



2006 Minerals Yearbook

ABRASIVES, MANUFACTURED

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In 2006, 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 \$1.5 million. The U.S. apparent consumption of fused aluminum oxide was estimated to be 155,000 t with an estimated value of \$11.7 million. U.S. silicon carbide production was estimated to be 35,000 t with an estimated value of \$24.3 million. The U.S. apparent consumption of silicon carbide was estimated to be 172,000 t with an estimated value of \$81.5 million. U.S. production of metallic abrasives was 200,000 t valued at \$102 million. U.S. shipments of metallic abrasives sold or used were 218,000 t, with a value of \$116 million. The U.S. apparent consumption of metallic abrasives was estimated to be 198,000 t with an estimated value of \$91.9 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, U.S. 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, 2007, the National Defense Stockpile (NDS), maintained by the Defense Logistics Agency, U.S. Department of Defense (DOD), contained 4,256 t of fused aluminum oxide abrasive grain valued at \$1.7 million. During 2006, the DOD reported sales of 2,146 t of NDS aluminum oxide abrasive grain for \$884,859. 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 9, 2007).

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. Quantity data from the two countries were combined to avoid disclosing company proprietary data and are reported estimated and rounded to the nearest 5,000 t.

Production of regular-grade fused aluminum oxide in 2006 was 10,000 t with a value of \$1.5 million. This represented a 24% increase in weight and a 31% increase in value compared with 2005 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 2006 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 estimated to be 155,000 t with an estimated value of \$11.7 million in 2006.

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 2006 was \$152 per metric ton at the point of production; the average value of high-purity fused aluminum oxide output was \$652 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 2006 was \$412 per ton.

Average unit values of fused aluminum oxide traded by the United States in 2006 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 \$2,700 per ton. Average unit values of crude fused aluminum oxide imports during the year ranged from \$174 per ton (France) to \$1,650 per ton (Germany), and those of fused aluminum oxide grain imports ranged from \$390 per ton (China) to \$4,510 per ton (Russia).

Foreign Trade.—Compared with those of the previous year, crude fused aluminum oxide exports in 2006 increased by 10% to 15,300 t, and the value of those exports decreased by 9% to \$41.2 million (table 5). Of the exports shipped to 27 countries, 76% went to Canada, Germany, Japan, and Mexico.

During 2006, imports of crude fused aluminum oxide were received from 9 countries and decreased by 15% to 168,000 t valued at \$52.1 million compared with those of 2005; imports of ground and refined fused aluminum oxide were received from 22 countries and decreased by 12% to 40,700 t valued at \$47.7 million (table 6). Some of the imported crude fused aluminum oxide was refractory-grade material. China, Venezuela, and Canada supplied 71%, 24%, and 3%, respectively, of the crude imports. Compared with those of 2005, crude imports from Canada decreased by 44%, and from China, by 29%, while imports from Venezuela increased by 95%. Brazil, Germany, Austria, Italy, and Hungary provided 28%, 24%, 16%, 7%, and 5%, respectively, of the ground and refined material.

Silicon Carbide

Production.—One company produced abrasive-grade silicon carbide in the United States during 2006 (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 decreased slightly during 2006 to an estimated 35,000 t, and the value of production increased by 15% to an estimated \$24.3 million (table 2).

Consumption.—Abrasive-grade silicon carbide has many end uses. Specific applications in 2006 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 172,000 t valued at more than \$81.5 million in 2006.

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 \$693 per ton

in 2006. The average value of total U.S. ground silicon carbide exports in 2006 was \$1,500 per ton.

During 2006, imports from China accounted for about 82% of total U.S. crude silicon carbide imports. This Chinese material had an average value of \$469 per ton. The average value of the remaining 18% of U.S. crude silicon carbide imports was \$512 per ton. The average value of silicon carbide grain imports was \$1,282 per ton; China accounted for 40% of such imports (table 6).

Foreign Trade.—During 2006, the United States exported crude silicon carbide to 27 countries and refined and ground silicon carbide to 36 countries. The total crude silicon carbide exports for 2006 increased by 46% compared with those of the previous year to 9,660 t valued at \$12.8 million (table 5). Compared with those of 2005, exports of refined or ground silicon carbide increased by 18% to 10,600 t valued at \$15.9 million. Of the refined and ground material, 83% was shipped to Canada.

In 2006, the United States imported crude silicon carbide from 12 countries and ground and refined silicon carbide from 16 countries. Imports of crude silicon carbide decreased by 7% during the year to 145,000 t valued at \$69.0 million (table 6). Imports of silicon carbide in ground or refined form decreased by 10% to 40,500 t valued at \$51.9 million. China accounted for 82% of the crude silicon carbide imports and 40% of the ground and refined silicon carbide. A large part of the imports from China reportedly included metallurgical-grade material.

Aluminum-Zirconium Oxide

During 2006, 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 2006. 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). Domestic production data for boron carbide are withheld to avoid disclosing company proprietary data.

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 2006 decreased by 4% compared with that of 2005; the average value was \$467 per ton. Seven companies reported production of cut wire shot in 2006, 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; 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 2006, total sales of all steel shot and grit by U.S. producers decreased by 4% compared with shipments in 2005 to 215,000 t with an average value of \$491 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 2006 are listed in table 4. Average values of steel shot and grit ranged from \$0.38 to \$5.74 per kilogram. Average values of cut wire shot ranged from \$2.65 to \$5.17 per kilogram for aluminum wire shot and from \$3.09 to \$6.30 per kilogram for stainless steel wire shot. Average unit values for metallic abrasives traded by the United States during 2006 were as follows: exports, \$1.09 per kilogram, and imports, \$0.74 per kilogram.

Foreign Trade.—During 2006, the United States exported metallic abrasives to 32 countries and imported metallic abrasives from 17 countries. U.S. exports of metallic abrasives decreased by 17% during the year to 22,300 t valued at \$24.4 million (table 5). Canada and Mexico received 84% of the U.S. exports of metallic abrasives in 2006. U.S. imports increased by 19% in 2006 to 19,600 t valued at \$14.4 million (table 6). About 63% of the imports came from Canada; most of the remaining imports, in descending order, were shipped from China, Germany, South Africa, Japan, Romania, and Spain.

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 2006

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	2005		2006	
	Quantity ^{3,4} (metric tons)	Value ^{r,3} (thousands)	Quantity ^{3,4} (metric tons)	Value ³ (thousands)
Aluminum oxide, regular, abrasives ⁵	10,000	\$1,400	10,000	\$1,500
Silicon carbide ⁶	35,000	21,100	35,000	24,300

^rRevised.

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 metric 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 2006

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)
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
2006:				
Steel shot and grit	198,000	92,300	215,000	106,000
Cut wire shot and other ^c	2,530	9,530	2,460	10,000
Total	200,000	102,000	218,000	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	2005		2006	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Aluminum oxide, crude:				
Belgium	452	\$4,440	--	--
Brazil	497	2,590	525	\$2,270
Canada	3,290	3,400	5,120	5,430
China	78	1,220	137	1,020
Germany	4,560	15,000	3,010	6,870
India	279	925	222	864
Japan	1,570	9,210	1,570	7,340
Korea, Republic of	566	2,670	939	5,200
Mexico	2,150	2,770	1,840	3,170
Other	452	2,910	1,890	9,090
Total	13,900	45,100	15,300	41,200
Silicon carbide:				
Crude:				
Finland	208	627	222	712
Germany	105	387	55	362
Japan	134	1,400	6	46
Mexico	458	877	482	1,100
Norway	5,470	4,320	8,620	7,910
Other	235	1,090	271	2,620
Total	6,610	8,690	9,660	12,800
Ground and refined:				
Canada	7,640	5,950	8,800	7,100
China	34	184	8	173
Costa Rica	24	69	16	49
France	51	143	29	364
Germany	75	91	145	4,410
Italy	18	29	53	195
Japan	173	315	200	521
Korea, Republic of	29	170	15	122
Mexico	278	492	474	866
Norway	331	206	545	676
Spain	44	108	66	154
United Kingdom	139	187	101	124
Other	95 ^r	732 ^r	129	1,150
Total	8,940	8,670	10,600	15,900
Metallic abrasives:				
Australia	47	28	7	5
Canada	11,200	7,290	9,680	7,260
China	141	790	141	724
France	200	187	203	231
Italy	138	74	24	16
Japan	2,080	1,240	28	92
Mexico	11,600	9,880	9,020	9,810
Taiwan	466	315	239	239
United Kingdom	1	22	1,960	2,630
Other	1,050 ^r	1,820 ^r	1,000	3,370
Total	26,900	21,600	22,300	24,400

^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	2005		2006	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Aluminum oxide:				
Crude:				
Canada	7,880	\$4,010	4,390	\$4,130
China	167,000	49,000	119,000	34,100
Venezuela	20,700	8,140	40,400	11,900
Other	1,980	957	4,480	2,060
Total	198,000	62,100	168,000	52,100
Ground and refined:				
Austria	6,370	9,150	6,410	9,560
Brazil	10,500	8,080	11,600	9,630
Canada	4,690	3,130	938	1,390
China	1,540	818	2,010	784
France	714	946	1,260	1,900
Germany	10,300	13,200	9,900	14,400
Hungary	3,420	2,660	2,120	1,730
Italy	4,450	3,570	3,030	2,660
Korea, Republic of	598	618	780	919
South Africa	1,820	850	40	115
United Kingdom	590	1,840	831	2,030
Other	1,160 ^r	1,680 ^r	1,800	2,640
Total	46,100	46,600	40,700	47,700
Silicon carbide:				
Crude:				
Brazil	1,980	1,030	380	167
China	113,000	58,800	118,000	55,400
Netherlands	5,830	1,140	4,140	558
Romania	16,100	4,350	6,180	720
Russia	2,060	1,040	1,510	913
Venezuela	14,300	6,030	8,050	3,280
Other	2,360	3,360	6,210	7,910
Total	156,000	75,800	145,000	69,000
Ground and refined:				
Brazil	10,700	7,600	10,500	9,250
Canada	18	48	756	814
China	13,400	11,400	16,300	13,700
Japan	1,380	6,980	2,040	10,700
Norway	2,270	8,540	1,300	6,170
Russia	9,990	5,810	1,710	1,310
Venezuela	3,380	3,760	2,680	1,540
Vietnam	1,960	1,430	3,450	2,660
Other	1,980 ^r	6,670 ^r	1,810	5,730
Total	45,000	52,200	40,500	51,900
Metallic abrasives:				
Canada	10,300	5,450	12,300	6,980
China	1,480	1,270	2,820	1,890
Germany	2,270	3,550	2,320	3,320
Other	2,410	2,250	2,100	2,220
Total	16,500	12,500	19,600	14,400

^rRevised.

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

²Customs value.

Source: U.S. Census Bureau.