

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 protect proprietary information 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 based on 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 friability, character of fracture (cleavage), 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 and 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, 2003, the National Defense Stockpile (NDS) maintained by the U.S. Department of Defense (DOD) contained 16,156 metric tons (t) of fused aluminum oxide abrasive grain valued at about \$7.5 million. During 2002, the DOD reported sales of about 59.9 t of NDS aluminum oxide abrasive grain for \$29,700. 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 plans to continue such sales until all the stockpiled aluminum oxide is sold (Janet Rollins, Market

Analyst, Defense National Stockpile Center, oral commun., 2003).

Production.—Production data for 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). Workers at Washington Mills Ltd. in Niagara Falls, NY, remained on strike during all of 2002. 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 2002 was 20,000 t with an estimated value of \$5.3 million. This was a decrease of about 60% by weight from the 2001 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 2002 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 [2002], 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 \$35 million in 2002—nearly a 45% decrease from the value of apparent consumption during 2001.

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 the United States and Canada during 2002 was \$271 per metric ton at the point of production; the average value of high-purity fused aluminum oxide output was \$494 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 2002 was \$495 per ton.

Average unit values of fused aluminum oxide traded by the United States in 2002 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 \$3,045 per ton. Average unit values of crude fused aluminum oxide imports during the year ranged from \$185 per ton (China) to \$391 per ton (Venezuela). Values of fused aluminum oxide grain imports ranged from \$229 per ton (China) to \$2,797 per ton (United Kingdom).

Foreign Trade.—Compared with 2001 exports of all fused aluminum oxides, 2002 exports increased 15% to 10,300 t, and the value of those exports increased by 19% to \$31.4 million (table 6). Of the exports shipped to 32 countries, 77% went to Canada, Germany, and Mexico.

During 2002, imports of crude fused aluminum oxide were received from 14 countries and decreased by 16% to 82,900 t valued at \$20.2 million compared with those of 2001, and imports of ground and refined fused aluminum oxide were received from 24 countries and decreased by 8% to 95,900 t valued at \$47.5 million (table 5). Some of the imported crude fused aluminum oxide was refractory-grade material. China, Canada, and Venezuela supplied 63%, 21%, and 16%, respectively, of the crude imports. Compared with 2001, crude imports from China increased by 4%, while imports from Canada and Venezuela decreased by 26% and 45%, respectively. China, Germany, Austria, Brazil, and Canada provided 70%, 7%, 6%, 5%, and 4%, respectively, of the ground and refined material. Compared with 2001, ground and refined imports from China increased by 18%, while imports from Canada, Austria, Brazil, and Germany decreased by 80%, 18%, 8%, and 6%, 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., 2003). The DOD was not expected to replenish the silicon carbide stockpile.

Production.—One company produced abrasive-grade silicon carbide in the United States during 2002 (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 Canada and the United States decreased 25% during 2002 to an estimated 30,000 t valued at \$15.9 million compared with an estimated 40,000 t valued at \$24 million in 2001 (table 2).

Consumption.—Abrasive-grade silicon carbide has many end uses. Specific applications in 2002 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 \$99 million in 2002—nearly a 27% increase from the value of apparent consumption during 2001.

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 \$532 per ton in 2002. The average value

of total silicon carbide exports in 2002 was approximately \$903 per ton.

During 2002, imports from China accounted for 95% of total U.S. crude silicon carbide imports and had an average value of \$290 per ton; the average value of the remaining 5% of U.S. crude silicon carbide imports was \$793 per ton. The average value of silicon carbide grain imports was \$1,210 per ton; China accounted for 35% of such imports.

Foreign Trade.—During 2002, 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 2002 increased by 16% to \$3.36 million from the total value for 2001 (table 6). Compared with 2001 exports of refined or ground silicon carbide, 2002 exports increased by about 32% to 13,000 t valued at \$8.96 million. Approximately one-third of the crude exports went to Mexico, and about 71% of the refined or ground material was shipped to Canada.

In 2002, 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 26% during the year to 134,000 t valued at \$42.6 million (table 5). Imports of silicon carbide in ground or refined form increased by 15% to 30,600 t valued at \$37.1 million. China accounted for 95% of the crude silicon carbide imports and 35% of the ground or refined silicon carbide. A large part of the Chinese imports, however, reportedly included metallurgical-grade material.

Aluminum-Zirconium Oxide

During 2002, 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 2002. 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 account for almost all of the metallic abrasives produced domestically (table 4). U.S. production of

steel shot and grit in 2002 decreased by 2% compared with that of 2001; the average value was \$448 per ton. Six companies reported production of cut wire shot in 2002, 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 2002, total sales of all steel shot and grit by U.S. producers decreased by 3% compared with shipments in the preceding year, and the average value was \$464 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 2002 are listed in table 4. Average values of steel shot and grit ranged from \$0.35 to \$0.47 per kilogram in 2002. Average values of cut wire shot in 2002 ranged from \$4.74 to \$5.85 per kilogram for aluminum wire shot and from \$1.97 to \$4.41 per kilogram for stainless steel wire shot.

Average unit values for metallic abrasives traded by the United States during 2002 were as follows: exports, \$0.69 per kilogram, and imports, \$0.66 per kilogram.

Foreign Trade.—U.S. exports of metallic abrasives decreased by 17% during the year to 18,800 t valued at \$12.9 million (table 6). Most of the exports went to Canada; most of the remainder, in descending order, was shipped to Mexico and Japan.

During 2002, the United States imported metallic abrasives from 15 countries and exported metallic abrasives to 33 countries. Domestic imports decreased by 34% in 2002 to 12,400 t valued at \$8.12 million (table 5). About 52% 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, and housing industries. In the United States, during most of 2002, the abrasives market was not very profitable, especially in the automotive and housing sectors. The slowdown in auto manufacturing and sales, in addition to a downturn in housing construction during 2001, had a noticeable impact (Kendall, 2001, p. 55). The aerospace sector, which held up reasonably well during the first half of 2001, experienced

a slump after the events of September 11. These trends in the aerospace, automotive, and housing sectors continued into 2002. 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, p. 39). The traditional suppliers among the Western industrialized nations are expected to continue consolidating and contracting.

Metal abrasives markets will continue to be influenced by improved technology in industries that use metallic abrasives. For example, better metal casting methods that achieve near-finish surfaces will reduce demand for some abrasives. Lesser quantities of metallic abrasives will be needed in foundries where new chemical cleaning and finishing techniques are employed.

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 remain a significant indirect influence on demand for manufactured abrasives. This is because of the large volumes of manufactured abrasives that are 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. Substitution by plastics and new lighter weight designs of automobiles and planes will likely decrease metals consumption and are important factors to be considered in long-range demand forecasts for manufactured abrasives.

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TABLE 1
 CRUDE ARTIFICIAL ABRASIVES MANUFACTURERS IN 2002

Company	Plant location	Product
Exolon-Esk Co., The	Hennepin, IL	Silicon carbide.
Do.	Thorold, Ontario, Canada	Fused aluminum oxide (regular).
Norton Co.	Huntsville, AL	Aluminum-zirconium oxide.
Do.	Chippewa, Ontario, Canada	Do.
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.
Washington Mills Ltd.	do.	Fused aluminum oxide (regular).

TABLE 2
 PRODUCTION OF CRUDE SILICON CARBIDE AND FUSED ALUMINUM OXIDE IN THE UNITED STATE AND CANADA

Product	2001			2002		
	Quantity ^{e, 1, 2} (metric tons)	Value ^{e, 1} (thousands)	Yearend stocks (metric tons)	Quantity ^{e, 1, 2} (metric tons)	Value ^{e, 1} (thousands)	Yearend stocks (metric tons)
Aluminum oxide, regular, abrasives ³	50,000	\$15,100	W	20,000	\$5,300	W
Silicon carbide ⁴	40,000	24,000	W	30,000	15,900	W

^eEstimated; estimated data are rounded to no more than three significant digits. W Withheld to avoid disclosing company proprietary data.

¹Owing to rounding, data do not match total quarterly Mineral Industry Surveys estimated data.

²Quantities are rounded to the nearest 5,000 tons to avoid disclosing proprietary data.

³Regular grade normally accounts for about 85% of total output, and high-purity material accounts for the remainder.

⁴Approximately 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 2002

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)
2001:				
Steel shot and grit	223,000 ^r	\$97,800 ^r	227,000 ^r	\$102,000
Cut wire shot and other ^e	1,310	4,380	1,320	4,460
Total	224,000 ^r	102,000	229,000 ^r	106,000
2002:				
Steel shot and grit	217,000	97,400	221,000	102,000
Cut wire shot and other ^e	1,060	3,470	1,060	3,750
Total	218,000	101,000	222,000	106,000

^eEstimated. ^rRevised.

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	2001		2002	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Aluminum oxide:				
Crude:				
Canada	23,300	\$9,890	17,300	\$5,190
China	50,700	8,470	52,500	9,710
Venezuela	23,400	10,700	12,900	5,050
Other	1,090	600 ^r	231	221
Total	98,600	29,600	82,900	20,200
Ground and refined:				
Austria	7,110	9,920	5,860	9,100
Brazil	5,050	3,560	4,650	2,920
Canada	20,900	7,280	4,130	2,420
China	56,900	13,400	67,200	15,400
France	1,360	1,780	1,930	2,470
Germany	7,010	8,420	6,600	9,250
Hungary	1,340	1,090	1,390	1,110
Italy	1,340	1,260	1,540	1,470
Russia	789	532	242	116
Slovenia	904	507	733	409
United Kingdom	454	1,280	661	1,850
Other	913 ^r	895 ^r	998	993
Total	104,000	49,900	95,900	47,500
Silicon carbide:				
Crude:				
Canada	9,790	5,570	609	168
China	91,200	29,700	127,000	36,800
Germany	111	496	93	491
Norway	381	862	1,070	3,000
Russia	2,890	1,130	2,660	1,130
Ukraine	1,530	532	--	--
Venezuela	500	289	2,930	1,040
Other	39	48	4	13
Total	106,000	38,600	134,000	42,600
Ground and refined:				
Brazil	5,240	3,730	6,300	4,790
China	7,760	4,740	10,800	7,320
Germany	2,110	5,890	1,620	6,140
Japan	1,310	6,590	1,330	5,570
Mexico	313	329	664	997
Norway	2,510	7,520	2,630	7,020
Philippines	714	517	1,820	1,330
Russia	3,170	1,430	683	333
Ukraine	2,170	1,430	--	--
Venezuela	1,100	458	4,090	2,360
Other	186	661	685	1,200
Total	26,600	33,300	30,600	37,100
Metallic abrasives:				
Canada	7,630	3,580	6,430	2,820
France	282	153	188	171
Germany	1,290	2,210	1,060	2,010
Hong Kong	35	24	119	85
Italy	145	139	90	130
Japan	4,690	3,410	504	657
Romania	234	261	584	474
South Africa	3,640	1,210	2,970	899
United Kingdom	437	125	69	39
Other	327 ^r	202 ^r	369	830
Total	18,700	11,300	12,400	8,120

^rRevised. -- Zero.

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

²Customs value.

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

Country	2001		2002	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Aluminum oxide, crude:				
Brazil	170	\$1,070	485	\$1,480
Canada	1,590	1,870	2,080	2,230
Germany	2,660	7,890	3,860	14,700
Italy	371	430	165	530
Japan	495	3,330	361	2,040
Korea, Republic of	551	2,060	378	1,690
Mexico	1,440	2,140	2,030	2,560
Netherlands	699	1,730	255	1,550
United Kingdom	360	3,570	156	2,570
Other	614 ^r	2,220 ^r	550	2,080
Total	8,950	26,300	10,300	31,400
Silicon carbide:				
Crude:				
Brazil	9	195	25	276
Germany	20	126	138	616
Japan	236	1,200	68	393
Mexico	203	703	213	888
Switzerland	⁽³⁾	40	117	355
United Kingdom	105	247	29	84
Other	56	383 ^r	77	745
Total	628	2,900	668	3,360
Ground and refined:				
Australia	639	219	973	397
Brazil	18	194	131	245
Canada	8,200	5,120	9,210	5,340
Germany	153	152	430	532
Japan	224	1,080	216	457
Mexico	220	212	809	591
Norway	41	50	898	705
United Kingdom	106	196	89	121
Other	232 ^r	794 ^r	221	573
Total	9,830	8,020	13,000	8,960
Metallic abrasives:				
Canada	12,400	5,040	9,890	5,900
Japan	759	370	505	270
Korea, Republic of	20	53	154	106
Mexico	6,380	4,990	7,280	5,010
Saudi Arabia	4	19	167	61
Taiwan	210	235	109	104
United Kingdom	1,560	1,980	239	300
Other	1,280 ^r	2,040 ^r	437	1,180
Total	22,600	14,700	18,800	12,900

^rRevised.

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

²Customs value.

³Less than 1/2 unit.

Source: U.S. Census Bureau.