INTRODUCTION

AIM Market Research recently conducted a survey of electric arc furnace (EAF) steel producers to make an up-to-date assessment of the generation and disposal of EAF dust in the U.S. and Canada. This is a summary of the results of this research.

The U.S. Environmental Protection Agency promulgated regulations during the 1980s which listed emission control dust from the primary production of steel in an electric arc furnace as a hazardous waste. The EPA identified this electric arc furnace dust as KO61. Throughout the 1990s, U.S. regulations evolved requiring that EAF dust be either treated in a High Temperature Metals Recovery (HTMR) process or stabilized chemically for disposal in a landfill. Similar regulations were also established in Canada. Today, the vast majority of EAF dust generated in the U.S. and Canada is disposed of by HTMR processing or landfilling. The total volume of electric arc furnace (EAF) dust generated by steel producers continues to grow. The treatment and disposal of EAF dust is a cost that contributes nothing to the value of the steel produced and continues to concern EAF steel producers.

The basis of this research was a telephone survey of 76 electric arc furnace (EAF) shops in the U.S. and Canada. This survey was conducted from March 17 to April 28, 2000. One hundred twenty-seven interviews were completed with appropriate and knowledgeable personnel in the EAF shops surveyed.

Each of the EAF steel plants surveyed was assigned to a specific category or “segment”. These segments were Minimill Carbon Strip Steel producers, Other Flat Roll Carbon Steel producers, Long Products Minimills,
Specialty Long Products mills, and Stainless Steel producers. The information obtained was then analyzed overall and by each of these segments. Presentation of the analysis of results by segment is limited in this manuscript in order to comply with the guidelines specified by The Iron and Steel Society.

ELECTRIC ARC FURNACE DUST GENERATION AND COMPOSITION

Total quantity of EAF dust generated - All of the EAF shops in the U.S. and Canada are estimated to have generated a total of 1.2 million tons of EAF dust in 1999. A total of 1,069,457 tons of EAF dust was generated by the plants surveyed in 1999. Thus, the survey accounted for about 90% of the EAF dust production in the U.S. and Canada. The survey covered all of the Minimill Carbon Strip EAF shops and a high percentage of EAF shops in the other segments. If Stainless Steel EAF shops and EAF based steel Foundries are not considered, the survey accounted for 94% of the total EAF dust generated from carbon steel production in the U.S. and Canada. EAF dust generated by Foundries is not subject to the same regulations as EAF dust from a primary steel plant. The treatment of Stainless Steel EAF dust in most cases is subject to a different cost structure than for EAF dust generated by carbon steel producers.

Table I below summarizes the share of EAF dust generated that is accounted for by the survey and in each industry segment. This analysis was based on the share of total EAF dust generation that was accounted for in the survey versus the EAF dust generation in the U.S. and Canada not included in the survey. AIM estimated the EAF dust generated by plants not surveyed by using a formula derived from the average level of EAF dust generated for the facilities within each segment that were surveyed.

Table I: Share of total EAF dust production by plants surveyed

<table>
<thead>
<tr>
<th>Segments</th>
<th>Dust Production by Plants Surveyed (tons)</th>
<th>Dust Production by Plants Not Surveyed (tons)</th>
<th>Total</th>
<th>Share of Total in Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimill Carbon Strip (9)</td>
<td>284,600</td>
<td>0</td>
<td>284,600</td>
<td>100%</td>
</tr>
<tr>
<td>Carbon/Alloy Flat Roll (8)</td>
<td>98,200</td>
<td>2,023</td>
<td>100,223</td>
<td>98%</td>
</tr>
<tr>
<td>Minimill Long Prod (41)</td>
<td>519,969</td>
<td>37,606</td>
<td>557,575</td>
<td>93%</td>
</tr>
<tr>
<td>Specialty Long Prod (15)</td>
<td>141,313</td>
<td>10,594</td>
<td>151,907</td>
<td>93%</td>
</tr>
<tr>
<td>Stainless Steel (3)</td>
<td>25,375</td>
<td>27,000</td>
<td>52,375</td>
<td>48%</td>
</tr>
<tr>
<td>EAF Based Steel Foundries</td>
<td>0</td>
<td>18,581</td>
<td>18,581</td>
<td>0%</td>
</tr>
<tr>
<td>Ingot Cast Shops</td>
<td>0</td>
<td>19,632</td>
<td>19,632</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>1,069,457</td>
<td>115,436</td>
<td>1,184,893</td>
<td>90%</td>
</tr>
</tbody>
</table>

The quantity of EAF dust generated by Stainless Steel facilities not surveyed was estimated by multiplying the average level of EAF dust generated in the three facilities surveyed (26.7 lbs./ton) by the estimated total steel production of all Stainless Steel facilities. The formula derived from plants surveyed in the Specialty Long
Products segment was used as a basis for projecting EAF dust production for Foundries and Ingot Cast Shops. This is because Specialty Long Products plants commonly cast ingots and therefore have high revert rates not unlike Foundries and Ingot Cast Shops.

Share of EAF dust generated by segment - EAF dust generating facilities (40) in the Minimill Long Products segment accounted for 49% of all EAF dust generated by the plants surveyed. A significant share (27%) of the total EAF dust generated was accounted for by the nine EAF Minimill Carbon Strip plants surveyed. The share of EAF dust generated by the 75 EAF plants surveyed that produced steel in 1999 is illustrated in Figure 1.

Rate of EAF dust generation per ton of steel - Of the EAF shops that responded to the survey, 82% generated from 25 to 44 pounds of EAF dust per ton of steel produced. Figure 2 provides a distribution of the generation of EAF dust per ton of steel produced.
The EAF Minimill Carbon Strip plants generated the most EAF dust per ton of steel produced. Of the EAF Minimill Carbon Strip plants surveyed, 77% generate at least 35 pounds per ton of steel produced.

**Annual level of EAF dust generation by each shop** - Of the EAF shops that responded, 42% (31) each generate from 7,500 to 14,999 tons of EAF dust per year. On-site EAF dust treatment will only be considered where the economies of scale necessary to justify the capital expense of an on-site treatment technology are realized. The survey reveals the rarity of instances in which an adequate level of EAF dust is generated to justify an on-site facility employing currently commercially viable technologies. Only seven of the EAF shops surveyed generated 30,000 tons or more of EAF dust per year, five of which were in the Minimill Carbon Strip segment. Plants with this level of EAF dust generation provide the strongest opportunity for justifying on-site EAF dust treatment. Of Minimill Carbon Strip EAF shops surveyed, 56% (5 of 9) each generated 30,000 or more tons of EAF dust annually. The other two EAF shops which generated 30,000 tons or more EAF dust per year produce carbon steel long products. The Minimill Long Products and Specialty Long Products plants exhibited a similar distribution profile regarding EAF dust annual generation. Figure 3 provides a distribution of the annual generation of EAF dust.

![Tons of EAF Dust Generated per Year](image)

Figure 3: EAF dust generated annually by (73) plants surveyed

**Expected changes in level of EAF dust generation** - No change in the quantity of EAF dust generated is expected by 88% (63) of the 72 EAF shops that responded. Of the nine plants that did project a change, all but one expect the volume of EAF dust to decline. Of these eight shops that project a reduction, five believe that the reduction will be attributed to an effort to minimize the quantity of EAF dust generated, or to a change intended to achieve that objective. New EAF steel production is contemplated by several steel producers in the U.S.; this would increase the volume of EAF dust generated in the U.S. and Canada.

**Typical chemistry of EAF dust currently generated** - The chemistry of EAF dust is a significant factor in determining the potential viability of recycling the EAF dust to recover metals. In carbon based steel
production, zinc oxide recovery provides the best opportunity to obtain some value from recycling EAF dust. A limited number of zinc producers use crude zinc oxide from an HTMR facility to produce zinc.

Of the 62 EAF shops that responded, 47% (29) indicated that the percentage of zinc oxide (ZnO) in their EAF dust ranged from 15 to 24.9% and 21% (13) had a zinc oxide content of 25% or more. Figure 4 indicates the share of EAF shops that responded overall that generate EAF dust within a range of zinc oxide content.

Figure 4: Percent zinc oxide content in EAF dust generated by (62) plants surveyed

The Minimill Long Products segment revealed the highest zinc oxide content in EAF dust. Of the 32 Minimill Long Products EAF shops, 84% generated EAF dust containing at least 15% zinc oxide. The Specialty Long Products plants were most likely (50%) to have generated EAF dust with a zinc oxide content of less than 15%.

Of the 64 EAF shops that responded, 47% (30) indicated that the percentage of iron oxide (FeO) in their EAF dust was 30% or more. The presence of iron oxide in EAF dust can be viewed as both positive and negative. Of course, zinc recovery offers a higher potential value compared to iron, so to the extent that iron displaces zinc, it diminishes the recycling value of the dust. However, recovery of the iron may be considered a positive economic factor, particularly when the recycling process employed involves recharging or injecting EAF dust back into the EAF melting process. The EAF flat roll shops surveyed indicated the greatest instance of EAF dust with iron oxide content of 40% or more. The segment with the lowest percentage of iron oxide in their EAF dust was the Minimill Long Products segment, in which 55% of the plants had an iron oxide content in EAF dust of less than 30%.

Of the 61 EAF shops that responded, 40% (25) indicated that the percentage of lead oxide (PbO) in their EAF dust was less than 1%. Another 31% had 1 - 1.99% lead oxide in their EAF dust. While recovering zinc oxide has potential economic benefit, the lead oxide content can diminish the value of recycling the EAF dust. Although some processes may ultimately result in the recovering of lead metal, in an HTMR process, the lead oxides are volatilized with the zinc oxides and contaminate the crude zinc oxide that is recovered. Consequently, lead oxide content has a negative impact on the value of recycling EAF dust.
Overall, 47% (29) of the 61 EAF shops that responded indicated that the percentage of cadmium oxide (CdO) in their EAF dust was .04% or more. As is the case with lead oxides, cadmium oxides in EAF dust are captured with the zinc oxide, therefore having a negative impact on the value of the crude zinc oxides.

Of the 47 EAF shops that responded, 34% (16) indicated that the percentage of lime (CaO) in their EAF dust was 10% or more. The long products EAF shops surveyed tended to have the greatest amount of lime in their EAF dust. Overall, 44% of the plants in the Specialty Long Products segment and 39% of plants in the Minimill Long Products segment had 10% or more lime in their EAF dust. The Minimill Carbon Strip EAF shops surveyed all indicated that the percentage of lime in their EAF dust was 5 to 9.9%.

**Charging lime into the EAF** - Steel producers add lime (CaO) to desulfurize the steel in the EAF. The particular practice employed in charging lime to the EAF can have a significant impact on the volume of the EAF dust generated. For example, when lime is injected pneumatically through the roof of an EAF, the lime can end up being sucked out the fourth hole along with the furnace off-gases.

Of the 60 EAF shops that responded, 63% (38) revealed that lime is charged into the EAF by first charging it into a Scrap Bucket. The next most common lime charging method is Injection (23%); this includes Injection in the front or side of the furnace, through the roof, or through a “fifth hole”. When using a Scrap Bucket to charge lime, the lime content in the dust tends to decline. When charging lime directly either into the furnace or through the roof, the lime content in dust tends to increase. Only 44% of the plants with a lime content above 15% use a Scrap Bucket. In contrast, the plants that have less than 15% lime in their dust predominantly (in 70 to 80% of the cases) are using a Scrap Bucket. This is illustrated in Figure 5.

![Figure 5: Correlation analysis between % CaO in EAF dust and method of charging lime (CaO)](image-url)
GENERAL EAF MELT SHOP INFORMATION

EAF shops in the survey produced 54.7 million tons of steel in 1999, and operated at roughly 82% of their capacity of 67.1 million tons. The plants surveyed represented 94% of the total EAF steel production in the U.S. and Canada and approximately 44% of the total steel production (123.8 million tons) for the U.S. and Canada in 1999. Overall, the EAF shops that responded to the survey projected an 11% increase in annual steel production in 2000.

Carbon steel production accounted for 81% of the steel produced by the EAF shops surveyed, alloy steels accounted for 15%, stainless steel accounted for 3%, and resulfurized and silicon steels accounted for the remaining 1%.

IRON BEARING CHARGE MATERIAL MELTED

The types of scrap and other iron bearing charge materials (IBCMs) consumed in the production of steel have a significant impact on the quantity of EAF dust generated. Higher qualities of steel scrap contain less residuals and other heavy metals, such as zinc, lead, cadmium, etc. and lower qualities of steel scrap result in greater dust volumes and higher levels of these heavy metals in the dust. For this reason, we also obtained information about the IBCMs consumed by these plants including scrap types, pig iron, and alternative iron sources such as DRI and HBI. Shredded scrap is the type of iron bearing charge material most frequently (85%) melted by the EAF plants surveyed. Shredded scrap also accounts for the largest single share (25%) of IBCM consumed by the EAF shops that responded.

CURRENT EAF DUST DISPOSITION

The two fundamental alternatives for disposing of EAF dust are landfilling and recycling. When deciding between these alternatives, several factors are essential. The main factors are economic (treatment and transportation costs), environmental (regulations and conservation), long term liability, and concerns over public opinion. Overall, 63% (47) of the 75 plants that responded arrange to have EAF dust recycled in a High Temperature Metals Recovery (HTMR) facility, 41% (31) utilize a Landfill, and 5% employ other recycling techniques. Several employ more than one EAF dust disposal solution.

Recycling EAF dust using an HTMR process is most common (73%) among the Minimill Long Products EAF shops and least common (50%) in the Carbon/Alloy Flat Roll plants. Employing landfills for disposal is most common (60%) in the Specialty Long Products plants, but these plants are also most likely (7%) to be using other recycling methods. Overall, 54% (586,939 tons) of the total quantity of EAF dust generated by the plants surveyed is recycled; 45% (470,518 tons) is landfilled. While some plants employ both options, the majority of
the plants employ either one method or the other exclusively. Table II summarizes the disposition by amount of the 1999 EAF dust generated overall and in each EAF segment.

### Table II - Tons of EAF dust landfilled, recycled, and not disclosed by segment

<table>
<thead>
<tr>
<th>Segment</th>
<th>Landfilled</th>
<th>Recycled</th>
<th>Not Disclosed</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimill Carbon Strip</td>
<td>154,250</td>
<td>130,350</td>
<td>0</td>
<td>284,600</td>
</tr>
<tr>
<td>Carbon/Alloy Flat Roll</td>
<td>65,000</td>
<td>33,200</td>
<td>0</td>
<td>98,200</td>
</tr>
<tr>
<td>Minimill Long Prod</td>
<td>190,453</td>
<td>317,516</td>
<td>12,000</td>
<td>519,969</td>
</tr>
<tr>
<td>Specialty Long Prod</td>
<td>59,190</td>
<td>82,123</td>
<td>0</td>
<td>141,313</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>1,625</td>
<td>23,750</td>
<td>0</td>
<td>25,375</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>470,518</strong></td>
<td><strong>586,939</strong></td>
<td><strong>12,000</strong></td>
<td><strong>1,069,457</strong></td>
</tr>
</tbody>
</table>

#### Landfilling of EAF dust
- Of the plants that landfill their EAF dust, 77% (24 of 31) landfill 100% of this dust. Another 10% (3) landfill at least 60%. In 93% (28) of the cases, the EAF dust is chemically treated prior to landfill. Of the plants that use a landfill, 87% (27) use a facility that is off-site. The remaining four steel plants use an on-site landfill facility which is owned by their company.

- The availability of landfill sites is a factor in the decision to recycle or landfill EAF dust. Only seven plants commented on the remaining life of their off-site landfill. Two indicated a remaining life of less than 10 years, two expected a remaining life of approximately 10 years, and three had a remaining life of more than 10 years.

- The distance that EAF dust must be shipped is a factor in the cost of landfill disposal. Twenty-five plants reported the locations of the landfills that they use. Of these plants, 28% (7) ship their EAF dust at least 500 miles for landfill disposal. Slightly fewer than half of these plants only need to ship their EAF dust less than 200 miles. A distribution of the distance ranges’ shares of EAF plants that use an off-site landfill processor is presented in Figure 6.

![Figure 6: Distance to off-site EAF dust landfill - overall](image)
Recycling of EAF dust - Of the 51 plants that recycle their EAF dust, 86% (44) recycle 100% of this dust, and another 8% recycle at least 50%. Only six of the EAF shops surveyed recycle all or a portion of their EAF dust in an on-site facility or directly into their EAF. Three other plants acknowledged having had on-site EAF dust processing operations in the past. Just two plants acknowledged that they are considering a new on-site EAF dust treatment technology.

Each plant that is not considering an on-site EAF dust treatment facility was asked what would motivate them to consider a new on-site technology. Overall, 46% (32) of the plants that responded said they would consider it if it were more *Cost Effective* than the present practice. However, 33% (23) of the plants said that they would not consider it in any case, believing that economies of scale would not permit an on-site facility to be economically viable considering today’s known EAF dust processing technology.

The distance that EAF dust must be shipped is also a factor in the cost of recycling EAF dust. Overall, 38% (17) of the 45 plants that identified the location of their off-site EAF dust recycling facility ship their EAF dust at least 500 miles for processing. Only 31% (14) of these plants only need to ship their EAF dust for landfill less than 200 miles. A distribution of the distance ranges’ shares of EAF plants that use an off-site landfill processor is presented in Figure 7.

![Figure 7: Distance to off-site EAF dust recycle processor - overall](image)

**DRIVERS AND TRENDS FOR EAF DUST PROCESSING**

Each plant was asked to indicate the relative importance of four leading drivers for EAF dust processing. Overall, *Economic Issues* was the most frequently identified driver indicated regarding EAF dust processing. *Regulatory Considerations* and *Industry Dynamics (such as Scrap Types)* were of secondary importance. *Technological Factors* was the least frequently identified driver.
**Economic issues** - When asked to rate the importance of reducing the cost of processing EAF dust, all but two plants replied “10” (on a scale from 0 to 10, 10 being highest). The highest level of activity among EAF steel producers in responding to EAF dust treatment and disposal drivers involves Economic Issues. When asked to describe their plant’s level of activity regarding Economic Issues associated with EAF dust, all plants indicated “High”.

Of the plants surveyed, 95% (72) acknowledged paying a processor to handle their EAF dust. However, only 11 plants would reveal the fee or fee range. The processing fees indicated by these plants ranged from a low of $70 per ton to a high of $150 per ton. The cost of recycling is generally higher than the cost of landfilling, except where either is affected by transportation costs. Figure 8 provides a distribution of the total cost of processing (including transportation) indicated by individual plants surveyed, whether the EAF dust is recycled (R) or landfilled (L), and the distance shipped.

![Figure 8: Cost of EAF dust processing vs. mileage to site](image)

Of the 72 plants that pay a processor to handle their EAF dust, 10% (7) expect the processing fee to increase, while 53% (38) do not. The remaining plants replied that they did not know what to expect. Of the seven that expect the fee to increase, five acknowledged that they expect this trend to continue. Of the 38 EAF shops overall that do not expect the EAF processing fee to increase, 53% (20) expect the EAF dust processing fee to remain stable.

**Regulatory considerations** - Based on the responses, it is clear that EAF steel plants are actively involved in addressing the Regulatory Considerations associated with EAF dust processing. Overall, 62% of the EAF plants surveyed indicated a “High” level of activity in dealing with Regulatory Considerations and another 37% indicated at least a “Medium” level of activity.
Generally speaking, the plants surveyed expect the regulations for treatment and disposal of EAF dust shall reflect the status quo. The regulatory authorities are keeping a low profile, while insuring compliance and enforcement of the existing regulations. Processors and acceptable treatment technologies have been in place for some time and appear to be handling EAF dust to the satisfaction of the regulatory agencies. State regulations are typically of the greatest concern to the EAF plants overall. In many cases the United States EPA has delegated enforcement to the state authorities.

Technological factors - All EAF shops indicated a “9” or “10” level of interest in response to the question of whether they would be interested in minimizing the amount of EAF dust generated.

Leading trends in EAF dust processing - The leading trend in EAF dust processing is an ongoing and concerted effort by steel producers to Reduce Spending, followed by a significant effort to Reduce EAF Dust Volumes. Overall, 68% of the plants commented that Reduced Spending on EAF dust processing is their main focus and 45% mentioned Reduced Dust Volume. Overall, 81% (51) of the 63 plants that responded expect that these trends will impact upon the viability of their operation.

Only five EAF shops said they plan to change their EAF dust processor. Just four acknowledged seeking a new solution for EAF dust disposition.

SUMMARY

In summary, despite continuing efforts to reduce the volume of electric arc furnace dust generated, the total volume of EAF dust generated by steel producers continues to grow. EAF dust disposal and treatment is a cost of EAF steel production that contributes nothing to the value of the steel produced. It is a cost burden that continues to plague EAF steel producers. A limited number of options for disposal and recycling are presently employed. EAF steel producers are ripe for considering any new technologies or treatment alternatives that will reduce the volume of EAF dust generated and ultimately the cost of processing EAF dust.

ACKNOWLEDGMENTS

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REFERENCES


