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SLAG—IRON AND STEEL

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Slag—Iron and Steel

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A total of about 15.4 million metric tons (Mt) of iron and steel slag was sold by U.S. slag processors in 2011, down by about 3% from total sales in 2010 (table 1). The value of slag sales decreased by about 4% to an estimated $257 million overall.

Slagging agents and fluxes (chiefly limestone or dolomite and silica sand) are added to blast furnaces and steel furnaces to strip impurities from iron ore, steel scrap, and other ferrous feeds. The slag thus formed is a 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 being cooled by various means to solid form, the slag is processed and may then be sold or, in some cases, returned to the furnace. Most types of processed slag have much lower unit values than do iron and steel (metal) and, for this reason, iron and steel companies generally contract with outside slag-processing companies to cool the slag and to remove it. The financial arrangements for this vary, but typically the processing company receives the slag for free, crushes it to various marketable sizes, uses screens and magnetic separators to recover entrained metal from the slag (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. Slag can be returned to the furnaces for use as flux and as a supplemental source of iron, but despite having a value, this return flow is commonly not included in the tonnages of slag reported as sold.

A listing of slag processors, processing sites, slag types, and the iron and steel companies serviced is provided in table 4. Apparent duplication at some sites is because processing contracts may have been transferred to other companies during the year and it is common for integrated iron and steel plants to have processing or marketing contracts with different companies for different slag types produced at the plant. In some cases, the slag is cooled by one company but is then further processed or marketed by another company or at another site.

Legislation and Government Programs

Consumption of slag for construction is influenced by Federal and State programs that affect construction spending levels, encourage the use of "alternative" materials in construction, and that may affect the availability of competing "alternative" or natural materials. Slags are considered to be "sustainable" raw materials mainly because they can substitute directly or indirectly for virgin raw materials (for example, for natural stone aggregates in concrete and for natural raw materials in cement manufacture), or, in the specific case of ground granulated blast furnace slag (GGBFS), can partially substitute for clinker in finished cement or for portland cement in concrete. With respect to clinker manufacture, substitution of slags for natural raw materials can reduce the unit consumption of fuel and limestone in the kiln, which then reduces the overall and unit emissions of certain pollutants, most notably carbon dioxide. Use of granulated blast furnace slag [either GGBFS, or unground material (GBFS)] in the finish mill allows more finished cement to be made from the same amount of clinker.

The future viability of some cement plants may be in jeopardy as a result of the very low limits for emissions of mercury, total hydrocarbons, hydrochloric acid, and particulates, set forth in a 2010 final rule within the National Emissions Standards for Hazardous Air Pollutants (NESHAP); various amendments to the 2010 rule, including an extension to September 2015 of the rule's 3-year compliance deadline, were proposed (U.S. Environmental Protection Agency, 2010b; 2012). Should plants close as a result of the NESHAP, the supply of domestically produced cement on the U.S. market would be reduced and likely could not be entirely offset in some markets by increased cement imports. This has the potential to increase demand for alternative or supplementary cementitious materials (SCM) such as GGBFS and fly ash. Also, the NESHAP likely would make fly ash (typically relatively high in mercury) less attractive as an alternative raw material for clinker manufacture and thus might increase demand for slag for this purpose.

The U.S. Environmental Protection Agency issued a proposed rule evaluating the reclassification of coal combustion byproducts, including fly ash, as hazardous waste for landfill disposal purposes but not for beneficial use purposes (U.S. Environmental Protection Agency, 2010a). Were even a limited designation as hazardous waste to stigmatize fly ash, construction market demand for this material might fall significantly. It remained unclear if the supply of GGBFS and other SCM would be adequate to fill the fly ash void, and this availability issue might work against efforts to promote increased use of these materials.

Production

The amount of slag tapped from the furnaces is not routinely measured and not all of the slag formed is tapped during a heat; accordingly, data on annual production of slag are generally unavailable. However, output levels can be broadly 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 normally will produce about 0.25 to 0.30 metric tons (t) of slag per metric ton of crude or pig iron produced. For ores of lower than average grade, the slag output will be higher, in some cases 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, but up to 50% of this slag is entrained metal, most of which would likely be recovered during slag processing and returned to the furnace. The amount of marketable steel slag remaining after entrained metal removal is thus 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 (2011, p. 121–126), U.S. blast furnace slag production in 2011 was estimated to be in the range of about 8 to 9 Mt, and world output, 263 to 328 Mt. Similarly, U.S. output of steel slag (after metal removal) in 2011 was estimated to be 9 to 13 Mt, and world output, 149 to 223 Mt. Estimated production of slag commonly will differ from total sales of slag (table 1) because of a combination of undocumented returns of slag to the furnaces, stockpiling of slag by the processors, and sales from stockpiles. Stockpiles include old slag banks from iron and steel plants long-since closed.

The commercial uses for ferrous slag are determined mainly by how the slag is cooled. Marketed blast furnace slags 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. Although it can have a vesicular texture with closed pores, the air-cooled slag is hard and dense and is especially suitable for use as construction aggregates. Formation of GBFS is by quenching molten slag in water to form sand-sized particles of glass. The disordered structure of this glass gives the material inherent moderate hydraulic cementitious properties when the slag is very finely ground (GGBFS), and the cementitious properties become strong if the material accesses free lime during hydration. In concrete having a proportion of GGBFS in the mix, hydration of portland cement releases the lime needed to fully activate the slag. Concretes incorporating GGBFS generally develop strength more slowly than concretes that contain only portland cement but can have similar or even superior long-term strength, release less heat during hydration, have reduced permeability, and generally exhibit improved resistance to chemical attack. 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, which itself is glassy. The vesicles reduce the overall density of the slag and allow for good mechanical binding with hydraulic cement paste. This slag type is most commonly used as a lightweight aggregate, but if very finely ground, it can have cementitious properties similar to those of GGBFS. Blast furnace slag (generally air-cooled) also can be made into mineral wool. For this purpose, slag 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, and this material is suitable for use as thermal insulation.

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

Consumption

Data in this report are based on an annual U.S. Geological Survey (USGS) canvass of slag processors and importers and pertain to sales of processed slag, not the amount of slag produced or even processed during the year. Processed slag is sold from stockpiles and although most of the material is a byproduct of current or recent iron and steel output or is of imported material, some slag sales are of material mined from old slag piles (slag banks) produced by iron and steel plants now closed. In 2011, canvasses were sent to 25 companies, covering 134 processing and (or) importation sites, and at least partial data (some within consolidated responses) were received for 131 sites; the reported data accounted for 98% of the total 2011 iron and steel slag tonnage for the year in table 1. In 2010, canvasses were sent to 24 companies, covering 138 sites, and at least partial data were received for 132 sites, accounting for 98% of the gross tonnage listed for the year. Because responses to the USGS canvasses vary greatly in the data detail provided and because estimates were made where needed, the data in table 1 have been heavily rounded. For both years, data on pelletized blast furnace slag have been withheld to avoid disclosing company proprietary information, but the quantities sold were very small. Sales data for granulated slag in both years exclude material sold by importers who as yet do not take part in the USGS canvass.

The data reported to the USGS for slag sales have traditionally excluded a significant fraction of the slag (both air-cooled and steel furnace) returned to the furnaces. In 2010, reporting of these furnace returns increased, thus increasing the overall sales tonnages for that year. In 2011, the overall decrease in slag sales included a 0.2 Mt (20%) decline in reported returns to furnaces—this could reflect an actual decline or a return to a more normal pattern of non- or underreporting of these flows. As in past years, the slag sales data in table 1 also exclude the free metal recovered from the slag and sold separately.

Air-cooled blast furnace slag and steel furnace slag together accounted for about 83% of total sales in 2010–11. Both of these slag types are used as aggregates in general construction (table 3), but their market areas are constrained by the location and operational status of the iron and steel furnaces and by high shipping costs for slag relative to sales prices. These factors, together with the common existence of long-term sales contracts and tendencies by processors to stockpile slag to allow bidding on large contracts, result in trends in slag consumption that commonly differ, at least in percentage change terms, from sales trends for competing natural aggregates and for cement. For example, USGS data for sales of crushed stone (largely for aggregate) decreased slightly in 2011 and sales of construction sand and gravel increased slightly (both aggregate types by about 1% only). Portland and blended cement sales (a proxy for concrete consumption) increased by 3% in 2011.

Output of crude iron and crude steel increased in 2011 by 2.8% and 5.8%, respectively (American Iron and Steel Institute, 2011, p. 121–126). Thus, slag output should have increased, but net slag sales declined in 2011 by about 2.5% mainly because of a 1 Mt or 12% decrease in steel slag sales (table 1). Price increases reported to the USGS in 2011 for both iron ore and scrap iron would have been expected to have led to higher returns of slag (an inexpensive source of metal) to the steel furnaces. However, as noted above, reported returns actually declined in 2011. It is thus unclear what share of the decrease in overall steel slag sales was from a decline in availability—either because of required stockpiling to allow for leaching or because of higher, but unreported, returns to the furnaces—as opposed to an actual decline in demand for some market applications. In contrast, air-cooled blast furnace slag sales increased in 2011 by 12%; the performance appears to reflect a combination of increased availability and growth in market share.

Air-cooled blast furnace and steel furnace slags are used primarily for a variety of aggregate applications (table 3). Because of potential expansion problems, steel slag finds little use in applications requiring maintenance of a fixed volume (for example, concrete). Both slag types also are used as a raw material for cement (clinker) manufacture (the slag contributes several major oxides), but steel slag has proven to be especially suitable for this use. Relative changes in the sales by type of use continue to be difficult to evaluate because the data incorporate estimates and much of the plant-level data reported in recent years have revealed only the dominant use(s) for the slag and thus the less common uses are likely understated. This could explain much of the large percentage increase, as a fraction of total slag sales, in sales of air-cooled slag for fill versus a similar percentage decrease for "miscellaneous" applications. Air-cooled and steel slag sales seem to have benefited from higher levels of asphaltic paving in 2011, but air-cooled slag may have lost market share as an aggregate in ready-mixed concrete; the reported slag sales tonnages for this purpose were lower in 2011 despite an increase (per higher portland cement consumption) in overall ready-mixed concrete sales. The relative decline in sales of steel slag for fill could represent a diversion of the product to asphaltic paving, a higher valued application.

Average sales prices for air-cooled blast furnace slag and for steel slag appear to have declined very slightly in 2011 (table 2); although not unexpected, the true degree of decline cannot be fully evaluated because of the incorporation of estimates within the data. Declines of just a few cents in the average prices are of no statistical significance. Major market factors affecting the prices of these two slag types are dominated by local competition from natural aggregates, the overall level of construction activity (particularly that for roads), and the existence of long-term supply contracts. Air-cooled and steel furnace slags sold for uses other than aggregates can command higher prices than slags sold as aggregates. Pelletized slag (not revealed in tables 1–3) can sell for prices well above those for air-cooled slag.

Although representing just 16% of the total sales tonnage, sales of granulated blast furnace slag (GBFS and GGBFS, combined) in 2011 accounted for 70% of the total value of slag sales and 82% of the blast furnace slag subset. Actual sales of GBFS in some years have been higher than those shown in table 1 because of some imports being missed by the USGS canvass; however, it is unclear if this was significant in 2010–11. About 92% of total reported granulated slag sales in 2010–11 was of GGBFS and the rest was GBFS. The average high unit sales value of granulated slag reflects the dominant use of GGBFS as a partial substitute for portland cement in blended cements and, especially, in concrete. Despite its relatively high unit price, GGBFS has in most years sold at a 20% to 25% discount to portland cement. The discount was closer to 15% in 2010–11, however, owing to significant declines in the price of portland cement. Overall sales of GBFS and GGBFS for cementitious use totaled 2.4 Mt in 2011, down by 4%. A small fraction of the GBFS on the market has been sourced from old slag piles and lacks cementitious character as a result of weathering; this material still has use as a fine grained aggregate in concrete, but sells for much lower prices than those indicated for the cementitious material in table 2.

No distinction is made in the USGS slag survey between granulated slag sold directly to cement companies and that (just GGBFS) sold directly to concrete companies, but data from recent USGS cement canvasses indicate that cement producers consume only about 15% of the total granulated slag sold, including that used to make clinker, blended or masonry cement, or used as a grinding aid to make portland cement. Sales in the United States of GGBFS under the designation "slag cement" are promoted by the Slag Cement Association (SCA), whose members account for much of the country's GGBFS output and sales. The SCA reported sales by its members of 2.1 Mt of GGBFS in 2011, an increase of 2.7% (Slag Cement Assoc., unpub. data, August 2012).

Foreign Trade

Most actual slag imports were of granulated slag (GBFS or GGBFS). However, import data within the granulated slag tariff code (HTS 2618.00) commonly contain entries that, based on excessively high or low unit dollar values, are likely either slags of other metallurgical industries or are unrelated materials altogether (such as silica fume, fly ash pozzolan, cenospheres from fly ash, other industrial residues, or metal concentrates). For example, although data from the U.S. Census Bureau listed imports of granulated slag totaling about 1.85 Mt in 2011, an increase of 35% from the equivalent total in 2010, the 2011 total included 0.24 Mt of material, primarily from Canada and South Africa, at listed cost-insurance-freight (c.i.f) valuations of between about $221 and $477 per metric ton, well above the unit value range of about $12 to $80 per metric ton expected for granulated slag. A similar tonnage of "expensive" material was also present in the 2010 imports. Both years also included significant tonnages of material that seem to be too inexpensive (commonly less than $10 per metric ton) to be either GBFS or GGBFS. In 2011, most of the inexpensive imports—amounting to approximately 0.20 Mt to 0.25 Mt—were of material from Japan; anecdotal information suggested that the material was copper slag. Thus, the imports in the HTS 2618.00 tariff code that were likely to actually have been granulated slag totaled about 1.4 Mt in 2011. Similarly, Census data for the more diverse import tariff code HTS 2619.00, which usually record just small tonnages of comparatively expensive metallurgical residues and metal drosses, included for 2011 nearly 0.2 Mt of material from Canada at c.i.f. prices suggestive of the material being granulated slag. Thus, for both tariff codes combined, and after deducting material unlikely to be granulated slag, overall imports of granulated slag in 2011 appeared to have been almost 1.6 Mt; this included a modest quantity of pelletized slag from Canada that was thought to have subsequently been finely ground into a product similar to GGBFS.

Comparison of the Census Bureau import data for slag with data from United Business Media Ltd. PIERS has generally revealed higher totals for PIERS in recent years, suggesting that the Census Bureau data were incomplete. However, the PIERS grand total (code 2618.00) in 2011 (1.66 Mt) was lower than the grand total from Census noted above. Although similar to the adjusted Census total for granulated slag, the PIERS data included at least 0.2 Mt of material that was unlikely to be granulated slag.

Census Bureau data for slag exports included many low tonnage shipments of very high unit value that were unlikely to be slag. Exports having unit values suggestive of granulated slag totaled only about 0.03 Mt in 2011.

Outlook

Almost all ferrous slag is consumed in the construction industry, and future slag sales will depend on construction spending levels, especially for public sector projects, perceived applicability of slag for specific construction applications, and, especially for aggregate applications, general levels of slag availability close to the construction projects. Slag sales should benefit from Government programs to promote the use of recovered mineral components in public sector construction projects but may not be able to capture a large share of this market because of limited slag availability. Slags are useful alternative raw materials for clinker production, and such use can reduce a cement plant's fuel consumption and overall emissions of carbon dioxide. Availability of sufficient slag near cement plants will continue to be a major determinant of demand for this purpose, as will the slag's chemical suitability. Long-term availability is a particular issue for blast furnace slag, as all of the U.S. blast furnaces are old, costly to operate, and require very expensive periodic major maintenance. The furnaces are part of major integrated iron and steel complexes that cannot easily financially weather major economic downturns and thus are subject to at least temporary closures such as were common in 2009. It is likely that the number of blast furnaces in operation will decline significantly in the next decade. Although blast furnace operations improved in 2010 and 2011, only 23 of the 27 remaining U.S. blast furnaces operated for at least part of 2011. Operational disruptions at the integrated complexes also affect the downstream basic oxygen furnaces and hence the availability of the steel slag from them; slag availability from electric arc furnaces, however, is more assured. Steel slag availability for the construction market is further constrained at times of high iron ore and scrap steel prices, when the steel companies tend to take back more of the slag as a ferrous feed to the furnaces.

Growing acceptance of GGBFS as a cementitious material should ensure a steady or increasing market share for this slag type. However, the supply of GBFS from domestic blast furnaces remains severely constrained by the fact that granulation cooling at yearend 2011 was installed at only four blast furnaces in the United States, and the grinding plant for one of these relied on outside sources for about two-thirds of the GBFS it consumed. Installation of granulators at other domestic blast furnaces is possible but very unlikely; it is expensive and would depend upon the perception of the specific furnace's future viability. Furthermore, not all blast furnaces produce a slag that is chemically suitable for GGBFS. Thus, future increases in GGBFS sales will depend on the availability of imported GGBFS or GGBFS ground from imported granules.

Changes in environmental rules governing the manufacture of portland cement and, potentially, the characterization of fly ash could increase the demand for slag as an alternative raw material for clinker manufacture and as an SCM.

References Cited

American Iron and Steel Institute, 2011, Annual statistical report: Washington, DC, American Iron and Steel Institute, 126 p.

U.S. Environmental Protection Agency, 2010a, Hazardous and solid waste management system; identification and listing of special wastes; disposal of coal combustion residuals from electric utilities: Federal Register, 40 CFR Parts 257, 261, 264, 265, 268, 271, and 302, v. 75, no. 118, June 21, p. 35128–35264.

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GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publication

Iron and Steel Slag. Ch. in Mineral Commodity 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)

	2010					2011				
	Blast furnace slag[1]			Steel	Total iron	Blast furnace slag[1]			Steel	Total iron
	Air-cooled	Granulated	Total	furnace slag[r]	and steel slag[r, 2]	Air-cooled	Granulated	Total	furnace slag	and steel slag[2]
Quantity	4.9	2.6	7.5	8.3	15.8	5.5	2.5	8.0	7.3	15.4
Value[e]	37	186	222	45	267	39	179	219	38	257

[e]Estimated. [r]Revised.

[1]Excludes expanded (pelletized) slag to protect company proprietary data. The quantities are very small (about 0.1 unit or less).

[2]Data may not add to totals because of independent rounding.

TABLE 2

SELLING PRICES FOR IRON AND STEEL SLAG IN THE UNITED STATES[1]

(Dollars per metric ton)

	2010		2011	
Slag type	Range	Average	Range	Average
Blast furnace slag:				
Air-cooled	3.34–18.40	7.48	2.20–18.46	7.14
Granulated[2]	16.53–102.69	74.51	9.92–107.21	74.25
Steel furnace slag	0.02–24.25	5.37	0.02–25.53	5.18

[1]Data contain a large component of estimates and some respondents provide values only on their total sales of a slag type, not value by type of use. Thus, the value ranges shown are likely too restrictive.

[2]Values are for material reported for use as a cementitious additive in cement or concrete manufacture. Material at or near the low end of the range was sold in unground form. Sales other than for cementitious use were generally at unit values below the ranges shown.

TABLE 3

SALES OF FERROUS SLAGS IN THE UNITED STATES, BY USE[1]

(Percentage of total tons sold)

	2010			2011		
	Blast furnace slag[2]		Steel	Blast furnace slag[2]		Steel
Use	Air-cooled	Granulated	slag	Air-cooled	Granulated	slag
Ready-mixed concrete	13.4	--	--	11.1	--	--
Concrete products	4.3	--	--	5.1	--	--
Asphaltic concrete	17.6	--	3.6 r	19.3	--	12.1
Road bases & surfaces	37.6	4.4	42.5 r	38.7	4.5	46.8
Fill	4.7	--	32.3 r	13.3	--	19.3
Cementitious material	--	95.1	--	--	95.0	--
Clinker raw material	0.4	(3)	2.4 r	0.8	--	4.7
Miscellaneous[4]	12.0	0.5	0.3	6.6	0.5	--
Other or unspecified[5]	10.0	--	18.9 r	5.1	(3)	17.1

[r]Revised. -- Zero.

[1]A number of respondents provide breakouts that represent only the dominant use(s) of their slag; accordingly, the minor use categories are likely underreported. The data also incorporate some estimates and thus should be viewed as accurate to no more than two significant figures.

[2]Excludes expanded or pelletized slag; this material is generally sold as a lightweight aggregate.

[3]Less than 0.1%.

[4]Reported as used for railroad ballast, roofing, mineral wool, or soil conditioner.

[5]Including return to furnaces (likely underreported) and other uses.

TABLE 4

PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2011

			Slag and furnace types[1]					
			Blast furnace slag			Steel furnace slag		
Slag processing company	Plant location	Steel company serviced[2, 3]	AC	GG	Exp	BOF	OHF	EAF
Alexander Mill Services Inc.	Hollsopple, PA	North American Höganäs, Inc.						X
Ash Grove Cement Co.	Portland, OR	Foreign		X				
Barfield Enterprises, Inc.	LaPlace, LA	ArcelorMittal USA						X
Beaver Valley Slag	Aliquippa, PA	Old slag pile site	X			X	X	
Beelman Truck Co.	Granite City, IL[4]	United States Steel Corp.	X					
Beemsterboer Slag Corp.	East Chicago, IN	ArcelorMittal USA (“East side”)	X					
Do.	Gary, IN	United States Steel Corp.	X			X		
Blackheart Slag Co.	Muscatine (Montpelier), IA	SSAB North America						X
City Slag LLC	Sharon, PA	Old slag pile site					X	
Dragon Products Co., Inc.	Thomaston, ME	Miscellaneous domestic & foreign		X				
Edward C. Levy Co.	Decatur (Trinity), AL	Nucor Corp.						X
Do.	Butler, IN	Steel Dynamics, Inc.						X
Do.	Columbia City, IN	do.						X
Do.	Crawfordsville, IN	Nucor Corp.						X
Do.	East Chicago (Indiana Harbor), IN	ArcelorMittal USA (“West side”)	X					
Do.	Detroit (Dearborn), MI	Severstal North America, Inc.	X			X		
Do.	Detroit (Ecorse), MI	United States Steel Corp.	X			X		
Do.	Columbus, MS	Severstal North America, Inc.						X
Do.	Canton, OH	The Timken Co.						X
Do.	Delta, OH	North Star BlueScope Steel LLC						X
Do.	Huger, SC	Nucor Corp.						X
Do.	Memphis, TN	do.						X
Do.	Seattle, WA	do.						X
Essroc Corp.	Middlebranch, OH	Miscellaneous domestic & foreign		X				
Fritz Enterprises, Inc.	Fairfield, AL[5]	United States Steel Corp.	X	X		X		
Do.	Sparrows Point, MD	RG Steel LLC[6]	X					
Gerdau Longsteel North America	Jacksonville, FL	Gerdau Longsteel North America						X
Do.	Charlotte, NC	do.						X
Harsco Metals Corp.	Birmingham, AL	SMI/CMI Steel Group						X
Do.	Blytheville, AR	Nucor Corp.						X
Do.	Blytheville (Armorel), AR	Nucor-Yamato Steel Co.						X
Do.	Pueblo, CO	Evraz Inc. NA						X
Do.	Wilton (Muscatine), IA	SSAB North America						X
Do.	Pittsboro, IN	Steel Dynamics, Inc.						X
Do.	Ghent, KY	Gallatin Steel Co.						X
Do.	do.	North American Stainless						X
Do.	Ahoskie (Cofield), NC	Nucor Corp.						X
Do.	Warren, OH	RG Steel LLC[6]				X		
Do.	Brackenridge, PA	Allegheny Ludlum Corp.						X
Do.	Butler, PA	AK Steel Corp.						X

See footnotes at end of table.

TABLE 4—Continued

PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2011

			Slag and furnace types[1]					
			Blast furnace slag			Steel furnace slag		
Slag processing company	Plant location	Steel company serviced[2, 3]	AC	GG	Exp	BOF	OHF	EAF
Harsco Metals Corp.—Continued:	Koppel, PA	TMK IPSCO						X
Do.	Latrobe, PA	Allegheny Ludlum Corp.						X
Do.	Midland, PA	Allegheny Ludlum Corp.						X
Do.	Steelton, PA	ArcelorMittal USA						X
Do.	Midlothian, TX	Gerdau Longsteel North America						X
Do.	Geneva (Provo), UT	Old slag pile site	X			X		
Holcim (US) Inc.	Birmingham (Fairfield), AL[5]	United States Steel Corp.		X				
Do.	Camden, NJ	Foreign		X				
Do.	Gary, IN	United States Steel Corp.		X				
Lafarge North America Inc.	South Chicago, IL	ArcelorMittal USA		X				
Do.	East Chicago (Indiana Harbor), IN[7]	do.		X	X			
Do.	Sparrows Point, MD	RG Steel LLC[6]	X	X				
Do.	Cleveland (Cuyahoga Co.), OH[4]	ArcelorMittal USA	X					
Do.	Lordstown, OH	Old slag pile site		X				
Do.	McDonald, OH	do.	X					
Do.	Salt Springs (Youngstown), OH	do.	X					
Do.	West Mifflin (Duquesne), PA	United States Steel Corp. (ET Works)	X					
Do.	Seattle, WA	Foreign		X				
Lehigh Hanson, Inc.	Cementon, NY	do.		X				
Do.	Evansville, PA	do.		X				
Do.	San Francisco, CA	do.		X				
Lehigh/Hanson Slag Cement, Inc.	Cape Canaveral, FL	do.		X				
The Levy Co., Inc.	Burns Harbor, IN[8]	ArcelorMittal USA	X			X		
Mountain Materials, Inc.	Ashland, KY[4]	AK Steel Corp.	X					
Phoenix Services LLC	Riverdale, IL	ArcelorMittal USA				X		
Do.	Indiana Harbor, East Chicago, IN[9]	do.				X		
Do.	Burns Harbor, IN[8]	do.	X			X		X
Do.	Wilton, IA	Gerdau Longsteel North America						X
Do.	Sparrows Point, MD	RG Steel LLC[6]				X		
Do.	Cool Springs/Steubenville, OH	Old slag pile site				X		
Do.	Warren, OH	RG Steel LLC[6]	X					
Do.	Johnstown, PA	Old slag pile site	X					
Do.	Latrobe, PA	Latrobe Specialty Steel Co.						X
Do.	Georgetown, SC[10]	ArcelorMittal USA						X
Do.	Vinton (El Paso), TX	do.						X
Do.	Roanoke, VA	Steel Dynamics, Inc.						X
Do.	Weirton, WV	Old slag pile site					X	
Recmix of PA, Inc.	Ghent, KY	North American Stainless						X
Do.	Sarver (Brackenridge), PA	Allegheny Ludlum Corp.						X

See footnotes at end of table.

TABLE 4—Continued
PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2011

			Slag and furnace types[1]					
			Blast furnace slag			Steel furnace slag		
Slag processing company	Plant location	Steel company serviced[2, 3]	AC	GG	Exp	BOF	OHF	EAF
St. Marys Cement Inc.	Detroit, MI	do.		X				
Do.	Milwaukee, WI	Domestic and foreign		X				
Stein, Inc.	Alton, IL	Alton Steel Inc.						X
Do.	Granite City, IL[4]	United States Steel Corp.	X			X		
Do.	Sterling, IL	Sterling Steel Co., LLC						X
Do.	Ashland, KY[4]	AK Steel Corp.	X			X		
Do.	Canton, OH	Republic Engineered Products, Inc.						X
Do.	Cleveland, OH[4]	ArcelorMittal USA	X			X		
Do.	Loraine, OH	Republic Engineered Products, Inc.	X			X		
Do.	Mansfield, OH[6]	AK Steel Corp.				X		
Do.	Coatsville, PA[6]	ArcelorMittal USA						X
Do.	Georgetown, SC[10]	Georgetown Steel Corp.						X
Tube City IMS, LLC	Axis, AL	SSAB North America						X
Do.	Birmingham, AL	Nucor Corp.						X
Do.	Tuscaloosa, AL	do.						X
Do.	Mesa, AZ	CMC Steel Group						X
Do.	Fort Smith, AR	Gerdau Special Steel North America						X
Do.	Rancho Cucamonga, CA	Gerdau Longsteel North America						X
Do.	Claymont, DE	Evraz Inc. NA						X
Do.	Cartersville, GA	Gerdau Longsteel North America						X
Do.	Kankakee, IL	Nucor Corp.						X
Do.	Peoria, IL	Keystone Steel & Wire Co.						X
Do.	Gary, IN	United States Steel Corp.				X		
Do.	Portage, IN	NLMK Indiana						X
Do.	Ashland, KY	Kentucky Electric Steel LLC						X
Do.	Jackson, MI	Gerdau Special Steel North America						X
Do.	Monroe, MI	do.						X
Do.	St. Paul, MN	Gerdau Longsteel North America						X
Do.	Jackson, MS	Nucor Corp.						X
Do.	Norfolk, NE	do.						X
Do.	Perth Amboy, NJ	Gerdau Longsteel North America						X
Do.	Sayreville, NJ	do.						X
Do.	Auburn, NY	Nucor Corp.						X
Do.	Marion, OH	do.						X
Do.	Middletown, OH	AK Steel Corp.	X			X		
Do.	Mingo Junction, OH	RG Steel LLC[6]	X			X		X
Do.	Youngstown, OH	V&M Star						X
Do.	McMinnville, OR	Cascade Steel Rolling Mills, Inc.						X
Do.	Braddock, PA	United States Steel Corp.				X		
Do.	Bridgeville, PA	Universal Stainless & Alloy Products, Inc.						X

See footnotes at end of table.

TABLE 4—Continued

PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2011

			Slag and furnace types[1]					
			Blast furnace slag			Steel furnace slag		
Slag processing company	Plant location	Steel company serviced[2, 3]	AC	GG	Exp	BOF	OHF	EAF
Tube City IMS, LLC—Continued:	New Castle, PA	Ellwood Quality Steels Co.						X
Do.	Park Hill (Johnstown), PA	Old slag pile site	X				X	
Do.	Pricedale, PA	do.				X		
Do.	Reading, PA	Carpenter Technology Corp.						X
Do.	Cayce, SC	CMC Steel Group						X
Do.	Darlington, SC	Nucor Corp.						X
Do.	Jackson, TN	Gerdau Longsteel North America						X
Do.	Knoxville, TN	do.						X
Do.	Beaumont, TX	do.						X
Do.	Jewett, TX	Nucor Corp.						X
Do.	Lone Star, TX	Lone Star Steel Co.						X
Do.	Longview, TX	LeTourneau Technologies Steel Products						X
Do.	Seguin, TX	SMI/CMC Steel Group						X
Do.	Plymouth, UT	Nucor Corp.						X
Do.	Petersburg, VA	Gerdau Longsteel North America						X
Do.	Saukville, WI	Charter Steel						X
Uniserve LLC	Newport, AR	Arkansas Steel Associates, LLC						X
Do.	Gallatin, TN	Hoeganaes Corp.						X
Vulcan Materials Co.	Tampa, FL	Foreign		X				

Do., do. Ditto.

[1]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.

[2]"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." "Domestic" implies grinding slag sourced from the domestic market, not a service contract.

[3]Currently operating iron and (or) steel company. Company is not shown for old slag pile sites.

[4]For the air-cooled slag, Stein was responsible for the cooling but the processing and marketing were handled by Beelman Truck Co. (Granite City, IL), Lafarge Corp. (Cleveland, OH), and Mountain Enterprises, Inc. (Ashland, KY).

[5]For granulated slag, Fritz Enterprises operates the granulator but Holcim (US) Inc. owns the apparatus and markets the slag.

[6]The facility was purchased by RG Steel LLC from Severstal North America in March 2011.

[7]Lafarge grinds some of the granulated slag from East Chicago, IN, at several of its cement plants located elsewhere.

[8]The processing contract at Burns Harbor, IN, was transferred to Phoenix Services at yearend 2011.

[9]Both "east" and "west" sides.

[10]The processing contract at Georgetown, SC, was transferred to Phoenix Services in March 2011.