

ABRASIVES, MANUFACTURED

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This report includes information on the following abrasives manufactured in the United States: aluminum-zirconium oxide, boron carbide, fused aluminum oxide, metallic shot and grit, and silicon carbide. In some cases, United States production data were combined with Canadian output to avoid disclosing company proprietary data and still provide useful data on the overall Canadian-United States market. Trade data in this report are from the U.S. Census Bureau. Quantities are reported in metric units unless otherwise noted. All percentages in the report were computed using the unrounded data.

Abrasives play an important role in the fashioning and finishing of many products with a wide range of end uses. 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 character of fracture (cleavage), friability, grain shape and size, hardness (scratch hardness), purity (uniformity), and toughness (rigidity). Additional considerations include availability, bonding characteristics, cost, and thermal stability. Manufactured abrasives are made from metals or minerals by heating or chemically treating them to enhance or give them abrasive properties. No single property is paramount for any use (Wellborn, 1996, p. 31, 43).

Manufactured abrasives generally dominate high-grade abrasive markets as opposed to natural abrasives because they have superior physical properties, more uniform quality, and can be tailored to meet users' needs. Consequently, manufactured abrasives typically are characterized by premium prices relative to natural abrasive minerals. Even though manufactured abrasives are usually more expensive, their durability and efficiency have proven to be more cost effective. They are preferred in many industrial applications, such as metal finishing, cutting, and polishing. In the United States, large volumes of abrasives also are used in cutting and finishing wallboard and timber. The abrasives market is mature, and the use of various manufactured abrasive materials is fairly well defined by application (Kendall, 2001, p. 55).

Fused Aluminum Oxide

Legislation and Government Programs.—As of January 1, 2004, the National Defense Stockpile (NDS) maintained by the U.S. Department of Defense (DOD) contained 13,800 metric tons (t) of fused aluminum oxide abrasive grain valued at about \$6.5 million. During 2003, the DOD reported sales of 2,359 t of NDS aluminum oxide abrasive grain for about \$643,000. All of the NDS crude fused aluminum oxide was sold during 2000. Under Federal legislation authorizing the disposal of all NDS aluminum oxide, the DOD planned to continue such sales until all the stockpiled aluminum oxide was sold (Janet

Rollins, market analyst, Defense National Stockpile Center, oral commun., 2004).

Production.—Production data for regular and high-purity fused aluminum oxide in this report were obtained by the U.S. Geological Survey (USGS) from producers in Canada and the United States. The data were collected from two companies that operated three plants and represented the entire Canadian and United States fused aluminum oxide industry (table 1). During 2003, two aluminum oxide plants permanently closed down their operations after both had been on strike for more than a year. One of these plants was Canadian, and it closed in February. The other plant was in the United States, and it closed in July. Washington Mills Electro Minerals Corp. operated fused aluminum oxide plants in Canada and the United States. Data from the two countries were combined to protect company proprietary information.

Estimated production of regular-grade fused aluminum oxide in 2003 was 20,000 t with an estimated value of \$5.8 million. This was about the same weight and about 9% more in value compared with 2002 regular-grade fused aluminum oxide production (table 2). Reporting on the output of high-purity fused aluminum oxide has been discontinued to avoid disclosing company proprietary data.

Consumption.—In all sections of this report, consumption is defined as apparent consumption, which is domestic production plus imports minus exports plus adjustments for Government and industry stock changes. Abrasive-grade fused aluminum oxide has many end uses. Specific applications in 2003 included antislip additives, bonded abrasives (such as abrasive grains that are made to adhere to each other and then are pressed or molded into abrasive tools), buffing/polishing compounds, coated abrasives (such as abrasive grains glued to a backing of paper or cloth), dry or wet blasting media, and tumbling media. Fused aluminum oxide in a micropowder form was used for industrial and electronic applications that require fine surface finishing. Fused aluminum oxide does not face any significant substitution threats at present as it is generally a very cost-effective abrasive. The total value of fused aluminum oxide abrasive grain consumed in the United States was estimated to be \$33 million in 2003—nearly a 6% decrease from the value of apparent consumption during 2002.

Prices.—The USGS canvassed fused aluminum oxide producers to determine the total value of their production for the year. The survey indicated that the average unit value of regular fused aluminum oxide produced in Canada during 2003 was \$279 per metric ton at the point of production; the average value of high-purity fused aluminum oxide output was \$514 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 fused aluminum oxide grain sold in 2003 was \$272 per ton.

Average unit values of fused aluminum oxide traded by the United States in 2003 are based on U.S. Census Bureau customs value data. The average value for U.S. exports of fused aluminum oxide during the year was about \$2,937 per ton. Average unit values of crude fused aluminum oxide imports during the year ranged from \$208 per ton (China) to \$367 per ton (Venezuela). Values of fused aluminum oxide grain imports ranged from \$294 per ton (China) to \$3,119 per ton (United Kingdom).

Foreign Trade.—Compared with 2002 exports of all fused aluminum oxides, 2003 exports increased by 14% to 11,800 t, and the value of those exports increased by 10% to \$34.6 million (table 6). Of the exports shipped to 32 countries, 72% went to Canada, Germany, and Mexico.

During 2003, imports of crude fused aluminum oxide were received from 14 countries and increased by 49% to 123,000 t valued at \$31.6 million compared with those of 2002, and imports of ground and refined fused aluminum oxide were received from 24 countries and decreased by 58% to 40,700 t valued at \$35.4 million (table 5). Some of the imported crude fused aluminum oxide was refractory-grade material. China, Canada, and Venezuela supplied 72%, 15%, and 11%, respectively, of the crude imports. Compared with 2002, crude imports from China increased by 70%, while imports from Canada and Venezuela increased only by 11% and 9%, respectively. China, Germany, Brazil, and Austria provided 30%, 19%, 18%, and 12%, respectively, of the ground and refined material. Compared with 2002, ground and refined imports from Brazil and Germany increased by 60%, and 20%, respectively, while imports from China and Austria decreased by 82% and 17%, respectively.

Silicon Carbide

Legislation and Government Programs.—The DOD completed sales of its stockpiled silicon carbide in 1999 (Janet Rollins, market analyst, Defense National Stockpile Center, oral commun., 2004). The DOD was not expected to replenish the silicon carbide stockpile.

Production.—One company produced abrasive-grade silicon carbide in the United States during 2003 (table 1). This company also produced similar amounts of metallurgical-grade silicon carbide. A second company, in Hopkinsville, KY, produced a small quantity of silicon carbide, primarily intended for use in heat-resistant products rather than abrasives. Production for the United States increased by 17% during 2003 to an estimated 35,000 t valued at \$18.5 million compared with an estimated 30,000 t valued at \$15.9 million in 2002 (table 2).

Consumption.—Abrasive-grade silicon carbide has many end uses. Specific applications in 2003 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 more than \$85 million in 2003—nearly a 14% decrease from the value of apparent consumption during 2002.

Prices.—The USGS does not collect price data on the various grades of silicon carbide. Based on 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 \$529 per ton in 2003. The average value of total silicon carbide exports in 2003 was approximately \$917 per ton.

During 2003, imports from China accounted for 74% of total U.S. crude silicon carbide imports and had an average value of \$311 per ton; the average value of the remaining 26% of U.S. crude silicon carbide imports was \$451 per ton. The average value of silicon carbide grain imports was \$1,010 per ton; China accounted for 43% of such imports (table 5).

Foreign Trade.—During 2003, the United States exported crude silicon carbide to 21 countries and exported refined or ground silicon carbide to 28 countries. The total value of crude silicon carbide exports for 2003 increased by 27% to \$4.90 million from the total value for 2002 (table 6). Compared with 2002, exports of refined or ground silicon carbide decreased by about 14% to 10,400 t valued at \$7.22 million. Approximately 82% of the refined or ground material was shipped to Canada.

In 2003, the United States imported crude silicon carbide from 7 countries and imported ground or refined silicon carbide from 20 countries. Imports of crude silicon carbide increased by 3% during the year to 139,000 t valued at \$48.1 million (table 5). Imports of silicon carbide in ground or refined form decreased slightly to 30,500 t valued at \$30.8 million. China accounted for 74% of the crude silicon carbide imports and 43% of the ground or refined silicon carbide. A large part of the imports from China reportedly included metallurgical-grade material.

Aluminum-Zirconium Oxide

During 2003, fused aluminum-zirconium oxide for abrasive applications, such as resin-bonded grinding wheels, was produced at one plant in the United States and one plant in Canada, both belonging to Norton Co. The USGS does not publish aluminum-zirconium oxide production data received from the producers to avoid disclosing company proprietary information.

Boron Carbide

Only one firm, Washington Mills, was a commercial producer of boron carbide in the United States during 2003. Boron carbide was used for grinding and lapping operations previously possible only with diamond dust; it also was molded to form highly wear-resistant products, such as pressure blast nozzle liners and extrusion dies. Domestic production data for boron carbide are not reported to avoid disclosing company proprietary information.

Metallic Abrasives

Production.—Data 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).

Steel shot and grit accounted for almost all of the metallic abrasives produced domestically (table 4). U.S. production of steel shot and grit in 2003 decreased by 12% compared with that of 2002; the average value was \$449 per ton. Six companies

reported production of cut wire shot in 2003, and most of that was cut from carbon steel wire and stainless steel wire. Other products reported included shot cut from aluminum, copper, and zinc wire. One company reported production of steel nuggets, a wrought carbon steel blast media with properties similar to steel shot.

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 75% of the abrasives are employed in cleaning operations. Principal consumers include foundries, machine tool industries, metalworking plants (particularly those supporting the automotive and aircraft industries), and steel manufacturers.

During 2003, total sales of all steel shot and grit by U.S. producers decreased by 5% compared with shipments in the preceding year, and the average value was \$466 per ton sold or used.

Prices.—The USGS compiles survey data on the value of production and shipments, but it does not collect price data. Values of production and shipments reported by metallic abrasive producers in 2003 are listed in table 4. Average values of steel shot and grit ranged from \$0.35 to \$0.47 per kilogram in 2003. Average values of cut wire shot in 2003 ranged from \$4.74 per kilogram to \$5.85 per kilogram for aluminum wire shot and from \$1.97 per kilogram to \$4.41 per kilogram for stainless steel wire shot. Average unit values for metallic abrasives traded by the United States during 2003 were as follows: exports, \$0.66 per kilogram, and imports, \$0.59 per kilogram.

Foreign Trade.—U.S. exports of metallic abrasives increased by 17% during the year to 22,000 t valued at \$14.6 million (table 6). Canada and Mexico received 94% of the U.S. exports of metallic abrasives in 2003.

During 2003, the United States imported metallic abrasives from 15 countries and exported metallic abrasives to 33 countries. Domestic imports increased by 33% in 2003 to 16,500 t valued at \$9.65 million (table 5). About 64% of the imports came from Canada; most of the remaining imports, in descending order, were shipped from South Africa, Germany, Romania, and Japan.

Outlook

Abrasives markets closely follow economic and technological trends and are greatly influenced by activity in the manufacturing sector in the United States. This is particularly true of manufacturing activities in the aerospace, automotive, furniture, housing, and steel industries. Even though abrasive markets are linked to these end use manufacturing sectors, growth in these sectors may not necessarily lead to an increase in abrasives consumption. Improved technology in these manufacturing sectors is resulting in surface quality that requires less grinding and finishing operations that use abrasives (O'Driscoll, 2003). Cheaper imports and higher domestic costs will continue to challenge U.S. producers of fused aluminum oxide and silicon carbide. Competition from developing nations, especially China, will probably lead to further decreases in domestic output. China has become a dominant force in both

fused aluminum oxide and silicon carbide in recent years. This has changed the makeup of the manufactured abrasives market. Lower priced Chinese exports have displaced and will continue to displace manufactured abrasive producers in Europe and North America (Gasser, 2002). The traditional suppliers among the Western industrialized nations are expected to continue consolidating and contracting.

Emerging suppliers of fused aluminum oxide and 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 such major markets as Japan, the United States, and Western Europe, will depend on their ability to provide higher grades of material and levels of 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).

The housing construction sector in North America will continue to have a significant indirect influence on demand for manufactured abrasives because of the large volumes of manufactured abrasives used in cutting and finishing wallboard and timber. The aerospace and automotive manufacturing sectors also will continue to be significant indirect influences on demand for manufactured abrasives used by metalworking operations supporting those sectors.

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TABLE 1
CRUDE ARTIFICIAL ABRASIVES MANUFACTURERS IN 2003

Company	Plant location	Product
Exolon Co., The	Hennepin, IL	Silicon carbide.
Norton Co.	Huntsville, AL	Fused aluminum oxide (high-purity) and aluminum-zirconium oxide.
Do.	Chippewa, Ontario, Canada	Aluminum-zirconium oxide.
Washington Mills Electro Minerals Corp.	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular).
Do.	Niagara Falls, NY	Fused aluminum oxide (high-purity) and boron carbide.

TABLE 2
ESTIMATED PRODUCTION OF CRUDE SILICON CARBIDE AND FUSED ALUMINUM
OXIDE IN THE UNITED STATES AND CANADA^{1,2}

Product	2002		2003	
	Quantity ^{3,4} (metric tons)	Value ³ (thousands)	Quantity ^{3,4} (metric tons)	Value ³ (thousands)
Aluminum oxide, regular, abrasives ⁵	20,000	\$5,300	20,000	\$5,800
Silicon carbide ⁶	30,000	15,900	35,000	18,500

¹Data are rounded to no more than three significant digits.

²Yearend stock data are withheld to avoid disclosing company proprietary data.

³Owing to rounding, data do not match total quarterly Mineral Industry Surveys estimated data.

⁴Quantities are rounded to the nearest 5,000 tons to avoid disclosing company proprietary data.

⁵Regular grade normally accounts for about 48% of total output, and high-purity material accounts for the remainder.

⁶Approximately one-half of the quantity and value consists of material for metallurgical and other nonabrasive applications.

TABLE 3
U.S. PRODUCERS OF METALLIC ABRASIVES IN 2003

Company	Plant location	Product (shot and/or grit)
Chesapeake Specialty Products, Inc.	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.	Scottsdale, PA	Do.
Metaltec Steel Abrasives Co.	Canton, MI	Steel.
National Metal Abrasive Inc.	Wadsworth, OH	Do.
Peerless Metal Powders & Abrasive Co., Inc.	Detroit, MI	Steel and steel nuggets.
Pellets, Inc.	Tonawanda, NY	Cut wire.
Platt Brothers, Inc., The	Waterbury, CT	Do.
Premier Shot Co.	Cleveland, OH	Do.
U.S. Filter Abrasive Materials, Inc.	Hillsdale, MI	Do.
Wheelabrator Abrasives, Inc.	Bedford, VA	Steel.

TABLE 4
 PRODUCTION AND SHIPMENTS FOR METALLIC ABRASIVES IN THE
 UNITED STATES, BY PRODUCT¹

Product	Production		Shipments ²	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2002:				
Steel shot and grit	217,000	\$97,400	221,000	\$102,000
Cut wire shot and other ⁶	1,060	3,470	1,060	3,750
Total	218,000	101,000	222,000	106,000
2003:				
Steel shot and grit	192,000	86,200	210,000	97,900
Cut wire shot and other ⁶	1,220	4,630	1,180	4,960
Total	193,000	90,800	211,000	103,000

⁶Estimated.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes reported exports.

TABLE 5
 U.S. IMPORTS OF ALUMINUM OXIDE, SILICON CARBIDE, AND METALLIC
 ABRASIVES, BY COUNTRY AND TYPE¹

Country	2002		2003	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Aluminum oxide:				
Crude:				
Canada	17,300	\$5,190	19,100	\$6,850
China	52,500	9,710	89,000	18,500
Venezuela	12,900	5,050	14,000	5,150
Other	231	221	1,170	1,000
Total	82,900	20,200	123,000	31,600
Ground and refined:				
Austria	5,860	9,100	4,840	6,500
Brazil	4,650	2,920	7,430	4,490
Canada	4,130	2,420	1,210	1,330
China	67,200	15,400	12,100	3,550
France	1,930	2,470	1,770	2,560
Germany	6,600	9,250	7,940	11,000
Hungary	1,390	1,110	2,340	1,870
Italy	1,540	1,470	1,650	1,350
Russia	242	116	48	64
Slovenia	733	409	493	269
United Kingdom	661	1,850	522	1,630
Other	998	993	398	807
Total	95,900	47,500	40,700	35,400
Silicon carbide:				
Crude:				
Canada	609	168	207	125
China	127,000	36,800	103,000	32,000
Germany	93	491	2	15
Netherlands	--	--	12,100	3,270
Norway	1,070	3,000	1,730	5,150
Russia	2,660	1,130	8,060	2,870
Venezuela	2,930	1,040	13,500	4,620
Other	4	13	--	--
Total	134,000	42,600	139,000	48,100

See footnotes at end of table.

TABLE 5--Continued
 U.S. IMPORTS OF ALUMINUM OXIDE, SILICON CARBIDE, AND METALLIC
 ABRASIVES, BY COUNTRY AND TYPE¹

Country	2002		2003	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Silicon carbide--Continued:				
Ground and refined:				
Brazil	6,300	4,790	7,220	5,170
China	10,800	7,320	13,200	7,980
Germany	1,620	6,140	1,010	3,880
Japan	1,330	5,570	1,070	4,730
Mexico	664	997	601	967
Norway	2,630	7,020	1,050	3,510
Philippines	1,820	1,330	1,330	987
Russia	683	333	1,100	557
Venezuela	4,090	2,360	3,700	2,220
Other	685	1,200	197	812
Total	30,600	37,100	30,500	30,800
Metallic abrasives:				
Canada	6,430	2,820	10,500	4,530
France	188	171	60	29
Germany	1,060	2,010	2,030	2,780
Hong Kong	119	85	149	89
Italy	90	130	64	100
Japan	504	657	400	534
Romania	584	474	806	758
South Africa	2,970	899	2,330	717
United Kingdom	69	39	--	--
Other	369	830	145	122
Total	12,400	8,120	16,500	9,650

-- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Customs value.

Source: U.S. Census Bureau.

TABLE 6
 U.S. EXPORTS OF ALUMINUM OXIDE, SILICON CARBIDE, AND METALLIC
 ABRASIVES, BY COUNTRY AND TYPE¹

Country	2002		2003	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Aluminum oxide, crude:				
Brazil	485	\$1,480	387	\$1,640
Canada	2,080	2,230	2,920	3,530
Germany	3,860	14,700	3,900	13,700
Italy	165	530	--	--
Japan	361	2,040	1,150	5,250
Korea, Republic of	378	1,690	539	2,540
Mexico	2,030	2,560	1,700	2,520
Netherlands	255	1,550	209	500
United Kingdom	156	2,570	128	1,510
Other	550	2,080	842	3,380
Total	10,300	31,400	11,800	34,600

See footnotes at end of table.

TABLE 6--Continued
 U.S. EXPORTS OF ALUMINUM OXIDE, SILICON CARBIDE, AND METALLIC
 ABRASIVES, BY COUNTRY AND TYPE¹

Country	2002		2003	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Silicon carbide:				
Crude:				
Brazil	25	\$276	18	\$185
Germany	138	616	91	192
Japan	68	393	343	1,690
Mexico	213	888	426	657
Norway	815 ^r	502 ^r	1,630	1,060
Switzerland	117	355	133	397
United Kingdom	29	84	24	87
Other	76 ^r	748 ^r	123	629
Total	1,480 ^r	3,860 ^r	2,780	4,900
Ground and refined:				
Australia	973	397	709	275
Brazil	131	245	128	157
Canada	9,210	5,340	8,550	5,010
Germany	430	532	51	236
Japan	216	457	56	111
Mexico	809	591	408	302
Norway	83 ^r	203 ^r	168	187
United Kingdom	89	121	105	156
Other	221	573	258	785
Total	12,200 ^r	8,460 ^r	10,400	7,220
Metallic abrasives:				
Canada	9,890	5,900	11,100	5,280
Japan	505	270	720	398
Korea, Republic of	154	106	6	30
Mexico	7,280	5,010	9,480	6,980
Saudi Arabia	167	61	84	42
Taiwan	109	104	122	114
United Kingdom	239	300	203	252
Other	437	1,180	268	1,460
Total	18,800	12,900	22,000	14,600

^rRevised. -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Customs value.

Source: U.S. Census Bureau.