (e.g., blast furnace slag, CCPs, cement kiln dust, etc.); the choice of material often depends on location-specific factors such as the proximity of material sources to the cement kiln and relative availability of different materials. Avoided upstream impacts depend heavily on the specific material being displaced in the lifecycle scenario.

## References

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