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PROVISIONAL INTELLIGENCE REPORT

THE ETHYL ALCOHOL INDUSTRY IN THE USSR

CIA/RR PR-27

27 February 1953

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MAR 16 1953

FOREWORD

Ethyl alcohol has long been an important basic chemical in the economy of industrialized nations. It is a solvent of great importance. It is used as an intermediate raw material for many other chemical products and as an ingredient or carrier for drugs, pharmaceuticals, cosmetics, and perfumes. This is particularly true in the USSR, where large quantities of synthetic rubber are manufactured using alcohol as a raw material. The purpose of this report is to present a study of the more important aspects of the ethyl alcohol industry in the USSR based on a technical study of the information available. It should be remembered that the data available are severely limited both qualitatively and quantitatively and are rarely subject to checking or confirmation. Consequently, it must be emphasized that estimates made throughout the report can be only tentative and are probably accurate within no less than plus or minus 15 to 20 percent.

Ethyl alcohol, normally produced by the fermentation of any organic product, is produced and consumed by every nation in the world in the forms of wine, beers, and all types of spirituous liquors for commercial or industrial uses and is easily recovered as pure alcohol by distillation. For industrial purposes, it is usually made from grains and is therefore sometimes called grain alcohol. With the greatly increased demand for ethyl alcohol for commercial uses, for example, in solvents and in rubber manufacture, ethyl alcohol is synthetically produced in greatly increased percentages from petroleum refinery gases and natural gases. Ethyl alcohol produced in the synthetic process and for technical purposes is called ethanol. The chemical compositions of ethyl alcohol and ethanol are identical, and all types of ethyl alcohol can be used interchangeably. Ethyl alcohol for spirituous liquors and medicinals must be of high purity.

For commercial purposes, ethyl alcohol is denatured by the addition of any one of many chemicals, so that the material is not potable. The potable ethyl alcohol can be used for all purposes, but the "denatured" can be used only for nonpotable purposes. Ethyl alcohol, ethanol, grain alcohol, wine spirits, etc., are all chemically the same product In this report, ethyl alcohol means every type of alcohol with the formula C_2H_2OH.

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THE ETHYL ALCOHOL INDUSTRY IN THE USSR*

Summary

Ethyl alcohol** is manufactured in the USSR predominantly by the fermentation of agricultural products, particularly grain, sugar-beet molasses, and potatoes. Smaller amounts are made by the fermentation of sulfite-pulp waste liquor, by the hydrolysis of wood, and by the conversion of ethylene gas from petroleum refineries.

Soviet production of ethyl alcohol in 1952 is estimated at approximately 304 million gallons. In addition, about 12 million gallons were imported from East Germany, giving a total supply of 316 million gallons. Roughly 100 million gallons of this supply were earmarked as raw material for the production of synthetic rubber, and 75 million gallons were destined to be consumed as beverages. The remainder was to be utilized in the manufacture of explosives, solvents, and other industrial chemicals.

A large volume of raw material is required in order to produce this quantity of alcohol, the most important being 1,880,000 tons of grain, 1,670,000 tons of potatoes, and 875,000 tons of sugar-beet molasses for fermentation ethyl alcohol, and 1,717,000 tons of coal. Lesser amounts of wood, ethylene from petroleum refining and natural gases, and sulfuric acid are consumed for the manufacture of synthetic ethyl alcohol.

It is felt that sufficient ethyl alcohol is available in the USSR for peacetime requirements. In the event of a major war, the reduction of beverage allotments, the reallocation for industrial uses, and the utilization of state reserves should satisfy needs until production capacity can be expanded.

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* This report contains information available to CIA as of 1 January 1953.

** Ethyl alcohol, the alcohol with the formula C_2H_5OH, is the only alcohol considered in this report. The terms alcohol, industrial alcohol, and grain alcohol all refer only to ethyl alcohol.

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I. Introduction.

A. Nature and Uses.

Industrial alcohol, a term generally applied to ethyl alcohol used for technical and industrial purposes rather than as a beverage, occupies an important place in the chemical economy of most nations. The standard commercial product is a highly purified liquid of 95- to 96-percent concentration (190 to 192 proof), the remaining few percent being pure water. It is normal practice in the US to render industrial alcohol nonpotable by the addition of suitable chemicals called denaturants. Thus denatured, ethyl alcohol is not subject to the Federal tax on beverage ethyl alcohol.

In those cases where the standard denaturants would interfere with a particular process, one of a series of special denaturants authorized by the US Government may be used. Alcohol also is sold undenatured and under bond for those uses where no denaturant would be suitable.

Perhaps the best way to illustrate the various uses of industrial alcohol is to present the US use pattern for a recent year (see Table 1).* It should be realized that this pattern is not applicable as such to any other country but is shown only for purposes of illustration.

The consumption pattern of ethyl alcohol in Europe, and particularly in the USSR, differs considerably from that indicated in Table 1. In the USSR a much larger proportion of ethyl alcohol is consumed in the manufacture of butadiene synthetic rubber, and relatively less is used as a chemical raw material.

From the US use pattern, illustrated in Table 1, it is apparent that the two major uses of industrial alcohol are as a solvent and as a chemical raw material. Less important uses are as a fuel in automobile engines and rockets and as a liquid for brake fluids, cutting oils, and the like.

B. History of the Industry.

Prior to World War I, Russian production of ethyl alcohol amounted to about 135 million gallons per year. 1/** Approximately 1,800 distilleries are reported to have been in operation, 2/ employing as raw materials mainly potatoes (50 to 70 percent of the total materials),

* Table 1 follows on p. 3.
** Footnote references in arabic numerals are to sources listed in Appendix C.

Table 1

US Consumption of Specially Denatured Ethyl Alcohol
1949 3/

	Thousand Gallons of 95 Percent Alcohol
Lacquers, Varnishes, and Enamels	3,530
Plastics	3,200
Proprietary Solvents	18,650
Toilet Preparations	5,570
Nitrocellulose	4,000
Rosin and Synthetic Resins	1,140
Drugs and Pharmaceuticals	2,840
Rubbing Alcohol	2,400
Cleaning, Preserving, and Flavoring Preparations	1,420
Vinegar	3,970
Acetic Acid	3,250
Ethyl Acetate	5,330
Ethyl Chloride	10,170
Other Ethyl Esters	2,740
Aldehydes	68,250
Ethyl Ether	1,000
Ethers, Glycols, etc.	1,900
Ethylene Dibromide (for TEL)	1,100
Synthetic Rubber	1,400
Dyes and Intermediates	760
Miscellaneous (Including Brake Fluids, Fuels, Cutting Oils, etc.)	7,300
Total	149,920

grain (25 to 40 percent), and molasses (5 to 10 percent). 4/ According to official statements, about 94 percent of this production was used in the preparation of vodka. 5/ During 1928-29, production was at the level of only 46 million gallons per year. 6/ This low production may have been due in part to the destruction of facilities during the war and subsequent fighting in the USSR and to reduced crop yields of the principal raw materials for ethyl alcohol: grain, potatoes, and sugar beets. By 1932, production had risen to 96.4 million gallons, 7/ or about 71 percent of the prewar level.

Production of ethyl alcohol during the years of the Second Five Year Plan (1933-37) is shown in Table 2.

Table 2

Production of Ethyl Alcohol in the USSR
Second Five Year Plan (1933-37) 8/

Million Gallons

Year	Production
1933	100
1934	124.8
1935	166.2
1936	185
1937	209

During this period, 19 alcohol plants are reported to have gone into operation. Fourteen of these were distilleries with a total capacity of 3.9 million gallons per year. The remaining five were wood-hydrolysis plants with a total capacity of 2 million gallons per year. 9/ Obviously, the great increase of production realized cannot be accounted for by a production increase of 5.9 million gallons. Although the reasons for this increase are not definitely known, reconstruction of damaged plants, greater availability of raw materials, and increasingly efficient use of existing equipment were probably the major contributing factors.

The Third Five Year Plan (1938-42) envisaged a doubling of production. This increase was to take place through greater efficiency, construction of additional capacity, and increased utilization of new food raw materials such as wood chips, sawdust, sulfite waste liquor, and petroleum refining and natural gases. The Plan stated: "The production of ethyl alcohol is to be expanded considerably by complete utilization of sulfite waste liquors from paper and cellulose plants and by development of wood hydrolysis ... The production capacity of /ethyl/ alcohol from wood is to be increased 9 to 10 times during the Third Five Year Plan." The Plan went on to say that "The amount of alcohol obtained from 1 ton of starch (carbohydrate material) will be raised from 60.96 decaliters (161 gallons) to 62.8 decaliters (166 gallons) and that five new alcohol plants will start operations, and expansion and reconstruction of the existing plants are planned." 10/

Table 3 shows the planned production, capacity, and, where possible, the actual production for the period of the Third Five Year Plan (1938-42).

Table 3

Planned Production, Capacity, and Actual Production of Ethyl Alcohol in the USSR Third Five Year Plan (1938-42)

Million Gallons

Year	Actual Production	Planned Production	Capacity
1938	243.8 11/	N.A.	313 (Actual) 16/
1939	245 12/	N.A.	N.A.
1940	235.1 13/	N.A.	N.A.
1941	N.A.	267.1 14/	N.A
1942	N.A.	409 15/	401 (Planned) 17/

It is apparent from Table 3 that the high hopes of the Third Five Year Plan failed to materialize. The annual rate of production increase dropped sharply in 1939 from the average of 24.5 million gallons of the preceding 6 years, and a decrease of 10 million gallons from the preceding year was registered in 1940. The reasons for this decrease are not known. The likelihood of war with Germany, however, was recognized in the USSR, and possibly a food-stockpiling program was instituted. Such a program, by taking grain and potatoes out of the normal channels, could have seriously affected ethyl alcohol production. The reduction in ethyl alcohol production because of such a program could have been offset by reducing the quantity allocated to vodka and other beverages.

Only the planned production is known for the years 1941 and 1942. It is obvious, however, that ethyl alcohol production must have been seriously reduced during these years and throughout the whole war period as well because of both the loss of plants and the loss of agricultural production. Approximately 116 million gallons of alcohol were shipped by the US to the USSR under the Land-Lease arrangement. 18/

With respect to ethyl alcohol production, the Fourth Five Year Plan (1946-50) appears to have been an attempt to boost output to the prewar level, in particular to the planned production for 1941. The planned production in 1950 of 266.1 million gallons was only slightly under the planned output in 1941 of 267.2 million gallons.

The following statement is quoted from the Fourth Five Year Plan: "68 new and 142 rehabilitated alcohol distilleries, plus expansion of the facilities of the distilleries now in operation, will increase the output of the alcohol industry." In addition, the Plan stated: "In 1950, the production of /ethyl/ alcohol by hydrolysis (of wood) shall be eight times greater than prewar. New plants with a capacity of 7 million decaliters (18.5 million gallons) shall be built for the sulfite-alcohol and hydrolysis industries ... ." Since alcohol production by hydrolysis before the commencement of the Third Five Year Plan was already about 2 million gallons, it is apparent that the planned expansion of the hydrolysis industry under the Third Five Year Plan failed to materialize.

Also outlined in the Fourth Five Year Plan were the production goals for several of the Soviet republics. The planned production for these areas is given in Table 4.

Table 4

Planned Production of Ethyl Alcohol
in Certain Areas of the USSR
1950

Million Gallons

Area	Planned Production in 1950
RSFSR	158.0
Belorussian SSR	20.2
Uzbek SSR	3.5
Lithuanian SSR	1.3
Latvian SSR	4.5
Estonian SSR	1.6
Subtotal	189.1
Other Areas	77.0
Total	266.1

For comparison with the planned production figures in 1950, given in Table 4, the planned production figures for the same Soviet republics announced in the 1941 State Plan are given in Table 5.*

* Table 5 follows on p. 7.

Table 5

Planned Production of Ethyl Alcohol
in Certain Areas of the USSR
1941

Million Gallons

Area	Planned Production in 1941
RSFSR	156.0
Belorussian SSR	27.2
Uzbek SSR	1.7
Lithuanian SSR	1.3
Latvian SSR	3.5
Estonian SSR	1.6
Subtotal	191.3
Other Areas	75.8
Total	267.1

The similarities between the 1941 State Plan and the Plan for 1950 are apparent. It appears safe to conclude, therefore, that very little new capacity was added to the nonoccupied regions of the USSR during World War II.

Using this conclusion as a basis, the 1946 production has been estimated at 130 million gallons by eliminating the output of those areas overrun by the Germans from the 1941 planned production.* No figures or percentages are available regarding the 1947 production. In 1946, according to the USSR Information Bulletin: "A severe drought played havoc with the crops in the southern and western regions, which include those that are still in the process of rehabilitation after the enormous damage inflicted by the German invasion and occupation ... the total harvest of grain, sugar beet and sunflower dropped substantially below the 1945 level." 19/

A poor harvest of grain and sugar beets in 1946 could have seriously affected the 1947 production of ethyl alcohol. Furthermore, the failure to report the 1947 production even percentagewise, although the production of the previous year and all subsequent years was reported, suggests that production was not substantially above that realized in 1946. For these reasons, it is assumed that the 1947 production is equal to that in 1946. The production of the years from

* This calculation is explained in detail in Appendix B.

1948 to 1951 has been reported by the Russians in terms of percentages of the previous year's production. Table 6 shows estimated ethyl alcohol production in the USSR for the postwar years.

Table 6

Estimated Production of Ethyl Alcohol in the USSR
1946-52

Million Gallons

Year	Production	
1946	130	
1947	130	
1948	191	20/
1949	239	21/
1950	254	22/
1951	282	23/
1952	304	a/

a. The derivation of this figure is explained in Appendix B.

The 1950 production (planned in 1946 under the Fourth Five Year Plan) was to have been 266.1 million gallons. This figure is in reasonably close agreement with the estimated production shown above and, assuming that the Plan was realistic, indirectly confirms the 1946 and 1947 production figures.

II. Technology.

Four basic processes for the production of ethyl alcohol are presently employed in the USSR. Three of these processes -- hydrolysis of wood, fermentation of sulfite waste liquor, and synthetic production from ethylene -- currently account for only a minor portion of total production. By far the most important process is the fermentation of starch and sugar materials from organic products.

A. Fermentation of Starch and Sugar. 24/

The principal raw materials employed in the USSR for the production of fermentation alcohol are grains, potatoes, and molasses. Among the grains, corn is preferred because of its high starch content (49 to 54 percent). Scores of other materials such as chicory,

Jerusalem artichokes, vetch, dried fruits, and kok-sagyz (alcohol is a by-product from the production of natural rubber) may be used. Production from such items, however, is rare and generally uneconomic.

The production of ethyl alcohol using grain or potatoes differs from that using molasses in that an additional step is required to convert the starch content of the grain or potatoes to sugar. After this conversion is accomplished, the processes are similar.

Clean grain or potatoes are subjected to a cooking treatment, under a pressure of up to 5 atmospheres, in order to render the carbohydrates soluble. The cooked mixture is cooled, and malt containing an enzyme is added which converts the starch to sugars. (The malt is produced in separate "houses" by the controlled germination of barley, wheat, millet, or oats.) The conversion of the starch may also be accomplished by the use of molds (the amylo process) or by hydrolysis with mineral acids such as hydrochloric or sulfuric.

The resulting sugar solution, or "wort," containing 10- to 15-percent fermentable sugars, is then run to the fermentation tanks. These tanks may vary in size up to 250 cubic meters. If molasses is the raw material employed, it is diluted to a sugar concentration of 10 to 15 percent and charged directly to the fermentation tanks. From here on, the processes for grain or potatoes and for molasses are similar.

In the fermentation tanks the sugar solution is inoculated with yeast to the extent of about 5 percent by weight. The yeast enzymes convert the sugars to ethyl alcohol and carbon dioxide, the latter being vented or recovered for other uses. The fermentation may run from 1 to 3 days, and the resulting "beer" has an alcohol concentration of 6 to 9 percent. Since 1924, Soviet alcohol plants, in order to increase production, have cut the fermentation period to 1.5 to 2 days, although it is known that a period of 3 days increases the alcohol yield by approximately 2.5 percent.

The "beer" is passed to a distillation column from which 50- to 60-percent alcohol is drawn. The residue, or "slop," from this operation is generally concentrated and used as cattle feed, core binder in foundries, or possibly as a raw material for vitamin production.

The ethyl alcohol is passed on to another distillation column where low-boiling impurities are run off and then to the rectifying column where the fusel oils and most of the water are removed. The resulting product is a 95- to 96-percent concentration of ethyl alcohol. Mention is made in Soviet literature of "new distillation units which

provide for separation of fusel oils during the first distillation, ... which enable 90 to 96 percent /ethyl/ alcohol to be obtained directly and continuously from a beer of 7 to 10 percent alcohol content."

Anhydrous alcohol (100-percent ethyl alcohol) may be obtained from the 95- to 96-percent product by adding a third component, usually benzene, and distilling the mixture. The benzene and water are distilled off, leaving pure ethyl alcohol.

A number of process improvements are in use in the USSR. These improvements are continuous fermentation of molasses, closed and hermetically sealed fermentation tanks, and a rapid fermentation process for molasses. The extent of application of these advances is not known.

The efficiency of the fermentation process in the USSR is between 85 and 90 percent of the theoretical yield, depending on the raw material. One metric ton of potatoes will yield commercially about 29.5 gallons of alcohol, and 1 ton of corn will yield about 87 gallons. Molasses for ethyl alcohol is a by-product from the processing of sugar beets and yields about 75 to 80 gallons of alcohol per metric ton. These yields are comparable to those obtained in the US.

B. Hydrolysis of Wood and Fermentation of Sulfite Waste Liquor.

The production of ethyl alcohol from wood by a new technology is a subject of much discussion in the Five Year Plans of the USSR. As previously noted, the planned expansion of this field under the Third Five Year Plan did not materialize. In accordance with the postwar plan, new plants will be constructed having a capacity of 18.5 million gallons of ethyl alcohol based on wood. This capacity is reported to be eight times the prewar production. It is apparent that wood is not a large-scale source of industrial alcohol in the USSR. It is of definite interest, however, as a field on which heavy emphasis is being placed and as a nonfood material source of ethyl alcohol.

Although the two processes discussed in this section are not similar, they are both referred to as hydrolysis processes in Soviet literature. Presumably the figures cited above apply to both methods, but the breakdown between them is not known.

1. Hydrolysis of Wood.

The hydrolysis of wood in the form of chips, shavings, or sawdust is accomplished by dilute sulfuric acid in successive steps to yield the following: hemicellulose, cellulose, and fermentable sugars. This is the Scholler process developed in Germany.

The "wort" from the hydrolysis contains about 4-percent fermentable sugars, and the "beer" resulting from the fermentation contains about 2-percent ethyl alcohol by weight. Distillation and rectification are carried out in the usual manner. The yield of ethyl alcohol per metric ton of dry wood waste varies between 40 to 55 gallons, depending on the amount of bark present. 25/

2. Fermentation of Sulfite Waste Liquor.

Sulfite waste liquor is the spent liquid from the manufacture of sulfite wood pulp. Aside from lignins and residual pulp fibers, it also contains between 1.3 and 1.8 percent of fermentable sugars. The liquor is screened to remove the fibers, stripped of sulfur dioxide, and then pumped into a series of fermentation tanks. The resulting "beer" containing about 1-percent alcohol by volume is passed to a beer still and then to a rectifying column. The product is stripped of both low- and high-boiling impurities and then condensed to 95-percent ethyl alcohol. A yield of 1 gallon of alcohol per 130 gallons of sulfite waste liquor is generally obtained. 26/

C. Conversion of Ethylene from Petroleum Refineries or Natural Gases.

Very little information has come out of the USSR concerning the production of ethyl alcohol from ethylene. The Third Five Year Plan stated that production from petroleum gases would be mastered. At least one plant has been reported as operating on the basis of ethylene from petroleum gases. In addition, a Soviet textbook on the production of alcohol, issued in 1950, stated: "Also of future importance is the preparation of alcohol by synthetic methods, i.e. from ethylene, a component of coke-oven gas, and from gases obtained in the cracking of petroleum."

The first and most widely applied method of producing alcohol from ethylene is the absorption of ethylene in sulfuric acid to give a mixture of ethyl sulfates, which are then hydrolyzed to crude ethyl alcohol and dilute sulfuric acid. The alcohol is purified by distillation and the acid concentrated for re-use.

Recently a process of hydrating ethylene to ethyl alcohol directly with the aid of a catalyst and under high pressure (1,000 pounds per square inch) has been developed in the US. Whether this method is being used or will be used in the USSR is not known. Presumably the plant presently operating is using the sulfuric-acid process. 27/

III. Input Requirements.

Before determining the input requirements for Soviet ethyl alcohol production, a breakdown of the output by process first must be established. Although very little information is available relating to this subject, it is possible to derive a rough estimate of this breakdown.

In the introduction it was noted that the Fourth Five Year Plan called for an increase of capacity in the hydrolysis industry (including sulfite liquor) of 18 million gallons. This increased capacity was reported to be eight times the prewar level of production. Assuming that this Plan has been completed, the production of ethyl alcohol from wood should be about 21 million gallons per year, or roughly 7 percent of the 1952 total production of ethyl alcohol.

The production of ethyl alcohol from ethylene is receiving attention in the USSR. Present information, however, indicates that only one plant is actually producing alcohol by this process. This plant, in Sumgait, provides ethyl alcohol for the production of synthetic rubber. 28/ Although the output of this plant is not known, it is believed that the synthetic rubber plant manufactures about 12,000 tons per year. 29/ Assuming that all alcohol required comes from the ethylene plant, a production of synthetic ethyl alcohol of about 8.7 million gallons is indicated. Lacking information on other possible plants, it also is assumed that this quantity represents total synthetic output. This assumed output equals 3 percent of the 1952 production.

Postwar information is not available regarding the proportion of ethyl alcohol produced from grain, potatoes, or molasses. The Third Five Year Plan reported that, in 1937, 37.4 percent of all ethyl alcohol was produced from potatoes and molasses and that by 1942 this figure would be 50.8 percent. In addition, a reported 15 percent of production in 1940 was from potatoes. 30/ Using the 1937 combined figure, the raw material pattern of the late 1930's would be as follows: potatoes, 15 percent; molasses, 22 percent; and grain, 63 percent.

The 1942 combined figure of 50.8 percent has not been selected, for reasons which will be explained shortly.

Since World War II the nonfood sources have been developed to the extent of about 10 percent of the total raw materials. Assuming that this saving of food materials would be applied to grain, the postwar percentage pattern of total alcohol production derived from the total raw materials would be as shown in Table 7.

Table 7

Postwar Input Pattern for the Production of Ethyl Alcohol in the USSR

Material	Percent of Output
Grain	53
Molasses	22
Potatoes	15
Wood a/	7
Ethylene	3
Total	100

a. Includes both hydrolysis and sulfite-waste-liquor processes.

The estimated 1951 production of sugar beets in the USSR was 13,430,000 metric tons. 31/ A maximum of approximately 181,000 metric tons of alcohol, or 21 percent of the 1951 production, could be produced from this amount of beets. This figure checks fairly closely with the estimate given above. The 1942 combined figure of 50.8 percent for potatoes and molasses would give a figure for production from molasses which is unrealistic compared with the sugar-beet production. The 1937 figure, therefore, was selected.

With an approximate breakdown of the production processes, it is now possible to estimate the input of materials for Soviet alcohol production. Table 8* summarizes this information.

The Fifth Five Year Plan (1951-55) envisages an increase in production from molasses, potatoes, wood, and ethylene as follows:

"...To increase production of ... sugar-beet root by 65 to 70 percent... ."

* Table 8 follows on p. 14.

Table 8

Input Requirements for the Production of Ethyl Alcohol in the USSR a/
1952

Process	Production (Thousand Gallons)	Production (Thousand Metric Tons)	Input Requirements: Thousand Metric Tons: Grain b/	Potatoes	Barley	Molasses	Wood	Sulfite Waste (Thousand Gallons)	Thousand Metric Tons: Ethylene	Coal	H_2SO_4	Labor (Thousand Man-hours)
Grain	161,000	488	1,880		151.					975		34,000
Molasses	67,000	204				875				203	10.2	14,000
Potatoes	46,000	139		1,670	41.7					349		9,700
Hydrolysis	10,600 c/	32					199			87	11.7	2,200
Sulfite Waste	10,600	32						1,400		103	0.76	2,200
Ethylene	9,100	28							17.4		2.2	1,900
Total	304,300	923	1,880	1,670	192.7	875	199	1,400	17.4	1,717	24.86	64,000

a. The methods of estimating the figures in Table 8 are explained in Appendix B.
b. Believed to be mainly corn.
c. Assuming that hydrolysis and sulfite waste liquor each account for one-half of the total ethyl alcohol made from wood.

"... To increase during the five years the production of potatoes in the zones of the distilleries and starch and molasses factories roughly by 50 percent ... ."

"To insure every development of the ... hydrolysis industry ... ."

"To provide for an expansion in the production capacities of ... synthetic alcohol."

IV. Supply.

A. Production.

The annual production of ethyl alcohol in the USSR has been presented piecemeal in a previous section of this report. Table 9 summarizes the production information and also includes estimates for future output through 1955.

Table 9

Production of Ethyl Alcohol in the USSR
1913, 1928-29, 1932-40, 1946-55

Million Gallons

Year	Production
1913	135
1928-29	46
1932	96.4
1933	100
1934	124.8
1935	166.2
1936	183
1937	209
1938	243.8
1939	245
1940	235.1
1946	130
1947	130
1948	191
1949	239
1950	254
1951	282
1952 a/	304
1953 a/	326
1954 a/	348
1955 a/	370

a. The derivation of these figures is explained in Appendix B.

B. Stockpiles.

No information is available regarding the stockpiling of alcohol in the USSR. It is reasonable to believe that a certain amount has been set in reserve, particularly in view of its use as a rocket fuel and as a raw material for synthetic rubber and other essential military products. If it is arbitrarily assumed that a stockpiling program started in 1950, the first year in which production was above the prewar level, and that 5 percent of the annual domestic production was withdrawn to state reserves, then the amount in reserve would be as shown in Table 10.

Table 10

Estimated Stockpiles of Alcohol in the USSR

Million Gallons

Date	Stockpiles
End of 1950	13
End of 1951	27
End of 1952	42
End of 1953	48
End of 1954	75
End of 1955	94

A reserve of 94 million gallons of alcohol would require 25 to 30 tanks of 80,000-barrel capacity, a type used frequently for petroleum storage.

C. Trade.

1. Exports.

No information is presently available indicating that alcohol has been or will be exported from the USSR.

2. Imports.

Present information shows only East Germany to be exporting ethyl alcohol to the USSR. In 1948 and 1949, approximately 2.6 million gallons per year were shipped as a form of reparations. 32/

During 1950, 1951, and 1952, very little evidence of ethyl alcohol shipments as such can be found. In all 3 years, however, large quantities of paraldehyde-alcohol mixture were shipped to the

USSR for the production of synthetic rubber. The alcohol content of this mixture varies from 50 to 70 percent and can be recovered. 33/ Shipments of ethyl alcohol in this fashion during these years were as follows:

Year	Shipments (Million Gallons)
1950	8 34/
1951	6 35/
1952	12 (Planned) 36/

No information on future shipments of ethyl alcohol from East Germany to the USSR is presently available. Statements of planned exports to all countries are available, but it is reported in these plans that large segments of the total shipments are earmarked for Western countries. 37/

D. Total Supply.

The total supply of alcohol available to the Russians in 1952 was as follows: production, 304 million gallons; imports, 12 million gallons; and total supply, 316 million gallons.

In the past, East Germany has exported sizable quantities of ethyl alcohol to Western countries and, as indicated above, plans to continue this policy. In view of this fact, it is believed that the Soviet supply of alcohol must be sufficient for present requirements.

V. Requirements.

Soviet requirements for ethyl alcohol have been calculated partly on the basis of what would be needed to supply other sectors of Soviet industry and partly from the known US use pattern of industrial alcohol. The employment of the use pattern was necessary in the solvents and chemicals categories because of the myriad uses of alcohol in these fields. In the case of rubber, beverages, reserve, explosives, and ethyl chloride, reasonable estimates of requirements could be calculated. Table 11* presents the estimated requirements of alcohol during 1952.

Soviet requirements for ethyl alcohol would be altered, of course, in the event of a general war. The requirements for explosives probably would increase several times. The utilization of alcohol as a rocket fuel, which at present is estimated to be negligible, would

* Table 11 follows on p. 18.

Table 11

Alcohol Requirements of the USSR a/
1952

Million Gallons

Use	Alcohol	
State Reserve	15	
Beverages	75	38/
Synthetic Rubber	100	
Explosives	7	
Ethyl Chloride	2	
Solvents	47	
Chemicals	58	
Miscellaneous	12	
Total	316	

a. The method of arriving at these figures is explained in Appendix B.

consume substantial quantities. Chemicals, ethyl chloride, rubber, and solvents also would show increased requirements. These additional demands could be met by reducing the quantity of alcohol allocated to beverage manufacture and by withdrawals from the state reserve, at least until sufficient additional capacity could be constructed.

The Fifth Five Year Plan provides "for an increase in the output of ... synthetic rubber /by/ 82 percent." Such a program would require substantial additional quantities of ethyl alcohol by 1955, but the planned increase would fall probably well within the increase of 88 million gallons indicated by Table 9.

VI. Capabilities, Vulnerabilities, and Intentions.

A. Capabilities.

The supply of ethyl alcohol in the USSR is considered sufficient for peacetime requirements. With reduction in the allotment to beverages, enough alcohol should be available for essential wartime use until additional capacity is built. Sufficient raw materials -- namely, wood and ethylene for synthetic production -- are available to provide for a considerable increase in ethyl alcohol output. Assuming the availability of construction materials

and equipment and ignoring the effects of wartime destruction, an adequate supply of alcohol should be available in the USSR to support a major war.

B. Vulnerabilities.

The Soviet ethyl alcohol industry comprises a large number of relatively small plants scattered throughout the country. None of these installations appears large enough to justify aerial attack. The industry is not dependent on imports for any of its input requirements and thus is not open to economic warfare. Large-scale destruction of crops -- namely, grain, sugar beets, and potatoes -- would, however, seriously reduce the availability of natural raw materials and, consequently, would lower the output of ethyl alcohol.

C. Intentions.

It is not believed that any realisitic conclusions regarding Soviet intentions can be drawn from a study of the ethyl alcohol industry without additional information on ethyl alcohol requirements.

APPENDIX A

GAPS IN INTELLIGENCE

The following is a list of gaps in intelligence which, if filled, would greatly improve the accuracy and usefulness of this report.

1. Soviet postwar production of industrial ethyl alcohol.
2. End-use requirements (particularly the potentially large use as rocket fuels).
3. Breakdown of production by processes.
4. Stockpiles.
5. Production plans.

APPENDIX B

METHODOLOGY

I. Calculation of 1946 Production.

The 1941 planned production of ethyl alcohol in the USSR by regions was as follows: 39/

Region	Million Gallons
Lithuanian SSR	1.3
Latvian SSR	3.5
Estonian SSR	1.6
Belorussian SSR	27.2
Central Region RSFSR	76.7
Ukrainian SSR	70.0
Moldavian SSR	0.9
Turkmen SSR	0.1
Uzbek SSR	1.7
Kazakh SSR	4.4
Transcaucasus	0.4
Regions of Far East and East Siberia	6.7
Urals and West Siberia	25.8
Southeast Regions	44.1
North and Northwest Regions	2.7
Total	267.1

It was assumed that the production of the following regions was lost because of the German invasion: Lithuanian SSR, Latvian SSR, Estonian SSR, Belorussian SSR, one-third of the Central Region of the RSFSR, Ukrainian SSR, and Moldavian SSR. The total lost production amounts to 130 million gallons.

Since the remainder, or 137 million gallons, was a plan figure, it was rounded to 130 million gallons to arrive at a more conservative estimate, and it was assumed to be equal to the 1946 production.

II. Estimation of 1952-55 Production.

Insufficient postwar data are available on which to base an estimate of future production. An estimate may be made, however, based on prewar production when it is recalled that little capacity

was added during the war, that the years until 1950 were spent in reconstruction, and that the production goals for 1941 and 1950 were virtually identical. In other words, for the purpose of an estimate, the production figures for the years from 1950 on have been assumed to be an extension of the prewar series of production figures. The production for the years from 1932 to 1939 was plotted and extrapolated. The annual production increases indicated by the extension of the figures were used to estimate 1952-55 production.

III. Methods Used in Estimating Figures in Table 8.

A. Grain Input.

A recent Soviet textbook (Technology of Alcohol Production, by D.M. Klimovskii and V.N. Stabnikov, Moscow, 1950) states that corn has an average starch content of 52.2 percent and that 1 ton of starch yields approximately 62 decaliters of alcohol.

B. Potatoes Input

The Rubber Economy of the Soviet Union, Wirtschaftsgruppe Chemische Industrie, states that, according to the Soviet press, 12 metric tons of potatoes are required to produce 1 metric ton of alcohol.

C. Barley Input.

Technology of Alcohol Production, by A.A. Fuks, Moscow, 1951, states that the requirement of grain (generally barley) for malt is 8 percent of the weight of corn (when corn is the raw material for alcohol production) and 2.5 percent of the weight of potatoes (when potatoes are the raw material).

D. Molasses Input.

A.A. Fuks states that 100 kilograms of beet molasses yield about 28 to 30 liters of alcohol.

E. Sulfite Waste Liquor Input.

No Soviet information was available on the yield of alcohol from sulfite liquor. Industrial Chemicals, by Faith, Keyes, and Clark, however, states that 125,000 gallons of liquor yield 1,000 gallons of 95-percent alcohol.

F. Wood Input.

Faith, Keyes, and Clark state that 39,000 pounds of wood waste yield 1,000 gallons of 95-percent alcohol.

G. Ethylene Input.

Faith, Keyes, and Clark give a yield of 1,000 gallons of 95-percent alcohol from 4,000 gallons of ethylene.

H. Coal Input.

The Rubber Economy of the Soviet Union states that, according to the Soviet press, coal consumption is as follows: grain, 2 metric tons per ton of alcohol; potatoes, 2.5 metric tons per ton of alcohol; and molasses, 1 metric ton per ton of alcohol.

No Soviet information was available concerning the consumption of coal by the hydrolysis of sulfite-waste processes. Faith, Keyes, and Clark mentioned that the hydrolysis process requires 125,000 pounds of steam per 1,000 gallons of 95-percent alcohol and that the sulfite-liquor process requires 150,000 pounds of steam per 1,000 gallons. Assuming that the average energy content of Soviet bituminous coal is 6,500 kilocalories per kilogram,* these figures can be converted to 7.8 metric tons of coal per 1,000 gallons of alcohol and 9.2 metric tons per 1,000 gallons of alcohol, respectively.

I. Sulfuric Acid Input.

Nepreryvnoye brozhenye pri pererabotke sveklosakharnoy patoki na spirt (Continuous Fermentation during Conversion of Sugar-Beet Molasses to Alcohol), by F.S. Gladkii, Moscow, 1949, gives a sulfuric acid consumption for the molasses process of 400 kilograms per 1,000 decaliters of alcohol.

Faith, Keyes, and Clark give sulfuric acid consumption per 1,000 gallons of 95-percent alcohol as 2,300 pounds for hydrolysis, 150 pounds for sulfite waste liquor, and 500 pounds for ethylene.

* GRR, D/M, M/S.

J. Labor Input.

An estimate of the production of alcohol per man-hour was made for four plants on which suitable information was available. The results were as follows:

Plant	Daily (Gallons)	No. of Workers	Gallons per Man-Hour
Dokshukino 40/	15,800	370	5.3
Pergana 41/	16,500	450	4.6
Blagoveshchensk 42/	9,900	212	5.8
Khabarovsk 43/	7,100	270	3.3
Average	Average		4.75

For lack of other information, the average of 4.75 gallons per man-hour was applied across the board to all processes.

II. Estimation of the Alcohol Requirements.

A. Synthetic Rubber.

Based on a CIA estimate for 1952 Soviet butadiene synthetic rubber production of 140,000 to 145,000 metric tons. This output would require 100 million gallons of alcohol.

B. Explosives.

Based on a CIA estimate of current Soviet ammunition production as follows: artillery ammunition, 12 million rounds; mortar ammunition, 3 million rounds; rocket ammunition, 300,000 rounds; small arms ammunition, 500 million rounds; mines, 475,000 pieces; and grenades, 2.3 million pieces.

This output of ammunition would require 47,000 tons of smokeless powder propellant, and the manufacture of the propellant would consume 21,000 tons, or 7 million gallons, of alcohol.

C. Ethyl Chloride.

Based on a CIA estimate for 1952 tetraethyl lead (TEL) production of 8,300 tons. Two million gallons of alcohol would be required to produce this amount of TEL.

D. Solvents, Chemicals, and Miscellaneous.

After allocating alcohol for rubber, reserve, beverages, explosives, and ethyl chloride, the remainder was apportioned using the US use pattern as a basis. For 1949 this pattern was approximately 30 percent to solvents, 60 percent to chemicals, and 10 percent to miscellaneous. A substantial part of the alcohol used for chemicals, however, went to the manufacture of acetaldehyde. It is not felt that the Russians would use large quantities of alcohol for this purpose. The pattern, therefore, was adjusted to 50 percent to chemicals, 40 percent to solvents, and 10 percent to miscellaneous.

APPENDIX C

SOURCES AND EVALUATION OF SOURCES

1. Evaluation of Sources.

Of the various sources used in the preparation of this repo... a few were used consistently. The Rubber Economy of the Soviet Union, prepared by the Wirtschaftsgruppe Chemische Industrie, i... difficult to evaluate. Published Soviet sources, from which a great deal of the information contained in this report was obtained, are subject to certain limitations. Information which was gathered from German technical experts who visited the USSR in the early 1930's is believed to be reliable.

The rest of the sources are dependent on Plan and Plan fulfillment figures which were published through the Fourth Five Ye... Plan. No reasons were discovered for considering the figures to be unreliable. On the contrary, the over-all development of the ethyl alcohol industry as indicated by these figures appeared to be logical and natural.

The sources used for the greater part of the technical discussion are believed to be reliable, since the majority of these sources are Soviet textbooks dealing with the ethyl alcohol industry.

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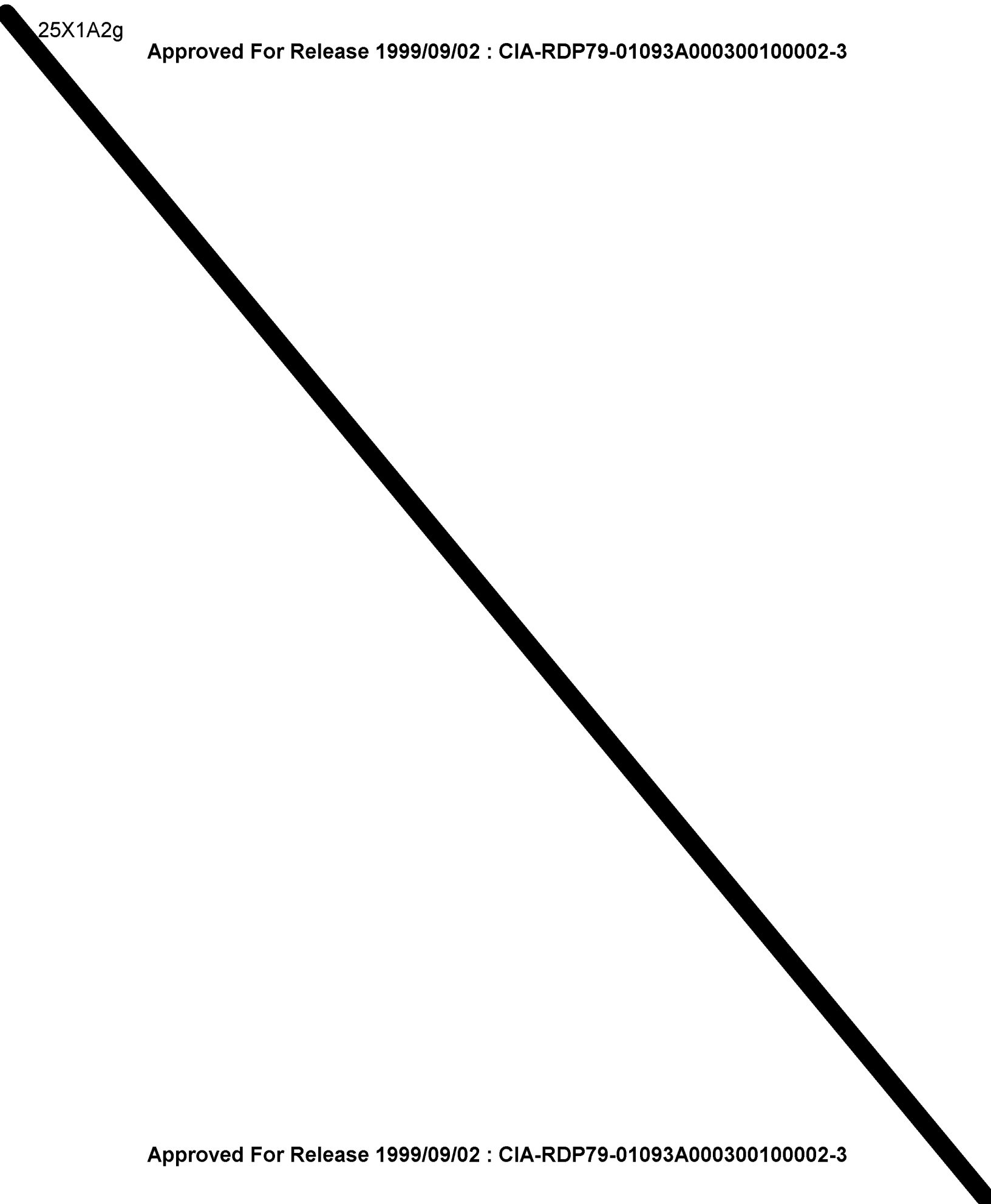

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