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PROVISIONAL INTELLIGENCE REPORT

THE ABRASIVES INDUSTRY IN THE USSR



CIA/RR PR-103
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PROVISIONAL INTELLIGENCE REPORT

THE ABRASIVES INDUSTRY IN THE USSR

CIA/RR PR-103

(ORR Project 34.231)

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CIA/RR PR-103
(ORR Project 34.231)

THE ABRASIVES INDUSTRY IN THE USSR*

Summary

The USSR will be self-sufficient in the production of abrasives by the end of 1955. The present emphasis on the development of the Soviet abrasives industry has enabled the Russians to overcome shortages prevalent in the economy before 1952 and to export small amounts of abrasives and abrasive products to Communist China.

Total production of crude artificial abrasives in the USSR is estimated to be 133,500 tons* in 1954, or approximately 61 percent as much as the average annual postwar production in the US and Canada.*** Currently the Soviet rate of production appears to be in line with its growing economy. The abrasives industry is only a small part of the gross national product but an industry upon which all other production is dependent. Without abrasives, modern mass production of interchangeable parts and moving mechanisms would be impossible. Metal-fabricating industries are therefore the major consumers of finished abrasive products.

The industry is patterned after that of the US and uses the same or similar techniques of manufacture. The production of crude abrasives is confined mainly to two products, aluminum oxide and silicon carbide. In the USSR the crude abrasives industry centers about four plants. These plants supply the required abrasive grain to some 12 to 14 plants engaged in manufacturing finished products (such as bonded and coated products, grinding powders, and refractories).

The inputs to the Soviet abrasives industry are relatively small. The industry is not even a major consumer of most of the raw materials needed, such as electrical energy, bauxite or alumina, petroleum coke, and silica sand. These all are found in sufficient quantities in the

* The estimates and conclusions contained in this report represent the best judgment of ORR as of 15 October 1954.

** Tonnages throughout this report are given in metric tons.

*** The US and Canadian crude abrasives industries are so interwoven that figures published are for the combined production of both countries.

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USSR to provide for the present and anticipated levels of production of this industry. Electrical energy, the most critical requirement for crude abrasives production, is available in the vicinity of the crude-producing plants. The total electrical requirement of the crude abrasives industry is estimated to be less than 5 percent of the total electricity produced in the areas in which the crude-producing plants are located.

The manpower requirements for the industry are small. On-the-job training of new workers is considered adequate except for a small group of skilled technicians and engineers. In 1954, fewer than 20,000 workers were estimated to be required for the entire industry, or less than 0.2 percent of the industrial labor force in the USSR.

The basic conclusions of this report are (1) that the Russians have achieved since 1930 an abrasives industry capable of producing more than present domestic requirements and (2) that there are no shortages of inputs which would prevent further expansion to meet civilian or war needs.

I. Introduction.

A. General.

The abrasives industry is an important component of the war-making capability of any nation because mass production of modern arms and machines of defense is impossible without an adequate supply of high-quality abrasive products.

The industry is characterized by a relatively small number of producing units and a dependence upon a stable supply of electric power. Its direct contribution to the gross national product is insignificant in spite of its essentiality in modern industry.

The production process has three major steps: (1) the high-temperature chemical process, which produces crude abrasives; (2) the pulverization and grading process, which produces abrasive grain in standard sizes; and (3) the manufacturing process, in which bonded, coated, and other abrasive products are made from the grain.

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This report is limited to that part of the abrasives industry of the USSR producing artificial abrasives -- aluminum oxide and silicon carbide -- and natural abrasives -- emery and corundum. Industrial diamonds or other natural abrasives such as garnet and flint are not evaluated in this report.

B. History.

The first abrasives plant in the USSR was the Il'ich Abrasives Plant, built in Leningrad in 1930. The Il'ich Abrasives Plant, which has facilities for producing both aluminum oxide and silicon carbide, was followed in 2 years by the construction of the Chelyabinsk Abrasives Plant, which has facilities for producing only aluminum oxide. The Zaporozh'ye Carborundum Plant, dedicated exclusively to the manufacture of silicon carbide, began production in 1939, and the Tashkent Carborundum Plant, with facilities for both silicon carbide and aluminum oxide, began production in 1942. 1/*

In addition to these 4 main plants, which produce crude abrasives, crush and sort the grain, and manufacture some finished products, some 12 to 14 other plants 2/ produce finished abrasive products, such as grinding wheels, stones, coated papers and cloths, grinding grain, and refractory products.

Before World War II a central scientific laboratory for abrasives and polishing materials, known as the All-Union Scientific Research Laboratory for Abrasives and Grinding, was established in Leningrad near the Il'ich Abrasives Plant. 3/

C. Technology.

1. General.

The basic operation in the production of artificial abrasives is the high-temperature chemical process during which a batch of raw materials is heated electrically until it fuses to form a crystalline structure possessing excellent abrasive properties.**

* For serially numbered source references, see Appendix C.

** For a diagram illustrating the processes of manufacturing abrasive products, see the chart following p. 4.

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The two industrially important abrasives formed in this way are aluminum oxide and silicon carbide. Regular aluminum oxide is formed from bauxite, coke, and iron filings in an arc-type furnace at an average rate of 3,000 kilowatt-hours (kwh) of electricity per ton of aluminum oxide formed. A somewhat better grade, white aluminum oxide, using alumina instead of bauxite in its manufacture, requires approximately 1,800 kwh of electricity per ton of white aluminum oxide formed.

Silicon carbide is formed from sand and coke in a resistance-type furnace at an average rate of 8,500 kwh of electricity per ton of silicon carbide formed.

In either operation, a block of crude abrasives weighing several tons is formed. This is crushed and pulverized and the grain accurately graded from coarse to fine.

Bonded abrasive products such as wheels and stones are manufactured by mixing grain with suitable bonding materials and then pressing the mix into shapes which are set by firing.

Coated products are made by distributing the grain over a surface of cloth or paper to which an appropriate adhesive has been applied.

2. Comparison of Soviet and US Technology.

The abrasives industry of the USSR is modeled after that of the US, and though methods are comparable, it is believed that Soviet finished products are somewhat inferior to US finished products. For example, a few Soviet abrasive wheels analyzed by a US manufacturer indicated some bonding deficiencies. 4/ Some Soviet arc-type furnaces used for aluminum oxide are, however, larger than those used in this country. The average US furnace will produce approximately 5-ton blocks of crude abrasives. 5/ The Russians are reported to be using furnaces with approximately 13,500-kilowatt capacity, 6/ which produce an aluminum oxide block weighing 25 to 30 tons. 7/

3. Convertibility to Wartime Economy.

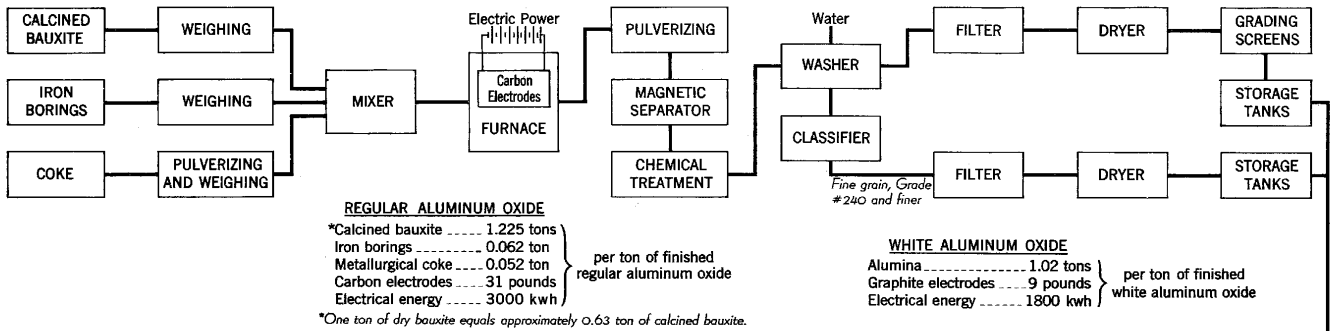
The abrasives industry requires no changeover in equipment and methods to convert from a peacetime to a wartime economy. The same products are essential to both economies, although a wartime

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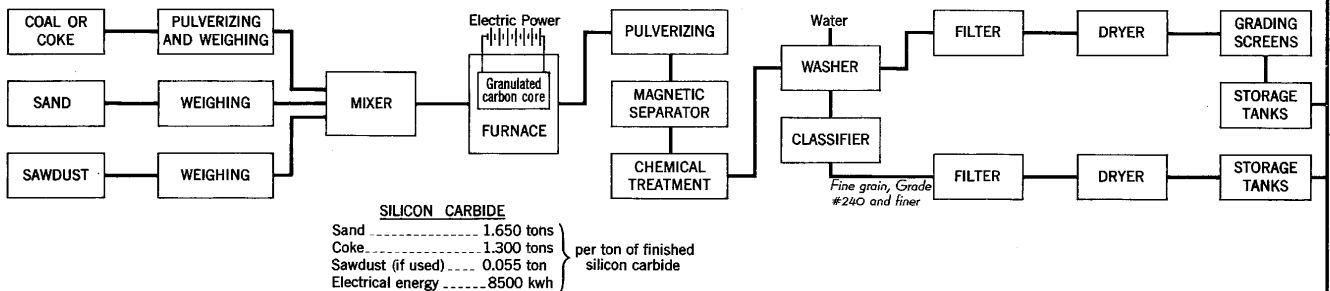
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TECHNOLOGY FOR THE SYNTHETIC PRODUCTION OF ABRASIVES

REGULAR ALUMINUM OXIDE



SILICON CARBIDE



FINISHED PRODUCTS			
REFRACTORIES	BONDED PRODUCTS	COATED PRODUCTS	OTHER PRODUCTS
Furnace linings	Grinding wheels	Abrasive cloth	Polishing powders
Laboratory ware	Segments	Abrasive paper	Lapping paste
Resistors	Stones	Abrasive discs	Buffing compounds

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economy requires substantially increased rates of production. Since the industry is operating at near-capacity levels, increased production would have to be met by expansion of facilities. There is no technological reason why expansion should be limited. In the short run, there may be some internal dislocations caused by an expansion, but given time for programming, a substantial expansion should be possible.

D. Organizational and Administrative Structure.

Before March 1953 the abrasives plants of the USSR were under the Main Administration of Abrasives in the Ministry of the Machine-Tool Industry, with A.I. Kostousov as the Minister. The Director of the Main Administration of Abrasives was P.P. Tubanov, as of September 1948, and presumably Tubanov was still Director of the Main Administration of Abrasives in 1952, when he coauthored an article on abrasives.

In March 1953 the Ministry of Machine-Tool Industry and several other ministries were combined to form the Ministry of Machine Building. Kostousov was a Deputy Minister in this Ministry. 8/

When the new government was announced on 27 April 1954, the Ministry of Machine Building was split into several new ministries, one of which was the Ministry of Machine-Tool Industry, with Kostousov as the Minister. 9/

The USSR has gone back to the same ministerial setup which existed before the merger of 1953, including the same minister. Although the abrasives industry has not been located in the new setup, the assumption is that the prior relationship, in substance, exists. The organization and administrative structure of the industry follow the normal Soviet pattern.

II. Supply.

A. Production.

1. Crude Abrasives.

Estimates of the production of the four plants in the USSR producing crude artificial abrasives are shown in Table 1.* Production

* Table 1 follows on p. 6.

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Table 1

Estimated Total Production of Crude Abrasives in the USSR a/
1940 and 1946-56

Type	Metric Tons											
	1940	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Artificial												
Aluminum oxide	19,100	37,000	45,000	53,500	61,500	70,000	76,000	83,500	91,500	100,000	109,500	120,000
Silicon carbide	5,200	7,000	11,000	15,000	18,500	22,500	25,500	28,000	30,500	33,500	36,500	40,000
Total artificial	24,300	44,000	56,000	68,500	80,000	92,500	101,500	111,500	122,000	133,500	146,000	160,000
Natural												
Corundum and emery	13,200	12,000	11,000	9,000	8,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
Total crude	37,500	56,000	67,000	77,500	88,000	99,500	108,500	118,500	129,000	140,500	153,000	167,000
Percent of natural to total crude	35	21	16	12	9	7	6	6	5	5	5	4

a. Estimates are based on plant studies and over-all announced production or plans. The range of error is plus 25 and minus 15 percent. See Appendix A, Methodology.

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of aluminum oxide was 37,000 tons in 1946 and 100,000 tons in 1954, approximately 2.7 times as great. Production of silicon carbide was 7,000 tons in 1946 and 33,500 tons in 1954, approximately 4.8 times as great. The production of both aluminum oxide and silicon carbide is expected to increase approximately 20 percent by 1956. The production of artificial abrasives in 1954 was a ratio of approximately 25 percent silicon carbide to 75 percent aluminum oxide. 10/

In the US and Canada,* average production of aluminum oxide was 153,800 tons for the period 1946-53,** and average annual production of silicon carbide was 66,000 tons for the same period. Thus the USSR in 1953 produced approximately 60 percent as much aluminum oxide as was produced in the US and Canada in an average postwar year and 46 percent as much silicon carbide, or for the artificial abrasives industry as a whole, approximately 56 percent.

The USSR recognizes the importance of artificial abrasives, and production of natural abrasives expressed as equivalents of artificial crude abrasives is expected to decline from approximately 21 percent of total crude production in 1946 to approximately 4 percent of total crude production in 1956.

The estimates of annual production shown in Table 1 are based in part on plant studies. These data have been evaluated in terms of over-all production increases reported from time to time and the announced plan of industrial growth, modified by estimates of fabricated metal production. 11/

Figures for the production of natural abrasive ore shown in Table 1 are approximations based on Shimkin studies 12/ and the US Bureau of Mines estimates. Natural abrasives as defined in this report are declining as an important material in the over-all Soviet abrasives industry, since (a) corundum deposits are becoming exhausted 13/ and (b) emery is less desirable in the manufacture of grinding wheels because of the variation in the ore and inferior cutting qualities. The inconsistency makes it difficult to control the quality of wheels on a production basis and to

* The US and Canadian crude abrasives industries are interwoven, and combined production totals are reported.

** The average of the postwar years was used, since it appears that the level of production has not changed substantially, but the totals for individual years show fluctuations that would not be representative.

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maintain the standardization required in the manufacture of modern wheels to meet the increasing demand by the growing machine-building industries for better grinding, polishing, and finishing of machine parts. 14/

Since there is considerably more loss in conversion of natural abrasive ore to grain than in conversion of artificial crude abrasives, an equivalent to the artificial crude has been calculated. This calculated equivalent is used in obtaining any figure for total crude production.

2. Abrasive Grain.

The estimated annual production of abrasive grain in the USSR is given in Table 2.* Before the crude abrasives can be used to make abrasive products, the blocks must be crushed into grain. The relationships pointed out in the last section, however, are maintained.

Grain production can be estimated by the use of US analogy because grain production is equal to crude production minus manufacturing losses. These losses in the US average 20 percent for artificial grain and 50 percent for natural grain.

3. Use of Abrasive Grain Produced in the USSR by Class of Product.

In the US, approximately 67 percent of all abrasive grain produced** is used for the manufacture of bonded products -- largely grinding wheels -- and 13 percent for the manufacture of coated products and grinding powders. The remaining 20 percent is used for non-abrasive applications, such as refractories and resistors. The grain for nonabrasive applications is primarily silicon carbide, and only a small percentage of aluminum oxide grain is used for these purposes.

The USSR apparently places a somewhat greater emphasis on bonded products than does the US. About 75 percent of all abrasive grain is being used for the production of bonded products, 12 percent for the production of coated products and grinding powders, and the remaining 13 percent for nonabrasive uses.

* Table 2 follows on p. 9.

** Produced in the US and Canada.

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Table 2
 Estimated Total Production of Abrasive Grain in the USSR a/
 1940 and 1946-56

Type	Metric Tons											
	1940	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Aluminum oxide b/	15,300	29,500	36,000	43,000	49,000	56,000	61,000	67,000	73,000	80,000	87,500	96,000
Silicon carbide b/	4,200	5,500	9,000	12,000	15,000	18,000	20,500	22,500	24,500	27,000	29,000	32,000
Natural corundum and emery b/	10,600	9,500	9,000	7,000	6,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500
Total grain production	30,100	44,500	54,000	62,000	70,500	79,500	87,000	95,000	103,000	112,500	122,000	133,500

a. See Table 1 for margin of error.

b. Calculated from the best estimate of crude production, assuming a 20-percent average loss in converting from crude to grain. 15/

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In the US it takes approximately 1.1 tons of abrasive grain to make 1 ton of finished bonded products. ^{16/} Since Soviet technology is similar, it is reasonable to use the same conversion factor for the USSR. Therefore, an estimated 63,000 tons of bonded products were produced in the USSR in 1953.

4. Estimated Value of Abrasive Grain Production.

The estimated value of abrasive grain produced in the USSR during 1954 in constant 1949 ruble prices is 61.5 million rubles of aluminum oxide grain, 36.5 million rubles of silicon carbide grain, and 3 million rubles of natural corundum and emery grain, or a total of 98 million rubles of abrasive grain. (See Table 3.*) The prices used for 1949 appeared in a Russian Export-Import Dictionary ^{17/} and are, therefore, presumably wholesale prices.

Evidence indicates that the price of aluminum oxide grain had not changed much on the average from 1942 to 1949, but that silicon carbide grain had increased in price considerably in 1949 over the average 1942-46 prices.

Although there is no evidence of the direction prices moved since 1949, it is felt that less error will be introduced by using constant 1949 prices than might occur if Soviet prices were adjusted on the basis of price movements in the US, Norway, or some other country producing artificial abrasives. A document ^{18/} with 1952 information indicates that for aluminum oxide the 1949 price is approximately correct in the latter period.

The price selected for natural corundum and emery is subject to considerable error because the average price varies greatly depending on the percentage of corundum to the percentage of emery included, and no Soviet price for either of these products is available. The value of natural abrasives produced, however, is only a small percent of the value of artificial abrasives produced and is declining in importance. Even a considerable error in the price of natural abrasives would have little effect on the value of total abrasives produced.

* Table 3 follows on p. 11.

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Table 3

Estimated Value of Total Production of Abrasive Grain in the USSR
1949-56

Type	Thousand 1949 Rubles							
	1949	1950	1951	1952	1953	1954	1955	1956
Aluminum oxide ^{a/}	37,500	43,000	47,000	51,500	56,000	61,500	67,500	74,000
Silicon carbide ^{b/}	20,000	24,500	27,500	30,500	33,000	36,500	39,000	43,000
Natural corundum and emery ^{c/}	3,500	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Total grain production	61,000	70,500	77,500	85,000	92,000	98,000	109,500	120,000

a. Calculated from Table 2, using 1949 prices throughout as calculated from prices given in the Russian Export-Import Dictionary. ^{19/} The dictionary gives a range of prices for 1949 and also breaks down aluminum oxide into regular and white. The average price for aluminum oxide was calculated on the assumption (based on US experience) that 7/8 was regular and 1/8 was white aluminum oxide. The midpoint of the range given (770 rubles) was assumed to be the average ruble price. A CIA document ^{20/} with 1952 information partially confirms these prices.

b. Calculated from the same source as a, above. However, the lower limit of the range, or 1,350 rubles, was used. Since the range of prices is for green silicon carbide, the lower limit is assumed to be the average ruble price for silicon carbide in general.

c. Calculated from Table 2 on the basis of 500 rubles per ton. US prices for a mixture of emery and corundum grains were on the average approximately 50 percent of the prices of a mixture of artificial abrasive grain.

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S-E-C-R-E-T5. Geographic Distribution of Production.

The production of crude abrasives and abrasive grain is concentrated in four plants located near plentiful sources of electric power. These plants are also on the periphery of the area containing the largest part of Soviet economic activity. In general, the finished products plants are located near the crude- and grain-producing plants. Three or four exceptions point to the influence of consuming areas on the location of finished products plants. The notable exceptions are the Moscow and Shuya plants located in Region VII,* which is probably the largest consuming region in the USSR, and the Khaikhta plant in Region XI. Khaikhta is located on the Trans-Siberian Railroad, approximately halfway between the supply of abrasive grain in Chelyabinsk and Tashkent and the shipyards, aircraft plants, and developing industries of the eastern section of the USSR. See Table 4** and the map*** for further details of geographic location of production.

B. Imports.

During World War II the USSR imported a considerable amount of abrasives from the West, especially from the US. Imports from the US during 1943-45 amounted to 5 or 6 million dollars of crude abrasives, abrasive grain, and finished products annually. 21/ US exports to the USSR declined rapidly after 1945 and ceased in 1948. Norway also exported small quantities of silicon carbide to the USSR from 1947 to 1949.

After World War II the USSR turned to the European Satellites for abrasives. Apparently the stocks of abrasives on hand in East Germany were seized and sent to the USSR as reparations. In 1946, East Germany shipped approximately 2,200 tons of silicon carbide and 660 tons of grinding wheels to the USSR as reparations payments. 22/ Since the East German silicon carbide plants were dismantled and shipped to the USSR after the war, 23/ the assumption is that this was shipped from stock and did not indicate current production. It is assumed that available East German stocks of aluminum oxide were also shipped to the USSR in 1946. This amount is estimated to be 3,000 tons for 1946.

* The term region throughout this report refers to the economic regions defined and numbered on CIA Map 12048.1, 9-51 (First Revision, 7-52), USSR: Economic Regions.

** Table 4 follows on p. 13.

*** Inside back cover.

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Table 4
Geographic Production of Abrasive Grain in the USSR
1953

Economic Region	Plants	Products	Percentage of Artificial Abrasive Grain Manufactured in the Area a/
I	Il'ich Abrasives Plant Luga (Krasnyy Tigel)	Aluminum oxide and silicon carbide crude and grain; also finished products Refractories, wheels, and lapping compounds	25
III	Luga (Smychka Abrasives) Abrasive Experimental Plant Zaporozh'ye Carborundum Plant	Refractories, wheels, and ceramics Research and development Silicon carbide crude and grain; also refractories	12
V	Rion b/		
VII	Moscow Abrasives Plant Shuya	Wheels, coated products, and lapping compounds Wheels and coated products	
VIII	CheLyabinsk Abrasives Plant Zlatoust Abrasives Plant Kyshtym Abrasives Plant Shiifoval'dny Abrasives Plant Kosulinskaye b/	Aluminum oxide crude and grain, wheels, and coated products Wheels and other finished products Natural corundum products Coated products and rubber bonded wheels	52
X	Tashkent Carborundum Plant Tashkent Abrasives Tpol Khat b/	Silicon carbide and aluminum oxide crude and grain lapping compounds Wheels, coated abrasives, refractories, and other finished products Grinding wheels and finished products	11
XI	Khaikhta Abrasives Plant	Wheels, refractories, ceramics, resistors, lapping compounds, and other finished products	

a. Based on estimated 1953 production.

b. Plants which have been mentioned in reports. Little or no information given.

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Imports of abrasives by the USSR from East Germany were calculated by estimating total production in East Germany and assuming that a certain percentage was shipped to the USSR. Reports for the years immediately after the war indicated that this percentage was very high, and most reports indicated that about 70 percent was going to the USSR. 24/ Later reports indicate that the percentage going to the USSR declined somewhat. 25/ It is estimated that by 1954 the Russians will become nearly self-sufficient in the production of abrasives.* This, together with the indication that East Germany is now attempting to export abrasives to West Germany, 26/ leads to the conclusion that the Soviet demand for Satellite abrasives is declining. Soviet imports from East Germany, which amounted to an estimated 7,300 tons of abrasive grain in 1950, are expected to decline to 1,900 tons in 1956.

Czechoslovakia has recently been reported to be shipping abrasive products to countries other than the USSR. 27/ However, about 25 percent of the abrasives production of Czechoslovakia went to the USSR in 1948. 28/ Czechoslovak statistics show exports of 687 tons of grinding wheels to the USSR in 1948. 29/ In 1950, Czechoslovakia was exporting about 25 percent of its total production of abrasives. 30/ Thus 2,600 tons of grinding wheels are estimated to be imported by the USSR from Czechoslovakia in 1953.

The other East European countries do not meet domestic requirements. Both Hungary 31/ and Rumania 32/ are reported to be planning new production capacity and are not now exporting significant quantities of abrasives to the USSR.

Table 5** summarizes the estimated imports of abrasives into the USSR during 1946-56.

C. Inventories and Stockpiles.

The estimated amount of abrasive grain available for stockpiling or export in the USSR in 1954 was 4,700 tons. For other years, the estimated amounts are as follows: 1952, 900 tons; 1953, 3,700 tons; 1955, 5,700 tons; and 1956, 8,300 tons. The amount of abrasives used by the USSR was determined by multiplying the estimated number of grinding machines in the USSR by the estimated amount of abrasives used

* See Table 7, p. 31, below, for estimates of Soviet requirements.

** Table 5 follows on p. 15.

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Table 5
Estimated Imports of Abrasive Grain into the USSR by Country of Origin a/
1946-56

	Metric Tons										
Country	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
US ^{33/}											
Artificial and crude grain	517	18	43								
Grain equivalent of finished products	255	256	29								
Total	772	274	72								
Norway ^{34/}											
Silicon carbide	300	420	450								
Czechoslovakia ^{35/}											
Grain equivalent of finished products	770	1,210	1,320	2,640	2,860	2,860	2,860	2,860	2,200	1,700	1,100
East Germany ^{36/}											
Aluminum oxide	3,000	2,500	3,400	4,600	5,900	5,200	4,800	4,100	3,200	2,400	1,600
Silicon carbide ^{37/}	2,200		400	400	1,400	1,200	1,000	800	600	400	300
Grain equivalent of finished products ^{38/}	700										
Total	5,900	2,500	3,400	5,000	7,300	6,400	5,800	4,900	3,800	2,800	1,900
Total imports	6,700	2,800	4,700	6,700	8,600	9,000	8,700	7,800	6,000	4,500	3,000

a. The margins of error for estimated imports of abrasive grain into the USSR are as follows: US, plus or minus 5 percent; Norway, plus or minus 5 percent; Czechoslovakia, plus or minus 40 percent; East Germany, plus or minus 40 percent; and for total imports, plus or minus 40 percent.

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annually per grinding machine. The use rate per machine was based on a 1937 article by a Soviet abrasives expert ^{39/} and brought up to date by analogy with US requirements. It was assumed that 20 percent of the machine tools in the USSR are grinding machines. ^{40/} The number of machine tools in the USSR was taken from a CIA estimate.

III. Demand.

A. Use Pattern.

Abrasive products are used in almost all industries, especially the machine-building and metalworking industries. Therefore, the geographic location of the manufacturing industry in the USSR is a geographic breakdown of the use pattern for the abrasives industry. This is in contrast to the relative concentration of production in a few areas.

The principal abrasive-consuming industries are the transportation equipment, metalworking equipment, and metallurgical industries. These three industries are estimated to consume approximately two-thirds of the abrasives in the USSR. The remaining one-third is widely distributed among various industries, including the ballbearing, ordnance, machine-building (excluding metalworking equipment), woodworking, leather, and optical industries.

B. Exports.

Recent reports indicate that the USSR is exporting a very small proportion of its annual abrasives production. ^{41/} These reports are of offers of abrasive grains, which are purported to have come from the USSR, and of shipment of finished products to Satellite countries. The offers of grain were made by East-West traders to non-Soviet Bloc countries.

Although the USSR is reported to be exporting abrasives to Communist China, Chinese imports are apparently coming mostly from the East European countries -- East Germany, Czechoslovakia, and Hungary. ^{42/}

C. Substitutes.

In general, there are no good substitutes for artificial abrasives. In some specialized applications, however, there are possibil-

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ities of substitution, which will reduce the need for abrasive materials. Recent developments of electrolytic methods of grinding and metal removal by the USSR indicate that the Russians have developed means of machining hard metals which were heretofore difficult to machine and the machining of which previously required many types of grinding wheels and other abrasives. 43/

Electrolytic methods of grinding, when applied to the cutting tool industry, will eliminate at least 50 percent of the need now found for special types of grinding wheels and diamond-impregnated wheels. 44/ There are various combinations of electrolytic processes of machining and grinding that permit the application of this new method of machining to a variety of uses in metal removal operations which will eliminate the need for an abrasive material.

The USSR is now apparently beyond the experimental stage in the use of these methods. Commercial models of anode mechanical grinders and electric spark apparatus for machining metals are reported to be in series production. 45/ Until detailed studies of the extent of possible use and the number of machines of this nature produced can be made, no estimate of the amount of abrasive materials saved is possible. Once a number of these machines are in operation, requirements for abrasives will be reduced.

Silicon carbide can be substituted to a certain extent for operations normally using diamond-impregnated wheels. This substitution, however, is somewhat limited.

IV. Future Expansion.

A. Existing Capacity.

The present production of abrasives in the USSR is believed to be near capacity level. Some of the most important abrasives plants in the USSR are reported to be competing to outproduce each other, fulfilling or exceeding their norms to win high honors in the All-Union Socialist competition. 46/ These factors, together with a continuing increase in the production of abrasives, indicate operations at near-capacity level. Recent reports 47/ indicate that improvement of equipment is being made to increase capacity.

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B. Projected Expansion.

The Fifth Five Year Plan (1951-55), while saying nothing specifically on abrasives, specifies "that the capacity of existing enterprises must be increased by reconstruction, installation of new equipment, mechanization of production, and improved technology to increase production." 48/

There have been no reports indicating construction of new abrasives plants. Production increases of crude and grain products through reconstruction of furnaces 49/ and technological advancements in furnace capacity are being accomplished. 50/ Dissemination of knowledge among workers in abrasives plants to increase their capabilities and output is under way. 51/

Mechanization and installation of new equipment has increased the production of grinding wheels and coated products immensely, reduced man-hour requirements, and produced a better quality product. 52/

V. Inputs.

A. For Production.

1. Raw Materials.

The requirements of the abrasives industry are relatively small. The industry is probably not even a major consumer of bauxite or alumina, petroleum coke, and silica sand, the major raw materials of the industry.

a. Crude Abrasives.

The crude abrasives industry requires, on the average, the following inputs for each ton of crude produced:

Regular aluminum oxide	<u>53/</u>	
Electrical energy		3,000 kwh
Calcined bauxite*		1.225 tons
Iron borings		0.062 ton
Metallurgical coke		0.052 ton
Carbon electrodes		35 pounds

* One ton of dry bauxite equals approximately 0.63 ton of calcined bauxite.

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White aluminum oxide	
Electrical energy	1,800 kwh
Alumina	1.02 tons
Graphite electrodes	10 pounds
Regular silicon carbide	
Electrical energy	8,500 kwh
Petroleum coke or pitch coke	1.3 tons
Silica sand	1.65 tons
Sawdust	0.055 ton
Electrodes	Negligible (electrodes last 2 or 3 years)

The USSR will produce approximately 1 million tons of bauxite in 1956, as compared with 800,000 tons in 1953 (dry basis but not calcined). 54/ In addition, approximately 900,000 tons of bauxite and 120,000 tons of alumina are imported from Hungary annually. 55/ On this basis, there is sufficient bauxite and alumina available to the USSR to produce the amounts of aluminum oxide estimated. 56/

There are apparently large resources of silica sand in the USSR and the European Satellites for manufacturing silicon carbide. 57/ Petroleum coke, a byproduct of the petroleum industry, also appears to be in sufficient supply. 58/

b. Finished Products.

The finished products -- bonded and coated products -- require the addition of numerous raw materials in relatively small amounts.

Approximately 15 to 20 percent of the weight of finished bonded products consists of bonding agents and centers made from lead, tin, natural rubber, cryolite, shellac, resins, kaolin, and felspar. The coated products require hide glue, paper made of manila rope, cloth, and the like. Although some of these items are necessary in the production of the finished products, the total amounts are not very large. Since each type of product does not require each of these inputs, the amounts required will depend upon the product mix produced. Including rejections and losses in manufacture, approximately 1.1 tons of grain are required per ton of grinding wheels. 59/

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When manufactured into coated products, a ton of abrasive grain will produce approximately 100 reams or rolls of aluminum oxide and 110 reams or rolls of silicon carbide. Fifty-one yards of cloth and 8.2 pounds of glue are required per ream or roll (9-inch by 11-inch sheet or 27-inch roll).

2. Fuel and Power.

The crude abrasives industry requires extraordinary amounts of electrical energy in relation to the amount of product. Soviet plants, however, are located in areas where the power is available. Using estimated production for 1954, the following energy requirements were calculated:

<u>Plant</u>	<u>Electrical Energy Requirements (Million Kilowatt-Hours)</u>	<u>Source and Capacity of Power Stations ⁶⁰/₆₀ (Million Kilowatt-Hours)</u>
Il'ich, Leningrad	170	Leningrad Network 4,200
Chelyabinsk	190	City of Chelyabinsk 2,900
Zaporozh'ye	100	City of Zaporozh'ye 2,500 to 3,000
Tashkent	100	Uzbek Power System 2,700

The above estimates of power output are for 1952 or earlier, while the abrasive requirements are based on estimated 1954 production. Therefore, because additional power capacity has been installed since 1952, the crude abrasives production requirements for electrical energy are very probably a smaller percentage of the regional output than is indicated.

Considerable electricity and fuel are also required for the production of finished products. The fuel to heat the kilns may be gas, oil, coal, or electricity. In a plant where the kilns are fired by coal, oil, or gas, approximately 800 kwh per ton of bonded products is required. Electrically heated kilns require almost 1,500 kwh per ton. For coated products approximately 22 kwh per ream or roll is required. Refractories require approximately the same electrical inputs as bonded products. Conversion from one fuel to another could be made without too much difficulty by alterations of the kilns.

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3. Capital Equipment.

Standard buildings and industrial machinery are adaptable in most instances to the production of abrasives. The crude furnaces, the crushing machinery, the wheel-curing kilns, temperature and humidity control devices, and other equipment are standard throughout the industry. The equipment used in this industry has a long service life. The equipment in a Czechoslovak plant was estimated to be possibly 50 years old. 61/ The industry thus operates with few or no replacements for long periods of time.

In grading the grain, the practice of the US industry is to use silk screens manufactured in Switzerland, France, or West Germany. In US practice these screens are estimated to last long enough to grade 20 to 100 tons. The coarser grains are now graded with metal screens, which last longer. The very fine grains (240 grit and finer) require water classification or mechanical methods. The USSR is presumably using these same methods and is also reported to be experimenting with centrifugal separators for grading. 62/

The jaws and the rollers of the crushing equipment require replacement from time to time. Although this equipment should not be difficult to duplicate, it is vital in maintaining the efficiency of production.

4. Manpower.

The manpower requirements, especially of the crude abrasives industry, are small. Because of the low total requirements for skilled personnel, manpower for the industry is not a problem. On-the-job training of new workers is considered adequate. 63/ A group of skilled technicians and engineers, however, is required.

By US standards, it is estimated that the abrasives industry employs 1 employee for every 11 tons of crude abrasives produced. This, however, includes the manufacture of artificial crude abrasives, the processing of abrasive grains, and the production of finished abrasive products. About 10 percent of the total employees are engaged in the manufacture of crude abrasives. 64/

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Table 6 shows the estimated manpower requirements for the industry. These estimates are calculated by US analogy with the assumption that the Soviet workers are only two-thirds as efficient as US workers.

Table 6

Estimated Manpower Requirements for the Abrasives Industry
in the USSR ^{a/}
1946-56

Year	Crude Abrasives Produced (Tons)	Number of Employees			
		US Standards	Soviet Standards	<u>Required to Manufacture</u>	
				Crude Abrasives	Finished Products ^{b/}
1946	56,300	5,100	7,600	800	6,800
1947	66,500	6,000	9,000	900	8,100
1948	77,600	7,100	10,600	1,100	9,500
1949	88,200	8,000	12,000	1,200	10,800
1950	99,500	9,000	13,500	1,400	12,100
1951	108,500	9,900	14,800	1,500	13,300
1952	118,200	10,700	16,000	1,600	14,400
1953	128,900	11,700	17,600	1,800	15,800
1954	140,500	12,800	19,200	1,900	17,300
1955	153,100	13,900	20,800	2,100	18,700
1956	166,900	15,200	22,800	2,300	20,500

a. Assuming that a Soviet worker is two-thirds as efficient as a US worker.

b. Figures may not total because of rounding.

There is considerable heavy work in both the primary and secondary industry for which male workers are desirable. Female workers, however, are used extensively in the secondary industry. In the US, approximately 75 percent male and 25 percent female workers are employed. ^{65/} Reports indicate that the USSR is using approximately 60 to 70 percent female workers. ^{66/}

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B. For Expansion.

Although proportionately more inputs would be necessary for expansion than are needed for continued production on the same level, the abrasives industry takes such a small percentage of the total supply of these inputs that an expansion as projected by this report is apparently feasible.

VI. Intentions and Vulnerabilities.

A. Intentions.

The abrasives industry is an indicator of changes in economic and military activity. Changes in amount and type of production cause a change in the demand for and consequently the production of abrasives. A change to consumer goods will cause a small increase in demand for abrasives for the tooling period and then a decline. A change to war materiel will, on the other hand, be characterized by a substantial increase in demand for and therefore production of abrasives.

At present the USSR is giving considerable attention to the abrasives industry. The industry shows a continuous growth pattern since it was started in the 1930's. Largely because of the rapid expansion of industry in general, the USSR has been deficient in abrasives until the last 2 or 3 years. Thus, until quite recently, the buildup in the production of abrasives was necessary to meet the demands of the expanding Soviet economy. Present indications are that the growth of the abrasives industry is to continue in the foreseeable future.

B. Vulnerabilities.

The abrasives industry is not vulnerable to economic pressures. A very rapid expansion to meet military requirements might cause short-term internal dislocations. Although the crude abrasives plants currently consume less than 5 percent of the total electric power produced in the regions in which the plants are located, electric power is an absolute necessity for producing crude abrasives.

Aluminum oxide, the most important abrasive for grinding steel, requires bauxite for continued production. Hungary is an important source of bauxite. ^{67/} Silicon carbide, the other artificial abrasive produced in quantity, is dependent upon petroleum or pitch coke. The bulk of this material at present is reported to be coming from Rumania. ^{68/}

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The production of crude abrasives is concentrated in four plants. Since aluminum oxide and silicon carbide are not both produced in all plants, the concentration is somewhat greater, only three plants producing each product.

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APPENDIX A

METHODOLOGY

1. Production.

Estimates of total production were derived from references to the producing plants in the abrasives industry, to the percentage change in the industry as a whole between specified periods, and to the development of an artificial abrasives industry.

a. Prewar.

(1) Artificial Crude Abrasives.

The production of crude abrasives was arrived at by establishing a prewar estimate from plant studies and an estimate of the natural abrasives output for the year 1940. ^{69/} In the Chelyabinsk Abrasives Plant, production was 9,000 tons in 1939 and about 10,000 tons at the beginning of the war (1941). ^{70/} Assuming a straight-line interpolation, Chelyabinsk in 1940 was producing approximately 9,500 tons.

A 1931 publication ^{71/} reports that the Il'ich Abrasives Plant has an annual capacity of 9,600 tons of aluminum oxide and 1,700 tons of silicon carbide. It is assumed that in 1940 this plant produced at this capacity.

The first section of the Zaporozh'ye Carborundum Plant started production in 1939. ^{72/} An early report ^{73/} indicated that this plant would have at least a 3,000-ton silicon carbide capacity for a 5-month operational period. A German report in June 1941 ^{74/} estimated silicon carbide production at this plant to be 3,600 tons annually. Therefore it is estimated that in 1940 the output of this plant was 3,500 tons. One report ^{75/} predicted that the 1939 silicon carbide production would be 3.5 times the 1938 silicon carbide production, which was estimated to be 1,500 tons. This would mean that in 1939 the Russians expected at least 5,200 tons of silicon carbide, the major difference in production to be taken up by the Zaporozh'ye plant.

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The total Soviet artificial crude abrasives production for 1940 is therefore estimated to have been 24,300 tons. This estimate appears likely because the Soviet plan for production of artificial abrasives in 1939 was for 35,456 tons. 76/ This same source stated that in the first quarter of 1939, fulfillment was approximately 65 percent of this plan. Assuming that this ratio continued through the four quarters (usually the Russians accelerate their production in the fourth quarter), they would have produced a total of approximately 23,000 tons. One reference 77/ stated that in 1937 in the USSR the capacity for manufacturing grinding grains was 23,000 tons, or approximately 29,000 tons of crude.

(2) Natural Abrasives.

The estimate for natural abrasives for 1940 was calculated as follows: one source 78/ stated that the output of natural abrasives for 1937 was reported to be 14,173 tons of corundum and 15,101 tons of emery. Since this is a mined product, it indicates a recovery of refined product (natural ore) of approximately 50 percent, or for the above production approximately 14,600 tons. In order to convert the natural ore to an equivalent value of that of artificial abrasives the following equivalent values were applied: 1.25 tons of artificial crude is equivalent to 1 ton of grain, and 2 tons of natural ore is equivalent to 1 ton of grain. Thus 1.25 divided by 2 equals 0.625. A unit weight of natural ore (refined) is equivalent to 0.625 unit weight of artificial crude in the manufacture of abrasive grain.* Therefore 14,600 tons of natural ore would be equivalent to 9,100 tons of crude for 1937.

The production of natural abrasives in 1940 is assumed to have continued at an average annual increase of 13 percent, or 13,200 tons crude equivalent. It is felt that at this time the production of natural abrasives continued to increase commensurate to the growth of the national economy 79/ (a) to supplement the greater demand made by the steady growth of the metal fabricating industries and (b) to help offset the deficits of artificial abrasives due to production difficulties encountered by the rapidly expanding abrasives industry.

* Due to the variable quality of the natural ore in hardness and structure, it is generally accepted by the abrasives industry and the US Bureau of Mines that natural abrasives have a work value of only 50 percent of the work value of artificial abrasives.

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b. Postwar.

Reports of construction and restoration of abrasives plants permitted a 1946 estimate. A report 80/ told of a 50-percent production increase over the prewar level, yielding an estimate of 56,000 tons for 1946.

(1) 1946.

(a) Artificial Abrasives.

Restored plants are assumed to have resumed production at or near a rate equivalent to the time of dismantling. In support of this reasoning, a report 81/ stated that the Tashkent carborundum or abrasive tool plant produced 4,700 tons in 1947, and a published report that this plant in 1947 produced 134.6 percent more in 1947 than in 1946 places the 1946 figure at 3,500 tons. The Chelyabinsk plant, which had acquired equipment from the dismantling of the Il'ich plant and two small plants in Luga during the war, increased their production considerably. A calculated estimate from reports stating the number of furnaces, the size of "pig," and the time cycle of furnace runs indicates that the Chelyabinsk plant in 1949 was producing about 43,000 tons of aluminum oxide. A report stated that at the beginning of the war this plant was producing 10,000 tons. 82/ Therefore it was estimated that Chelyabinsk was producing approximately 27,500 tons of aluminum oxide.

(b) Natural Abrasives.

The estimate for the output of natural abrasives is a residual which is reasonable, considering the declining emphasis being placed on natural abrasives. It is perfectly clear from all evidence that the Soviet emphasis is on artificial abrasives and not on natural. A diminishing supply of corundum and the unsuitability of natural abrasives for most modern metalworking requirements have produced this trend. 83/ There are some abrasive operations, however, such as polishing precision lenses and foundry uses, where corundum is desirable. Some emery is also used in the manufacture of coated abrasives. Therefore the estimate of natural abrasives was calculated on an arithmetical decline to an approximate 7,000 tons in 1950 and then held constant at

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this level because of the probable constant requirements to meet special needs.* In evaluating this estimate, the annual requirements of the US abrasives industry for natural abrasives were considered. The USSR would probably require a proportionate amount of US requirements.

(2) 1950.

Nikitin stated that production of abrasives in 1950 was to increase 2.6 times over prewar production, 84/ and the estimate for 1950 was thus made by taking 2.6 times the 1940 estimate. The total planned output for 1950 was therefore 97,500 tons. At least one plant fulfilled the gross plan by 105 percent, 85/ and reports stating that other crude abrasives plants were being converted to high-speed smelting 86/ lead to the assumption that an average estimate of a 102-percent plan fulfillment for the industry in 1950, or a production of 99,500 tons, was likely.

The total of 99,500 tons was allocated to the individual producing plants on the basis of information obtained from various sources. These allocations indicate that approximately 75 percent of the artificial crude was aluminum oxide and 25 percent silicon carbide. These figures agree with a goal announced earlier. 87/

The estimates for the years 1947-49 were obtained by a straight-line interpolation with the exception of the calculated estimates for Chelyabinsk and Tashkent.

(3) 1951-56.

For the best estimate of production subsequent to 1950, production was estimated to increase 9 percent per year. The 1955 index of production for fabricated metal products (1950 = 100) is estimated to be 154. 88/ The average increase therefore would be approximately 9 percent per year.

Another estimate is based on reports of percentage increases of production of finished products which stated that 1951 production was 13 percent over 1950 and that 1952 production was 28 percent over 1950. 89/ A report stated that 1953 production of finished products was 50 percent

* The range of error is plus 50 and minus 25 percent.

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over 1950. 90/ The above percentages were applied to the estimate of 1950 production of crude in the USSR plus the estimated imports of grain (converted to crude equivalents). Then for each year the estimated annual imports were subtracted from the results of the above calculations to give estimates of production in the USSR. The estimates for 1954 and beyond were calculated on an assumed 9-percent annual increase over the 1953 estimate.

The totals calculated in the above manner were distributed as follows: the best estimate of natural abrasives was subtracted from the total, giving the estimate for artificial crude. The artificial crude was distributed on the basis of 75 percent aluminum oxide and 25 percent silicon carbide.

2. Requirements.

The estimate of total abrasive grain required was made as follows: an article in Stanki i instrument 91/ said that in 1937 the Soviet abrasives requirements totaled 27,000 tons for 27,000 grinding machines. Their stated goal was to reduce the requirements to 0.5 ton per grinding machine by 1942, by improving quality and utilization.

It is assumed that the USSR has improved the quality of production and the efficiency of use since the 1930's. This assumption is supported by the following factors:

(a) Soviet periodicals and press frequently mention improved quality of abrasives and new techniques of grinding. 92/

(b) Analysis of Soviet wheels indicates that construction and grain are comparable to US wheels but that they had an incomplete bond development. 93/

(c) Various reports have indicated that imports have been declining in recent years.

(d) Recent reports have indicated some small amounts of exports.

(e) The estimate of requirements based on the number of grinding machines and the assumption of grain required per grinding machine, together with estimates of production, indicate that the USSR is now self-sufficient in abrasives production.

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On this assumption, a requirement of 1,000 pounds of grain per grinding machine was assumed for 1946. Since about 75 percent of all abrasive grain goes into grinding wheels and 1.1 tons of grain are necessary to make a ton of wheels, the assumption is that 680 pounds of grinding wheels were used per grinding machine in the USSR in 1946. The total 1,000 pounds of grain per grinding machine is broken down as 750 pounds into wheels (680 pounds of wheels) and 250 pounds into coated abrasives, grinding grains, refractories, and the like.

In the US an average of approximately 500 pounds of grinding wheels per grinding machine was required in 1952. An analysis of Soviet grinding wheels showed that although the wheels tested showed construction and grain comparable to US wheels, they had an incomplete bond development and thus would wear faster. On this basis the USSR is assumed to require 20 percent more wheels, or 600 pounds of grinding wheels, per machine. This is equivalent to 660 pounds of grain for wheels, or 880 pounds of grain total. Periods between 1946 and 1952 were determined by interpolation. For 1953-56 it is assumed that total grain requirements will decline another 20 pounds to 860 pounds per machine.

Twenty percent of the Soviet machine tool park 94/ consists of grinding machines. The 20-percent figure is the approximate breakdown in the US and agrees with the Soviet goal. 95/ Table 7* is a summary of the estimates of grain requirements.

* Table 7 follows on p. 31.

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Table 7

Estimated Requirements for Abrasive Grain in the USSR
1946-56

<u>Year</u>	<u>Requirements</u>				
	<u>Grinding Wheels (Pounds)</u>	<u>Abrasive Grain for Wheels (Pounds)</u>	<u>Grain Per Grinding Machine (Pounds)</u>	<u>Grinding Machines (Units)</u>	<u>Total Grain (Metric Tons)</u>
1946	680	750	1,000	134,000	60,900
1947	670	735	980	157,000	69,900
1948	655	720	960	182,000	79,400
1949	640	705	940	209,000	89,300
1950	625	690	920	225,000	94,100
1951	615	675	900	241,000	98,600
1952	600	660	880	257,000	102,800
1953	585	645	860	274,000	107,100
1954	585	645	860	291,000	113,800
1955	585	645	860	309,000	120,800
1956	585	645	860	328,000	128,200

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APPENDIX B

GAPS IN INTELLIGENCE

Current information on the Soviet abrasives industry is limited to fragmentary reports from Soviet newspapers, periodicals, and radio broadcasts. Detailed information on types of products and quantities manufactured, sources of raw materials, distribution of finished products, number of furnaces, and number of employees, especially for the four plants which produce crude abrasives -- the Chelyabinsk Abrasives Plant, the Il'ich (Leningrad) Abrasives Plant, the Zaporozh'ye Carborundum Plant, and the Tashkent Carborundum Plant -- is needed.

Further information on representative sizes and types of grinding wheels is necessary. Estimates of Soviet requirements are affected by the quality of wheels.

Detailed information on types of plants and amounts of production, number of employees, size of plants, and sources of abrasive grain is needed. Further information is needed for firm estimates of breakdowns of total production into types of products and geographical distribution patterns.

Information on exports is practically nonexistent, and information on imports is very fragmentary. Further collection from the Satellites may fill this gap.

There is no information available on the Soviet distribution of finished products. Current information on abrasives prices in the USSR is lacking.

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APPENDIX C

SOURCE REFERENCES

This report is based largely on official Soviet information, such as periodicals, newspapers, books, and radio broadcasts, supplemented by information reports collected by the intelligence community. From the information collected from the above sources, estimates of production, distribution, and the like were made by use of conversion factors determined from information collected from official US publications, US abrasive industry representatives, and the US Bureau of Mines.

Thirty-five percent of the sources are official Soviet information sources; 30 percent are intelligence reports with evaluations ranging from A-1 to F-6; and the remaining 35 percent are references to US practice. Most of these reports are believed to be fairly reliable, and the over-all evaluation of the sources is estimated to be B-2.

Evaluations, following the classification entry and designated "Eval.," have the following significance:

<u>Source of Information</u>	<u>Information</u>
Doc. - Documentary	1 - Confirmed by other sources
A - Completely reliable	2 - Probably true
B - Usually reliable	3 - Possibly true
C - Fairly reliable	4 - Doubtful
D - Not usually reliable	5 - Probably false
E - Not reliable	6 - Cannot be judged
F - Cannot be judged	

"Documentary" refers to original documents of foreign governments and organizations; copies or translations of such documents by a staff officer; or information extracted from such documents by a staff officer, all of which may carry the field evaluation "Documentary."

Evaluations not otherwise designated are those appearing on the cited document; those designated "RR" are by the author of this report.

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No "RR" evaluation is given when the author agrees with the evaluation on the cited document.

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93. [REDACTED]

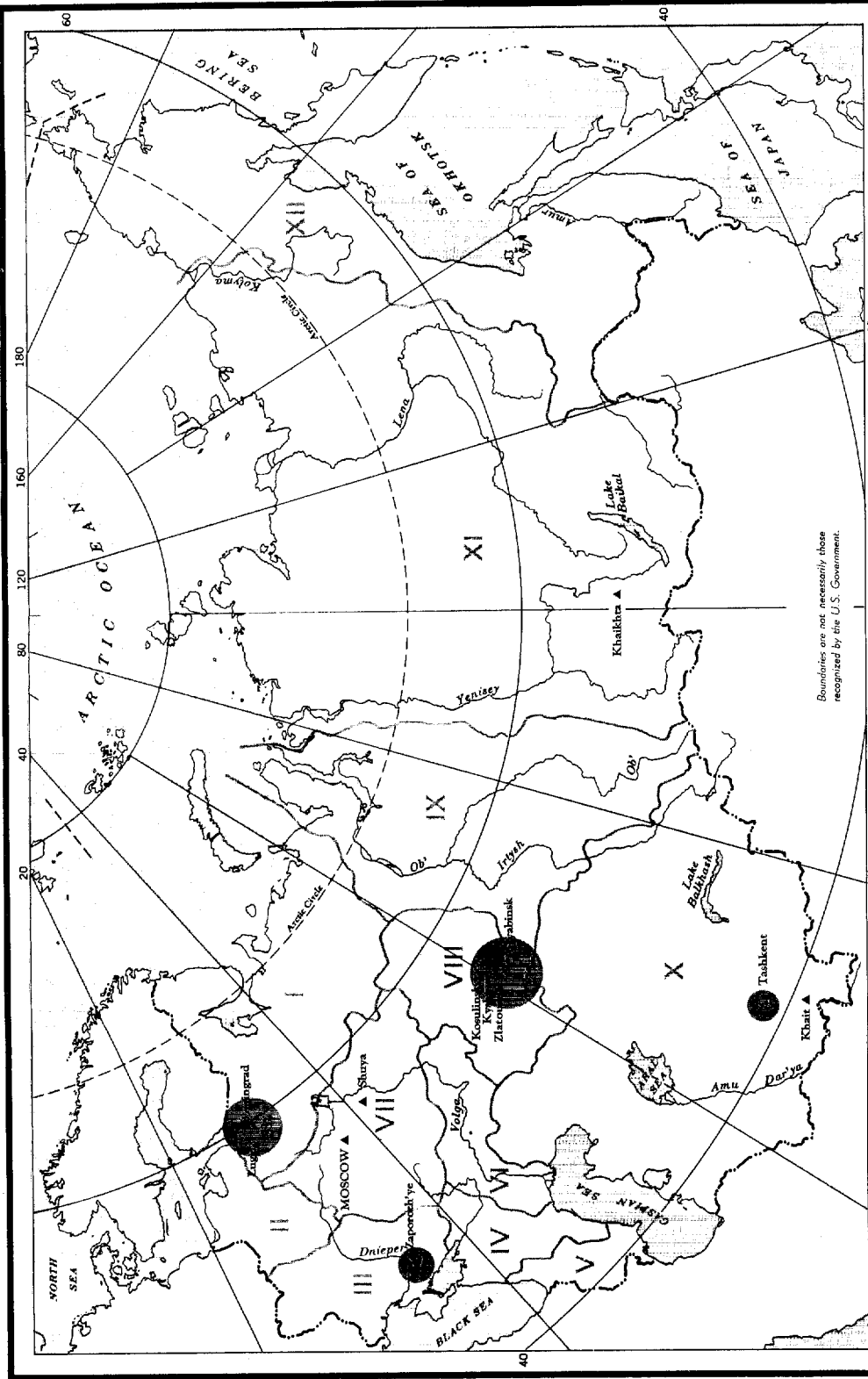
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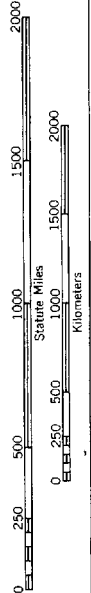
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SECRET



Estimated Production of Abrasives in the USSR — 1954

- Crude and grain production site
(Size of circle is proportional to the percentage of total USSR production produced at the given site)
- ▲ Finished-products production site



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