Crude Abrasives

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I N D U S T R Y P R O F I L E

1990–1991

CRUDE ABRASIVES

FOREWORD

In a rapidly changing global trade environment, the international competitiveness of Canadian industry is the key to growth and prosperity. Promoting improved performance by Canadian firms in the global marketplace is a central element of the mandates of Industry, Science and Technology Canada and International Trade Canada. This Industry Profile is one of a series of papers in which Industry, Science and Technology Canada assesses, in a summary form, the current competitiveness of Canada's industrial sectors, taking into account technological, human resource and other critical factors. Industry, Science and Technology Canada and International Trade Canada assess the most recent changes in access to markets, including the implications of the Canada-U.S. Free Trade Agreement. Industry participants were consulted in the preparation of the profiles.

Ensuring that Canada remains prosperous over the next decade and into the next century is a challenge that affects us all. These profiles are intended to be informative and to serve as a basis for discussion of industrial prospects, strategic directions and the need for new approaches. This 1990–1991 series represents an updating and revision of the series published in 1988–1989. The Government will continue to update the series on a regular basis.

Michael H. Wilson
Minister of Industry, Science and Technology
and Minister for International Trade

Structure and Performance

Structure

The term crude abrasives, as used in this profile, refers to abrasives that are synthetic; that is, produced either by chemical conversion at high temperature or by changing crystal structure through fusion at high temperature. These are differentiated from natural abrasives, which do not undergo high temperature processing. Crude abrasives are superior to natural abrasives in hardness, toughness and other abrasive characteristics and are used in grinding, polishing and trimming cast materials to finished size and shape.

Canada is a major producer of three important types of crude abrasives: silicon carbide, fused aluminum oxide or alumina, and fused alumina/zirconia. The principal products made from crude silicon carbide and aluminum oxide are shown in the table on the next page.

Major market segments of users are the construction (22 percent), automotive equipment (16 percent), machine tools (12 percent), aircraft (11 percent), miscellaneous machine equipment (8 percent), consumer goods (6 percent), steel (5 percent), monuments (4 percent), electrical (4 percent), packaging (2 percent), marine (1 percent) and miscellaneous (9 percent) industries. The usage pattern shows how widespread the need for crude abrasives is to the industries of Canada and the United States.

Crude abrasives are generally produced by heating specific materials in large electric arc or resistance furnaces at temperatures between 1 900°C and 2 400°C. A mixture of silica and coke produces silicon carbide; bauxite or high-purity alumina produces fused aluminum oxide; and a mixture of bauxite or high-purity alumina plus a zirconium oxide-bearing mineral, such as zircon sand or baddeleyite, produces fused aluminum oxide/zirconium oxide, an extremely tough abrasive.

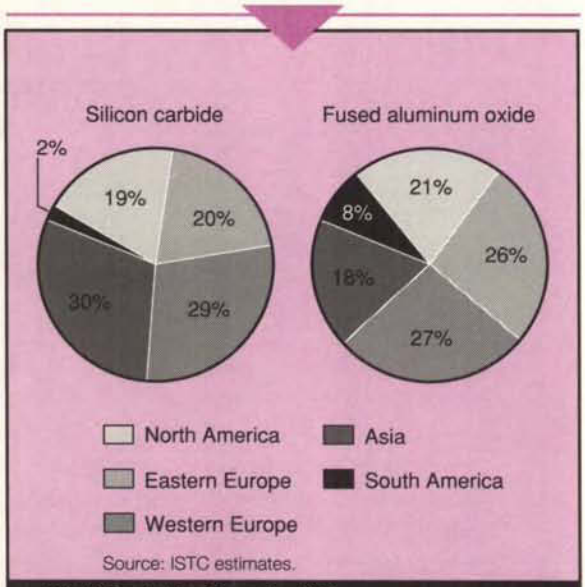
The crude abrasives industry operates on a North American basis, since the Canadian plants and their sister plants in the United States have mainly the same owners and supply virtually the entire North American market. While there are no ownership linkages of crude producers to companies supplying raw materials (mainly silica sand, coke, bauxite, high-purity alumina and zirconia), the North American companies have important downstream ownership linkages to plants producing intermediate products such as abrasive grains, coated abrasives, bonded abrasives and refractory shapes, such as bricks and nozzles. Crude abrasives are manufactured by four companies in 10 plants: six in Canada and four in the United States. All are located in areas where the cost of electrical energy is relatively low. Five are located in or near Niagara Falls, Ontario, two in Niagara Falls, New York, one in Shawinigan, Quebec, and one each in Hennepin, Illinois, and Huntsville, Alabama.

Ownership of all Canadian operations is foreign, with the exception of Exolon ESK, which is jointly owned by Canadian and German interests. Washington Mills and General Abrasives are owned by U.S. interests. Ultimate ownership of Norton changed in 1990 from U.S. to French interests.

The major role of Canadian companies is to supply crude abrasives to their U.S. parents, who process them into sized and shaped grains. The major exception to this pattern is the Norton facility in Niagara Falls, Ontario, which converts its crude alumina/zirconia into finished grains in Canada. Grains are converted into value-added products by the parent plants in the United States and Canada or are sold to other companies that do not have their own facilities for producing crude abrasives.

Products Made from Crude Abrasives

Product type	Percentage of use
Aluminum oxide in bonded abrasives (e.g., grinding wheels)	23
Metallurgical silicon carbide (e.g., additive in production of steel or ferrosilicon)	22
Aluminum oxide in miscellaneous applications	16
Aluminum oxide in refractories	10
Silicon carbide in refractories	7
Silicon carbide in bonded abrasives	6
Silicon carbide as wire-saw grain	6
Aluminum oxide in coated abrasives (e.g., sandpaper)	5
Silicon carbide in coated abrasives	5



World Production Capacity, 1988

Complete statistics on this industry sector are difficult to obtain, as companies are reluctant to disclose information. Two plants in North America, both owned by Norton, produce fused alumina/zirconia: one in Canada and one in the United States. Three other plants exist in France, Germany and Japan. No production figures are available for these plants. Production statistics for alumina/zirconia are withheld by the major producer because of the proprietary nature of the material and method of production. Fused aluminum oxide production in Canadian plants, which were operating at full capacity in 1988, amounted to 186 000 tonnes and had a total value of $76 million, or an average value of $408 per tonne. North American production of this commodity reached 226 000 tonnes in 1988, or 83 percent of total capacity, valued at U.S.$71 million, for an average of U.S.$314 per tonne (C$386.50 per tonne).

For silicon carbide, Canadian plants operating at an average of 70 percent of capacity in 1988 produced 92 000 tonnes valued at $48 million or $522 per tonne. On a North American basis, plant production capacity of this abrasive in the same year averaged 79 percent, for a total output of 130 000 tonnes, having a total value of U.S.$51 million, or U.S.$392 per tonne (C$482.50 per tonne). The Canada/U.S. ratio of plant capacity is 55:45 for silicon carbide and 90:10 for fused aluminum oxide. Consumption, on the other hand, is about 1:15 for both materials.

World production capacity of silicon carbide and of fused aluminum oxide for 1988 is shown in the figure above.

Performance

Western world producers of crude abrasives have been affected by the volatility of supply and demand. Consumption and prices increased sharply in the 1970s and were forecast to continue rising. This caused new sources of supply, particularly of fused oxides, to be brought into production. Heavy investments were initiated to convert small-batch Higgins arc furnaces to large, intermittent tilt-pouring furnaces, to make secondary-type improvements in silicon carbide furnaces and, in some cases, to install pollution abatement equipment. As a result of the oil price shock of 1979, which led indirectly to reduced consumption of abrasives in the early 1980s, the industry found itself facing significant overcapacity.

This situation was aggravated by structural changes in the major markets, such as downsizing in the North American automotive and agricultural equipment industries. In addition, increased imports of high-quality castings from offshore suppliers and the increased substitution of materials requiring less finishing than steel reduced the consumption of abrasives. This declining demand led to restructuring and a reduction in the world production of abrasives. In North America in the early 1980s, Carborundum closed plants in three U.S. states — Tennessee, Washington and New York; Ferro closed plants in Buffalo, New York, and Cap-de-la-Madeleine, Quebec; Norton Co. closed its silicon carbide operation in Niagara Falls, Ontario, and transferred its production to Cap-de-la-Madeleine; and American Manufacturing closed its operation in the Cap-de-la-Madeleine/Shawinigan region of Quebec. In the mid-1980s, Carborundum, for many years a world leader in the abrasives industry, was virtually dismantled. Its fused aluminum oxide plants in the Niagara area were sold to Washington Mills, and its crude silicon carbide operation in Shawinigan, Quebec, and its downstream coated abrasives plant in Plattsville, Ontario, were sold to Norton Capital Inc. More recently, ownership of General Abrasives changed hands when Sterling Abrasives, headquartered in Florida, bought it from Dresser Industries of Mississauga, Ontario. In 1990, the Norton parent company in Worcester, Massachusetts, was bought by Saint Gobain of Paris, France.

Besides the decline in market demand, a major reason for closures in the United States was the rapid escalation of electrical energy costs, which represent almost one-third of total production costs. Low productivity and the high cost of implementing pollution controls were additional reasons for the closures in Canada. Health and environmental considerations exacerbated the situation, particularly for the production of crude silicon carbide, a process for which pollutants are difficult to control and pollution-control equipment is expensive. Consequently, from the late 1970s until about 1986, the world abrasives industry was characterized by low demand, excess capacity and significant financial costs, partly as a result of the installation of pollution control equipment. Fortunately, several companies were sheltered during the downturn by virtue of their being part of large corporations.

World demand and prices began to recover in 1987 and profits of the surviving companies have improved. The North American industry has returned to a healthier position, although the consolidation and restructuring are not finished. Exolon ESK has reduced its silicon carbide capacity at Thorold, Ontario, and has almost doubled the capacity of its silicon carbide plant at Hennepin, Illinois. Norton, one of the world's largest producers of silicon carbide, closed its Cap-de-la-Madeleine, Quebec, plant in 1990 because of the high cost of complying with environmental standards.

At the end of 1988, the U.S. National Defense stockpile contained 250 000 tonnes of crude fused aluminum oxide and 51 000 tonnes of abrasive grains, representing about one year of North American production, and 72 000 tonnes of crude silicon carbide, representing over half a year of production. The U.S. policy decision on the amount of stockpile is an important consideration for Canada, because much of this stockpile comes from Canadian production.

Strengths and Weaknesses

Structural Factors

Canada's fused aluminum oxide and fused alumina/zirconia operations use large, state-of-the-art, highly mechanized and computerized tilt furnaces at low energy cost. Therefore, their output levels rank among the world's highest in productivity and lowest in cost. Canada's silicon carbide operations have the advantages of large-scale operation and relatively low energy cost, although they are not generally as mechanized as Exolon ESK's plant in Hennepin, Illinois, or some offshore operations.

One Canadian producer has set up a facility to refine abrasive grains from one of its major products, but other Canadian producers are constrained because their sister and parent companies in the United States perform these downstream operations. Therefore, while U.S. ownership provides Canadian subsidiaries with ready market access, major management decisions such as the location of downstream operations are made at corporate offices outside Canada. Finally, as in the rest of the world, Canada's silicon carbide operations generally require much high-cost pollution-control equipment.

The abrasives industry in general is a mature industry. It suffers from advances in the development of substitute products and of improved methods of achieving near net shape cast and other products that require less, if any, finishing. Canada's disadvantages as a producing country are an absence of domestic reserves of bauxite ore and zirconium oxide-bearing materials, high freight and distribution costs resulting from the size of the country, a fragmented market and a small though increasingly integrated production facility for converting crude abrasives to grains. In contrast to the above constraints, Canada offers the advantage of relatively inexpensive electrical power, a competent labour force, reliable infrastructure, reliable power supply, political stability and a sizable domestic market.

Technological Factors

An important technical factor in the production of crude silicon carbide is the continued use of the original type of Acheson furnace developed near the turn of the century. This is a relatively low productivity type of furnace and it also creates considerable pollution. The cost of pollution control is high, as shown by Norton's decision in 1990 to close its plant at Cap-de-la-Madeleine, Quebec. All world crude silicon carbide plants are of the old Acheson design, in which heat is transferred from the electrical resistor to the coke/silica mixture. One Canadian, one European and one American producer (a sister company of a Canadian producer) have modified the furnace design so that loading and unloading can be done more efficiently and pollutants can be collected more readily, resulting in significant productivity improvements. Producers have never been able to develop an economical process to replace the Acheson process for producing crude silicon carbide. To date, they can only improve materials handling and, at high cost, pollution control. Canadian producers are therefore in the same general situation as those in the rest of the world.

On the other hand, Canadian producers of fused aluminum oxide and fused alumina/zirconia generally use state-of-the-art technology. The high-power, tilting arc furnaces give extremely high productivity and operate at low cost. Many producers in the world use these, although some still use the out-dated, smaller Higgins furnaces. The Canadian industry has several of the world's largest tilting furnaces and is in the forefront of competitiveness in the production of crude fused oxide abrasives.

The Canadian industry does not undertake much of its own research and development (R&D) in the furnacing of crude abrasives and development of new products. Norton had a significant R&D facility at Niagara Falls, Ontario, to develop new and improved production methods, but this responsibility was transferred in 1990 to its Huntsville, Alabama, crude abrasives plant. Generally, Canadian plants perform some development work on an ad hoc basis and from time to time may license the use of some processes from other North American or offshore companies.

Trade-Related Factors

Over three-quarters of Canada's production of crude abrasives is exported to the United States. This includes almost all the fused alumina, a portion of the fused alumina/zirconia and up to three-quarters of the silicon carbide. Also, a small amount of fused aluminum oxide is exported to the United Kingdom. The remaining crude abrasives are shipped to Canadian customers, mostly as a metallurgical silicon carbide additive in the production of steel. The alumina/zirconia crude made in Canada is also processed in Canada into sized and shaped grains. Most of these grains are then shipped to the United States for fabrication into bonded and coated articles. No tonnage or cost figures are available.

Crude abrasives cross the Canada-U.S. border in either direction duty-free. In 1990, grains made from crude abrasives had a tariff of 0.4 cents per kilogram, which represents less than 1 percent of total value on average. Even this small duty will eventually be reduced to zero by 1 January 1993 under the Canada-U.S. Free Trade Agreement (FTA). Therefore, this industry sector will not be affected by the FTA. However, the Canadian coated and bonded abrasives industry might come under pressure because of the FTA. Canadian tariffs are 10 to 12 percent and U.S. tariffs are 2.5 to 5 percent. Under the FTA, which will gradually eliminate tariffs on finished products by 1 January 1998, Canadian producers of these downstream products might be under pressure to rationalize, with the resulting possibility that some production of bonded and coated products will be transferred between Canada and the United States. If this occurs, however, it should not significantly affect Canadian production of crude and grains because these will still be made in Canadian electrothermal plants, where relatively cheap electric power is available.

Evolving Environment

For the next 10 years, it is expected that total demand for crude silicon carbide and fused aluminum oxide will not increase significantly. The crude abrasives industry is a mature industry but is being continually challenged by a number of factors, including increasingly tough environmental laws that will be costly to the industry, particularly for silicon carbide production.

Natural abrasives such as garnet and emery will continue to take their historical share of the market because they do not require expensive electrothermal processing or as much anti-pollution equipment, even though they are not as abrasive as the synthetic abrasives of this profile. In addition to natural abrasives, new synthetic crude abrasives such as diamonds, cubic boron nitride and seeded aluminum oxide sol gel (SG) continue to be developed and improved. SG is not a high-temperature fused material, but takes on abrasive characteristics by a series of dehydration low-temperature sintering/nucleation steps. SG has been replacing other materials used in grinding wheels and coated abrasives and can be applied to a wide range of metals and high-technology alloys.

While the parents of the Canadian synthetic abrasives producers have been prominent in developing these new abrasives, it is not likely that their Canadian subsidiaries will be the commercial producers. The exception is fused alumina/zirconia (AZ). Norton, the patentee and developer of AZ, uses an electrothermal method similar to that used for fused alumina to produce one type of AZ in Canada and another type in the United States. In time, these relatively expensive materials will come down in price and will replace the standard abrasive materials in some applications because their high price is more than compensated for by their superior wear performance.

Technological improvements in the heavy industries such as foundry and automotive have also reduced the demand for abrasives. With improved casting techniques, the production of near net final shapes has reduced the amount of abrasive needed at the finishing stage. Material substitution, such as plastic or aluminum for steel, also diminishes the demand for abrasive materials because, being softer than steel, they require lesser amounts of abrasives when they are polished to final form.

Most silicon carbide producers are in the process of modernizing operations. They are installing additional mechanized equipment to mix raw materials, load, unload, sort and crush. One company has conducted sufficient development work on automatic sorting of crude abrasives to consider placing the system into full production. All Canadian companies have made major improvements in arc furnacing of fused oxides, but only one Canadian company has installed a new configuration of silicon carbide furnace.

Restructuring in this industry is continuing. With the closure of the Norton crude silicon carbide plant in Cap-de-la-Madeleine, Quebec, and with the sale of all of its Canadian and other worldwide operations to Saint Gobain of France, the controlling influence of this sector is shifting toward Europe.

Moreover, since this is basically a North American industry and since it supplies a wide range of industries, the recent 1990–1991 recession will have an impact. The eventual extent of the impact will depend on the duration and rate of the recovery.

Competitiveness Assessment

Canadian companies and their sister companies in the United States are competitive, world-class producers of fused crude aluminum oxide and fused crude alumina/zirconia because of their use of state-of-the-art technology.

The same cannot be said for Canadian companies producing crude silicon carbide, whose plants require better furnace design and pollution control. With few exceptions, most producers around the world use the old, low-productivity, polluting type of furnaces, and major modernizations do not appear to be under way. There is, however, the possibility that foreign owners could move their silicon carbide operations out of Canada and into countries having cheap electric power and less stringent pollution control laws.

The major challenges facing the world electrothermal crude abrasives industry arise from the substitution of both abrasive materials and base materials. New abrasive materials that are more cost-effective in use than synthetic abrasives are making slow but steady inroads into their market. Meanwhile, the use of softer base materials in place of steel is reducing the overall quantities of abrasives required to shape them.

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PRINCIPAL STATISTICS[a]

		1984	1985	1986	1987	1988
Employment		N/A	N/A	N/A	N/A	1 100
Shipments ($ millions)						
	silicon carbide	49.6	49.3	48.5	50	48
	fused alumina	66.6	63.4	55.8	61	76
	total	116.2	112.7	104.3	111	124
Shipments (thousands of tonnes)						
	silicon carbide	81.6	81.0	82.8	84	92
	fused alumina	140.9	131.1	121.4	117	186
	total	222.5	212.1	204.2	201	278

[a]All data are ISTC estimates. Statistics on fused alumina/zirconia are withheld to avoid disclosure of company proprietary data. This profile relates to the abrasives industry, SIC 3571 (see *Standard Industrial Classification, 1980*, Statistics Canada Catalogue No. 12-501). See *Monthly Survey of Manufacturing*, Statistics Canada Catalogue No. 31-001, monthly, for data on manufacturers' shipments, inventories and orders for SIC 3571. For detailed information, see *Non-Metallic Mineral Products Industries*, Statistics Canada Catalogue No. 44-250, annual.

N/A: not available

SOURCE OF IMPORTS

(Almost 100 percent from the United States.)

DESTINATIONS OF EXPORTS[a] (% of total tonnage exported)

		1983	1984	1985	1986	1987	1988
United States	silicon carbide	100	100	99	100	99	99
	fused alumina	95	94	92	96	93	94
United Kingdom	silicon carbide	–	–	–	–	–	–
	fused alumina	5	5	7	3	6	5
Other	silicon carbide	–	–	1	–	1	1
	fused alumina	–	<1	<1	1	1	<1

[a]ISTC estimates.

MAJOR FIRMS[a]

Name	Country of ownership	Location of major plants
Exolon ESK Company	Canada/Germany	
Exolon ESK Company		Hennepin, Illinois (SC)
Exolon ESK Company of Canada, Limited		Thorold, Ontario (SC) (FA)
General Abrasives (division of Abrasive Industries Inc.)	United States	
General Abrasives		Niagara Falls, New York (FA)
General Abrasives		Niagara Falls, Ontario (SC) (FA)
Norton Co.	France	
Norton Advanced Ceramics of Canada Inc.		Niagara Falls, Ontario (FA) (AZ)
Norton Céramiques Avancées du Canada Inc.		Shawinigan, Quebec (SC)
Norton Co.		Huntsville, Alabama (FA) (AZ)
Washington Mills Electro-Minerals Corporation	United States	
Washington Mills Electro-Minerals Corporation		Niagara Falls, Ontario (FA)
Washington Mills Electro-Minerals Corporation		Niagara Falls, New York (FA)
Washington Mills Ltd.		Niagara Falls, Ontario (FA)

[a]Statistics on capacity and production for individual companies are not shown, as requested by most companies. Total North American capacity is about 127 000 tonnes of silicon carbide and 272 000 tonnes of fused aluminum oxide.

(SC) Silicon carbide

(FA) Fused alumina

(AZ) Fused alumina/zirconia