

# SLAG—IRON AND STEEL

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Ferrous slags are produced by adding slagging agents (chiefly limestone or dolomite) and/or fluxing materials to blast furnaces and steel furnaces to strip the impurities from iron ore, steel scrap, and other iron or steel feeds. The molten slag forms as a liquid silicate melt that floats on top of the molten crude iron or steel and is tapped from the furnace separately from the liquid metal. After cooling, the slag is processed and may then be sold. Sales of iron and steel slags in the United States in 2004 totaled about 21.2 million metric tons (Mt), up by 7.6% from sales in 2003; the overall value of sales in 2004 was about \$328 million, up by almost 11% (table 1).

Most slags have very low unit values compared with those of pig iron and steel products. Iron and steel companies, accordingly, consider the slag they produce to be a nuisance and generally contract with outside slag-processing companies to remove it; the slag-processing company may also be responsible for cooling the slag. Although the financial arrangements vary, typically the processing company receives the cooled slag for free, crushes it to various marketable sizes, uses screens and magnetic separators to recover entrained metal from the slag (this metal to be returned to the furnace for a low charge), sells the slag on the open market, and pays a small percentage of the net slag sales revenues or profits to the iron or steel company. Also, slag may be returned to the furnaces for use as flux and as a supplemental source of iron; this return of slag is typically not reported as a sale.

A list of slag processors, processing sites, and the iron and steel companies serviced is provided in table 4. Apparent duplication at some sites is explained by the fact that certain processing contracts were transferred to other companies during the year and the fact that integrated iron and steel plants may have contracts with different processing companies for different slag types produced at the plant. In some cases, the slag is cooled by one processing company and then is further processed and sold by another. Apart from a number of contract transfers among processing companies, there was a major consolidation in the slag-processing industry when, in December, International Mill Services, Inc. (IMS) merged with Tube City LLC [the parent company of Olympic Mill Services (OMS)]. After the merger, IMS was renamed Tube City-IMS, IMS Division, and OMS was renamed Tube City IMS Corp. In November, Civil & Marine, Inc. began producing ground granulated blast furnace slag (GGBFS) at the company's new grinding plant at Cape Canaveral, FL; all of the unground feed for the plant is imported.

## Legislation and Government Programs

Demand for slag in the construction sector is influenced by Federal and State programs that affect construction spending levels. The main Federal funding program of this type continued to be the Transportation Equity Act for the 21st

Century (TEA-21). Funding under the TEA-21 in 2004 was through temporary continuations of the Act; both houses of Congress proposed reauthorizing the Act during the year, but had not reached agreement as to the total funding levels by yearend. Slags are promoted as “sustainable” construction materials, and slag sales benefit from programs that promote use of such materials in construction projects. In this respect, the attributes cited for slag include the fact that it substitutes directly or indirectly for virgin raw materials (for example, natural stone aggregates in various applications and natural raw materials for cement manufacture). Through its role as a partial substitute for portland cement in concrete, GGBFS reduces the unit carbon dioxide emissions associated with the concrete; also, the GGBFS generally enhances the durability of the concrete.

## Production

Blast furnace slags, as sold, are of three main types: air-cooled, granulated, and pelletized (or expanded). Air-cooled blast furnace slag is formed by allowing the molten slag to cool relatively slowly under ambient conditions; final cooling can be accelerated with a water spray. The cooled material is hard and dense, although it can have a vesicular texture with closed pores. After crushing and screening, air-cooled slag is used mainly as an aggregate for various purposes (table 3). Granulated slag is formed by quenching molten slag in water to form sand-sized particles of glass. The disordered structure of this glass gives the material moderate hydraulic cementitious properties when very finely ground into GGBFS, but if it can access free lime, the GGBFS develops strong hydraulic cementitious properties. Pelletized or expanded slag is cooled through a water jet, which leads to rapid steam generation and the development of innumerable vesicles within the slag. The vesicular texture reduces the overall density of the slag and allows for good mechanical binding with hydraulic cement paste. Blast furnace slag (generally air-cooled) also can be made into mineral wool. Slag for this purpose is remelted and then poured through an air stream or jet of steam or other gas to produce a spray of molten droplets; alternatively, the droplets can be formed by passing the melt through a perforated or fast spinning disc. The droplets elongate into long fibers that are collected and layered.

Steel furnace slag is cooled similarly to air-cooled blast furnace slag, has similar properties to it, and is used for many of the same purposes. Steel slags containing large amounts of dicalcium silicate are prone to expansion and commonly are cured in piles for some months to allow for this and for leaching out of lime.

Data are generally unavailable from plants on the actual output of iron and steel slags for an extended series of production cycles (heats). This generally is because not all of the slag is tapped during a heat, and the amount of slag tapped is not routinely measured. Accordingly, there are no data on

U.S. production of ferrous slags and few, if any, data on foreign production, although both can be estimated based on typical slag to metal production ratios, which in turn are related to the chemistry of the ferrous feeds to the furnaces. For typical iron ore grades (60% to 66% iron), a blast furnace will normally produce about 0.25 to 0.30 metric ton (t) of slag per ton of crude iron. For ore grades lower than average, the slag output will be higher—sometimes as much as 1.0 to 1.2 t of slag per ton of crude iron. Steel furnaces typically produce about 0.2 t of slag per ton of crude steel. However, up to 50% of the molten steel slag is entrained metal, most of which is generally recovered during slag processing and returned to the furnace. The amount of marketable slag remaining after entrained steel removal is usually equivalent to about 10% to 15% of the crude steel output. Using these ratios and data for U.S. and world iron and steel production from the American Iron and Steel Institute (2004, p. 125-138), it was estimated that U.S. blast furnace slag production in 2004 was in the range of about 12 to 14 Mt, and world output was in the range of 200 to 240 Mt. Likewise, U.S. output of steel slag (after metal removal) in 2004 was estimated to be 11 to 16 Mt, and world output, 115 to 175 Mt.

## Consumption

Data in this report are based on an annual U.S. Geological Survey (USGS) canvass of slag processors and relate to sales of processed slag rather than to the amount of slag processed by the same firms or to the actual production of slag by iron and steel companies. Processed slag is sold from stockpiles, and although most of the material is a byproduct of current or recent iron and steel production or is of imported material, some is material mined from old slag piles (slag banks) and reflects iron and steel production from plants now closed. In 2004, canvasses were sent to 28 processing companies, covering 130 processing sites, and at least partial data were received for 126 sites. The reported data account for about 98% of the gross tonnage for 2004 in table 1. In 2003, surveys were sent to 24 processing companies, covering 128 processing sites, and at least partial data were received for 126 sites. The reported data accounted for 99.9% of the gross tonnage for 2003. For both years, data are presented only for air-cooled and granulated blast furnace slags, as well as steel slag. Data on pelletized slag have been withheld for proprietary data protection reasons, but the quantities sold were very small; prior to 2002, pelletized data were presented combined with granulated slag under the term “Expanded slag.”

In terms of tonnage, U.S. slag sales in 2004 continued to be dominantly of air-cooled blast furnace slag and steel slag (table 1). Air-cooled blast furnace slag sales totaled about 8.1 Mt in 2004, up by about 11% from the amount sold in 2003. Steel furnace slag sales rose by about 2% in 2004 to 9.0 Mt. For all years, the sales data for air-cooled and steel furnace slags largely exclude material returned to the furnaces (and likewise exclude the weight of free metal recovered from the slag and returned to the furnace); data on these returns are substantially unavailable. Air-cooled and steel furnace slags have a similar set of uses—mostly for various applications as aggregates (table 3). Because of potential expansion problems, steel slags

find less use for applications requiring maintenance of a fixed volume (for example, concrete). Steel slags that contain a lot of free lime can have application as a soil conditioner. Most slags can be used as raw material for cement (clinker) manufacture (the slag contributes aluminum, calcium, iron, and silicon oxides) but steel slags have proven to be especially suitable for this use. Although the sales price data for air-cooled and steel slags contain a large component of estimates, it appears that the average selling price of air-cooled slag was more or less stagnant in 2004, whereas the prices for steel slag may have risen slightly (table 2). Typically, the major factors affecting the sales volumes and prices of these slags include local competition from natural aggregates, the overall level of construction activity (particularly that for roads), and the existence of some long-term supply contracts. Because of generally low unit sales values, slags for aggregate applications generally cannot sustain long-distance transportation. Slag converted to mineral wool is mainly used for thermal insulation. Although the specific sales data are withheld, pelletized slag is primarily used for lightweight concrete aggregate. When finely ground, pelletized slag can be used as a supplementary cementitious material similar to GGBFS.

In terms of value (in contrast to tonnages), the slag market in the United States is dominated by sales of granulated blast furnace slag, particularly GGBFS. In 2004, granulated slag accounted for almost 82% of the value of total blast furnace slag sales and 73% of total ferrous slag sales; both of these percentages were slightly higher than in 2003 (table 1). The tonnage of granulated slag sold in 2004 increased about 14% to 4.1 Mt. Although not revealed in table 1, about 3.6 Mt of this was GGBFS, and the rest was unground material. The value dominance of granulated slag reflects its high unit value relative to the other slag types (table 2), and this, in turn, reflects the ready market for GGBFS as a partial substitute for portland cement in ready-mixed concrete or mixed with portland cement to make finished blended cement. In both applications, the hydration of the portland cement releases the lime needed to activate the GGBFS. Concrete that contains a proportion of GGBFS generally develops strength more slowly than concretes containing only portland cement but can have similar or even superior long-term strength, releases less heat during hydration, has reduced permeability, and shows improved resistance to chemical attack. A small fraction of the (unground) granulated slag on the market has been sourced from old slag piles and lacks cementitious properties as a result of weathering; this material can still be used as a fine grain aggregate for concrete, but sells for much lower prices than those indicated in table 2 for the cementitious material.

The USGS slag survey does not distinguish between granulated slag sold directly to cement companies and that sold directly to concrete companies, but the 2004 USGS cement survey indicated that the cement producers themselves consumed only about 8% of the total granulated slag sales. Sales of GGBFS under the designation “slag cement” are promoted by the Slag Cement Association (SCA), whose members accounted for most of the U.S. output of this ground material. The SCA Web site reported sales of 3.46 Mt of GGBFS in 2004, which is in close agreement with the USGS

data (Slag Cement Association, written commun., June 2, 2005).

Imports of ferrous slags (excluding iron scales) totaled about 1.0 Mt in 2004, down by about 10% from levels in 2003. The imports continued to be dominated by granulated blast furnace slag. In 2004, imports of granulated slag (mostly as unground material) totaled 0.76 Mt compared with 0.75 Mt in 2003. For 2004, the average unit value (customs value) for imported granulated slag was \$36.93 per metric ton; it averaged \$34.93 per ton in 2003. By comparison, the cost, insurance, and freight value was \$49.89 per metric ton in 2004 and \$44.54 per ton in 2003; the differences relative to the customs values largely reflect the shipping charges, which rose substantially in 2004. Of the nine countries that supplied granulated slag in 2004, the leading sources were France (37%), Italy (25%), and Canada (18%).

## Outlook

Granulators are currently installed at only five locations in the United States, and despite the high prices realized for GGBFS, it is unclear if granulation capacity will be increased. This is because of the high costs to install granulators, the costs of constructing an associated grinding plant, and by the precarious health of the integrated iron and steel plants. Together with

the output from existing import-based grinding plants, it is likely that additional demand for GGBFS will be met by adding import-based grinding capacity; the new grinding plant in Florida is an example of this trend. Growth in the market for slag as an aggregate will depend on overall construction spending levels and on the success of industry efforts to promote slag as a sustainable construction material.

## Reference Cited

American Iron and Steel Institute, 2004, Annual statistical report: Washington, DC, American Iron and Steel Institute, 138 p.

## GENERAL SOURCES OF INFORMATION

### U.S. Geological Survey Publication

Iron and Steel Slag. Ch. in Mineral Commodities Summaries, annual.

### Other

National Slag Association.  
Portland Cement Association.  
Slag Cement Association.

TABLE 1  
IRON AND STEEL SLAG SOLD OR USED IN THE UNITED STATES

(Million metric tons and million dollars)

|                       | 2003                            |            |                    |                       |   |                                 | 2004       |                    |                       |   |  |
|-----------------------|---------------------------------|------------|--------------------|-----------------------|---|---------------------------------|------------|--------------------|-----------------------|---|--|
|                       | Blast furnace slag <sup>1</sup> |            |                    | Steel<br>furnace slag | Total iron<br>and steel slag <sup>2</sup> | Blast furnace slag <sup>1</sup> |            |                    | Steel<br>furnace slag | Total iron<br>and steel slag <sup>2</sup> |  |
|                       | Air-cooled                      | Granulated | Total <sup>2</sup> |                       |   | Air-cooled                      | Granulated | Total <sup>2</sup> |                       |   |  |
| Quantity <sup>3</sup> | 7.3                             | 3.6        | 10.9               | 8.8                   | 19.7                                      | 8.1                             | 4.1        | 12.2               | 9.0                   | 21.2                                      |  |
| Value <sup>e,4</sup>  | 49                              | 212        | 261                | 35                    | 296                                       | 53                              | 236        | 289                | 39                    | 328                                       |  |

<sup>e</sup>Estimated.

<sup>1</sup>Excludes expanded (pelletized) slag to protect company proprietary data. The quantity is very small (less than 0.1 unit).

<sup>2</sup>Data may not add to totals shown because of independent rounding.

<sup>3</sup>Quantities are rounded to reflect inclusion of some estimated data and to reflect inherent accuracy limitations of reported data.

<sup>4</sup>Values are rounded because of the inclusion of a large estimated component.

TABLE 2  
SELLING PRICES FOR IRON AND STEEL SLAG IN THE UNITED STATES<sup>1</sup>

(Dollars per metric ton)

| Slag type               | 2003        |         | 2004        |         |
|-------------------------|-------------|---------|-------------|---------|
|                         | Range       | Average | Range       | Average |
| Blast furnace slag:     |             |         |             |         |
| Air-cooled              | 3.11-17.25  | 6.71    | 1.54-17.35  | 6.58    |
| Granulated <sup>2</sup> | 16.53-78.20 | 62.52   | 22.05-71.65 | 61.49   |
| Steel slag              | 0.73-11.02  | 3.95    | 0.22-7.89   | 4.32    |

<sup>1</sup>Underlying data contain a large component of estimates.

<sup>2</sup>Range shown is for material reported for use as a cementitious additive in cement or concrete manufacture. Material at the low end of the range is sold in unground form.

TABLE 3  
SALES OF FERROUS SLAGS IN THE UNITED STATES , BY USE<sup>1</sup>

(Percentage of total tons sold)

| Use                        | 2003                            |            |                         | 2004                            |            |                         |
|----------------------------|---------------------------------|------------|-------------------------|---------------------------------|------------|-------------------------|
|                            | Blast furnace slag <sup>2</sup> |            | Steel slag <sup>3</sup> | Blast furnace slag <sup>2</sup> |            | Steel slag <sup>3</sup> |
|                            | Air-cooled                      | Granulated |                         | Air-cooled                      | Granulated |                         |
| Ready-mixed concrete       | 9.3                             | --         | --                      | 20.4                            | --         | --                      |
| Concrete products          | 6.4                             | --         | --                      | 3.5                             | --         | --                      |
| Asphaltic concrete         | 20.6                            | --         | 17.0                    | 20.4                            | --         | 12.9                    |
| Road bases and surfaces    | 34.7                            | --         | 46.4                    | 32.3                            | --         | 63.5                    |
| Fill                       | 3.1                             | --         | 11.1                    | 4.9                             | --         | 9.6                     |
| Cementitious material      | --                              | 92.8       | --                      | --                              | 91.1       | --                      |
| Clinker raw material       | 5.7                             | --         | 5.4                     | 1.9                             | --         | 5.5                     |
| Miscellaneous <sup>4</sup> | 4.0                             | --         | 2.5                     | 4.2                             | --         | 2.9                     |
| Other or unspecified       | 16.2                            | 7.2        | 17.6                    | 12.4                            | 8.9        | 5.6                     |

-- Zero.

<sup>1</sup>Data contain a large component of estimates and are reliable to no more than two significant digits.

<sup>2</sup>Excludes expanded or pelletized slag; this material is generally sold as a lightweight aggregate.

<sup>3</sup>Steel slag use is based on the 89% of total tons sold in 2003 and the 77% of total tons in 2004 (table 1) for which usage data were provided.

<sup>4</sup>Reported as used for railroad ballast, roofing, mineral wool, or soil conditioner.

TABLE 4  
PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2004

| Slag processing company       | Plant location             | Steel company serviced <sup>2,3</sup> | Slag and furnace types <sup>1</sup> |    |     |                    |     |     |
|-------------------------------|----------------------------|---------------------------------------|-------------------------------------|----|-----|--------------------|-----|-----|
|                               |                            |                                       | Blast furnace slag                  |    |     | Steel furnace slag |     |     |
|                               |                            |                                       | AC                                  | GG | Exp | BOF                | OHF | EHF |
| AMSI                          | Holsopple, PA              | North American Höganäs, Inc.          |                                     |    |     |                    |     | X   |
| Barfield Enterprises, Inc.    | La Place, LA               | Bayou Steel Corp.                     |                                     |    |     |                    |     | X   |
| Do.                           | Lone Star, TX              | Lone Star Steel Corp.                 |                                     |    |     |                    |     | X   |
| Beaver Valley Slag            | Aliquippa, PA              | Old slag pile site                    | X                                   |    |     |                    | X   |     |
| Do. (Thor Mill Services)      | Roanoke, VA                | Roanoke Electric Steel, Inc.          |                                     |    |     |                    |     | X   |
| Blackheart Slag Co.           | Muscatine (Montpelier), IA | IPSCO Steel, Inc.                     |                                     |    |     |                    |     | X   |
| Border Steel, Inc.            | El Paso, TX                | Border Steel, Inc.                    |                                     |    |     |                    |     | X   |
| Buffalo Crushed Stone, Inc.   | Woodlawn, NY               | Old slag pile site                    | X                                   |    |     |                    |     |     |
| Buzzi Unicem USA, Inc.        | New Orleans, LA            | Various foreign                       |                                     | X  |     |                    |     |     |
| Civil & Marine, Inc.          | Cape Canaveral, FL         | do.                                   |                                     | X  |     |                    |     |     |
| Edward C. Levy Co.            | Decatur (Trinity), AL      | Nucor Steel Corp.                     |                                     |    |     |                    |     | X   |
| Do.                           | Butler, IN                 | Steel Dynamics Inc.                   |                                     |    |     |                    |     | X   |
| Do.                           | Columbia City, IN          | do.                                   |                                     |    |     |                    |     | X   |
| Do.                           | Crawfordsville, IN         | Nucor Steel Corp.                     |                                     |    |     |                    |     | X   |
| Do.                           | Detroit, MI                | Severstal North America, Inc.         | X                                   |    |     | X                  |     |     |
| Do.                           | do.                        | U.S. Steel Corp.                      | X                                   |    |     | X                  |     |     |
| Do.                           | Canton, OH                 | The Timken Co.                        |                                     |    |     |                    |     | X   |
| Do.                           | Delta, OH                  | North Star-Bluescope Steel Inc.       |                                     |    |     |                    |     | X   |
| Do.                           | Huger, SC                  | Nucor Steel Corp.                     |                                     |    |     |                    |     | X   |
| Essroc Corp.                  | Middlebranch, OH           | Miscellaneous domestic and foreign    |                                     | X  |     |                    |     |     |
| Florida Rock Industries, Inc. | Tampa, FL                  | Various foreign                       |                                     | X  |     |                    |     |     |
| Fritz Enterprises, Inc.       | Fairfield, AL              | U.S. Steel LLC                        | X                                   |    |     | X                  |     |     |
| Gerdau Ameristeel Corp.       | Jacksonville, FL           | Gerdau Ameristeel Corp.               |                                     |    |     |                    |     | X   |
| Do.                           | Charlotte, NC <sup>4</sup> | do.                                   |                                     |    |     |                    |     | X   |
| Glens Falls-Lehigh Cement Co. | Cementon, NY               | Various foreign                       |                                     | X  |     |                    |     |     |
| Holcim (US) Inc.              | Birmingham (Fairfield), AL | U.S. Steel LLC                        |                                     | X  |     |                    |     |     |
| Do.                           | Gary, IN                   | do.                                   |                                     | X  |     |                    |     |     |
| Do.                           | Weirton, WV                | Weirton Steel Corp.                   |                                     | X  |     |                    |     |     |

See footnotes at end of table

TABLE 4—Continued  
PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2004

| Slag processing company          | Plant location                            | Steel company serviced <sup>2, 3</sup>   | Slag and furnace types <sup>1</sup> |    |                    |     |     |     |
|----------------------------------|---|--|-------------------------------------|----|--------------------|-----|-----|-----|
|                                  |   |  | Blast furnace slag                  |    | Steel furnace slag |     |     |     |
|                                  |   |  | AC                                  | GG | Exp                | BOF | OHF | EAF |
| Lafarge North America Inc.       | Chicago, IL                               | Ispat Inland Steel, Inc.                 |                                     | X  |                    |     |     |     |
| Do.                              | Joppa, IL                                 | do.                                      |                                     | X  |                    |     |     |     |
| Do.                              | East Chicago, IN                          | do.                                      |                                     |    | X                  |     |     |     |
| Do.                              | Sparrows Point, MD                        | International Steel Group Inc.           |                                     | X  |                    |     |     |     |
| Do.                              | Cleveland (Cuyahoga Co.), OH <sup>5</sup> | do.                                      | X                                   |    |                    |     |     |     |
| Do.                              | Lordstown, OH                             | Old slag pile site                       |                                     | X  |                    |     |     |     |
| Do.                              | McDonald, OH                              | Youngstown Sheet and Tube Co.            | X                                   |    |                    |     |     |     |
| Do.                              | Salt Springs (Youngstown), OH             | do.                                      | X                                   |    |                    |     |     |     |
| Do.                              | Warren, OH                                | WCI Steel Inc.                           | X                                   |    |                    |     |     |     |
| Do.                              | West Mifflin, PA                          | U.S. Steel LLC (ET Works)                | X                                   |    |                    |     |     |     |
| Do.                              | West Mifflin (Brown Reserve), PA          | Old slag pile site                       | X                                   |    |                    |     |     |     |
| Do.                              | Whitehall, PA                             | Various foreign                          |                                     | X  |                    |     |     |     |
| Do.                              | Seattle, WA                               | do.                                      |                                     | X  |                    |     |     |     |
| Do.                              | Weirton, WV                               | Weirton Steel Corp.                      | X                                   |    |                    |     |     |     |
| Lehigh Cement                    | Evansville, PA                            | Various foreign                          |                                     | X  |                    |     |     |     |
| Levy Co., Inc., The              | Burns Harbor, IN                          | International Steel Group Inc.           | X                                   |    |                    | X   |     |     |
| Do.                              | East Chicago, IN                          | do.                                      | X                                   |    |                    |     |     |     |
| Do.                              | Gary, IN                                  | U.S. Steel LLC                           | X                                   | X  |                    |     |     |     |
| Mountain Enterprises, Inc.       | Ashland, KY <sup>5</sup>                  | AK Steel Corp.                           | X                                   |    |                    |     |     |     |
| MultiServ                        | Birmingham, AL                            | Structural Metals Corp.                  |                                     |    |                    |     |     | X   |
| Do.                              | Tuscaloosa, AL                            | Nucor Steel Corp.                        |                                     |    |                    |     |     | X   |
| Do.                              | Blytheville, AR                           | do.                                      |                                     |    |                    |     |     | X   |
| Do.                              | Blytheville (Armored), AR                 | Nucor-Yamato Steel Co.                   |                                     |    |                    |     |     | X   |
| Do.                              | Pueblo, CO                                | Rocky Mountain Steel Mills               |                                     |    |                    |     |     | X   |
| Do.                              | Wilton (Muscatine), IA                    | IPSCO Steel, Inc.                        |                                     |    |                    |     |     | X   |
| Do.                              | East Chicago, IN                          | Ispat Inland Steel, Inc.                 |                                     |    |                    | X   |     |     |
| Do.                              | Indiana Harbor, IN                        | International Steel Group Inc.           |                                     |    |                    | X   |     |     |
| Do.                              | Ghent, KY                                 | Gallatin Steel Co.                       |                                     |    |                    |     |     | X   |
| Do.                              | Sparrows Point, MD                        | International Steel Group Inc.           | X                                   |    |                    | X   |     |     |
| Do.                              | Ahoskie (Cofield), NC                     | Nucor Steel Corp.                        |                                     |    |                    |     |     | X   |
| Do.                              | Canton, OH                                | Republic Engineered Products LLC         |                                     |    |                    |     |     | X   |
| Do.                              | Mansfield, OH                             | AK Steel Corp.                           |                                     |    |                    | X   |     |     |
| Do.                              | Warren, OH                                | WCI Steel Inc.                           |                                     |    |                    | X   |     |     |
| Do.                              | Braddock (Mon Valley), PA                 | U.S. Steel/Republic Technologies         |                                     |    |                    | X   |     |     |
| Do.                              | Butler, PA                                | AK Steel Corp.                           |                                     |    |                    |     |     | X   |
| Do.                              | Coatesville, PA                           | International Steel Group Inc.           |                                     |    |                    |     |     | X   |
| Do.                              | Koppel, PA                                | Koppel Steel Co. (NS Group, Inc.)        |                                     |    |                    |     |     | X   |
| Do.                              | Steelton, PA                              | International Steel Group Inc.           |                                     |    |                    |     |     | X   |
| Do.                              | Midlothian, TX                            | TXI Chaparral Steel Co.                  |                                     |    |                    |     |     | X   |
| Do.                              | Geneva (Provo), UT                        | Geneva Steel Holdings Corp. <sup>6</sup> | X                                   |    |                    | X   |     |     |
| Do.                              | Seattle, WA                               | Nucor Steel Corp.                        |                                     |    |                    |     |     | X   |
| Rinker Materials Corp.           | Miami, FL                                 | Various foreign                          |                                     | X  |                    |     |     |     |
| St. Lawrence Cement, Inc.        | Camden, NJ                                | do.                                      |                                     | X  |                    |     |     |     |
| St. Marys Cement, Inc.           | Detroit, MI                               | do.                                      |                                     | X  |                    |     |     |     |
| Stein, Inc.                      | Sterling, IL                              | Sterling Steel, Inc.                     |                                     |    |                    |     |     | X   |
| Do.                              | Ashland, KY <sup>5</sup>                  | AK Steel Corp.                           | X                                   |    |                    | X   |     |     |
| Do.                              | Cleveland, OH <sup>5</sup>                | International Steel Group Inc.           | X                                   |    |                    | X   |     |     |
| Do.                              | Loraine, OH                               | Republic Engineered Products LLC         | X                                   |    |                    | X   |     |     |
| Titan Florida, Inc.              | Medley, FL                                | Various foreign                          |                                     | X  |                    |     |     |     |
| Tube City IMS Corp. <sup>7</sup> | Birmingham, AL                            | Nucor Steel Corp.                        |                                     |    |                    |     |     | X   |
| Do.                              | Newport, AR <sup>8</sup>                  | Arkansas Steel Assoc.                    |                                     |    |                    |     |     | X   |
| Do.                              | Rancho Cucamonga, CA                      | TAMCO Steel                              |                                     |    |                    |     |     | X   |
| Do.                              | Portage, IN                               | Beta Steel Corp.                         |                                     |    |                    |     |     | X   |
| Do.                              | Norfolk, NE                               | Nucor Steel Corp.                        |                                     |    |                    |     |     | X   |
| Do.                              | Perth Amboy, NJ <sup>9</sup>              | Gerdau Ameristeel Corp.                  |                                     |    |                    |     |     | X   |
| Do.                              | Sayreville, NJ <sup>9</sup>               | do.                                      |                                     |    |                    |     |     | X   |
| Do.                              | Middletown, OH                            | AK Steel Corp.                           | X                                   |    |                    | X   |     |     |
| Do.                              | Mingo Junction, OH                        | Wheeling Pittsburgh Steel Corp.          | X                                   |    |                    | X   |     |     |
| Do.                              | Youngstown, OH                            | V&M Star (North Star, Inc.)              |                                     |    |                    |     |     | X   |
| Do.                              | Sand Springs, OK                          | Sheffield Steel Corp.                    |                                     |    |                    |     |     | X   |

See footnotes at end of table



TABLE 4—Continued  
PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2004

| Slag processing company                     | Plant location               | Steel company serviced <sup>2, 3</sup>    | Slag and furnace types <sup>1</sup> |    |     |                    |     |     |
|---|------------------------------|---|-------------------------------------|----|-----|--------------------|-----|-----|
|   |                              |   | Blast furnace slag                  |    |     | Steel furnace slag |     |     |
|   |                              |   | AC                                  | GG | Exp | BOF                | OHF | EAF |
| Tube City IMS Corp.—Continued: <sup>7</sup> | Cayce, SC                    | SMI/CMC Steel Group                       |                                     |    |     |                    |     | X   |
| Do.   | Knoxville, TN                | Gerdau Ameristeel Corp.                   |                                     |    |     |                    |     | X   |
| Do.   | Seguin, TX                   | SMI/CMC Steel Group                       |                                     |    |     |                    |     | X   |
| Do.   | Petersburg, VA               | TXI Chaparral Steel Co.                   |                                     |    |     |                    |     | X   |
| Tube City-IMS, IMS Division <sup>10</sup>   | Axis, AL                     | IPSCO Steel, Inc.                         |                                     |    |     |                    |     | X   |
| Do.   | Fort Smith, AR               | Macsteel                                  |                                     |    |     |                    |     | X   |
| Do.   | Newport, AR <sup>8</sup>     | Arkansas Steel Assoc.                     |                                     |    |     |                    |     | X   |
| Do.   | Kingman, AZ                  | North Star Steel Inc.                     |                                     |    |     |                    |     | X   |
| Do.   | Claymont, DE                 | CitiSteel USA, Inc.                       |                                     |    |     |                    |     | X   |
| Do.   | Cartersville, GA             | Gerdau Ameristeel Corp.                   |                                     |    |     |                    |     | X   |
| Do.   | Wilton (Muscatine), IA       | do.                                       |                                     |    |     |                    |     | X   |
| Do.   | Kankakee, IL                 | Nucor Steel Corp.                         |                                     |    |     |                    |     | X   |
| Do.   | Peoria, IL                   | Keystone Steel & Wire Co.                 |                                     |    |     |                    |     | X   |
| Do.   | Laplace, LA                  | Bayou Steel Corp.                         |                                     |    |     |                    |     | X   |
| Do.   | Jackson, MI                  | Macsteel                                  |                                     |    |     |                    |     | X   |
| Do.   | Monroe, MI                   | Macsteel (Quanex)                         |                                     |    |     |                    |     | X   |
| Do.   | St. Paul, MN                 | Gerdau Ameristeel Corp.                   |                                     |    |     |                    |     | X   |
| Do.   | Jackson, MS                  | Nucor Steel Corp.                         |                                     |    |     |                    |     | X   |
| Do.   | Charlotte, NC <sup>4</sup>   | Gerdau Ameristeel Corp.                   |                                     |    |     |                    |     | X   |
| Do.   | Perth Amboy, NJ <sup>9</sup> | do.                                       |                                     |    |     |                    |     | X   |
| Do.   | Sayreville, NJ <sup>9</sup>  | do.                                       |                                     |    |     |                    |     | X   |
| Do.   | Auburn, NY                   | Nucor Steel Corp.                         |                                     |    |     |                    |     | X   |
| Do.   | Marion, OH                   | Marion Steel Co.                          |                                     |    |     |                    |     | X   |
| Do.   | McMinnville, OR              | Cascade Steel Rolling Mills, Inc.         |                                     |    |     |                    |     | X   |
| Do.   | Portland, OR                 | Oregon Steel Mills Inc.                   |                                     |    |     |                    |     | X   |
| Do.   | Bethlehem, PA                | Old slag pile site                        | X                                   |    |     | X                  |     |     |
| Do.   | Bridgeville, PA              | Universal Stainless & Alloy Products Inc. |                                     |    |     |                    |     | X   |
| Do.   | Midland, PA                  | J&L Specialty Products, Inc.              |                                     |    |     |                    |     | X   |
| Do.   | Monroeville, PA              | Old slag pile site                        |                                     |    |     |                    | X   |     |
| Do.   | New Castle, PA               | Ellwood Quality Steels Co.                |                                     |    |     |                    |     | X   |
| Do.   | Park Hill (Johnstown), PA    | Old slag pile site                        |                                     |    |     | X                  |     |     |
| Do.   | Pricedale, PA                | do.                                       |                                     |    |     | X                  |     |     |
| Do.   | Reading, PA                  | Carpenter Technology Corp.                |                                     |    |     |                    |     | X   |
| Do.   | Darlington, SC               | Nucor Steel Corp.                         |                                     |    |     |                    |     | X   |
| Do.   | Georgetown, SC <sup>11</sup> | Georgetown Steel Corp.                    |                                     |    |     |                    |     | X   |
| Do.   | Jackson, TN                  | Gerdau Ameristeel Corp.                   |                                     |    |     |                    |     | X   |
| Do.   | Beaumont, TX                 | do.                                       |                                     |    |     |                    |     | X   |
| Do.   | Jewett, TX                   | Nucor Steel Corp.                         |                                     |    |     |                    |     | X   |
| Do.   | Longview, TX                 | LeTourneau Steel Group                    |                                     |    |     |                    |     | X   |
| Do.   | Plymouth, UT                 | Nucor Steel Corp.                         |                                     |    |     |                    |     | X   |
| Do.   | Saukville, WI                | Charter Steel                             |                                     |    |     |                    |     | X   |
| Do.   | Weirton, WV                  | Weirton Steel Corp.                       |                                     |    |     |                    | X   |     |

<sup>1</sup>Blast furnace slag type abbreviations: AC, air-cooled; GG, granulated; Exp, expanded. Steel furnace slag types: BOF, basic oxygen furnace; OHF, open hearth furnace; EAF, electric arc furnace.

<sup>2</sup>"Various foreign" refers to the fact that the facility imports unground granulated blast furnace slag and grinds it on site to make ground granulated blast furnace slag, commonly now referred to as "slag cement."

<sup>3</sup>Currently operating iron and/or steel company. Company is not shown for old slag pile sites.

<sup>4</sup>IMS processing contract was taken over by Gerdau Ameristeel in June 2004.

<sup>5</sup>For the air-cooled slag, Stein was responsible for the cooling, but the processing and marketing was handled by Lafarge Corp. (Cleveland, OH) and Mountain Enterprises, Inc. (Ashland, KY), respectively.

<sup>6</sup>The Geneva Steel plant shut down in 2002; slag processing is of small residual piles.

<sup>7</sup>Formerly Olympic Mill Services, Inc. (OMS) and was renamed following the December 2004 merger of OMS' parent company, Tube City, LLC, with Olympic Mill Services, Inc.

<sup>8</sup>Contract transferred from Tube City-IMS to Uniserve LLC in February 2004.

<sup>9</sup>Contracts were transferred to OMS (became Tube City-IMS) in September 2004 (Perth Amboy), and December 2004 (Sayreville).

<sup>10</sup>Formerly International Mill Services, Inc. (IMS) and was renamed following the December 2004 merger of IMS with Tube City, LLC.

<sup>11</sup>Contract was transferred to Stein, Inc. in July 2004.