



2005 Minerals Yearbook

ABRASIVES, MANUFACTURED

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In 2005, estimated United States and Canadian combined production of regular-grade fused aluminum oxide was 10,000 metric tons (t) with a value estimated to be \$4.9 million. The U.S. apparent consumption of fused aluminum oxide was an estimated 232,000 t with an estimated value of \$64.4 million. U.S. silicon carbide production was an estimated 35,000 t with an estimated value of \$21.5 million. The U.S. apparent consumption of silicon carbide was estimated to be more than 220,000 t with an estimated value of \$132 million. U.S. production of metallic abrasives was 209,000 t valued at \$102 million. U.S. shipments of metallic abrasives sold or used was 226,000 t, with a value of \$116 million. The U.S. apparent consumption of metallic abrasives was estimated to be 199,000 t with an estimated value of \$92.4 million.

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. 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 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 abrasives 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, 2006, the National Defense Stockpile (NDS) maintained by the U.S. Department of Defense (DOD) contained 6,224 t of fused aluminum oxide abrasive grain valued at about \$2.2 million. During 2005, the DOD reported sales of 2,064 t of NDS aluminum oxide abrasive grain for about \$871,000. All the NDS crude fused aluminum oxide had been 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., February 21, 2006).

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). Norton Co. operated a fused aluminum oxide plant in the United States, and Washington Mills Electro Minerals Co. operated fused aluminum oxide plants in Canada and the United States. Data from the two countries were combined to avoid disclosing company proprietary data.

Estimated production of regular-grade fused aluminum oxide in 2005 was 10,000 t with an estimated value of \$4.9 million. This was about a 50% decrease in weight and a 25% decrease in value compared with 2004 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 2005 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 U.S. apparent consumption of fused aluminum oxide was an estimated 232,000 t with an estimated value of \$64.4 million in 2005.

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 2005 was \$144 per metric ton at the point of production; the average value of high-purity fused aluminum oxide output was \$656 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 2005 was \$422 per ton.

Average unit values of fused aluminum oxide traded by the United States in 2005 as reported here 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 \$3,250 per ton. Average unit values of crude fused aluminum oxide imports during the year ranged from \$293 per ton (China) to \$509 per ton (Canada), and those of fused aluminum oxide grain imports ranged from \$468 per ton (South Africa) to \$3,120 per ton (United Kingdom).

Foreign Trade.—Compared with the previous year, crude fused aluminum oxide exports in 2005 remained about the same at 13,900 t, and the value of those exports increased by 9% to \$45.1 million (table 5). Of the exports shipped to 32 countries, 72% went to Canada, Germany, and Mexico.

During 2005, imports of crude fused aluminum oxide were received from 15 countries and increased by 9% to 198,000 t valued at \$62.1 million compared with those of 2004, and imports of ground and refined fused aluminum oxide were received from 22 countries and decreased by 10% to 46,100 t valued at \$46.6 million (table 6). Some of the imported crude fused aluminum oxide was refractory-grade material. China, Venezuela, and Canada supplied 85%, 11%, and 4%, respectively, of the crude imports. Compared with 2004, crude imports from China increased by 15%, and from Venezuela, by 37%, while imports from Canada decreased by 61%. Brazil, Germany, Austria, Canada, and Italy provided 23%, 22%, 14%, 10%, and 10%, respectively, of the ground and refined material.

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., February 21, 2006). The DOD was not expected to replenish the silicon carbide stockpile.

Production.—One company produced abrasive-grade silicon carbide in the United States during 2005 (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. U.S. silicon carbide production increased slightly during 2005 to an estimated 35,000 t, and the value of production also increased slightly to an estimated \$21.5 million (table 2).

Consumption.—Abrasive-grade silicon carbide has many end uses. Specific applications in 2005 included antislip abrasives, blasting abrasives, bonded abrasives, coated abrasives, polishing/buffing compounds, tumbling media, and wiresawing abrasives. The total silicon carbide consumed in the United

States was estimated to be about 220,000 t valued at more than \$132 million in 2005.

Prices.—Based on information from industry sources and publications, the average value of abrasive-grade silicon carbide at the point of manufacture was estimated to be about \$603 per ton in 2005. The average value of total U.S. ground silicon carbide exports in 2005 was approximately \$970 per ton.

During 2005, imports from China accounted for 73% of total United States crude silicon carbide imports. This Chinese material had an average value of \$520 per ton. The average value of the remaining 27% of U.S. crude silicon carbide imports was \$397 per ton. The average value of silicon carbide grain imports was \$1,161 per ton; China accounted for 30% of such imports (table 6).

Foreign Trade.—During 2005, the United States exported crude silicon carbide and refined and ground silicon carbide to 30 countries each. The total crude silicon carbide exports for 2005 increased by 78% compared with those of the previous year to 6,610 t valued at \$8.69 million (table 5). Compared with 2004, exports of refined or ground silicon carbide decreased by about 12% to 8,940 t valued at \$8.67 million. Approximately 86% of the refined and ground material was shipped to Canada.

In 2005, the United States imported crude silicon carbide from 10 countries and ground and refined silicon carbide from 20 countries. Imports of crude silicon carbide decreased by about 5% during the year to 156,000 t valued at \$75.8 million (table 6). Imports of silicon carbide in ground or refined form decreased slightly to 45,000 t valued at \$52.2 million. China accounted for 73% of the crude silicon carbide imports and 30% of the ground and refined silicon carbide. A large part of the imports from China reportedly included metallurgical-grade material.

Aluminum-Zirconium Oxide

During 2005, 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., but production data from the producing plants are withheld to avoid disclosing company proprietary information.

Boron Carbide

Washington Mills was the only commercial producer of boron carbide in the United States during 2005. Boron carbide was used as abrasives for lapping and ultrasonic cutting operations previously possible only with diamond dust; it was also molded to form highly wear-resistant products, such as pressure blasting nozzles, wire-drawing dies, powdered metal and ceramic forming dies, thread guides, and armor. Boron carbide was also used in nuclear applications, such as reactor control rods and neutron absorbing shielding (Washington Mills Electro Minerals Co., 2006^{§1}). Domestic production data for boron carbide are withheld to avoid disclosing company proprietary data.

¹A reference that includes a section mark (§) is found in the Internet Reference Cited section.

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 13 companies operating 15 plants in the United States and accounted for all domestic production (table 3).

Steel shot and grit accounted for almost all the metallic abrasives produced domestically (table 4). U.S. production of steel shot and grit in 2005 increased by 8% compared with that of 2004; the average value was \$456 per ton. Seven companies reported production of cut wire shot in 2005, 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 medium 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 is 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 2005, total sales of all steel shot and grit by U.S. producers increased by 12% compared with shipments in 2004 to about 226,000 t with an average value of \$512 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. The values of production and shipments reported by metallic abrasive producers in 2005 are listed in table 4. Average values of steel shot and grit ranged from \$0.38 to \$1.11 per kilogram. Average values of cut wire shot ranged from \$4.42 to \$6.27 per kilogram for aluminum wire shot and from \$2.88 to \$6.23 per kilogram for stainless steel wire shot. Average unit values for metallic abrasives traded by the United States during 2005 were as follows: exports, \$0.80 per kilogram, and imports, \$0.76 per kilogram.

Foreign Trade.—During 2005, the United States exported metallic abrasives to 39 countries and imported metallic abrasives from 13 countries. U.S. exports of metallic abrasives increased slightly during the year to 26,900 t valued at \$21.6 million (table 5). Canada and Mexico received 85% of the U.S. exports of metallic abrasives in 2005. U.S. imports increased by 4% in 2005 to 16,500 t valued at \$12.5 million (table 6). About 63% of the imports came from Canada; most of the remaining imports, in descending order, were shipped from Germany, China, South Africa, and Romania.

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 abrasives 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). Less expensive imports and higher domestic costs will continue to challenge U.S. producers of fused aluminum oxide and silicon carbide to maintain market share. 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 produced 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 2005

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	2004		2005	
	Quantity ^{3, 4} (metric tons)	Value ³ (thousands)	Quantity ^{3, 4} (metric tons)	Value ³ (thousands)
Aluminum oxide, regular, abrasives ⁵	20,000	\$6,500	10,000	\$4,900
Silicon carbide ⁶	35,000	21,500	35,000	21,500

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 2005

Company	Plant location	Product (shot and/or grit)
Abrasive Materials Inc.	Hillsdale, MI	Cut wire.
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)
2004:				
Steel shot and grit	193,000	\$87,800	200,000	\$92,700
Cut wire shot and other ^c	1,260	4,250	1,310	4,750
Total	194,000	92,000	201,000	97,400
2005:				
Steel shot and grit	207,000	94,400	224,000	108,000
Cut wire shot and other ^c	2,120	7,170	2,150	7,580
Total	209,000	102,000	226,000	116,000

^cEstimated.

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

²Includes reported exports.

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

Country	2004		2005	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Aluminum oxide, crude:				
Belgium	425	\$722	452	\$4,440
Brazil	587	3,100	497	2,590
Canada	3,280	4,010	3,290	3,400
China	104	1,220	78	1,220
Germany	4,610	15,100	4,560	15,000
India	163	610	279	925
Japan	1,270	6,920	1,570	9,210
Korea, Republic of	921	4,320	566	2,670
Mexico	2,200	2,850	2,150	2,770
Other	383 ^r	2,380 ^r	452	2,910
Total	13,900 ^r	41,200 ^r	13,900	45,100
Silicon carbide:				
Crude:				
Finland	34	99	208	627
Germany	33	89	105	387
Japan	1,070	2,440	134	1,400
Mexico	174	455	458	877
Norway	2,290	1,480	5,470	4,320
Other	109 ^r	946 ^r	235	1,090
Total	3,720 ^r	5,510	6,610	8,690
Ground and refined:				
Canada	8,830	5,690	7,640	5,950
China	17	52	34	184
Costa Rica	28	69	24	69
Finland	119	348	--	--
France	65	214	51	143
Germany	127	379	75	91
Korea, Republic of	29	138	29	170
Mexico	411	508	278	492
Norway	109	199	331	206
Russia	97	298	--	--
Spain	62	141	44	108
United Kingdom	195	319	139	187
Other	82 ^r	693	287	1,080
Total	10,200 ^r	9,050	8,940	8,670
Metallic abrasives:				
Australia	125	83	47	28
Canada	11,500	7,070	11,200	7,290
China	38	305	141	790
France	150	171	200	187
Italy	136	51	138	74
Japan	400	234	2,080	1,240
Mexico	13,500	11,300	11,600	9,880
Taiwan	154	176	466	315
Vietnam	151	53	--	--
Other	391 ^r	1,180 ^r	1,030	1,750
Total	26,500 ^r	20,600 ^r	26,900	21,600

^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.

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

Country	2004		2005	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Aluminum oxide:				
Crude:				
Canada	20,100	\$8,140	7,880	\$4,010
China	145,000 ^r	35,600 ^r	167,000	49,000
Venezuela	15,100	6,280	20,700	8,140
Other	1,290	581 ^r	1,980	957
Total	181,000^r	50,600^r	198,000	62,100
Ground and refined:				
Austria	6,470	8,660	6,370	9,150
Brazil	8,980	5,610	10,500	8,080
Canada	5,010	3,590	4,690	3,130
China	2,810	1,090	1,540	818
France	2,150	3,360	714	946
Germany	10,400	13,100	10,300	13,200
Hungary	3,340	2,510	3,420	2,660
Italy	4,580	3,220	4,450	3,570
South Africa	960	448	1,820	850
United Kingdom	976	2,890	590	1,840
Venezuela	3,990	1,430	--	--
Other	1,580 ^r	1,860 ^r	1,760	2,290
Total	51,200	47,800	46,100	46,600
Silicon carbide:				
Crude:				
Brazil	12,000	5,520	1,980	1,030
China	92,800	41,900	113,000	58,800
Netherlands	17,100	5,220	5,830	1,140
Romania	13,500	4,550	16,100	4,350
Russia	6,030	2,430	2,060	1,040
Venezuela	21,100	7,880	14,300	6,030
Other	690	1,810	2,360	3,360
Total	163,000	69,300	156,000	75,800
Ground and refined:				
Brazil	11,600	7,870	10,700	7,600
China	16,100	11,800	13,400	11,400
Japan	1,320	6,360	1,380	6,980
Norway	3,270	10,500	2,270	8,540
Philippines	2,190	1,490	--	--
Russia	3,940	1,980	9,990	5,810
Venezuela	3,490	2,070	3,380	3,760
Vietnam	1,170	793	1,960	1,430
Other	2,270 ^r	7,070 ^r	2,000	6,710
Total	45,300	49,900	45,000	52,200
Metallic abrasives:				
Canada	11,300	5,660	10,300	5,450
China	59	56	1,480	1,270
Germany	1,230	1,490	2,270	3,550
Other	3,310 ^r	2,310 ^r	2,410	2,250
Total	15,900^r	9,520	16,500	12,500

^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.