

ABRASIVES, MANUFACTURED

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Manufactured abrasives are made by heating or chemically treating metals or minerals to give them physical properties needed to abrade, clean, etch, grind, polish, scour, or otherwise remove material by rubbing action (as in a grinding wheel) or impact (pressure blasting). Their most important properties are hardness, toughness (rigidity), grain shape and size, character of fracture, and purity (uniformity). Additional considerations include thermal stability, bonding characteristics, cost, and availability. No single property is paramount for any use (Wellborn, 1996).

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

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

The manufactured abrasives industry in the United States was distinguished by the following developments during 1998: (1) Demand for manufactured abrasives grew in response to a strong domestic economy, particularly in the metals casting and fabrication sectors; (2) imports of aluminum oxide and silicon carbide, especially from China, continued to increase; (3) a U.S. metals abrasive company purchased another domestic metals abrasive firm; and (4) a domestic metals abrasive company was planning to purchase a plant in Mexico at yearend. More information on these developments and others is presented in the text and tables that follow.

Fused Aluminum Oxide

Legislation and Government Programs.—On January 1, 1998, the National Defense Stockpile (NDS) maintained by the U.S. Department of Defense (DOD) contained 114,817 metric tons (t) of crude fused aluminum oxide valued at \$21.4 million and 24,395 t of fused aluminum oxide abrasive grain valued at \$10.9 million. During 1998, the DOD sold 41,192 t of NDS crude fused aluminum oxide valued at \$8.8 million and 4,356 t

of NDS aluminum oxide abrasive grain valued at \$1.3 million. 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. All the stockpiled aluminum oxide will be sold before 2004 if the current disposal rate and NDS sales schedules are continued.

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

Estimated production of regular-grade fused aluminum oxide in 1998 was 99,600 t, an increase of 7% compared with that of 1997 output (table 2). Reporting on the output of high-purity fused aluminum oxide was discontinued to avoid disclosing company proprietary data. The increased output was attributed to a strong domestic economy, particularly in the metals finishing sector, that helped to offset the impact of imports from competing abrasive producers abroad.

Consumption.—Abrasive-grade fused aluminum oxide has many end uses. Specific applications in 1998 included bonded abrasives (i.e., abrasive grains that are made to adhere to each other and then are pressed or molded into abrasive tools), coated abrasives (i.e., abrasive grains glued to a backing such as paper or cloth), tumbling media, air/water blasting media, polishing/buffing compounds, and antislip additives. The total value of fused aluminum oxide abrasive grain consumed in the United States was estimated to be at least \$150 million in 1998.

Prices.—The USGS surveyed fused aluminum oxide producers to determine value of production. The survey indicated that the average value of regular fused aluminum oxide produced in the United States and Canada during 1998 was \$361 per ton at the point of production; the average value of high-purity fused aluminum oxide output was \$550 per ton at the point of production. Prices of abrasive grain produced from these materials and sold to consumers were significantly higher.

The average price of NDS crude fused aluminum oxide sold by the DOD in 1998 was \$214 per ton. The average price of stockpiled fused aluminum oxide grain sold in 1998 was \$298 per ton. The lower values compared with those of producers reportedly reflected the quality and the less suitable locations of some stockpiled material.

Values of fused aluminum oxide trade by the United States in 1998 are summarized as follows: Almost all the crude fused

aluminum oxide imports during the year ranged from \$206 per ton (Chinese) to \$443 per ton (Canadian), but some very small amounts (less than 1%) were valued at more than \$1,000 per ton. More than 92% of fused aluminum oxide grain imports ranged from \$268 per ton (Chinese) to \$1,300 per ton (Austrian); a small amount exceeded \$2,000 per ton. Values reported for U.S. exports of fused aluminum oxide during the year generally exceeded \$1,000 per ton.

Foreign Trade.—In 1998, exports of all fused aluminum oxide declined by 17% to 8,910 t. These exports were valued at \$19.6 million. The exports were shipped to 28 countries, but 76% of all shipments went to Canada, Germany, and Mexico.

During 1998, imports of crude fused aluminum oxide were received from 9 countries and increased by 41% to 127,000 t valued at \$47.2 million, and imports of ground and refined fused aluminum oxide were received from 18 countries and increased by 11% to 52,800 t valued at \$34.9 million (table 5). Some of the imported crude fused aluminum oxide reportedly was refractory-grade material. Canada and China supplied 69% and 31%, respectively, of the crude imports. China provided 52% of the ground and refined material. Imports of fused aluminum oxide, particularly from China, have become so important to the manufactured abrasives industry in the United States that table 5 showing additional details on such trade has been added to this report.

Silicon Carbide

Legislation and Government Programs.—On January 1, 1998, the National Defense Stockpile contained 10,855 t of silicon carbide valued at \$5.1 million. Under Congressional authority to dispose of all NDS silicon carbide, the DOD sold 9,971 t of stockpiled silicon carbide valued at \$3.9 million during the year. The remaining NDS silicon carbide was sold in early 1999. The DOD is not expected to replenish the stockpile with silicon carbide.

Production.—Two companies produced abrasive-grade silicon carbide in Canada and the United States during 1998 (table 1). These companies also produced similar amounts of metallurgical-grade silicon carbide. To protect company proprietary information, additional silicon carbide output data from the producers are not presented in this report. Another company in Hopkinsville, KY, produced a small quantity of silicon carbide, but the output primarily was intended for use in thermal- and heat-resistant products rather than abrasives.

Consumption.—Abrasive-grade silicon carbide has many end uses. Specific applications in 1998 included bonded abrasives, coated abrasives, tumbling media, blasting abrasives, wiresawing abrasives, polishing/buffing compounds, and antislip abrasives. The total value of U.S. producer sales of silicon carbide in 1998 was estimated to be \$180 million (Anwar, 1999).

Prices.—The USGS does not collect price data on the various grades of silicon carbide. On the basis of information from industry sources and publications, however, the average value of abrasive-grade silicon carbide at the point of manufacture was estimated to be about \$610 per ton in 1998.

The average price of NDS silicon carbide sold by the DOD in

1998 was \$391 per ton. The average market value for all the NDS silicon carbide stockpiled during 1998 was \$470 per ton. The lower values compared with those of producers reportedly reflected the quality and the less suitable locations of some stockpiled silicon carbide.

Values of silicon carbide traded with the United States in 1998 were as follows: The value of crude silicon carbide from China, which accounted for 84% of such imports, was \$290 per ton. The average value of the remaining imports was \$665 per ton. The average value of silicon carbide grain from China, which accounted for 75% of such imports, was \$290 per ton. The average value of the remaining imports was \$2,800 per ton. The average value of total silicon carbide exports in 1998 was approximately \$1,200 per ton.

Foreign Trade.—During 1998, the United States exported crude silicon carbide to 14 countries and exported refined or ground silicon carbide to 26 countries. Exports of crude silicon carbide increased by 12% during the year to 2,960 t valued at \$2.2 million. Exports of refined or ground silicon carbide, however, declined by 36% to 8,643 t valued at \$11.4 million. Approximately 91% of the crude exports went to the Netherlands, and about 74% of the refined or ground material was shipped to Canada.

In 1998, the United States imported crude silicon carbide from 10 countries and imported ground or refined silicon carbide from 20 countries. Imports of crude silicon carbide rose by 10% during the year to 234,000 t valued at \$81.8 million (table 5). Imports of silicon carbide in ground or refined form increased by 26% to 34,600 t valued at \$31.8 million.

Table 5 has been added to this report in response to increasing imports of manufactured abrasives, especially from China. China accounted for 84% of the crude silicon carbide imports and 75% of the ground or refined silicon carbide. A large part of the Chinese imports, however, reportedly included metallurgical-grade material. As shown in the preceding section, the value of the imports from China was significantly less than the average values of silicon carbide imports from other sources.

Aluminum-Zirconium Oxide

During 1998, Norton Company and Washington Mills Electro Minerals Corp. produced fused aluminum-zirconium oxide for abrasive applications (such as resin-bonded grinding wheels); output was from two plants in the United States and one plant in Canada (Martin Wozniak, Washington Mills Electro Minerals Corp., oral commun., 1999). In order to protect company proprietary information, the USGS does not publish aluminum-zirconium oxide production data received from the producers.

Boron Carbide

Only one firm, Washington Mills Electro Minerals Corp., was a commercial producer of boron carbide in the United States during 1998 (Martin Wozniak, Washington Mills Electro Minerals Corp., oral commun., 1999). Boron carbide

was used for grinding and lapping operations previously possible only with diamond dust; it also was molded to form very wear-resistant products, such as pressure blast nozzle liners and extrusion dies.

To protect company proprietary interests, domestic production data for boron carbide are not reported here. However, the following trade information on boron carbide was available: In 1998, the United States imported 349 t of boron carbide valued at \$6.3 million from 7 countries, primarily Germany, the Ukraine, and China; exports totaling 25 t valued at \$980,000 went to 21 nations, principally Western Europe.

Metallic Abrasives

Production.—Data in this report on U.S. production and shipments of metallic abrasives were based on a survey of domestic producers conducted by the USGS. Survey data were collected from 12 companies operating 14 plants in the United States and accounted for all the domestic industry (table 3). During 1998, one of the companies, Ervin Industries, Inc., purchased another producer, formerly Barnsteel Abrasives (Ervin Industries, Inc., 1998). In addition, Wheelabrator Abrasives, Inc., prepared to purchase a metals abrasive plant in Mexico at yearend; the purchase was completed in early 1999 (Victoria. DeSanctis, Panabrasives, Inc., oral commun., 1999). Wheelabrator announced that the acquired plant will serve markets in the United States as well as Mexico (Wheelabrator Abrasives, Inc., 1999).

Steel shot and grit account for almost all metallic abrasives produced domestically (table 4). Sustained by a strong industrial economy, U.S. production of steel shot and grit increased slightly compared with 1997 output; the average value per ton remained at \$438. Six companies reported production of cut wire shot in 1998. Most of the shot was cut from carbon steel wire and stainless steel wire; other products reportedly included shot cut from aluminum, copper, and zinc wire.

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

During 1998, total sales of all steel shot and grit by U.S. producers increased by 5% compared to shipments in the preceding year; sales value increased slightly. The average value per ton sold or used during 1998, however, decreased to \$484.

Prices.—Although the USGS compiles survey data on the value of production and shipments, it does not collect price data. Values of production and shipments reported by metallic abrasive producers in 1998 are shown in table 4. Restrained by import competition, prices of steel shot and grit were estimated to be about \$0.45 to \$0.55 per kilogram in 1998. Estimated average prices of cut wire shot in 1998 were \$4.50 to \$9.00 per kilogram for aluminum wire shot and \$6.50 to \$9.00 per

kilogram for stainless steel wire shot.

Average values for metallic abrasives traded by the United States during 1998 were as follows: Exports averaged \$0.61 per kilogram and imports averaged \$0.55 per kilogram.

Foreign Trade.—During 1998, the United States exported metallic abrasives to 36 countries and imported metallic abrasives from 11 countries. U.S. exports of metallic abrasives decreased slightly during the year to 25,800 t valued at \$15.7 million. Most of the exports went to Canada; the remaining amount was shipped to Belgium, Japan, Mexico, and the United Kingdom.

Domestic imports of metallic abrasives increased by 10% in 1998 to 25,600 tons valued at \$14 million. About 90% of the imports came from Canada; most of the remaining imports were shipped from Germany and the United Kingdom.

Outlook

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

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

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

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

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¹ Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1
CRUDE ARTIFICIAL ABRASIVES MANUFACTURERS IN 1998

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

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

Product	1997			1998		
	Quantity (metric tons)	Value (thousands)	Yearend stocks	Quantity (metric tons)	Value (thousands)	Yearend stocks
Silicon carbide 2/	68,200	\$36,500 e/	6,500	69,800	\$41,900 e/	9,280
Aluminum oxide, regular, abrasives 3/	93,500 e/	34,600 e/	7,280	99,600 e/	36,000 e/	5,830

e/ Estimated.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Approximately one half of the quantity and value consists of material for metallurgical uses and other applications.

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

TABLE 3
U.S. PRODUCERS OF METALLIC ABRASIVES IN 1998

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

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

Product	Production		Shipments 2/	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1997:				
Steel shot and grit	262,000	\$115,000	264,000	\$119,000
Cut wire shot and other	2,450	12,900	2,390	12,600
Total	264,000	128,000	266,000	132,000
1998:				
Steel shot and grit	265,000	116,000	277,000	124,000
Cut wire shot and other e/	2,150	10,600	2,140	10,700
Total	267,000	127,000	279,000	135,000

e/ Estimated.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes reported exports.

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

Country	1997		1998	
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
Crude Aluminum Oxide:				
Canada	71,900	\$33,900	87,600	\$38,800
China	11,900	2,970	39,300	8,100
Venezuela	5,790	2,840	--	--
Other	389	381	253	346
Total	90,000	40,100	127,000	47,200
Ground and Refined Aluminum Oxide:				
Austria	6,500	8,430	5,590	7,240
Brazil	596	494	5,870	4,520
Canada	2,990	5,380	2,120	968
China	27,800	7,800	27,600	7,400
Germany	6,810	8,240	7,580	9,800
Italy	1,890	2,040	1,450	1,460
Other	1,070	2,820	2,600	3,490
Total	47,600	35,200	52,800	34,900
Crude Silicon Carbide:				
Canada	27,000	18,300	26,100	17,600
China	172,000	46,900	196,000	56,900
Russia	3,000	384	7,680	3,560
Venezuela	5,240	2,250	1,200	673
Other	5,250	3,880	2,440	3,070
Total	212,000	71,700	234,000	81,800
Ground and Refined Silicon Carbide:				
Brazil	2,530	1,820	2,270	1,470
Canada	1,610	1,160	253	180
China	16,700	5,900	25,900	7,500
Germany	1,550	6,230	1,670	6,690
Japan	920	6,000	1,090	6,020
Norway	2,650	8,300	2,490	7,170
Other	1,480	2,200	903	2,790
Total	27,400	31,600	34,600	31,800

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Customs value.

Source: Bureau of the Census.