ABRASIVES, MANUFACTURED

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Abrasives play an important role in most manufacturing processes because most end products require some degree of finishing. Abrasives are natural or manufactured substances that are used to abrade, clean, etch, grind, polish, scour, or otherwise remove solid material by rubbing action (as in a grinding wheel) or impact (as in pressure blasting). The most important physical properties for abrasives are hardness ("scratch" hardness), toughness (or rigidity), friability, grain shape and size, character of fracture (or cleavage), and purity (uniformity). Additional considerations include thermal stability, bonding characteristics, cost, and availability. Manufactured abrasives are made from metals or minerals by heating or chemically treating them to enhance or give them abrasive physical properties. No single property is paramount for any use (Wellborn, 1996).

Manufactured abrasives generally dominate high-grade abrasive markets as opposed to natural abrasives because they have superior physical properties and more uniform quality and can be tailored to meet user needs. Consequently, manufactured abrasives typically are characterized by premium prices relative to natural abrasive minerals. Even though manufactured abrasives are more expensive, their durability and efficiency have proven to be more cost-effective. Therefore, they are preferred in many industrial applications, such as metal finishing, cutting, and polishing.

This report presents information on the following abrasives manufactured in the United States: alumina-zirconia oxide, boron carbide, fused aluminum oxide, metallic shot and grit, and silicon carbide. In some cases, U.S. production data were combined with Canadian output to protect proprietary information. Trade data in this report are from the U.S. Bureau of the Census. Quantities are reported in metric units, unless otherwise noted.

Combined U.S. and Canadian production of aluminum oxide and silicon carbide declined in 1999 from that of 1998. Imports of crude, ground, and refined silicon carbide and of ground and refined aluminum oxide decreased. U.S. metallic abrasives production increased compared with that of 1998.

Fused Aluminum Oxide

Legislation and Government Programs.—On January 1, 1999, the National Defense Stockpile (NDS) maintained by the U.S. Department of Defense (DOD) contained 126,486 metric tons (t) of crude fused aluminum oxide valued at $16.2 million and 21,646 t of fused aluminum oxide abrasive grain valued at $7.4 million. During 1999, the DOD sold 49,603 t of NDS crude fused aluminum oxide valued at $6.2 million and 2,725 t of NDS aluminum oxide abrasive grain valued at $1.1 million. Under Federal legislation that authorizes the disposal of all NDS aluminum oxide, the DOD planned to continue such sales until all the stockpiled aluminum oxide is sold. All the stockpiled aluminum oxide will be sold before 2004 if the current disposal rate and NDS sales schedules are continued.

Production.—The production data for fused aluminum oxide in this report were obtained by the U.S. Geological Survey (USGS) from producers in the United States and Canada. The data were collected from three companies that operated six plants and represented the entire United States and Canadian fused aluminum oxide industry (table 1). Two of the companies operated fused aluminum oxide plants in the United States and Canada; data from the two countries were combined to protect company proprietary information.

Estimated production of regular-grade fused aluminum oxide in 1999 was 92,600 t, which was a decrease of 7% compared with that of 1998 (table 2). Reporting on the output of high-purity fused aluminum oxide was discontinued to avoid disclosing company proprietary data.

Consumption.—Abrasive-grade fused aluminum oxide has many end uses. Specific applications in 1999 included bonded abrasives (such as abrasive grains that are made to adhere to each other and then are pressed or molded into abrasive tools), coated abrasives (such as abrasive grains glued to a backing of paper or cloth), tumbling media, air or water blasting media, polishing/buffing compounds, and antislip additives. The total value of fused aluminum oxide abrasive grain consumed in the United States was estimated to be at least $120 million in 1999.

Prices.—The USGS surveyed fused aluminum oxide producers to determine value of production. The survey indicated that the average value of regular fused aluminum oxide produced in the United States and Canada during 1999 was $351 per metric ton at the point of production; the average value of high-purity fused aluminum oxide output was $425 per ton at the point of production. Prices of abrasive grain produced from these materials and sold to consumers were significantly higher.

The average price of NDS crude fused aluminum oxide sold by the DOD in 1999 was $125 per ton. The average price of stockpiled fused aluminum oxide grain sold in 1999 was $404 per ton. The lower values compared with those of producers reportedly reflected the lower quality and the less suitable locations of some stockpiled material.

Values of fused aluminum oxide trade by the United States in 1999 are summarized as follows: Almost all the crude fused aluminum oxide imports during the year ranged from $218 per ton (China) to $565 per ton (Venezuela). Values of fused aluminum oxide grain imports ranged from $273 per ton (China) to $1,378 per ton (France). Values reported for U.S. exports of fused aluminum oxide during the year generally exceeded $2,260 per ton.

Foreign Trade.—Compared with 1998 exports of all fused aluminum oxides, 1999 exports increased slightly to 9,020 t valued at $20.4 million. Of exports shipped to 29 countries, 69% went to Canada, Germany, and Mexico.

During 1999, imports of crude fused aluminum oxide were received from 10 countries and decreased by 28% to 91,400 t valued at $31.5 million, and imports of ground and refined fused aluminum oxide were received from 18 countries and increased by 41% to 74,400 t valued at $47 million (table 5). Some of the imported crude fused aluminum oxide was refractory-grade material. Canada and China supplied 61% and 34%, respectively, of the crude imports. China provided 32% of the ground and refined material.

Silicon Carbide

Legislation and Government Programs.—On January 1, 1999, the NDS contained 1,243 t of silicon carbide valued at $0.5 million. Under Congressional authority to dispose of all NDS silicon carbide, the DOD sold all this remaining stockpiled silicon carbide during the first quarter of the year. The DOD was not expected to replenish the stockpile with silicon carbide.

Production.—Two companies produced abrasive-grade silicon carbide in Canada and the United States during 1999 (table 1). These companies also produced similar amounts of metallurgical-grade silicon carbide. Another company in Hopkinsville, KY, produced a small quantity of silicon carbide, but the output primarily was intended for use in heat-resistant products rather than abrasives.

Consumption.—Abrasive-grade silicon carbide has many end uses. Specific applications in 1999 included antislip abrasives, blasting abrasives, bonded abrasives, coated abrasives, polishing/buffing compounds, tumbling media, and wiresawing abrasives. The total value of silicon carbide consumed in the United States was estimated to be at least $180 million in 1999 (Anwar, 2000).

Prices.—The USGS does not collect price data on the various grades of silicon carbide. On the basis of information from industry sources and publications, however, the average value of abrasive-grade silicon carbide at the point of manufacture was estimated to be about $600 per ton in 1999.

The average price of NDS silicon carbide sold by the DOD in 1999 was $402 per ton. The lower values compared with those of producers reportedly reflected the lower quality and the less suitable locations of some stockpiled silicon carbide.

During 1999, imports from China accounted for 79% of total U.S. crude silicon carbide imports and had an average value of $271 per ton; the average value of the remaining 21% of U.S. crude silicon carbide imports was $634 per ton. The average value of silicon carbide grain imports was $1,820 per ton; China accounted for 25% of such imports. The average value of total silicon carbide exports in 1999 was approximately $1,275 per ton.

Foreign Trade.—During 1999, the United States exported crude silicon carbide to 17 countries and exported refined or ground silicon carbide to 24 countries. The total value of crude silicon carbide exports for 1999 declined by 17% to $2.5 million from the total value for 1998. Compared with 1998 exports of refined or ground silicon carbide, 1999 exports declined slightly to 8,255 t valued at $8.5 million. Approximately 44% of the crude exports went to the Mexico, and about 82% of the refined or ground material was shipped to Canada.

In 1999, the United States imported crude silicon carbide from 11 countries and imported ground or refined silicon carbide from 18 countries. Imports of crude silicon carbide declined by 34% during the year to 155,000 t valued at $53.6 million (table 5). Imports of silicon carbide in ground or refined form declined by 59% to 25,900 t valued at $25.9 million.

China accounted for 79% of the crude silicon carbide imports and 25% of the ground or refined silicon carbide. A large part of the Chinese imports, however, reportedly included metallurgical-grade material.

Aluminum-Zirconium Oxide

During 1999, Norton Company (James Chenard, Norton Company, oral commun., 2000) and Washington Mills Electro Minerals Corp. produced fused aluminum-zirconium oxide for abrasive applications (such as resin-bonded grinding wheels); output was from two plants in the United States and one plant in Canada (Martin Wozniak, Washington Mills Electro Minerals Corp., oral commun., 2000). To avoid disclosing company proprietary information, the USGS does not publish aluminum-zirconium oxide production data received from the producers.

Boron Carbide

Only one firm, Washington Mills Electro Minerals Corp., was a commercial producer of boron carbide in the United States during 1999 (Martin Wozniak, Washington Mills Electro Minerals Corp., oral commun., 2000). Boron carbide was used for grinding and lapping operations previously possible only with diamond dust; it also was molded to form very wear-resistant products, such as pressure blast nozzle liners and extrusion dies.

To avoid disclosing company proprietary information, domestic production data for boron carbide are not reported here. However, the following trade information on boron carbide was available: the United States imported 342 t of boron carbide valued at $7.6 million from 7 countries, primarily Germany, Ukraine, and China, and exported 16.7 t valued at $652,000 to 16 nations in 1999.

Metallic Abrasives

Production.—Data in this report on U.S. production and shipments of metallic abrasives were based on a survey of domestic producers conducted by the USGS. Survey data were collected from 12 companies operating 14 plants in the United States and accounted for all the domestic industry (table 3). After purchasing a metals abrasive plant in Mexico at yearend 1998, Wheelabrator Abrasives, Inc. announced that the

acquired plant will serve markets in the United States as well as Mexico (Wheelabrator Abrasives, Inc., 1999). However, the plant had not begun production as of July 2000 (William Rhodaburger, Ervin Industries, Inc., oral commun., 2000).

Steel shot and grit account for almost all metallic abrasives produced domestically (table 4). Sustained by a strong industrial economy, U.S. production of steel shot and grit increased slightly compared with that of 1998; the average value per ton was $439. Six companies reported production of cut wire shot in 1999. Most of the shot was cut from carbon steel wire and stainless steel wire; other products reportedly included shot cut from aluminum, copper, and zinc wire.

Consumption.—Metal abrasives are used primarily as loose particles propelled at high velocities for blast cleaning or to improve the properties of metal surfaces; approximately three-fourths of the abrasives are employed in cleaning operations. Principal consumers include foundries, steel manufacturers, machine tool industries, and metalworking plants, particularly those supporting the automotive and aircraft industries.

During 1999, total sales of all steel shot and grit by U.S. producers increased slightly compared with shipments in the preceding year. The average value per ton sold or used during 1999, however, decreased slightly to $458.

Prices.—Although the USGS compiles survey data on the value of production and shipments, it does not collect price data. Values of production and shipments reported by metallic abrasive producers in 1999 are shown in table 4. Restrained by import competition, prices of steel shot and grit were estimated to be about $0.35 to $0.60 per kilogram in 1999. Estimated average prices of cut wire shot in 1999 were $3.40 to $7.00 per kilogram for aluminum wire shot and $2.75 to $7.00 per kilogram for stainless steel wire shot.

Average values for metallic abrasives traded by the United States during 1999 were as follows: exports averaged $0.67 per kilogram, and imports averaged $0.50 per kilogram.

Foreign Trade.—During 1999, the United States exported metallic abrasives to 31 countries and imported metallic abrasives from 13 countries. U.S. exports of metallic abrasives increased slightly during the year to 26,600 t valued at $17.9 million. Most of the exports went to Canada; the remaining amount was shipped to Belgium, Japan, Mexico, and the United Kingdom.

Domestic imports of metallic abrasives increased by 17% in 1999 to 30,100 t valued at $15 million. About 83% of the imports came from Canada; most of the remaining imports were shipped from Germany and the United Kingdom.

Outlook

Several economic and technological trends will continue to influence the manufacturing of abrasive materials in the United States. Cheaper imports and higher domestic costs will challenge U.S. producers of fused aluminum oxide and silicon carbide. Continued competition from developing nations, especially China, could further curtail domestic output. More consolidation and contraction of traditional suppliers among the Western industrialized nations is expected.

Markets for metal abrasives will be influenced by technological improvements in industries where they are used. For example, better metal casting methods that achieve near-finish surfaces will reduce demand for some abrasives. Less metal abrasive will be needed in foundries where new chemical cleaning and finishing techniques are employed (Ted Giese, Abrasive Engineering Society, oral commun., 1998).

Emerging suppliers of fused aluminum oxide and/or silicon carbide in China, Eastern Europe, India, the Republic of Korea, and South America will continue to increase their prominence in world markets. Further success for these suppliers, particularly in major markets, such as Japan, the United States, and Western Europe, will depend on their ability to provide higher grades of material and supply reliability while maintaining lower prices. Energy costs, furnace size, quality-control systems, and the availability of essential mineral inputs will be the dominant factors influencing the competitive stance of these suppliers (O'Driscoll, 1997; Zhilun, 1997; Lunghofer and Wolfe, 1998).

Motor vehicle manufacturing will remain a significant, although indirect, influence on demand for manufactured abrasives that are used by metalworking operations supporting the industry. Curbs on metals consumption by the industry (substitution by plastics, downsizing of automobiles, etc.) are important factors to be considered in long-range demand forecasts for manufactured abrasives.

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[1] Prior to January 1996, Published by the U.S. Bureau of Mines.

TABLE 1
CRUDE ARTIFICIAL ABRASIVES MANUFACTURERS, 1999

Company	Location	Product
The Exolon-Esk Co.	Hennepin, IL	Silicon carbide.
Do.	Thorold, Ontario, Canada	Fused aluminum oxide (regular).
Norton Company	Huntsville, AL	Fused aluminum oxide (high-purity) and aluminum-zirconium oxide.
Do.	Worcester, MA	General abrasive processing.
Do.	Chippewa, Ontario, Canada	Fused aluminum oxide (regular and high-purity) and aluminum-zirconium oxide.
Do.	Shawinigan, Quebec, Canada	Silicon carbide.
Washington Mills Electro Minerals Corp.	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular).
Do.	Niagara Falls, NY	Fused aluminum oxide (high-purity).
Washington Mills Ltd.	do.	Fused aluminum oxide (regular).

TABLE 2
PRODUCTION OF CRUDE SILICON CARBIDE AND FUSED ALUMINUM OXIDE
IN THE UNITED STATES AND CANADA 1/

	1998			1999		
Product	Quantity (metric tons)	Value (thousands)	Yearend stocks (metric tons)	Quantity e/ (metric tons)	Value e/ (thousands)	Yearend stocks (metric tons)
Silicon carbide 2/	W	W	W	69,800	$41,900	W
Aluminum oxide, regular, abrasives 3/	99,600 e/	$36,000 e/	5,830	92,600	32,500	W

e/ Estimated. W Withheld to avoid disclosing company proprietary data.
1/ Data are rounded to no more than three significant digits.
2/ Approximately one-half of the quantity and value consists of material for metallurgical and other nonabrasive applications.
3/ Regular grade normally accounts for about 85% of total output, and high-purity material accounts for the remainder.

TABLE 3
U.S. PRODUCERS OF METALLIC ABRASIVES, 1999

Company	Location	Product (shot and/or grit)
Chesapeake Specialty Products	Baltimore, MD	Steel.
Ervin Industries, Inc.	Adrian, MI	Do.
Do.	Butler, PA	Do.
Do.	do.	Do.
Frohn North America, Inc.	Austell, GA	Cut wire.
Marwas Steel Co.	Scottdale, PA	Do.
Metaltec Steel Abrasives Co.	Canton, MI	Steel.
National Metal Abrasive Inc.	Wadsworth, OH	Do.
Peerless Metal Powders & Abrasive	Detroit, MI	Do.
Pellets, Inc.	Tonawanda, NY	Cut wire.
The Platt Brothers, Inc.	Waterbury, CT	Do.
Premier Shot Co.	Cleveland, OH	Do.
U.S. Filter Abrasive Materials	Fortville, IN	Cut wire, steel.
Wheelabrator Abrasives, Inc.	Bedford, VA	Steel.

TABLE 4
ANNUAL PRODUCTION AND SHIPMENTS FOR METALLIC
ABRASIVES IN THE UNITED STATES, BY PRODUCT 1/

Product	Production		Shipments 2/	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1998:				
Steel shot and grit	265,000	$116,000	277,000	$124,000
Cut wire shot and other e/	2,150	10,600	2,140	10,700
Total	267,000	127,000	279,000	135,000
1999:				
Steel shot and grit	278,000	122,000	282,000	122,000
Cut wire shot and other e/	2,010	7,150	2,010	7,170
Total	280,000	129,000	284,000	130,000

e/ Estimated.
1/ Data are rounded to no more than three significant digits; may not add to totals shown.
2/ Includes reported exports.

TABLE 5
U.S. IMPORTS OF ALUMINUM OXIDE AND SILICON CARBIDE, BY COUNTRY AND TYPE 1/

Country	1998		1999	
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
Crude aluminum oxide:				
Canada	87,600	$38,800	55,600	$22,400
China	39,300	8,100	31,200	6,800
Russia	--	--	1,320	638
Venezuela	--	--	2,600	1,470
Other	253	346	566	249
Total	127,000	47,200	91,400	31,500
Ground and refined aluminum oxide:				
Austria	5,590	7,240	8,910	12,200
Brazil	5,870	4,520	6,900	4,850
Canada	2,120	968	22,500	8,390
China	27,600	7,400	23,600	6,440
France	795	936	1,660	2,290
Germany	7,580	9,800	7,380	8,640
Italy	1,450	1,460	1,210	1,140
Slovenia	868	577	1,110	699
Other	935 r/	1,980 r/	1,130	2,380
Total	52,800	34,900	74,400	47,000
Crude silicon carbide:				
Canada	26,100	17,600	27,100	17,800
China	196,000	56,900	123,000	33,200
Russia	7,680	3,560	3,960	1,690
Venezuela	1,200	673	616	282
Other	2,440	3,070	523	635
Total	234,000	81,800	155,000	53,600
Ground and refined silicon carbide:				
Brazil	2,270	1,470	2,300	1,840
Canada	253	180	247	78
China	25,900	7,500	3,490	2,540
Germany	1,670	6,690	1,470	5,630
Japan	1,090	6,020	1,250	7,570
Norway	2,490	7,170	2,600	5,890
Mexico	340	535	347	383
Russia	234	158	2,070	839
Other	329 r/	2,100 r/	473	1,130
Total	34,600	31,800	14,200	25,900

r/ Revised. -- Zero.
1/ Data are rounded to no more than three significant digits; may not add to totals shown.
2/ Customs value.

Source: Bureau of the Census.