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PROVISIONAL INTELLIGENCE REPORT

THE SYNTHETIC AMMONIA INDUSTRY IN THE USSR

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THE SYNTHETIC AMMONIA INDUSTRY IN THE USSR

CIA/RR PR-115

(ORR Project 22.456)

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(ORR Project 22.456)

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THE SYNTHETIC AMMONIA INDUSTRY IN THE USSR*

Summary

The synthetic ammonia industry in the USSR is essential to the development of the Soviet industrial economy in time of peace and would be a highly strategic industrial factor in time of war. Synthetic ammonia, the most important of the basic nitrogen compounds, is widely used in the manufacture of nitrogenous fertilizers and industrial explosives and is required for the manufacture of all nonatomic military explosives and propellants.

Production of synthetic ammonia in the USSR in 1954 is estimated to have been about 714,000 metric tons** -- equal to about three-tenths of 1954 production of synthetic ammonia in the US. There is no evidence to indicate either trade in or stockpiling of synthetic ammonia by the USSR, and total available supply is assumed to be equal to production.

About 464,000 tons of synthetic ammonia are estimated to have been consumed by Soviet industry in the manufacture of nitrogenous fertilizers in 1954, and about 175,000 tons were required for other industrial uses. The remaining 75,000 tons represent apparent consumption in the production of military explosives.

It is estimated that annual production of synthetic ammonia in the USSR will increase at a rate of almost 5.5 percent per year during the 1954-57 period, providing agriculture with a substantially increased supply of nitrogenous fertilizers. The amount of nitrogen required to meet anticipated increases in food production is large, however, and it is estimated that production of synthetic ammonia will have to be at least 2.5 times the 1954 level before there is an adequate supply of nitrogenous fertilizers for agriculture.

* The estimates and conclusions contained in this report represent the best judgment of ORR as of 1 March 1955.

** Throughout this report, tonnages are given in metric tons.

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As indicated by Khrushchev's 1953 proposal to increase mineral fertilizer capacity to about 17 million tons by 1959 and to 29 million tons by 1964 -- almost 3 and 5 times the 1953 level, respectively -- the USSR apparently plans a substantial increase in synthetic ammonia capacity. Assuming that the USSR plans to produce the same relative quantities of each type of fertilizer as were produced in 1953, the fertilizer program would require 1.1 million tons of synthetic ammonia in 1959 and 2 million tons in 1964. Adding 300,000 tons to cover peacetime military and industrial needs, planned production of fertilizer for 1959 would require about 1.4 million tons of synthetic ammonia and for 1964 about 2.3 million tons. Although it cannot be stated categorically that synthetic ammonia goals of this order of magnitude will prove to be unattainable within the given time limits, the current growth rate appears to be about one-half that required to attain the goals.

In terms of the present capability of the USSR to meet emergency conditions, synthetic ammonia currently being used in the production of fertilizers could be reallocated quickly to the manufacture of military explosives. Such reallocation would provide the USSR with ample synthetic ammonia capacity to sustain a war of major proportions.

The synthetic ammonia industry in the USSR is vulnerable only in that production facilities are concentrated in nine plants.

The synthetic ammonia industry is potentially a good indicator of Soviet intentions. Preparatory to initiating large-scale military action, Soviet production of military explosives would be greatly increased. Synthetic ammonia -- primarily in the form of its derivative, nitric acid -- would be diverted from intraplant manufacture of fertilizers and shipped to explosives-manufacturing installations, most of which are located at some distance from the ammonia plants. Conversely, major increases in the production of nitrogenous fertilizers which could not be accounted for by expansion in synthetic ammonia facilities would indicate reduced production of military explosives.

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I. Introduction.

A. Significance.

Synthetic ammonia is the most important of the basic nitrogen compounds.* In wartime it is converted to nitric acid, which is used in the manufacture of all nonatomic high explosives and propellants, and it is also used for certain industrial products of an indirect military nature. In peacetime, synthetic ammonia is widely used for the manufacture of nitrogenous fertilizers. Currently it is the source of almost three-fourths of the nitrogen used for these types of fertilizers in the USSR.**

Because synthetic ammonia is an essential material in the manufacture of military explosives, its availability places a measurable limitation on the Soviet capability for the production of military explosives. At the same time, production of synthetic ammonia provides some indication of Soviet capabilities for the production of nitrogenous fertilizers. This information is useful, in combination with other factors, in gauging the progress of agricultural production.

It should be emphasized that future expansion in the synthetic ammonia industry will have the dual effect of increasing Soviet capabilities for both peacetime production of fertilizer and wartime production of military explosives.

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* Chemical nitrogen, as distinguished from organic nitrogen which occurs in vegetable and animal matter, can be obtained from air, from coal, and from certain other mineral resources. There are three commercial methods of "fixing" atmospheric nitrogen -- that is, combining it with other elements into useful compounds: (1) the synthesis of ammonia by direct combination of nitrogen and hydrogen; (2) the treatment of calcium carbide with nitrogen gas, yielding calcium cyanamide; and (3) by passing an electric spark through air, forming oxides of nitrogen. Combined nitrogen can also be recovered from gases produced in the coking of coal as byproduct ammonia and can be obtained from mineral deposits (as in Chile) in the form of sodium nitrate.

** It is estimated that 1.76 million tons of nitrogen fertilizers with a nitrogen content of 361,000 tons were produced in the USSR in 1953. Of the total amount of nitrogen, 253,000 tons were furnished by synthetic ammonia; 103,000 tons, by byproduct ammonia; and 5,000 tons, by calcium cyanamide. (For methodology, see Appendix B.)

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B. Organization.

The nine plants producing synthetic ammonia in the USSR in 1954 were subordinate to the Main Administration of the Nitrogen Industry, Ministry of the Chemical Industry.

C. Technology.

The general method of synthesizing ammonia is standard throughout the world, and any variations in manufacturing techniques represent only modifications of the original German process. Hydrogen and nitrogen, in a ratio of 3 to 1, are subjected to high pressure and temperature and are then passed over a suitable catalyst. As nitrogen can be obtained fairly simply from the air, usually by liquefaction, the key to an efficient production process is a low-cost source of hydrogen.

In the USSR, synthetic ammonia plants obtain their hydrogen by one of the following methods: (1) by fractional distillation of hydrogen from coke-oven gas; (2) by electrolytic decomposition of water into hydrogen and oxygen; or (3) by passing steam through a bed of incandescent coke, which produces a mixture of hydrogen and carbon monoxide. The source of the hydrogen has a locational significance for the industry. Plants which use the first method are located close to plants producing metallurgical coke. The electrolytic method requires great amounts of electricity and is feasible only in areas with ample supplies of low-cost electric power. The use of the water-gas method permits a somewhat wider choice of location from the point of view of a hydrogen source, but the cost of shipping coke to the plant is a significant factor. A fourth method -- the production of hydrogen from natural gas, which is widely used in the US today because of its low cost -- has apparently been under investigation by Soviet engineers, and plans for a plant have been drawn up. There is no evidence to indicate, however, that any units based on this method are in operation or under construction. 1/*

* For serially numbered source references, see Appendix D.

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II. Supply.

A. Production.

1. Prewar.

The synthetic ammonia industry in the USSR was begun during the First Five Year Plan (1928-32) with the construction of the Dneprodzerzhinsk plant near Gor'kiy and the Berezniki plant in the Urals. In the Second (1933-37) and Third (1938-42) Five Year Plans, additional plants were completed at Dneprodzerzhinsk and Gorlovka in the Ukraine, Stalinogorsk in the Moscow area, Chirchik in Central Asia, and Kemerovo in West Siberia. These seven plants produced an estimated 335,000 tons of synthetic ammonia in 1940.*

2. Wartime.

With the German invasion the plants at Dneprodzerzhinsk, Gorlovka, and Stalinogorsk suspended operations, thereby reducing the synthetic ammonia capacity to about 50 percent of prewar 2/ and the annual rate of production to about 170,000 tons.** All of this capacity, however, was not permanently lost -- the equipment at Gorlovka and at least part of the equipment at Stalinogorsk was shipped east for reassembly. 4/ Between 1942 and 1944, annual production was probably increased about 100,000 tons as a result of the expansion of the Kemerovo and Dzerzhinsk plants; the increase in production at the new Chirchik plant; and, possibly, the partial resumption of operations at Stalinogorsk.*** By 1944 the industry was producing synthetic ammonia at an estimated annual rate of 270,000 tons.

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* See Appendix B.

** Estimated capacity in 1940 was 425,000 tons, and postinvasion capacity was therefore about 210,000 tons. Individual plant studies indicate an annual rate of production of 170,000 tons from Dzerzhinsk (15,000 tons), Berezniki (80,000 tons), Kemerovo (35,000 tons), and Chirchik (40,000 tons) in the autumn of 1941. 3/

*** According to information on Soviet plans, production at Dzerzhinsk was to have been increased about 30,000 tons between 1940 and 1944. 5/ It was announced that Kemerovo increased production by 30 percent from 1942 to 1953, 6/ and it is believed that production rose 100 percent during the 1941-44 period (see Appendix A). Chirchik's capacity was about 60,000 tons, 7/ and it was announced that production

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3. Postwar.

The Fourth Five Year Plan (1946-50) stated that "three nitrate plants shall be restored to their prewar capacity and new plants built." 9/ In accordance with the Plan, the plants at Stalinogorsk, Gorlovka, and Dneprodzerzhinsk, which were shut down during the war, were back in operation on a partial basis before the end of 1947, 10/ and it is estimated that by 1950 they were back to approximately their prewar production level. Capacity at Chirchik was increased substantially -- probably doubled -- between 1945 and 1950. 11/ By the end of the Five Year Plan the industry's seven plants were producing at an annual rate of 520,000 tons, 55 percent more than in 1940. In addition, new plants at Kirovakan, Severo Donetsk, and Rustavi with a production potential of upwards of 185,000 tons were under construction.* Estimated production of synthetic ammonia in the USSR during selected years from 1940 to 1957 is shown in Table 1.**

The Fifth Five Year Plan (1951-55), as published, provided simply for an "expansion in the production capacities of ammonia." 12/ It is estimated that production was increased 194,000 tons between 1950 and 1954, chiefly as a result of expansion at Stalinogorsk and Dneprodzerzhinsk and of the beginning of operations at Severo Donetsk and Kirovakan.*

B. Comparison of Soviet and US Production.

Estimated production of synthetic ammonia in the USSR and in the US, 1949-54, is shown in Table 2.*** For the most part, the rapid rise in US production in recent years has been in response to an increased demand for synthetic ammonia and synthetic-ammonia-based fertilizers for agriculture.

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rose about 50 percent from 1942 to 1943 -- presumably from about 40,000 to 60,000 tons. 8/ These increases total 85,000 tons, and it is possible that by 1944 an additional small amount of synthetic ammonia was being produced at Stalinogorsk.

* See Appendix A.
** Table 1 follows on p. 7.
*** Table 2 follows on p. 8.

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Table 1

Estimated Production of Synthetic Ammonia in the USSR a/
Selected Years, 1940-57

Year	Amount (Thousand Metric Tons)	Index (1940 = 100)
1940	335	100
1944	270	81
1946	318	95
1947	362	108
1948	436	130
1949	476	142
1950	520	155
1951	568	170
1952	620	185
1953	677	202
1954	714 b/	213
1955	753	225
1956	794	237
1957	837	250

a. For methodology, see Appendix B.
b. Probable range: 650,000 to 800,000 tons. Ranges were estimated for individual plants, as shown in Appendix A, and they add to an aggregate range of 565,000 to 895,000 tons. As the probability of the actual total falling within the aggregate range is greater than the probability of the individual estimates falling within their respective ranges, the aggregate range can be reduced by a substantial amount. Assuming that the true figure for 1954 production falls within the extreme range from 565,000 to 895,000 tons, it is estimated, at about the 85-percent confidence level, that the true figure lies in the range from 650,000 to 800,000 tons.

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Table 2

Estimated Production of Synthetic Ammonia in the USSR and in the US
1949-54

Year	Soviet Production (Thousand Metric Tons)	US Production (Thousand Metric Tons)	Soviet Production as Percent of US Production
1949	476	1,174 a/	40.5
1950	520	1,420 a/	36.6
1951	568	1,603 a/	35.4
1952	620	1,863 a/	33.3
1953	677	2,074 b/	32.6
1954	714	2,467 b/	28.9

a. 13/
b. 14/

C. Location and Production of Plants.

Estimated production of synthetic ammonia plants in the USSR in 1954, by region,* is shown in Table 3.** Studies of each of these installations, outlining the information and methods used in arriving at the estimates of output, are presented in Appendix A.

D. Stockpiling and Inventories.

There is no information on Soviet stockpiling practice, but it is probable that synthetic ammonia is not stockpiled in the USSR. Such large quantities of synthetic ammonia are used in wartime that prohibitive amounts of high-pressure tankage would be required for the stockpiling of a significant quantity of the chemical. The more convenient practice -- and the one undoubtedly followed in the USSR -- is

* The term region in 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 3 follows on p. 10.

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that of stockpiling finished and semifinished products such as filled munitions, high explosives, and ammonium nitrate.

E. Trade.

There is no evidence of Soviet trade in synthetic ammonia with non-Soviet Bloc countries. Since September 1951, when East Germany planned to ship 70 tons to the USSR,* 15/ there has been no evidence of trade with other Bloc countries.

F. Total Supply.

Because of the probable nonexistence of a stockpile of synthetic ammonia in the USSR and the absence of significant trade, the total supply of synthetic ammonia available to the USSR in 1954 is assumed to be about equal to the estimated production of 714,000 tons.

III. Expansion.

Expansion in the synthetic ammonia industry during the 1954-57 period cannot be estimated with any degree of certainty, but the information available indicates a lower rate of expansion than for the 1948-53 period. Projections beyond 1957 can be made only on the basis of past experience and on what little can be inferred from announced Soviet objectives and related statements.

New production from plants either under construction or believed to be undergoing expansion is estimated at 123,000 tons. Severo Donetsk is estimated to be currently operating 91,000 tons short of its estimated potential; Rustavi, when completed, will contribute an estimated 32,000 tons.** If this new tonnage materializes by 1957, as is estimated, it will represent an average annual rate of increase of almost 5.5 percent.***

* The volume of Soviet trade in certain ammonia end products, such as ammonium sulfate and ammonium nitrate fertilizers, is fairly substantial. The available evidence indicates, however, that the net balance is close to zero. 16/

** See Appendix A.

*** Continued on p. 12.

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Table 3

Estimated Production of Synthetic Ammonia Plants in the USSR by Region
1954

Economic Region and City [a/*]	Plant Name	Amount (Thousand Metric Tons)	Percent Distribution
III (South)			
Dneprodzerzhinsk	Nitrogen Fertilizer Plant	95	13.3
Gorlovka	Sergo Ordzhonikidze Nitrogen Fertilizer Plant	55	7.7
Severo Donetsk	N.A.	36	5.0
Subtotal		186	26.0
V (Transcaucasus)			
Kirovakan	N.A.	29	4.1
Rustavi	Nitrogen Fertilizer Plant	Under construction	
Subtotal		29	4.1
VII (Central)			
Dzerzhinsk	Chernorech'ye Chemical Combine imeni Kalinin	56	7.8
Stalinogorsk	Stalin Chemical Combine	140	19.7
Subtotal		196	27.5

* Footnote for Table 3 follows on p. 11.

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Table 3

Estimated Production of Synthetic Ammonia Plants in the USSR by Region
1954
(Continued)

Economic Region and City [a]	Plant Name	Amount (Thousand Metric Tons)	Percent Distribution
VIII (Urals)			
Berezniki	Voroshilov Chemical Combine	88	12.3
Subtotal		88	12.3
IX (West Siberia)			
Kemerovo	Nitrogen Fertilizer Combine	70	9.8
Subtotal		70	9.8
Xb (Central Asia)			
Chirchik	Stalin Electrochemical Combine	145	20.3
Subtotal		145	20.3
Total		714	100.0

a. Economic regions for which estimated production is zero are not shown.

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No definite information on long-range plans for the nitrogen industry is available beyond the announced Soviet plan to increase mineral fertilizer capacity. In 1953, Khrushchev announced that mineral fertilizer capacity would be 16.5 million to 17.5 million tons by 1959 and 28 million to 30 million tons by 1964 (about 3 and 5 times, respectively, the 1953 production level of 6 million tons). 17/ A breakdown of this planned production by type of fertilizer has not been announced, and thus the planned increases for nitrogenous fertilizers (and more specifically for synthetic ammonia) are not known. Assuming, however, that the USSR plans to produce the same relative quantities of nitrogenous fertilizers and synthetic ammonia as were produced in 1953, the fertilizer program would require 1.1 million tons of synthetic ammonia in 1959 and 2 million tons in 1964.* Adding 300,000 tons to cover military and industrial requirements, planned production totals for 1959 and 1964 would be roughly 1.4 million and 2.3 million tons, respectively.

In terms of the past performance and current growth of the industry, these goals appear to be rather ambitious, although there is no available information on the production of chemical equipment and on other factors with which a more definite appraisal of the situation may be made. As stated above, the annual increase in production during this period from 1954 to 1957 is estimated at almost 5.5 percent, which is considerably lower than the 9.3 percent growth rate from 1948 to 1953 and about equal to the over-all rate for 1940-53. A projection from 1954 to 1964 to meet the synthetic ammonia goals derived from Khrushchev's mineral fertilizer proposals, however, would require an annual growth rate of about 12 percent.

* The 1953 output of fertilizer in terms of nitrogen was 361,000 tons (see Appendix B); so the 1959 and 1964 goals would be 1,023,000 tons and 1,745,000 tons, respectively. In 1953, byproduct ammonia and calcium cyanamide supplied 108,000 tons of nitrogen, and synthetic ammonia the remaining 253,000 tons. Assuming that byproduct ammonia and calcium cyanamide will contribute 172,000 tons in 1959 and 227,000 tons by 1964 (based on expansion of coke production), the remaining 851,000 tons and 1,518,000 tons of nitrogen would have to be supplied by synthetic ammonia. When these requirements are converted to synthetic ammonia and 8 percent is added to cover conversion losses, the totals become 1.1 million tons and 2 million tons.

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It is evident, however, that the Soviet planners are dissatisfied with current progress and intend to accelerate the growth of the industry. Shortly after the new fertilizer goals were announced the Minister of the Chemical Industry stated:

> Together with a considerable expansion of the operating plants, a large construction program must be undertaken for the building of new plants for the production of nitrogen, phosphate, and potash fertilizers in various regions of the country. 18/

Pointing to the current unsatisfactory rate of growth, the Minister said:

> The plan for increasing production capacities of mineral fertilizers provided by the Plenum's decision calls for the realization of a large program of capital construction. At the present time, this program is being carried out in a definitely unsatisfactory manner. ... The Ministry of Construction is faced with the task of considerably increasing the volume of capital work in the construction of enterprises for the production of mineral fertilizers and insecticides. 19/

This latter statement seems to agree with -- or at least does not contradict -- estimates of expansion through 1957.

In summary, the assumed long-range goals for the synthetic ammonia industry appear to be rather optimistic, but in view of the fact that the current over-all growth rate for basic chemicals is estimated at 10 percent per year, they are not unattainable. Fulfillment of the goals will require, however, a considerable increase in the current rate of expansion of the synthetic ammonia industry.

IV. Consumption.

A. Current Use Pattern.

End uses for synthetic ammonia, as indicated above, fall into three general categories: military, agricultural, and industrial. In addition to its consumption in military explosives and its primary peacetime use as a fertilizer, synthetic ammonia is

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also consumed by a number of industries, the most important of which is the chemical industry itself. The chemical industry consumes sizable quantities of synthetic ammonia in the production of industrial explosives, of various inorganic and organic chemicals, of plastics, and of synthetic fibers. Synthetic ammonia is also used in the production of paper, petroleum, metals, rubber, and other products.

On the basis of estimates of consumption in the manufacture of fertilizers and estimates of industrial requirements, a general use pattern can be established. The estimated use pattern of synthetic ammonia in the USSR in 1953 and 1954 is shown in Table 4.

Table 4

Estimated Use Pattern of Synthetic Ammonia in the USSR
1953 and 1954

Consumer	Amount (Thousand Metric Tons)		Percent Distribution	
	1953	1954	1953	1954
Agriculture a/	332	464	49.0	65.0
Industry a/	159	175	23.5	24.5
Military	186	75	27.5	10.5
Total	677	714	100.0	100.0

a. See Appendix B.

An estimated military consumption of synthetic ammonia in 1953 of 186,000 tons was obtained by subtracting agricultural and industrial estimates totaling 491,000 tons from estimated synthetic ammonia production of 677,000 tons. As it is a residuum, this military consumption estimate may include an accumulation of errors

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contained in the estimate of total synthetic ammonia production and in the industrial and agricultural estimates.*

A recent piece of information indicates that a significant shift in the consumption pattern for synthetic ammonia may have taken place in 1954 as the result of a large reallocation from military to agricultural uses. According to a Soviet announcement, production of mineral fertilizer in 1954 increased 16 percent over 1953, 21/ which was considerably in excess of the announced increases of 7 percent, 6 percent, and 9 percent in 1951, 1952, and 1953, respectively.** As there is no evidence indicating that such a sharp increase in 1954 could have been accounted for by expansion of superphosphate, ground phosphorite, or potassium types of fertilizers, or by expansion in the nitrogen industry, it is reasonable to assume that synthetic ammonia was diverted from the military to the agricultural sector. Requirements for 1954 were therefore derived by assuming a 10-percent increase in fertilizers other than nitrogen types (in line with increases for the past few years) and by assuming that most of the remainder of the over-all increase resulted from a reallocation of synthetic ammonia.

Total production of synthetic ammonia for 1955 is estimated at 753,000 tons, and if combined military and industrial consumption for 1955 were to remain at the estimated 1954 level, about 500,000 tons would be available for production of fertilizer -- an estimated 80 percent to 85 percent more than in 1950.*** Although the nitrogen

* An estimate of military consumption, based on ammunition production for 1953 which amounted to about 55,000 tons, 20/ falls within the range of the military consumption obtained by the residual method, if the lower limit of total production is combined with the upper limit of the industrial estimate. The estimate based on ammunition production does not, however, include all military requirements. Certain quantities, which may or may not be significant, are required for guided missiles and for any stockpiling of explosives in bulk rather than in the form of finished ammunition.

** The increase was apparently much sharper (about 20 percent) in the last half of 1954, as the USSR announced the increase for the first half of the year to be only 11 percent over the corresponding period of 1953. 22/

*** See Appendix B.

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fertilizer goal for 1955 was not announced in the Fifth Five Year Plan, this percent increase in synthetic ammonia tonnage allocated to agriculture appears to be of the same order of magnitude as the planned increase of 88 percent for all mineral fertilizers during the Fifth Five Year Plan.

B. Wartime Requirements.

Assuming a complete diversion from fertilizer production and allowing a small quantity, about 50,000 tons, for indirect military and essential civilian use, the maximum tonnage available for military explosives in 1955 would be an estimated 700,000 tons.

For purposes of comparison, the Soviet explosives program in 1944 required an estimated 285,000 tons of synthetic ammonia, 23/ US peak consumption in World War II was at the rate of about 850,000 tons per year,* peak German consumption was about 300,000 tons, 25/ and peak Japanese consumption was less than 100,000 tons. 26/ On the basis of estimates of World War II military consumption, it appears that sufficient ammonia capacity is now available in the USSR to fight a sustained war of major proportions. It should be emphasized at this point that substantial production should be forthcoming as a result of the fertilizer goals announced for 1959 and 1964, which will provide a strong base for production of ammonia in the event of war.**

C. Current Requirements.

There is sufficient tonnage of synthetic ammonia available in the USSR to meet current military and industrial requirements, but the quantity allocated for nitrogenous fertilizer manufacture is substantially below the minimum amount which Soviet planners would consider satisfactory for current operations. According to recent statements, the bulk of mineral fertilizers are applied to the basic industrial crops -- cotton, sugar beets, and flax -- leaving an insufficient quantity available for food and fodder crops. 27/

* Production estimate for first 8 months of 1945 converted to annual rate. Estimated from data on wartime munitions production. 24/

** See p. 12, above.

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On the basis of published Soviet material, a rough estimate can be made of what current requirements for fertilizer production would have to be to provide an adequate level of agricultural output. In 1945 the late Pryanishnikov, a leading Soviet agricultural chemist whose work has recently been praised in the press, 28/ drew up a proposed system of nitrogen balance for Soviet agriculture. 29/ This system was designed to provide (among other things) an adequate quantity of grain in the USSR, and it was based in part on a more intensive application of mineral fertilizers. Pryanishnikov visualized it as an intermediate plan, with fertilizer requirements determined largely by the potential growth rate of the chemical industry, and he intended that it be superseded by better systems when even greater quantities of mineral fertilizers became available. In the proposal, chemical nitrogen requirements were set at 1.3 million tons, about 3.6 times the actual nitrogen input in 1953 (361,000 tons).* That this might well be viewed by Soviet planners as a realistic minimum is evident from the Khrushchev proposal of 1953 to increase mineral fertilizer capacity by 1959 to about 3 times and by 1964 to about 5 times the estimated 1953 production.**

Assuming that the Pryanishnikov proposal can be taken as a fair approximation of current requirements for fertilizer nitrogen, about 1.5 million tons of synthetic ammonia would then be required for agriculture,*** and total requirements would be 1.8 million tons -- at least 2.5 times the estimated 1954 production.

V. Prices.

The latest available price quotations for synthetic ammonia in the USSR were published in 1950. Comparison of 1950 prices of synthetic ammonia in the USSR and in the US is shown in Table 5.**** Since 1950, prices of synthetic ammonia in the US have risen somewhat and as of December 1954 were about $98 per ton for refrigeration grade and about $95 per ton for fertilizer grade. 30/

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* P. 3, note **, above.

** See p. 12, above.

*** Assuming that byproduct ammonia and calcium cyanamide will shortly be contributing about 150,000 tons of nitrogen, the remaining 1.15 million tons of nitrogen would have to be supplied by synthetic ammonia. In terms of synthetic ammonia, and adding 8 percent to cover conversion losses, the total would be 1.5 million tons.

**** Table 5 follows on p. 18.

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Table 5

Comparison of Prices of Synthetic Ammonia in the USSR and in the US a/ 1950

Grade	USSR 31/ (Rubles per Metric Ton)	US b/ 32/ (US $ per Metric Ton)	Ruble-Dollar Ratio
Refrigeration	1,240	84.15	14.7: 1
Fertilizer	1,160	81.40	14.3: 1

a. F.O.B. point of manufacture.
b. Prices at beginning of 1950.

VI. Raw Materials.

The input requirements for the manufacture of synthetic ammonia in the USSR in 1954 are shown in Table 6.

Table 6

Input Requirements for the Manufacture of Synthetic Ammonia in the USSR 1954

Material	Quantity a/
Electricity	3,596 Million kilowatt-hours
Coke (for gas generation)	915 Thousand metric tons
Coke-oven gas	935 Million cubic meters

a. Requirements for the production of 714,000 tons of synthetic ammonia. The methods used in calculating the estimates are presented in Appendix B.

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VII. Capabilities, Vulnerabilities, and Intentions.

A. Capabilities.

The supply of synthetic ammonia available in the USSR in 1954 is estimated at 714,000 tons (probable range: 650,000 to 800,000 tons), equivalent to about three-tenths of US production in 1953. This supply is considered to be adequate to meet the requirements for explosives and the needs of industry but insufficient to meet minimum demands in all sectors of agriculture. According to official statements, supplies of fertilizer (presumably including nitrogenous fertilizers) are adequate to satisfy requirements for the basic industrial crops, but for food and fodder crops there is an unspecified shortage, the effect of which is to hamper current production of those crops.*

In the event of a general war in the immediate future, much of the synthetic ammonia which is allocated to fertilizer would be diverted to the defense industry, principally in the form of nitric acid to be used for the manufacture of high explosives and smokeless powder and, to a lesser extent, for the manufacture of fuming nitric acid for use as a rocket fuel oxidizer. In addition, some of the remaining production of ammonium nitrate would be reallocated for admixture with TNT, picric acid, hexogen, and other high explosives. In the absence of wartime destruction, the output of synthetic ammonia is sufficient to sustain a prolonged military effort of major proportions.

B. Vulnerabilities.

The Soviet synthetic ammonia industry is self-sufficient, and no economic vulnerabilities are apparent.

C. Intentions.

Preparatory to the initiation of large-scale war, Soviet production of military explosives would be greatly increased. This would necessitate a change in the allocation patterns of ammonia and its two primary derivatives -- nitric acid and ammonium nitrate. Ammonia and nitric acid, the latter in large quantities, would be diverted from intraplant manufacture of ammonium nitrate to explosives-

* See p. 15, above.

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manufacturing installations, most of which are located at some distance from the ammonia plants. In addition, the production of ammonium nitrate would be reduced, and part of the remaining output probably would be reallocated from agriculture to the plants manufacturing military explosives. In view of the changes which would take place in the ammonia industry in preparation for war, the industry is potentially a good indicator of Soviet intentions.

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APPENDIX A

SYNTHETIC AMMONIA PLANTS IN THE USSR

1. Nitrogen Fertilizer Plant.

a. Location.

Dneprodzerzhinsk, Dnepropetrovsk Oblast, Ukraine (South, III).

b. Coordinates.

48°29'30" N - 34°40'00" E.

c. Estimated Annual Production.

95,000 tons (range: 65,000 to 125,000 tons).

Estimates based on German intelligence place the 1945 planned production of this plant at 67,000 tons of synthetic ammonia, but it is probable that some expansion has taken place since then, as the nitric acid capacity is believed to have been increased about 50 percent sometime after 1949. 33/ If the total nitric acid production of this plant -- estimated to be 180,000 tons in 1953 -- were converted to ammonium nitrate, it would require an ammonia production of 104,000 tons. It is probable, however, that some of the nitric acid would not be converted, in which case the ammonia requirements would be reduced. In view of the assumption that 150,000 tons of the nitric acid production are being converted to ammonium nitrate and 30,000 tons are being shipped out as acid, an ammonia production of 95,000 tons would be required.

2. Sergo Ordzhonikidze Nitrogen Fertilizer Plant.

a. Location.

Gorlovka, Stalino Oblast, Ukraine (South, III).

b. Coordinates.

48°18'00" N - 38°05'50" E.

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c. Estimated Annual Production.

55,000 tons (range: 45,000 to 65,000 tons).

Nitric acid production at this plant has been estimated at 77,000 tons, 34/ of which an estimated 15,000 to 20,000 tons are probably shipped to the nearby Gorlovka explosives plant. Ammonium sulfate production is reported to be about 55,000 tons annually. 35/

Assuming that all nitric acid not shipped to the explosives plant (59,500 tons) is converted to ammonium nitrate, ammonia requirements for nitric acid, ammonium sulfate, and ammonium nitrate would be about 55,000 tons per year.

3. (Plant Name Not Available).

a. Location.

Severo Donetsk, Voroshilovgrad Oblast, Ukraine (South, III).

b. Coordinates.

48°56'30" N - 38°28'00" E.

c. Estimated Annual Production.

36,000 tons (range: 20,000 to 50,000 tons).

It is known that the synthetic ammonia plant under construction in Severo Donetsk was not completed in January 1951, but according to a Soviet report it has since been put in operation. 36/ Many reports from returning prisoners of war and German technicians indicate that the equipment for this plant was taken, at least in part, from the Leuna Works in East Germany. On the basis of one of these reports, it is estimated that the capacity production of synthetic ammonia using this equipment will eventually reach 300 tons per day of nitrogen or, assuming 350 working days per year, an annual production of about 127,000 tons of synthetic ammonia. 37/ Based on a 50,000-ton production of nitric acid in 1953 and assuming sufficient ammonia capacity to convert all the acid into ammonium

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nitrate, synthetic ammonia production in 1953 is estimated at 29,000 tons. 38/ Production in 1954 is estimated at 36,000 tons. It is assumed that production will reach 127,000 tons by 1957.

4. (Plant Name Not Available).

a. Location.

Kirovakan, Armenian SSR (Transcaucasus, V).

b. Coordinates.

40°48'56" N - 44°28'06" E.

c. Estimated Annual Production.

29,000 tons (range: 20,000 to 35,000 tons).

The construction of a synthetic ammonia plant based on electrolytic hydrogen was begun at Kirovakan after World War II, probably sometime during 1946. According to a Soviet report, this plant was in operation sometime before 1953. 39/

Several reports indicate that 16 electrolyzers were installed, 40/ and the description furnished by one source 41/ indicates that they are Bamag C-500 cells or Soviet copies of the Bamag cell. Sixteen electrolyzers of this type would produce sufficient hydrogen for about 82 tons of ammonia per day, about 29,000 tons per year.

5. Chernorech'ye Chemical Combine imeni Kalinin.

a. Location.

Dzerzhinsk, Gor'kiy Oblast (Central, VII).

b. Coordinates.

56°14'31" N - 43°32'09" E.

c. Estimated Annual Production.

56,000 tons (range: 45,000 to 65,000 tons).

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Planned capacity of this plant for 1945 was reported to be about 58,000 tons, 42/ and there is no evidence of expansion beyond that figure. On a basis of 350 operating days per year, this would equal about 56,000 tons of ammonia annually.

6. Stalin Chemical Combine.

a. Location.

Stalinogorsk, Moscow Oblast (Central, VII).

b. Coordinates.

54°05'27" N - 38°13'10" E.

c. Estimated Annual Production.

140,000 tons (range: 100,000 to 200,000 tons).

According to a reliable report, the Stalinogorsk plant was built to produce at least 100,000 tons of synthetic ammonia per year. 43/ During the early part of World War II the plant was shut down and at least partially dismantled but it was back in operation sometime before 1947. According to the Fourth Five Year Plan (1946-50), the plant was to be rebuilt to its prewar capacity. 44/ Recent press reports state that the output of ammonia was increased 50 percent during the 1951-53 period "without expanding the production area" and that output of ammonia in 1953 was increased 56 percent over 1950. 45/ The plant capacity could have been increased 50 percent or more by technical changes inside the converters. 46/ It is assumed that production in 1950 was 90,000 tons (near the prewar level) and that production in 1953 was 140,000 tons.

7. Voroshilov Chemical Combine.

a. Location.

Berezniki, Molotov Oblast (Urals, VIII).

b. Coordinates.

59°24' N - 56°44' E.

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c. Estimated Annual Production.

88,000 tons (range: 75,000 to 95,000 tons).

Two units with capacities of 125 tons of ammonia per day were installed at Berezniki, one in 1932 and the other in 1934. 47/ On the basis of 350 operating days, annual production would be about 88,000 tons per year. Reports of expansion after 1934 have not been confirmed and are assumed to be based on plans which were never carried out. The Soviet press announced that production of ammonium nitrate in the first quarter of 1947 was 35,000 tons, a rate of about 140,000 tons per year. 48/ Such a tonnage would require about 64,000 tons of ammonia and would be well within the estimated capacity of the plant. Industry experts state, however, that the capacity of this plant could be increased 50 percent or more by changes inside the converter. 49/

8. Nitrogen Fertilizer Combine.

a. Location.

Kemerovo, Kemerovo Oblast (West Siberia, IX).

b. Coordinates.

55°21'45" N - 83°01'15" E.

c. Estimated Annual Production.

70,000 tons (range: 60,000 to 105,000 tons).

A report based on German intelligence states that the synthetic ammonia capacity of this installation was 100 tons per day in 1938 and was increased in 1941 by the addition of a second ammonia synthesis unit with double the capacity of the first. 50/ No information is available substantiating this figure, however, and it is assumed that the second unit has the same capacity as the first. Assuming the plant is operated 350 days per year, production would be 70,000 tons per year.

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9. Stalin Electrochemical Combine.

a. Location.

Chirchik, Uzbek SSR, Tashkent Oblast (Central Asia, Xb).

b. Coordinates.

41°27'25" N - 69°35'00" E.

c. Estimated Annual Production.

145,000 tons (range: 135,000 to 155,000 tons).

An announcement in 1946 stated that during the 1946-50 period it was planned to increase the ammonia capacity of this plant to 120,000 tons. 51/ It is assumed that the plan was carried through; that production in 1950 was 85 percent of capacity; and that production in 1953 was 96 percent of capacity (350 days), about 115,000 tons. According to a recent press statement, it was planned to increase 1954 production of ammonia 27 percent over 1953 production. 52/ It is assumed that this plan was carried through and that production in 1954 was about 145,000 tons. According to prewar German intelligence, the original plan was a 3-stage expansion to about 150,000 tons. 53/

10. Nitrogen Fertilizer Plant.

a. Location.

Rustavi, Georgian SSR (Transcaucasus, V).

b. Coordinates.

41°33' N - 45°03' E.

c. Estimated Annual Production.

At a meeting of the Supreme Soviet in 1946, a delegate proposed that a nitrogen fertilizer plant producing at least 70,000 tons of fertilizer annually and costing about 150 million rubles be constructed at this site. 54/ In June 1954 it was reported that "the

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first section of the new plant is intended to be completed by the end of this year" and in August 1954 that the plant was "entering the final inspection period." 55/ It is estimated that this plant will be put in operation by the end of 1955 and, on the basis of planned fertilizer production, will eventually produce 32,000 tons of ammonia per year.

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APPENDIX B

METHODOLOGY

1. Soviet Production of Synthetic Ammonia, 1940-53.

A study of the six plants in operation in 1940* revealed that 1940 production of synthetic ammonia was about 335,000 tons. Using this figure as a base, production totals for 1946, 1947, and 1948 were calculated from the information that the output of nitrogen fertilizers in these years was 95 percent, 108 percent, and 130 percent (planned), respectively, of 1940 production. 56/ Although a shift in the consumption pattern for synthetic ammonia from military to civilian could account for a share of the reported increase in nitrogen fertilizer production and thus give an upward bias to estimates of ammonia production, the few bits of information available on production of individual plants for the immediate post-war years indicate that the totals derived by these percentage increases are not unreasonably high.

From plant studies it was concluded that production was 677,000 tons in 1953. Production totals for 1949, 1950, 1951, and 1952 were obtained by interpolation (9.2 percent increase per year).

2. Estimate of Industrial Consumption, 1953.

The estimate of industrial consumption was built up mainly from estimates of individual industry requirements. Estimates of synthetic ammonia consumption in the production of industrial explosives, plastics, metals, textiles, petroleum, and sulfuric acid were calculated. The remaining end uses were estimated from the US consumption pattern** by assuming that they were in proportion to gross national product originating in industry in the two countries. In view of the sketchy nature of the data on which the estimate is based, the range

* Chirchik did not begin operations until November 1940 and thus did not contribute appreciably to production in that year.
** Estimated. 57/

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of error is set at plus or minus 35 percent. The industry estimates were made as follows:

a. Industrial Explosives.

An estimate of 38,000 tons of explosives required by the Soviet coal industry in 1951 was revised to 40,000 tons to allow for increases in production and changes in techniques. Industrial explosives requirements for construction, metal mining, quarrying, and nonmetal mining were computed on the basis of the relative magnitudes of the industries in the US and in the USSR and totaled 83,000 tons. 58/ Applying an estimated factor of 0.37, total synthetic ammonia requirements for industrial explosives were estimated at 46,000 tons.

b. Metal Treating.

Primary uses for synthetic ammonia are in the nitriding of steel and as a processing agent in the recovery of metal from ores. Inputs were based on requirements for synthetic ammonia in the US (37,000 tons) and the ratio of steel production in the US and the USSR.*

c. Textiles, Including Rayon and Nylon.

The primary use for synthetic ammonia in the textile industry is in the manufacture of kapron, a nylon-type Soviet synthetic. A US ammonia factor of 0.28 60/ for the production of nylon was applied to an estimated production of 6,000 tons of kapron in 1953.

d. Petroleum.

The primary use for synthetic ammonia in the petroleum industry is in the refining of crude oil. Inputs were based on requirements for synthetic ammonia in the US (22,000 tons) and the ratio of petroleum production in the US and the USSR.**

* Steel production in 1953: US, 101 million tons; USSR, 38 million tons. 59/

** Petroleum refined in 1953: US, 2.155 billion barrels; USSR, 360 million barrels (estimated). 61/

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e. Sulfuric Acid.

An estimate of 3,000 tons was obtained from a published report. 62/

f. Plastics, Synthetic Resins, and Lacquers.

It is estimated that 10,000 tons of synthetic ammonia were consumed in the production of plastics, synthetic resins, and lacquers: 5,000 to 6,000 tons, for the manufacture of urea-formaldehyde and cellulose nitrate plastics; and the remainder for cellulose nitrate lacquers. This is to be compared with an estimated 80,000 tons consumed in the manufacture of plastics, resins, and lacquers in the US in 1953.

g. Other End Uses.

The remaining end uses for synthetic ammonia in the US consumed an estimated 220,000 tons. On the basis of the ratio of gross national product originating in industry in the US and the USSR (0.37), 63/ it is estimated that about 81,000 tons of synthetic ammonia were consumed in the USSR in 1953 for other end uses..

h. Total Requirements.

Total industrial requirements for synthetic ammonia in 1953 are therefore estimated at 159,000 tons with a range of error of plus or minus 35 percent.

3. Calculation of the 1953 Input Requirements.

Input requirements were calculated separately for three types of plants, according to the method used for obtaining hydrogen. Estimates were based on published Soviet input factors, which, in most cases, agree closely with comparable US data.

a. Electrolysis of Water.

The 1954 estimated production of synthetic ammonia from the two plants using the electrolytic method (Chirchik and Kirovakan) is 174,000 tons. A Soviet text reports that by this method the consumption of electric power per ton of ammonia is 15,000 kilowatt-hours. 64/ The power requirement is therefore estimated at 2.61 billion kilowatt-hours.

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b. Coke-Oven Gas.

The 1954 estimated production of synthetic ammonia from the three plants extracting hydrogen from coke-oven gas (Gorlovka, Dneprodzerzhinsk, and Kemerovo) is 220,000 tons. A Soviet text reports the consumption of electric power at 2,100 to 2,500 kilowatt-hours per ton of ammonia. 65/ Using an average of these two figures, the estimated requirement is 506 million kilowatt-hours. A Soviet handbook lists the requirements of raw coke-oven gas per ton of ammonia as 4,100 to 4,400 cubic meters. 66/ Based on an average of those two figures, the total requirement is 935 million cubic meters.

c. Water Gas.

The 1953 estimated production of synthetic ammonia for the four plants using the water-gas method (Severo Donetsk, Stalinogorsk, Dzerzhinsk, and Berezniki) is 320,000 tons. A Soviet text lists the average power requirements per ton as 1,500 kilowatt-hours. The estimated total, therefore, is 480 million kilowatt-hours. 67/ The carbon requirements for making water gas were derived from the following input factors: (1) 2,200 to 2,250 cubic meters of hydrogen are used per ton of synthetic ammonia, 68/ (2) the content of water gas averages about 50 percent hydrogen by volume, 69/ and (3) 540 kilograms of carbon are required to make 1,000 cubic meters of water gas. 70/ On these bases the requirement per ton of ammonia is 2.4 tons of carbon, and the total requirement is 768,000 tons of carbon.

d. Total Requirements.

Summarizing the estimates outlined above, the major inputs for the production of synthetic ammonia in 1953 were as follows:

Electricity	3,596	Million kilowatt-hours
Coke-oven gas	935	Million cubic meters
Carbon	768	Thousand metric tons

The equivalent of 768,000 tons of carbon in terms of coke would be approximately 915,000 tons.

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4. Estimate of Agricultural Requirements for Synthetic Ammonia.

The 1953 estimate of agricultural requirements for synthetic ammonia was derived from the following nitrogen fertilizer estimates for 1953:

	Thousand Metric Tons
Total production of nitrogen fertilizer (20.5 percent N)	1,760
Calcium cyanamide	25
Byproduct ammonium sulfate	500
Synthetic ammonium sulfate	130
Ammonium nitrate	1,105

Calcium cyanamide and byproduct ammonium sulfate require no synthetic ammonia. It is estimated that 332,500 tons of synthetic ammonia were required for the production of the other nitrogen fertilizers -- 36,400 tons for synthetic ammonium sulfate and 295,100 tons for ammonium nitrate.

The 1950 estimate of agricultural requirements for synthetic ammonia was derived from the following nitrogen fertilizer estimates for 1950:

	Thousand Metric Tons
Total production of nitrogen fertilizer (20.5 percent N)	1,400
Calcium cyanamide	25
Byproduct ammonium sulfate	354
Synthetic ammonium sulfate	130
Ammonium nitrate	891

It is estimated that 274,000 tons of synthetic ammonia were required for production of synthetic ammonium sulfate and ammonium nitrate -- 36,400 tons and 238,000 tons, respectively.

5. Estimate of 1954 Consumption Pattern.

The revised but unpublished 1953 estimate of production of mineral fertilizer was as follows:

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	Thousand Metric Tons
Total production of mineral fertilizer	6,000
Nitrogen	1,760
Superphosphate	2,040
Ground phosphorite	1,415
Potassium	620
Thomas slag	165

The announced 1954 increase in the production of mineral fertilizers was 16 percent, a total of 960,000 tons. Applying an increase of 10 percent to all types of fertilizers except nitrogen gives an increment of 424,000 tons, and it is assumed that the remaining 536,000 tons were obtained through an increase in nitrogen types. The estimated production of nitrogen fertilizer for 1954 is, therefore, 2,296,000 tons.

The breakdown of nitrogen fertilizers by type for 1954 was then estimated as follows:

	Thousand Metric Tons
Total production of nitrogen fertilizer (20.5 percent N)	2,296
Calcium cyanamide	25
Byproduct ammonium sulfate	540
Synthetic ammonium sulfate	130
Ammonium nitrate	1,601

No increase was estimated in the production of calcium cyanamide and synthetic ammonium sulfate, and on the basis of coke estimates the increase in byproduct ammonium sulfate was estimated to have been 8 percent.

The amount of synthetic ammonia required to produce 130,000 tons of synthetic ammonium sulfate is 36,400 tons, and that required to produce 1,601,000 tons of ammonium nitrate is 427,400. These add to a total of 463,800 tons.

The industry requirement for 1954 was obtained by adding 10 percent to the 1953 estimate, an increase from 159,000 to 175,000 tons. Subtracting the industrial and agricultural requirements from the 1954 estimated total production of 714,000 tons leaves a remainder of 75,000 tons, which represents estimated military consumption.

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APPENDIX C

GAPS IN INTELLIGENCE

The most important gaps in information about the synthetic ammonia industry in the USSR are in production and distribution. As reports on total production are practically impossible to obtain, estimates must be built up from plant data. More information is needed on current production of individual plants, particularly those for which estimates are based on German intelligence, which is now more than 10 years old.

The component in the distribution pattern for which information could most likely be obtained is nitrogenous fertilizers, particularly ammonium nitrate. More definite information on current and planned production of this type of fertilizer would be useful in deriving estimates of the consumption pattern of synthetic ammonia. At the same time, information on nitrogenous fertilizers would provide useful indications of planned expansion in the synthetic ammonia industry.

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APPENDIX D

SOURCE REFERENCES

The main sources used in compiling this report may be classified in the following groups:

1. Soviet Sources.

Soviet sources are books, periodicals, press statements, speeches, and state plans and Plan fulfillment data. They are considered reliable and were useful in estimating current production of several plants and in preparing several other important sections of the report. A CIA report on mineral fertilizer production, based for the most part on open Soviet sources, was very useful in estimating the consumption pattern for synthetic ammonia.

2. German Intelligence.

German sources are considered fairly reliable and were useful in estimating 1940 production. Some of the individual plant estimates in this report, however, are still based primarily on German intelligence, which is now more than 10 years old.

3. Army and Air Force Prisoner-of-War Interrogation Reports.

The interrogation reports are considered fairly reliable but were of direct usefulness only in estimating production at 1 or 2 plants, but a CIA report on the nitric acid industry, which included production estimates based primarily on prisoner-of-war reports, was, in turn, very useful in estimating production at several plants.

4. Reports Received through CIA Channels.

These reports are considered to be reliable for the most part and were of principal value in estimating the production of certain of the plants.

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

Source of Information	Information
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 will carry the field evaluation "Documentary" instead of a numerical grade.

Evaluations not otherwise designated are those appearing on the cited document; those designated "RR" are by the author of this report. No "RR" evaluation is given when the author agrees with the evaluation on the cited document.

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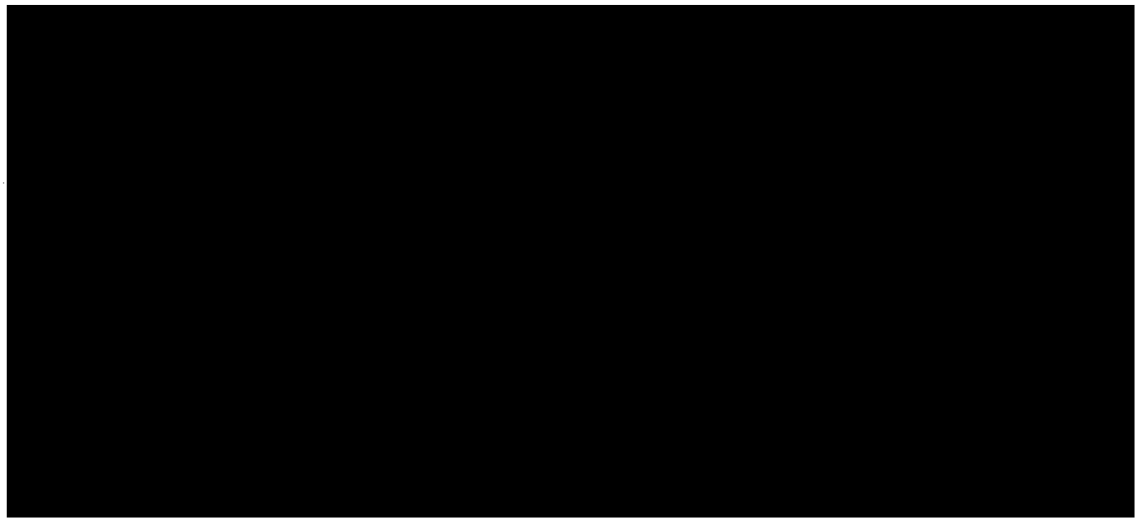

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