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THE CAUSTIC SODA AND CHLORINE INDUSTRIES IN THE USSR

12 December 1951

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FOREWORD

This report is divided into two parts: Part I, The Caustic Soda Industry in the USSR, and Part II, The Chlorine Industry in the USSR.

Although these two Soviet industries are discussed separately, they are included in the same report for two reasons. First, the principal process used to produce caustic soda and chlorine is the same, namely, the electrolytic decomposition of a solution of common salt. In this process caustic soda and chlorine are therefore coproducts and are produced simultaneously. Second, since the USSR has never published figures on chlorine production and since individual plant information is generally inadequate, the best approach to an estimate of the Soviet chlorine production is through those caustic soda statistics which have been published by the USSR.

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PART I

THE CAUSTIC SODA INDUSTRY IN THE USSR

Summary

Caustic soda, one of the basic inorganic chemicals essential in many industrial processes, is believed to be in short supply in the USSR, and the use of any known substitute would not greatly reduce Soviet requirements. Efforts probably are being made to expand output within the Bloc.

Soviet production of caustic soda in 1951 is estimated at 325,000 metric tons, about two times the 1940 output of 138,000 to 185,000 tons. Production has not increased according to plan, however, as the Five Year Plan goal for caustic soda production in 1950 was 390,000 tons. Output of the Satellite countries in 1951 is estimated at 311,000 metric tons, giving a total Bloc production of 636,000 tons in contrast to estimated US production for 1951 of 2.8 million metric tons. Although small quantities of caustic soda are imported by the Satellite countries from Western Europe, these amounts are not sufficient to alleviate the existing shortage of this chemical in the Bloc. Despite the shortage, however, the USSR is believed to have accumulated caustic soda stockpiles, the sizes of which are not known.

In the event of a major war, utilization of these stockpiles would be necessary to meet essential military demands. Although the present supply of caustic soda might be sufficient to meet the requirements of limited military operations or of a major war of short duration, a major war of long duration would demand construction of additional production facilities in order to maintain the output of commodities essential to the war effort. The Soviet caustic soda industry apparently is not vulnerable to economic warfare, but the bombing of a few key installations probably would effectively restrict supplies.

I. Introduction.

1. Nature and Uses.

Caustic soda, or sodium hydroxide (NaOH), is a brittle white solid, extremely hygroscopic and readily soluble in water. A basic inorganic chemical, among the alkalis it is second in importance only to soda ash. Used in tonnage lots, it is essential in many industrial processes, the most important of which is the manufacture of rayon and cellulose film and of other chemical products such as military explosives, synthetic phenol, and plastics. Caustic soda also is essential for petroleum refining; for treatment of textiles; for manufacture of vegetable oils, soaps and cleansers, and pulp and paper; and for the reclaiming of rubber.

Production of caustic soda is based on two processes: (a) the electrolytic decomposition of a solution of common salt in either diaphragm or mercury electrolytic cells and (b) the causticization of soda ash with slaked lime, usually called the lime-soda process. The electrolytic process also produces chlorine and hydrogen; the lime-soda process does not. From the point of view of quantity produced, the lime-soda process, formerly the more important, now has been displaced in most countries by the electrolytic method because of a more rapid increase in the demand for chlorine than for caustic soda. US production of electrolytic caustic soda exceeded output of the lime-soda type for the first time in about 1937; in 1948, 67 percent of the total US output was produced by the electrolytic process.

2. History of the Industry.

Development of the caustic soda industry in the USSR proceeded slowly. Output fell sharply during and after the Revolution, dropping from a reported 53,000 metric tons in 1913 to 36,000 tons in 1924-25. 1/* The First Five Year Plan (1928-32) apparently placed little emphasis on expansion of the industry, and production in 1932 probably did not exceed 55,000 tons. The Second Five Year Plan (1933-37) provided for the construction of seven caustic soda plants. The annual planned production goals for this period have been reported by [redacted] 25X1X7

* Footnote references in arabic numerals refer to sources listed in Appendix B.

Planned Soviet Production of Caustic Soda
1933-37

Metric Tons (100% NaOH)

Year	Production
1933	58,500
1934	63,500
1935	69,000
1936	83,000
1937	126,000

It is not known whether or not the seven new plants were installed during this period; however, the 1936 output is estimated at 112,000 metric tons, 3/ and production in 1937 is estimated at about 118,000 tons, only 8,000 tons short of the Plan goal, [redacted] 25X1X7

The Third Five Year Plan (1938-42) called for a 50-percent increase in the production of caustic soda, which was stated to be "one of the most deficient chemical products." 4/ This planned increase established the 1942 Plan goal at about 177,000 metric tons. A Soviet chemical industry periodical in 1947 reported that output in 1940 was 2.6 times greater than output in 1913 5/; consequently, production in 1940 may have been about 138,000 metric tons. On the other hand, another source stated that in the Fourth Five Year Plan (1946-50) "it is proposed to increase the production of caustic soda 2.1 times over the prewar level." 6/ It appears, from this information, that 1940 production was about 185,000 metric tons instead of 138,000 metric tons, since the planned goal for caustic soda production in the Fourth Five Year Plan (1946-50) was 390,000 tons.

The Plans for 1941 and 1942 were not fulfilled, the German invasion in 1941 causing the evacuation and destruction of the lime-soda plants at Lisichansk and Slavyansk and the electrolytic plants at Stalinogorsk, Moscow, Tambov, Leningrad, and Beketovka. The cessation of operations at these plants is reported to have resulted in a 70-percent decrease in caustic soda production, which would have amounted to a loss of from about 96,500 to 130,000 metric tons, leaving only about 41,500 to 55,000 tons available to the Soviets in early 1942. 7/

The status of the industry during the war is obscure, but Lend Lease shipments of nearly 100,000 short tons of caustic soda to the USSR from 1942 to 1945 attest to the shortage of this basic chemical. 8/ The extent to which the Soviets were able to remove and re-install caustic soda equipment in plants farther east, as well as the results achieved in expanding facilities and increasing production in existing plants, is unknown. Assuming that production in 1942 was between 41,500 and 55,000 metric tons, it appears, from evidence

contained in the Fourth Five Year Plan (1946-50), that considerable effort was directed toward rehabilitation of the industry from 1942 to 1945.

The Fourth Five Year Plan (1946-50) visualized a production of 390,000 metric tons of caustic soda in 1950 and stated that "factories for the production of caustic soda with a capacity of 278,000 tons are to be put into operation." It can be deduced from this statement that production at the end of 1945 was at the rate of 112,000 tons a year, or about 62.81 percent of the 1940 output. Since 1945, percentage increases over each previous year's production have been reported, indicating that output in 1950 was 277,000 metric tons, a figure 113,000 tons short of the planned goal.

The Soviet production of caustic soda since prerevolutionary times is estimated as follows:

Estimated Soviet Production of Caustic Soda
1913, 1924-25, 1932, 1936-50

Metric Tons (100% NaOH)

Year	Production	Year	Production
1913	53,000	1942	41,500 to 55,000
1924-25	36,000	1943	N.A.
1932	55,000	1944	N.A.
1936	112,000	1945	112,000
1937	118,000	1946	122,000 a/
1938	126,000	1947	152,000 a/
1939	132,000	1948	190,000 a/
1940	138,000 to 185,000	1949	241,000 a/
1941	100,000 to 120,000	1950	277,000 a/

a/ Published percentage increases over the previous year's output are 9 percent for 1946, 25 percent for 1948, 27 percent for 1949, and 15 percent for 1950. 9/ No figure for 1947 was published, although the State Planning Commission reported the quarterly production index as being 121, 123, and 126 (the corresponding quarter of the previous year equals 100) in the first, second, and third quarters of 1947, respectively. 10/ No figures are available for the fourth quarter. It is therefore estimated that the 1947 increase over 1946 was about 25 percent instead of the Plan goal of 36 percent. 11/

II. Operation.

1. Technology.

a. Electrolytic Process.

A saturated solution of common salt (sodium chloride) is heated, treated with soda ash, caustic soda, and sometimes barium chloride, to remove impurities such as calcium, magnesium, and sulphate compounds. The purified solution, after neutralization with hydrochloric acid, is reheated and fed to specially designed electrolytic cells. In these cells the salt solution is decomposed by electric current to form a solution of caustic soda, chlorine gas and hydrogen gas being formed simultaneously as coproducts.

Two general types of cells, the mercury cathode and the diaphragm, are the only caustic soda cells of commercial importance at the present time. Mercury cells are more expensive to operate because of the high initial investment in mercury and because of the higher voltage required. They have, however, the advantage of producing, directly from the cell, a concentrated solution of caustic soda of high purity. Diaphragm cells produce a rather impure 10- to 12-percent solution of caustic soda, which must be concentrated and purified before shipment.

b. Lime-soda Process.

A 20-percent solution of soda ash (sodium carbonate) is treated with slaked lime (calcium hydroxide) at about 85°C to produce an aqueous solution of caustic soda (sodium hydroxide) and a precipitate of calcium carbonate. The insoluble calcium carbonate is removed, and the solution of caustic soda is purified and concentrated.

The caustic soda produced by the electrolytic diaphragm cell and by the lime-soda process is in too diluted a form for shipment. It usually is concentrated to approximately 50-percent NaOH (sodium hydroxide) in multieffect evaporators. Many plants also produce solid fused and flake forms, and recently the use of a 73-percent solution in the US has been increasing. Shipment to large consumers usually is in the liquid form in tank cars at a concentration of either 50 or 73 percent. Less water is shipped with the higher concentrated solution, but certain disadvantages arise. The 73-percent caustic soda, for example, solidifies at about 144°F, whereas 50-percent caustic soda remains liquid above 51°F. Moreover, although the 50-percent solution can be shipped in iron tank cars, for 73-percent solution a nickel lining or special plastic lining must be used. Tank cars for either concentration must be fitted with steam coils to allow remelting of solidified caustic soda.

Caustic soda generally is sold on the basis of its sodium oxide (Na_2O) content. Seventy-six-percent Na_2O (98.06-percent NaOH) is considered to be commercial caustic soda, and prices are quoted per pound or per kilogram of 76-percent Na_2O.

2. Input Requirements.

a. Raw Materials.

The manufacture of 177,000 metric tons of electrolytic caustic soda in 1950 in the USSR required 285,000 metric tons of salt and 4,500 metric tons of soda ash (58-percent Na_2O). In producing 100,000 tons of caustic soda by the lime-soda process the industry consumed 150,000 metric tons of soda ash and 8,250 tons of lime (90-percent CaO). Salt and lime are found in abundance in many localities in the USSR, and sufficient supplies are available for expansion of the industry. Any increase in capacity of the lime-soda process, however, will require a corresponding increase in production of soda ash.

b. Fuel and Power.

The production of caustic soda by the electrolytic process requires large amounts of electricity. Soviet production of 177,000 metric tons in 1950 consumed about 515 million kilowatt-hours of electricity. On the other hand, only 2 million kilowatt-hours were used in the production of 100,000 tons of caustic soda by the lime-soda process. Further increases in electric power capacity will be necessary if electrolytic caustic soda capacity is to be significantly expanded.

The industry's fuel requirements have not yet been calculated. Such calculations depend on a determination of the proportions of power supplied by hydroelectric and thermal plants.

c. Transport and Manpower.

No effort has been made to determine transport and manpower requirements for the Soviet caustic soda industry. As in all chemical plants, however, manpower requirements are comparatively small. A limited number of skilled workers and technical personnel are required for this industry. It is believed that they are available in the USSR.

III. Availabilities.

Soviet Bloc production of caustic soda in 1951 is estimated at 636,000 metric tons (range, from 600,000 to 750,000 tons). This output, plus unknown quantities of imports and stocks, constitutes the total supply available to the Bloc in 1951. In contrast, US production of caustic soda for 1951 is estimated at

approximately 2.8 million metric tons.

1. Domestic Production.

Soviet production of caustic soda is estimated as follows:

Estimated Soviet Production of Caustic Soda
1950-51

Metric Tons

Year	Production	Probable Range of Variation of Estimate
1950	277,000	250,000 to 325,000
1951	325,000	300,000 to 400,000

Information on the individual caustic soda plants in the USSR is not adequate to determine accurately the production of each region. Based on available information, however, the estimated production of caustic soda by regions in the USSR during 1950 was approximately as follows:

Estimated Soviet Production of Caustic Soda by Regions
1950

Metric Tons (100% NaOH)

Region	Quantity	Percent of Total
Northwest	23,200	8
West	0	0
South	81,300	29
Southeast	0	0
Transcaucasus	13,400	5
Volga	45,000	16
Central Industrial	47,700	17
Urals	64,000	23
West Siberia	1,350	1
Kazakhstan	0	0
East Siberia	2,500	1
Soviet Far East	0	0
Total	278,450	100

The locations and estimated capacities of the caustic soda plants in the USSR are as follows:

Estimated Capacities of Caustic Soda Plants in the USSR
1951

Metric Tons (100% NaOH)

Location	Plant Name	Capacity
Lime-soda Process Plants a/		
South Region		
Lisichansk	Donsoda	40,000 to 50,000
Slavyansk	Slavsoda	25,000 to 35,000
Gorlovka 12/	Atz	2,000
Central Industrial Region		
Kineshma b/	Chemical Plant Dmitri	400
Urals Region		
Berezniki	Soda Plant	25,000 to 35,000
Electrolytic Process Plants c/		
Northwest Region		
Arkhangelsk	Solombalski Cellulose Combine	5,600
Enso	Paper and Cellulose Plant	4,000
Kotlas	Cellulose Combine	5,600
Leningrad	Okhtinski Chemical Combine	6,200
Pitkyaranta	Cellulose Plant	1,800
South Region		
Rubezhnoye	Rubezhansky Chemical Combine	5,600
Slavyansk	Krasny Khimik or Slavsoda	5,700
Transcaucas Region		
Sumgait	N.A.	7,400
Yerevan	Synthetic Rubber Plant Kirov	6,000

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Estimated Capacities of Caustic Soda Plants in the USSR
1951
(Continued)

Metric Tons (100% NaOH)

Location	Plant Name	Capacity
Volga Region		
Chapayevsk	Chemical Plant No. 102	11,000
Beketovka	Chemical Plant No. 91	34,000
Central Industrial Region		
Dzerzhinsk	Chemical Plant Kalinin	6,100
Dzerzhinsk	Chemical Plant Zavod Stroy	10,000
Dzerzhinsk	Chemical Plant Zavod Stroy	8,400
Moscow	Chemical Plant Ugreshskiy	6,100
Stalinogorsk	Chemical Combine Stalin	6,700
Tambov	Powder Factory Krasny Oktyabr	10,000
Urals Region		
Berezniki	Chemical Combine Voroshilov	34,000
West Siberian Region		
Tomsk	Chemical Warfare Plant Princess Gagarin	1,350
East Siberian Region		
Usolye	Chemical Plant No. 97	2,500

a. The following plants have been reported as being planned, under construction, or in operation, but production has not been confirmed for any: Volkhov, Leningrad Oblast, Northwest Region; Sumgait, Azerbaijan SSR, Transcaucasus Region; Sterlitamak, Bashkir ASSR, Urals Region; Kulunda, Altai Krai, West Siberian Region; Aralsk, Kyzl-Orda Oblast, Kazakh SSR, Central Asia; Kara-Bogaz-Gol, Turkmen SSR, Central Asia; Balkhash, Karaganda Oblast, Kazakh SSR, Central Asia. A plant at Ivanovo, Ivanovo Oblast, Central Industrial Region, reportedly is producing caustic soda, soap, and other products. 13/

b. There may be a number of such small plants in the USSR, but unless this number were large, which evidence does not indicate, their contribution to total caustic soda production would not be significant.

c. The total capacity of the electrolytic process plants listed (continued on next page)

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Since all plants are believed to be operating at near-capacity levels, production estimates for 1950 also indicate capacity estimates. The lack of idle capacity, however, will prevent the USSR from achieving significant expansion of output in the event of a general war in 1951.

The USSR never has published statistics concerning the distribution of caustic soda production between the lime-soda and the electrolytic processes, and the available information concerning individual plants is not sufficient to make reliable estimates of the quantity of caustic soda produced by each process. An analysis of the data available concerning those plants believed to be employing the lime-soda process, however, indicates a probable Soviet output of 100,000 metric tons in 1950 by this process. In that event the probable 1950 output by the electrolytic process would be about 177,000 tons, or 64 percent of total caustic soda production.

Caustic soda is believed to be in short supply in the Soviet Union. Despite the lack of information regarding construction of new production facilities, efforts probably are being made to expand output. A soda ash plant reportedly was under construction in 1948 at Sterlitamak in the Urals, and Soviet press articles have stated that this will be the largest soda combine in Europe. Undoubtedly this plant will have caustic soda production facilities, but no information has been received to indicate that production has begun.

It is not possible to increase production capacity for caustic soda by the diversion of plants from other uses, because of the specialized nature of the equipment required. The only other product manufactured with this type of equipment is caustic potash, which is produced in such small volume that it would not be practical to divert caustic potash producing facilities to the production of caustic soda.

2. External Sources.

a. Satellites.

The production of caustic soda in the Satellites in 1951 is estimated as follows:

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c. (continued). is 178,050 metric tons a year, a figure closely agreeing with the estimate of 177,000 tons of caustic soda produced by this process during 1950. Current plant information, however, is inadequate, and there is no assurance that this list includes all electrolytic process plants or that estimates of capacities are accurate.

Estimated Satellite Production of Caustic Soda
1951

Country	Metric Tons (100% NaOH) Production
East Germany	150,000
Poland	60,000
Czechoslovakia	55,000
Rumania	23,000
China a/	14,000
Hungary	9,000
Total	311,000

a. Including only Manchuria and the territory north of the Yellow River but excluding the Shantung peninsula area.

b. Non-Bloc Countries.

There is no information on Soviet imports of caustic soda from non-Bloc sources. East Germany, Czechoslovakia, and China, however, receive such imports, principally from Western Europe, and some of these supplies possibly are transshipped to the USSR. The amount of Bloc imports from non-Bloc sources, however, is unknown.

Large but undetermined supplies of caustic soda are available in those Western European countries which might be invaded by the USSR, chiefly West Germany, France, the UK, Italy, and Belgium.

It is not believed that Western European countries have controlled exports of caustic soda to the Soviet Bloc. The US, however, has placed caustic soda (in packages of over 50 pounds net) on its Positive list, and this action has prevented direct shipments of significant quantities of caustic soda to the USSR from the US. Were this restriction not in force, the USSR could at least partially satisfy its caustic soda requirements with US imports and thereby release engineering skills and equipment-manufacturing facilities for the development of other industries.

3. Stockpiles.

Both working inventories and strategic reserves of caustic soda are maintained in the Soviet Union. Although believed to be sizable, the amount of these stocks is unknown.

4. Substitutes.

Soda ash and caustic potash can be substituted in some applications of caustic soda, but, in practice, use of these substitutes would not significantly reduce the requirements for caustic soda. Soda ash cannot be used when a strong alkali of causticizing action is required, and caustic potash cannot be substituted in large volume, because it is produced in much smaller quantities than caustic soda. Furthermore, substitution of caustic potash for caustic soda would not be practical, since both products are produced in the same type of plant.

IV. Requirements.

Domestic industry consumes virtually the entire output of caustic soda in the USSR. Small exports are made to Communist China and Bulgaria, but the tight supply situation in the Soviet Bloc prevents the use of caustic soda in waging economic warfare or in securing essential imports. No study has been made of military consumption, but it appears that, in the event of a general war, the USSR would face a serious caustic soda shortage, even if civilian consumption were cut to a minimum.

Domestic consumption in 1950 is estimated as follows, the soap, chemical, and rayon industries being the chief users:

Estimated Soviet Domestic Consumption of Caustic Soda a/
1950

Industry	Consumption (Metric Tons)	Percent of Total
Soap	52,000	19
Chemicals	44,000	16
Rayon	35,000	13
Petroleum Refining	23,000	8
Lye and Cleansers	14,000	5
Textiles	14,000	5
Pulp and Paper	11,350	4
Reclaimed Rubber	4,500	2
Vegetable Oils	11,800	4
Metallurgy, Bleaching, Dyes, Drugs, Food, and Others	67,350	24
Total	277,000	100

a. The methods used in arriving at these estimates are presented in Appendix A.

V. Capabilities, Vulnerabilities, and Intentions.

1. Capabilities.

Caustic soda reportedly is in short supply in the Soviet Bloc at the present time, and, in the event of a major war, utilization of the stockpiles would be necessary to meet essential military demands. While the supply of this basic chemical might be sufficient to meet the requirements of a limited campaign or of a major war of short duration, however, a major war of long duration would demand construction of additional production facilities in order to maintain the output of commodities essential to the war effort.

2. Vulnerabilities.

The Bloc imports small quantities of caustic soda from non-Bloc countries, but for all practical purposes this Soviet industry is self-sufficient and not vulnerable to economic warfare. The controls which are now exercised by the US over export of this commodity, however, prevent the USSR from diverting at least some of the industry's resources to production of other commodities.

No study has been made regarding the vulnerability of caustic soda producing installations to strategic bombing, but the bombing of a few such key installations, as those at Lisichansk, Slavyansk, and Berezniki in the USSR and Schkopau and Bitterfeld in East Germany, would effectively restrict supplies. A further restriction of caustic soda supplies would result from the bombing of important chemical producing centers such as Dzerzhinsk and Stalinogorsk in the USSR, where caustic soda plants probably would be "bonus" targets. Since the size of the Soviet caustic soda stockpiles is not known, it is impossible to state how soon the disruption of output would affect the Soviet economy.

3. Intentions.

Accurate knowledge of actual and potential supplies of caustic soda would not be an indication of Soviet intentions. Unless detailed information regarding allocations of this chemical to Soviet consumers were available, it is doubtful whether any conclusions concerning Soviet intentions could be drawn from a study of the caustic soda industry alone.

APPENDIX A

METHOD OF ESTIMATING CAUSTIC SODA REQUIREMENTS IN THE USSR

Estimates of domestic consumption of caustic soda in the USSR in 1950, presented on page 13, were made in the following manner:

1. Soap.

The 1950 Plan goal for soap production in the Soviet Union called for an output of 870,000 metric tons. Assuming fulfillment of this goal, the amount of caustic soda required was about 52,000 metric tons.

2. Chemicals.

Caustic soda enters into the manufacture of such a great variety of chemicals that it is impossible to estimate requirements directly from chemicals production. Therefore, the problem must be approached by an indirect and inferior method. In the US the consumption of caustic soda in the manufacture of chemicals from 1935 to 1939 averaged about 16 percent of the total output of caustic soda in those years. 14/ Assuming that a similar percentage of the Soviet production of caustic soda in 1950 was consumed in the manufacture of chemicals, the quantity required was about 44,000 metric tons.

3. Rayon.

Production of rayon filament yarn and staple in the USSR in 1950 is estimated at 77 million pounds, or 40 million pounds of filament and 37 million pounds of staple. 15/ The quantity of caustic soda required was about 35,000 metric tons.

4. Petroleum Refining.

The 1950 output of crude oil in the USSR is estimated at about 37 million metric tons. The quantity of caustic soda required for refining this output probably was about 23,000 metric tons.

5. Lye and Cleansers.

Since no figures on Soviet production of lye and cleansers are available, the indirect method employed in estimating the requirements of the chemical industry must be used in estimating caustic soda consumption. In the US the consumption of caustic soda in the manufacture of lye and cleansers from 1935

to 1939 averaged about 5 percent of total caustic soda production. 16/ If the same percentage is applied to Soviet production in 1950, the amount of caustic soda used in the manufacture of lye and cleansers was about 14,000 metric tons.

6. Textiles.

The treatment of textiles required about 5 percent of total US production of caustic soda from 1935 to 1939. 17/ Assuming that the Soviet textile industry required a similar percentage, the industry's caustic soda consumption in 1950 is estimated at 14,000 metric tons.

7. Pulp and Paper.

The Fourth Five Year Plan (1946-50) referred to the paper industry as follows: "The rehabilitation of the industry shall be completed by 1948 and its further development undertaken, so that by 1950 the output of paper exceeds the prewar level by 65 percent, provision being made for a far greater proportionate increase in the output of high-grade bleached paper." On the basis of this information it is estimated that the 1950 production goal was 1.34 million metric tons of paper, but actual production is believed to have been about 1.19 million tons. In 1940 the US produced 7.3 million tons of paper and consumed 71,000 tons of caustic soda in the manufacture of pulp and paper. 18/ Since Soviet paper production in 1950 was 16 percent of US production in 1940, Soviet caustic soda requirements in 1950 are estimated at 16 percent of US requirements in 1940, or 11,350 metric tons.

8. Vegetable Oils.

The 1950 goal for vegetable oil production was 880,000 metric tons, but actual output is estimated at about 900,000 tons. Caustic soda requirements for this production are estimated at about 11,800 metric tons.

9. Reclaimed Rubber.

Caustic soda requirements for the estimated Soviet output of approximately 45,000 metric tons of reclaimed rubber in 1950 are estimated at about 4,500 metric tons.

10. Other.

The remaining 67,350 metric tons of caustic soda probably were consumed in metallurgy; bleaching; the manufacture of dyes, drugs, and foods; and other minor uses. A small part of this quantity may have been exported to China and Bulgaria, but the USSR imports caustic soda from Poland, Rumania, and Czechoslovakia and possibly was a net importer in 1950.

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APPENDIX B

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PART II

THE CHLORINE INDUSTRY IN THE USSR

Summary

Chlorine, one of the basic inorganic chemicals essential in the production of many indispensable commodities, is believed to be in short supply in the Soviet Bloc, although all plants are apparently producing at near maximum capacity. Probably because of requirements of Western countries for pressure containers in which chlorine must be shipped, Western export controls on chlorine have not been necessary, and no chlorine is known to be imported by the Bloc. The only known exports of the Bloc are small quantities from the USSR to Finland, probably for use in the bleaching of wood pulp to be delivered to the USSR.

Production of chlorine in the USSR increased from about 8,000 metric tons in 1917 to an estimated 220,000 to 250,000 metric tons in 1951, equivalent to about 12 percent of US 1950 production. Output in the Satellite countries in 1951 is estimated at 220,000 metric tons, giving a 1951 total chlorine output in the Soviet Bloc of from 440,000 to 470,000 metric tons.

In the event of a major war in the near future, construction of additional production facilities probably would be necessary to ensure enough chlorine essential to the war effort. The chlorine industry of the Soviet Bloc is not vulnerable to economic warfare, but the bombing of a limited number of the Bloc's chlorine-producing plants and/or their power installations probably would effectively restrict production.

I. Introduction.

1. Nature and Uses.

Chlorine is a greenish yellow gas with a disagreeable odor and is extremely poisonous when inhaled in large amounts. A basic inorganic chemical, it is used in tonnage lots for a great variety of industrial purposes. In its elemental state, chlorine is used in bleaching operations and in the prevention

of disease by the sterilization of water supplies and sewage wastes. By far the greater part of the chlorine produced, however, is used in the manufacture of chemical end products and chemical intermediates, the intermediates being further processed into a wide range of end products. Some of the many outstanding chemical products derived from chlorine are tetraethyl lead, synthetic rubber, plastics, synthetic fibers, ethylene glycol (antifreeze), picric acid, chemical warfare agents and screening smokes, synthetic glycerine, metal degreasers, solvents, dry cleaners, insecticides and fungicides, medicines, special paints, adhesives, bleaching powder, aniline, phenol, chlorinated rubber, and aluminum chloride.

2. Technology.

Chlorine is produced commercially by several processes, the most important being the brine electrolysis process, which consists of the electrolytic decomposition of a solution of common salt in an electrolytic cell. Other methods of chlorine production include (a) electrolysis of fused chlorides of sodium, potassium, and magnesium, producing as coproducts metallic sodium, potassium, and magnesium, respectively, and (b) the nitrosyl chloride process. Chlorine also may be produced by the oxidation of hydrochloric acid with manganese dioxide or by air in the presence of a suitable catalyst. This latter method, however, is now outdated.

a. Brine Electrolysis Process.

The brine electrolysis process supplies by far the greater part of chlorine in the USSR and elsewhere in the world and, in addition, produces caustic soda and hydrogen as coproducts. A purified, saturated solution of common salt is heated and fed to the electrolytic cells, which, by means of electric current, decompose the solution into chlorine, caustic soda, and hydrogen. The hot chlorine gas, as it evolves from the anodes of these cells, contains considerable water vapor, which is partially removed by cooling and is then completely removed by scrubbing with concentrated sulphuric acid in a packed stoneware tower.

b. Other Processes.

In the metallic sodium, potassium, and magnesium processes, electrolytic decomposition of the fused chloride yields chlorine as a coproduct in addition to the respective metal. The chlorine produced by electrolysis of fused chlorides is dry and quite pure.

In the nitrosyl chloride process, chlorine and sodium nitrate are produced by treating salt with nitric acid. This process has the economic advantage, peculiar only to the US, of producing sodium nitrate rather than caustic soda as a coproduct of chlorine. No plants of this type are known to be installed in the USSR.

The anhydrous chlorine gas produced by any of these processes is either piped to adjacent installations for the manufacture of chlorinated products or liquefied by compression and cooling.

Liquid chlorine is shipped to small consumers in steel pressure cylinders (84 psig* at 70°F) of 10, 15, 25, 100, and 150 pounds capacity each. Consumers of larger quantities sometimes receive cylinders of 2,000 pounds capacity on multiple-unit flatcars. In the US the major part of the chlorine produced is shipped in high-pressure, single-unit tank cars of 15, 30, and 55 tons capacity each. Information on methods of shipping liquid chlorine in the USSR is scant, but it is known that shipments are made in cylinders, 1-ton containers, and tank cars. It is believed that most of the chlorine produced in the Soviet Union is not liquefied but is piped as a gas to adjacent installations for conversion to the desired product.

3. History of the Industry.

The USSR has never published statistics concerning the production of chlorine. A few scattered facts revealed by the Soviets from time to time, however, give a general idea of the development of the chlorine industry in the USSR. According to a Soviet chemical industry periodical of 1949, there were only two chlorine manufacturing plants in the USSR in 1917; and a number of new plants for the electrochemical preparation of chlorine and caustic soda were established in 1930, an original Soviet chlorine cell being developed about that time. 1/** The production from the two plants in 1917 probably did not exceed 8,000 metric tons per year. Apparently there was little development in the Soviet chlorine industry until 1930, its backwardness during the 1917-30 period being shown by the relative size of the US chlorine industry. In the US in 1917, for example, 31 plants were producing at an annual rate of about 180,000 metric tons; in 1930, 38 plants were producing approximately 330,000 metric tons per year. 2/

Detailed information on the Soviet chlorine industry from 1930 to 1940 is lacking. Estimates of output, based upon a knowledge of the caustic soda, caustic potash, magnesium, and sodium industries during this period, are as follows:

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* Pounds per square inch, gauge pressure.
** Footnote references in arabic numerals refer to sources listed in Appendix B.

Estimated Soviet Annual Production of Chlorine
1931-40

Year	Metric Tons
1931-33	10,000 to 20,000
1934	20,000 to 30,000
1935	30,000 to 45,000
1936	45,000 to 55,000
1937	55,000 to 75,000
1938	75,000 to 95,000
1939	90,000 to 100,000
1940	100,000 to 110,000

An interesting check on the above estimates was provided by a US graphite manufacturer who calculated chlorine production from shipments of graphite anodes from his company to the USSR during the period from 1934 to 1946. Graphite anodes are consumed in the process of producing chlorine, and this source states that during this period his company was the sole source of anodes purchased outside the USSR and that Soviet domestic production of anodes was not substantial. His figures for the average annual Soviet production of chlorine are as follows 3/:

Estimated Soviet Average Annual Production of Chlorine
1934-39 and 1942-46

Period	Average Annual Production, Tons a/
1934-36	53,000
1935-37	89,000
1936-38	123,000
1937-39	104,000
1942-44	138,000
1943-45	157,000
1944-46	159,000

a. Probably short tons.

These figures do not include chlorine production from magnesium and sodium plants. Nevertheless, for the prewar years they are reasonably accurate, if somewhat high, and serve as a good check on the chlorine production estimates in this report. For the period from 1942 to 1946 the figures of the above source are based on the assumption that all of the anodes shipped to the USSR during these years were consumed, but this is not necessarily true. These figures are believed to be too high, particularly since it is unlikely that production increased during the war years with the destruction of the plants at Leningrad, Moscow, Pitkyaranta, Slavyansk, Beketovka, Stalinogorsk, Tambov, and Zaporozhye.

Production during the war years is unknown and almost impossible to estimate because of such unknown factors as the capacity of the destroyed plants, the removal and reinstallation of equipment, and the increase of producing in existing plants. Production estimates for 1945 of 112,000 metric tons of caustic soda (about 82,000 electrolytic and 30,000 lime-soda), of about 5,000 tons of magnesium, and of about 3,000 tons of metallic sodium indicate that the output of chlorine in 1945 was from 90,000 to 100,000 tons.

The 1950 Soviet output of chlorine produced from electrolytic caustic soda plants is estimated at about 157,000 metric tons (as compared with an electrolytic caustic soda production of about 177,000 tons). In addition, about 43,000 tons of chlorine were produced by the metallic sodium plants at Berezniki, Chirchik, and Dzerzhinsk; by the magnesium plants at Solikamsk and Zaporozhye; by the caustic potash plant at Rubezhnoye; and by the lead-sodium alloy plant at Dzerzhinsk. Thus it is estimated that the total Soviet output of chlorine in 1950 was about 200,000 metric tons, or between 190,000 and 220,000 tons. The 1951 production is estimated at from 220,000 to 250,000 tons, although this estimate does not take into account any construction of new chlorine plants on which there is little information.

Summarizing, the production of chlorine in the USSR in 1917 and since 1930 is estimated as follows, using US production data during certain years for comparison purposes:

Estimated Soviet Production of Chlorine
As Compared with US Production
1917, 1930-51

Year	Soviet Production (Metric Tons)	US Production (Metric Tons)	Soviet Production as Percent of US Production
1917	8,000	180,000	4
1930	8,000	330,000	2
1931-33	10,000 to 20,000		
1934	20,000 to 30,000		
1935	30,000 to 45,000		
1936	45,000 to 55,000		
1937	55,000 to 75,000		
1938	75,000 to 95,000		
1939	90,000 to 100,000		
1940	100,000 to 110,000	600,000	18
1941-44	N.A.		
1945	90,000 to 100,000		
1946	100,000 to 110,000		
1947	110,000 to 120,000		
1948	120,000 to 150,000		
1949	150,000 to 190,000		
1950	190,000 to 220,000	1,700,000	12
1951	220,000 to 250,000		

The relatively undeveloped state of the Soviet chlorine industry as of 1947 was disclosed in a Soviet article entitled "Problems of the Chlorine Industry in the Fourth Five Year Plan," 4/ which stated as follows:

> "We believe that in the next few years it will be possible to carry out in good time the recommendations made by our specialists a long time ago to have in the Soviet Union several installations based on the Mercury method."

Thus it is apparent that in 1947 the USSR had no installations for production of chlorine by the mercury method of electrolysis. It is reported, however, that a mercury cell plant, allegedly built with dismantled German equipment, was put into operation at Dzerzhinsk about May 1949. 5/ Other information confirms this report and further states that, at the end of 1948, about 120 dismantled German mercury cells were sent from Dzerzhinsk to Moscow and that, a few weeks later, about 100 more were sent from Dzerzhinsk to the eastern part of the USSR. 6/ Therefore, at least two more mercury cell plants may be in operation in the USSR. The Soviet article quoted above also revealed that the outstanding weaknesses of the Soviet chlorine industry in 1947 were lack of skill in operation and maintenance of plants, shortage of graphite anodes and shipping containers, poor quality of asbestos paper used in diaphragm cells, and insufficient production of liquid chlorine. In addition, the article implied that expansion of the chlorine industry was limited by the availability of electric power as well as by the lack of demand for chlorine, indicating that the Soviet organic chemical industry was not well-developed. These and other comments in this article are proof of the backward state of the Soviet chlorine industry in 1947.

II. Input Requirements.

a. Raw Materials.

Salt is the primary raw material required for the production of chlorine and is found in abundance in many localities in the USSR. Sufficient supplies are available for expansion of the chlorine industry.

The amount of each principal raw material required for the manufacture of approximately 200,000 metric tons of chlorine during 1950 was about as follows:

	Metric Tons
Salt (Sodium Chloride) a/	370,000
Soda Ash (for Brine Purification)	4,400
Sulphuric Acid (66°Be')	18,000

a. A relatively small quantity of potassium chloride was undoubtedly substituted for some of the sodium chloride in order to produce caustic potash rather than caustic soda.

b. Fuel and Power.

Electricity is the principal power required for the production of chlorine. Because of the large quantities of electricity required, any significant increase in chlorine production must be accompanied by a corresponding increase in electric power supply. About 650 million kilowatt-hours of electricity were required in 1950 for the manufacture of approximately 200,000 metric tons of chlorine.

In order to calculate fuel requirements, a detailed study to determine how much of the electric power is supplied by hydroelectric plants and how much by thermal power plants would be necessary.

c. Transport.

No effort has been made to date to determine transport requirements for this industry. As stated previously, chlorine must be shipped in pressure containers (tank cars, 1-ton containers on multiple-unit flatcars, or cylinders of varying capacities). Soviet transport requirements for the chlorine industry probably are small, since it is believed that most of the chlorine produced is not liquefied but is piped as a gas to adjacent installations for conversion to other chemical products.

d. Manpower.

No effort has been made to date to determine manpower requirements or supplies for the Soviet chlorine industry. As in all chemical plants, however, manpower requirements are comparatively small. A limited number of skilled workers and technical personnel, believed to be available, are required for this industry.

III. Availabilities.

1. Domestic Production.

As previously stated, Soviet estimated chlorine production ranged from 190,000 to 220,000 metric tons in 1950 and from 220,000 to 250,000 metric tons in 1951. With Satellite production estimated at 220,000 metric tons for 1951, the total supply of chlorine available to the Bloc for 1951 is estimated at from 440,000 to 470,000 metric tons. It is believed that this supply does not at present fully cover needs.

Although available information on the individual Soviet chlorine plants is inadequate, their location and capacities are estimated as follows:

Location and Estimated Capacities of Soviet Chlorine Plants

Location	Plant	Capacity (Metric Tons per Year)
Northwest		
Arkhangelsk	Solombalski Cellulose Combine	5,000
Enso	Paper and Cellulose Plant	3,500
Kotlas	Cellulose Combine	5,000
Leningrad	Okhtinski Chemical Combine	5,500
Pitkyaranta	Cellulose Plant	1,600
South		
Rubezhnoye	Rubezhansky Chemical Combine	5,000
Slavyansk	Krasny Khimik or Slavsoda Plant	5,000
Zaporozhye	Magnesium Plant	14,000
Transcaucasus		
Sumgait	N.A.	6,600
Yerevan	Kirov Synthetic Rubber Plant	5,400
Volga		
Chapayevsk	Chemical Plant No. 102	9,800
Beketovka	Chemical Plant No. 91	30,000

Location and Estimated Capacities of Soviet Chlorine Plants
(Continued)

Location	Plant	Capacity (Metric Tons per Year)
Central Industrial		
Dzerzhinsk	Kalinin Plant (Krebs Cell Installation)	5,400
Dzerzhinsk	Plant No. 96 (Stroy)	
	Vorce Cell Installation	9,000
	Mercury Cell Installation	7,500
	Lead-Sodium Alloy Cell Installation	6,500
	Sodium Cell Installation	1,500
Moscow	Ugreshskiy Chemical Plant	5,400
Stalinogorsk	Stalin Chemical Combine	6,000
Tambov	Krasny Oktyabr Powder Factory	9,000
Urals		
Berezniki	Voroshilov Chemical Combine	
	Siemens-Billiter Plant	30,000
	Sodium Plant	3,000
Solikamsk	Carnallite-Magnesium Plant	14,000
West Siberia		
Tomsk	Princess Gagarin Chemical Warfare Plant	1,200
Kazakhstan		
Chirchik	Stalin Electrochemical Combine (Sodium Plant)	1,500
East Siberia		
Usolye	Chemical Plant No. 97	2,200
Total		198,600 a/

a. This figure checks closely with the statistically derived 1950 production figure of from 190,000 to 220,000 tons. As stated previously, however, the plant information is inadequate, and there is no assurance that the above list includes all of the plants or that the capacities listed are accurate.

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Estimated Soviet chlorine capacity by region is given in the following table:

Estimated Soviet Chlorine Capacity by Region

Region	Quantity (Metric Tons)	Percent of Total
Northwest	20,600	10
West	0	0
South	24,000	12
Southeast	0	0
Transcaucasus	12,000	6
Volga	39,800	20
Central Industrial	50,300	25
Urals	47,000	24
West Siberia	1,200	1
Kazakhstan	1,500	1
East Siberia	2,200	1
Soviet Far East	0	0
Total	198,600 a/	100

a. Sum total of estimated plant capacities.

2. External Sources.

a. Satellites.

It is estimated that chlorine will be produced in the Satellite countries in the following quantities during 1951:

Country	Metric Tons
East Germany	156,000
Czechoslovakia	40,000
Poland	8,000
Rumania	6,000
Hungary	5,000
Bulgaria	0
Manchuria	1,000
North China	4,000
Total	220,000

b. Non-Bloc Countries.

Controls on exports of chlorine from Western countries have not been necessary, probably because it is not feasible for these countries to ship chlorine in view of Western requirements for the pressure containers in which chlorine must be transported. This would explain largely why, despite the short supply within the Soviet Bloc, no chlorine is known to be imported. There are Western export controls, however, on chlorine-derived products which are important militarily to the Soviet Bloc, such as chlorates, perchlorates, phenols, chlorbenzenes, anilins, aluminum chloride, silicones, and freons.

Accurate knowledge of the chlorine supplies available in European countries which might be occupied by the USSR is not available, since this would be based largely on a study of the chlorine industry in Western Europe which has not yet been completed. However, large quantities are known to be available in West Germany, France, England, Italy, Belgium, and other European countries.

3. Stockpiles.

Because of the large requirements for high-pressure tank storage facilities, it can be assumed that there are no reserves of chlorine in the Soviet Bloc, with the exception of a relatively small quantity in the industrial pipeline.

4. Substitutes.

There are no economical substitutes for chlorine in its principal applications.

IV. Requirements.

1. Domestic.

Little information is available concerning the distribution of chlorine among consuming industries in the USSR. Since about one-half of the chlorine produced goes into the manufacture of chemical intermediates and products about which no quantitative information is available regarding Soviet production, it is impossible to arrive at an accurate consumption pattern. With a few exceptions, it has been necessary to make some broad assumptions in order to estimate the distribution of chlorine among Soviet chemical industries for 1950. This distribution is given in the following table, the methods used to calculate this distribution being described in Appendix A:

Estimated Chlorine Consumption by Industry in the USSR
1950

Industry	Quantity (Metric Tons)	Percent of Total
Organic Chemicals	100,000	50.0
Bleaching Compound	20,000	10.0
Pulp and Paper	22,000	11.0
Textiles and Cellulose	10,000	5.0
Sanitation	7,000	3.5
Bromine	5,000	2.5
Aluminum Chloride	5,000	2.5
Synthetic Hydrochloric Acid	2,000	1.0
Miscellaneous	29,000	14.5
Total	200,000	100.0

The above table includes all Soviet chlorine requirements. Information is lacking on which to estimate civilian needs as opposed to military. In the event of a general war, however, the USSR undoubtedly will suffer a considerable shortage of chlorine. Chlorine now allocated for bleaching and for the manufacture of nonessential products would be

diverted to the manufacture of explosives (picric acid), chemical warfare agents, screening smokes, and other military uses.

2. Exports.

Small quantities of chlorine are believed to have been exported during 1950 to Finland, Bulgaria, and Hungary. In 1948 and in the first half of 1949 the USSR reportedly exported 583 and 790 metric tons of chlorine, respectively, to Finland. No data on exports are available for the second half of 1949 or for 1950. The purpose of these shipments of chlorine to Finland is thought to be for the bleaching of wood pulp for delivery to the USSR. Quantities of chlorine exported to Hungary and Bulgaria are not known but are believed to be small.

Requirements for high-pressure storage tank facilities and the limited supply of chlorine in the USSR make it very unlikely that chlorine would be used by the Soviets either for economic warfare purposes or even for export to secure essential imports.

V. Capabilities, Vulnerabilities, and Intentions.

1. Capabilities.

The supply of chlorine available to Soviet Bloc countries during 1951 will amount to an estimated 440,000 to 470,000 metric tons, or only about 26 to 28 percent of the 1950 production in the US. Chlorine is believed to be in short supply in the Soviet Bloc at the present time, and, in the event of a major war, civilian and nonessential industrial uses would have to be eliminated in order to meet military requirements. While the supply of this basic chemical might be sufficient to meet the requirements of a limited campaign or of a major war of short duration, it is believed that a major war of long duration would require construction of additional production facilities in order to avoid limitation of production essential to the military effort.

2. Vulnerabilities.

As chlorine is not imported into the Soviet Bloc, restriction of supplies through the use of economic warfare is not possible. Expansion in the USSR of this industry is being retarded, however, by the Western embargo on exports of chlorine-producing equipment.

No studies have been made regarding the vulnerability of the chlorine-producing installations to strategic bombing, but it is believed that the bombing of a limited number of important installations and/or of their power plants would effectively restrict production of chlorine. This would have an almost immediate effect on chlorine supplies, since it is not practically possible for the Soviet Bloc to maintain stockpiles of chlorine or of all chlorine-derived chemicals essential for military use.

3. Intentions.

It is unlikely that any conclusions regarding Soviet intentions could be drawn from the operation of the chlorine industry unless detailed information regarding allocations of chlorine to Soviet consumers were available.

APPENDIX A

METHOD OF ESTIMATING 1950 CHLORINE REQUIREMENTS IN THE USSR

The estimated 1950 chlorine consumption by industry in the USSR as given in a table on page 30 is repeated as follows:

Estimated Chlorine Consumption by Industry in the USSR
1950

Industry	Quantity (Metric Tons)	Percent of Total
Organic Chemicals	100,000	50.0
Bleaching Compound	20,000	10.0
Pulp and Paper	22,000	11.0
Textiles and Cellulose	10,000	5.0
Sanitation	7,000	3.5
Bromine	5,000	2.5
Aluminum Chloride	5,000	2.5
Synthetic Hydrochloric Acid	2,000	1.0
Miscellaneous	29,000	14.5
Total	200,000	100.0

The following method was used to reach an estimate for each industry.

1. Organic Chemicals.

The organic chemicals industry in the USSR is the largest consumer of chlorine. The principal chlorine-derived organic chemicals are as follows:

a. Ethylene glycol, the principal antifreeze motor coolant.
b. Carbon tetrachloride, a solvent and the raw material used for DDT and Freon.
c. Chlorinated benzenes, used as intermediates for dyes, synthetic phenol, medicinals, high-pressure lubricants, moth repellants, etc.

d. Dichlorethane, trichlorethane, trichloroethylene, tretrachloroethylene, perchloroethylene, hexachlorethane, solvents for metal degreasing, vegetable oil extraction, etc.
e. Ethyl chloride, used in the manufacture of tetraethyl lead.
f. Vinyl chloride and vinylidene chloride, which are monomers for production of plastics and synthetic rubber.
g. Many other chemicals, dyes, chemical warfare agents, screening, smokes, plastics, etc.

At present an accurate calculation of the chlorine consumed in the manufacture of the above products in the USSR is impossible. The following statement made in a Soviet chemical industry periodical, however, sheds some light on this subject and allows an approximate estimate to be made of the quantity of chlorine going into the manufacture of organic chemicals:

> "The current Five Year Plan calls for the use of 45 to 50 percent of the total output of chlorine by the organic synthesis industry." 7/

Therefore, assuming that 50 percent of the Soviet chlorine production during 1950 was consumed in the manufacture of organic chemicals, the quantity allocated for this purpose would have been approximately 100,000 metric tons.

2. Bleaching Compound.

In the US in 1948, approximately 28,500 metric tons of chlorine, or about 2 percent of total output, were consumed in the manufacture of sodium hypochlorite and bleaching powder. 8/ It is believed that the percentage of chlorine used to produce bleaching compounds in the USSR probably is considerably higher than the percentage used for this purpose in the US, principally because of the lack of adequate Soviet facilities for producing liquid chlorine and also because of the shortage of liquid chlorine transportation facilities. It is probable that the 1950 Soviet consumption of chlorine for these purposes amounted to about 10 percent of Soviet total production, or about 20,000 metric tons.

3. Pulp and Paper.

About 150,000 short tons, or 136,000 metric tons, of chlorine were consumed in the US during 1940 in the manufacture of pulp and paper. 9/

In Part I of this report (The Caustic Soda Industry in the USSR) it was estimated that the 1950 production of pulp and paper in the USSR was about 16 percent of the 1940 production in the US. About 22,000 tons of chlorine, or about 11 percent of the estimated total production, therefore, was consumed by the USSR during 1950 for the manufacture of pulp and paper.

4. Bleaching Textiles and Cellulose.

In the US in 1937, about 5 percent of the total chlorine production was consumed by the textile industries. 9/ Assuming that the textile and cellulose enterprises in the USSR during 1950 consumed 5 percent of the total production, the quantity allocated for these purposes was about 10,000 tons.

5. Sanitation.

In the US in 1948, about 48,000 metric tons of chlorine were consumed in the sterilization of water supplies and sewage wastes. 8/ This represented about 3.5 percent of the total production. Assuming that Soviet consumption of chlorine during 1950 for sanitation purposes amounted to 3.5 percent of production, the quantity consumed for these purposes was about 7,000 tons.

6. Bromine.

In the US in 1948, about 32,000 metric tons of chlorine were consumed in the manufacture of bromine. 10/ This amounted to about 2.5 percent of total output. Assuming the same percentage for the USSR, the quantity of chlorine consumed for the manufacture of bromine during 1950 was about 5,000 tons.

7. Aluminum Chloride.

In the US in 1944, approximately 32,800 metric tons of chlorine were consumed in the manufacture of aluminum chloride, which is used principally as a catalyst for petroleum refining. 11/ Crude oil output in the USSR during 1950 was estimated at about 37.5 million metric tons, which was about 15 percent of the US 1944 output of approximately 240 million metric

tons. Assuming, therefore, that the production of aluminum chloride in the USSR during 1950 was about 15 percent of the US 1944 production, the consumption of chlorine for this purpose in the Soviet Union during 1950 was about 5,000 tons, or about 2.5 percent of the estimated total chlorine production.

8. Synthetic Hydrochloric Acid.

In the US in 1948, approximately 9,500 metric tons of chlorine were consumed in the manufacture of synthetic hydrochloric acid. 10/ This represented about 0.7 percent of the total production. Assuming that Soviet consumption of chlorine for the manufacture of synthetic hydrochloric acid during 1950 amounted to 1 percent of total production, the quantity consumed for this purpose was about 2,000 metric tons.

9. Miscellaneous.

The remaining 14.5 percent of 1950 production, or 29,000 metric tons, probably was consumed in the recovery of metals from their ores, in the detinning and dezincing of scrap metals, in the manufacture of metallic and other inorganic chlorides, in chlorinated rubber, military poison gases, and screening smokes, and in numerous other uses. Small but undetermined quantities are believed to have been exported to Finland, Hungary, and Bulgaria.

~~SECRET~~

APPENDIX B

SOURCES

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4. [redacted]

5. WDGS Intelligence Rpt., RT-182-50, 10 February 1950, CIA 446321.

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25X1A2g 7. [redacted] 5 October 1948, Future Development of the Organic Synthesis Industry, Khimicheskaya Promyshlennost, No. 12, 1946.

8. The Chlor-Alkali Industry in the United States, by R. L. Murray, October 1949.

9. Materials Handbook Chlorine, War Production Board.

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