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DIRECTORATE OF
INTELLIGENCE

Intelligence Memorandum

Upgrading Soviet Fertilizer Technology

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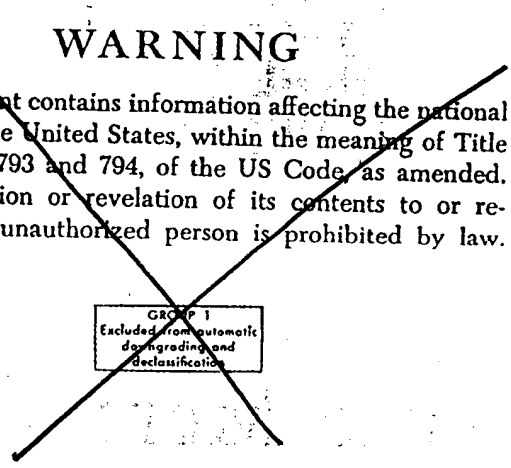

CENTRAL INTELLIGENCE AGENCY
Directorate of Intelligence
May 1969

INTELLIGENCE MEMORANDUM

Upgrading Soviet Fertilizer Technology

Summary

Recently developed methods of producing ammonia -- the basic ingredient of all synthetic nitrogen fertilizer -- could, if extensively applied over the next several years, save the USSR hundreds of millions of dollars. New technology, based on large single-train units equipped with centrifugal compressors, has permitted savings of up to 50 percent in capital and operating costs in plants in the United States and other Free World countries. Planners in the Soviet Union are only beginning to introduce the new techniques, although they are well aware of the potential benefits offered. Soviet ammonia is therefore likely to remain relatively high cost in comparison to the West, for many years.

No Soviet ammonia plant in operation at the end of 1968 is believed to have been of comparable efficiency to modern installations in the Free World. One large-capacity ammonia plant incorporating several features of the new technology was purchased from France in 1965 and was scheduled for operation by the end of 1968, but start-up has not been announced. The Soviet press has reported that Soviet designers and machine builders are now designing and constructing equipment for large single-train units equipped with centrifugal compressors and that three Soviet-designed plants incorporating new technology were under construction in 1968. At least one of these plants was in operation by April 1969.

Note: This memorandum was produced solely by CIA. It was prepared by the Office of Economic Research.

The success or failure of the USSR in adopting the new technology will influence the efficiency of investment in fertilizer production facilities for years to come and will provide an important test of the ability of Soviet industry to take advantage of new technological developments. Its past record in this regard has been poor, partly because immediate increases in production have been given priority over improved plant efficiency and longer range reduction in costs. Although the USSR undoubtedly is upgrading the efficiency of its ammonia production capacity and will achieve significant reductions in costs, the full potential of the new ammonia technology will probably not be realized in the next few years. Soviet production of ammonia has increased rapidly, and throughout the past four years has been equal to about one-half of US production.

Present plans call for doubling Soviet fertilizer production capacity during 1968-72. It is doubtful, however, that this goal will be attained, or that all of the ammonia production capacity added will be of the new type. Delays almost certainly will occur in building large new plants and in getting them to operate at designed levels. Soviet-developed equipment with the capacities now contemplated has not yet been tested on a commercial scale. Construction of the new-type plants will probably not be rapid enough to permit replacement of many obsolescent plants within the near future. Under pressure of high targets for the production of fertilizer, output is likely to be given priority over cost reduction, as it was during 1959-65.

The USSR is continuing to depend in part on imported equipment and technology for its new plants. Czechoslovakia is supplying equipment for one of the three large Soviet-designed plants in which new technology is being employed and has agreed to cooperate with the USSR in manufacturing additional modern, large-capacity ammonia installations. Soviet officials are also seeking to purchase additional plants or components from Free World firms.

While the USSR is off to a late start in introducing the new technology, Free World countries are moving quickly ahead in its application. In the United States, for example, 28 plants of the new type -- accounting for perhaps one-half of the total US ammonia production capacity -- were scheduled to be in operation by the end of 1968, and 17 obsolescent plants were closed down during 1967-68. With the adoption of the new ammonia technology progressing slowly in the USSR, the average level of Soviet technology for the production of fertilizer, although improving, probably will remain far behind that of the United States.

Soviet Need for Improved Ammonia Technology

1. The USSR, like other countries, has been seeking more productive and less expensive ways of manufacturing ammonia, the basic ingredient of all synthetic nitrogen fertilizers. Approximately 40 percent of all chemical fertilizer produced in the USSR is nitrogen fertilizer, and three-fourths of the total Soviet output of ammonia goes for this purpose. Production of nitrogen fertilizer is scheduled to increase by about 110 percent and ammonia by 120 percent during 1966-70. Goals for expanding the output of these products after 1970 are not known, but published Soviet plans call for doubling total capacity to produce chemical fertilizers during 1968-72. A proportionate increase in capacity to produce nitrogen fertilizer -- coupled with greater use of ammonia in the manufacture of plastics, explosives, chemicals, animal feeds, and other products -- would require an approximate doubling of ammonia production capacity during the same period. This would entail adding some 6 million metric tons of ammonia production capacity during 1969-72. Application of the ammonia technology that has been increasingly used in recent years in Free World countries can effect substantial savings for the USSR.

Basic Technology -- Old and New

2. In this "new" technology the basic reactants, hydrogen and nitrogen, have remained unchanged, and the manner of reacting them -- under pressure and over a catalyst -- although different in degree, employs essentially the same principles that have been followed since before World War I. The conditions under which the various reactions occur, however, have been altered. Ammonia plants using either the new or older technology begin by preparing a raw synthetic gas. Various hydrocarbons can be used as the source of hydrogen. Older plants around the world frequently employed coal or coke, but the new large plants going up in the United States are based on natural gas, refinery gas, by-product gases from chemical processes, or naphtha. The hydrocarbon feed and steam are preheated and partly combined or "reformed" in a primary reforming furnace. The mixture is then further combined with preheated air (the nitrogen source) under pressure in a secondary

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to the success of the single-train concept, but the major key to the dramatically improved economics of ammonia production is the integrated energy system. This system recovers "waste heat" from the gas-reforming process in the form of steam that is used to power the turbine drive of a centrifugal compressor and to satisfy further plant requirements for process steam and heating. Economies have been achieved by increasing the pressure used in reforming the natural gas from around 100 pounds per square inch (psi) to 500-600 psi, and by reducing the ammonia synthesis pressure to 2,000-3,000 psi. The reduction in synthesis pressure has been accomplished by use of a single steam-driven centrifugal compressor -- or, in a few partial single-train units, two centrifugal compressors. Older plants frequently employed several reciprocating compressors that, in some cases, developed up to 15,000 psi. The lower pressure in the new plants reduces the amount of power required for refrigeration. Thus the centrifugal compressor is an important element of the more efficient energy system. For a diagram of the ammonia production process, annotated to indicate sources of savings in the new large plants, see the flow chart.

Past Soviet Record

6. The extent to which the new technology is employed in the USSR will affect the efficiency of investment in fertilizer production capacity for years to come. Construction of the new-type ammonia plants will provide a test of the ability of Soviet industry to respond quickly to technological innovation. Its past record in this regard has been poor, partly because immediate increases in production have been given priority over improved plant efficiency and longer range reduction in costs. Soviet output of ammonia -- which throughout the past four years has been equal to about one-half of US production -- has increased rapidly as is indicated by the following tabulation of estimated production:

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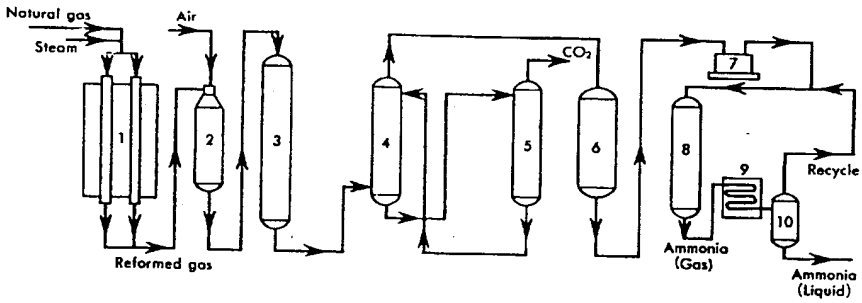
Year	Production (Thousand Metric Tons)	Year	Production (Thousand Metric Tons)
1955	994	1965	4,322
1958	1,372	1966	5,049
1959	1,468	1967	5,958
1960	1,615	1968	6,550

7. During the seven-year plan (1959-65), production of ammonia in the USSR more than tripled, part of the increase coming from equipment purchased from Free World firms and from Czechoslovakia. The imported equipment probably was modern in comparison with that in most Soviet-designed plants, but all plants that went into operation in this period were smaller and certainly less efficient than the large single-train plants that the United States began to put into operation in 1965. The USSR did, however, succeed in reducing the unit cost of ammonia production by 21 percent during 1959-65, largely by increased use of natural gas rather than coal or coke as the basic raw material. In 1965, more than half of all ammonia produced in the USSR was derived from natural gas, compared with less than one percent in 1958.

8. Progress in introducing other process improvements during the seven-year plan period, however, was slow. In an attempt to meet output goals, newly developed equipment was produced and installed without adequate testing. Defects in design and manufacture played havoc with schedules for commissioning new plants. Problems with compressors, for example, delayed the start-up of one Soviet ammonia installation for six months. The USSR also encountered lags in developing a process for producing feed material for ammonia plants by steam conversion of natural gas under pressure. The rising demand for ammonia, accentuated by Soviet purchase of four large nitrogen fertilizer plants from the Netherlands in 1960-62, apparently led to a Soviet decision to continue building ammonia plants based on an older, less efficient feed-material process. The Soviet press has indicated



SINGLE-TRAIN PROCESS FOR PRODUCTION OF AMMONIA BY STEAM-REFORMING OF NATURAL GAS

Ammonia Production Process	Major Improvements Permitting Savings
Various feedstocks can be used. Older plants used coal or coke. New large plants favor natural gas, refinery gas, by-product gases from chemical processes, or naphtha.	Larger plants with single-train capacities of 200,000 tons to 500,000 tons per year permit economies of scale. Improved equipment design and plant layout facilitate waste-heat recovery and reduced energy requirements.
1. The primary reformer partly combines preheated hydrocarbon feed and steam and also preheats air.	Better placement of furnace burners. Simplified piping to secondary reformer.
2. The secondary reformer combines the hydrocarbon and steam mixture with the air into synthetic gas containing hydrogen, nitrogen, carbon oxides, argon, water, and methane.	Improved reformer design. Pressures, formerly about 100 psi, are increased to a range of 500-600 psi. Waste-heat recovery for use in CO conversion.
3. Carbon monoxide (CO) converter.	Improved catalyst. Waste-heat recovery for use in CO_2 removal and purification.
4. Carbon dioxide (CO_2) absorber.	
5. The CO_2 stripper removes CO_2.	Heat is recovered in the form of steam to power the turbine drive of the centrifugal compressor.
6. In the methanator, final purification takes place; the remaining CO and CO_2 are removed.	
7. Gas compressor.	Use of a single (in some cases two) steam turbine-driven centrifugal compressor with exhaust conditions set to supply steam for the ammonia synthesis process. Older plants used several reciprocating compressors driven by electric motors or gas engines which were efficient but expensive to procure and to operate. The use of a steam turbine with a centrifugal compressor, rather than a reciprocating compressor, eliminates the need for expensive reduction gears. Compression, formerly as high as 15,000 psi in some plants, is dropped to 2,000-3,000 psi. Lower pressure reduces the amount of power required for refrigeration.
8. In the ammonia converter, synthesis gas, now rich in hydrogen and nitrogen, is passed over a catalyst to make ammonia (NH_3).	Improved catalyst.
9. In the ammonia condenser, NH_3 is liquefied at 0° F at atmospheric pressure.	Reduced power requirement for refrigeration and recycling.
10. Ammonia separator.	

that losses to the Soviet economy stemming from this decision alone will amount to 20 million rubles per year for some time to come.

Recent Soviet Interest in Large Modern Plants

9. In 1957, Soviet ammonia plants generally consisted of two or more lines, each producing 20,000-35,000 tons per year. By early 1964, Soviet statements began to show an awareness of the potential savings offered by large, single-train units with annual capacities of 200,000 tons or more. Soviet machine builders, however, were only beginning to produce lines with capacities of about 100,000 tons per year. Obviously unprepared to produce larger units, the USSR in 1965 purchased from a French firm an ammonia plant consisting of two lines, each with an annual capacity of 200,000 tons. This large plant incorporates several features of the most modern technology and will employ centrifugal compressors for preparation of the gas. It will, however, use reciprocating compressors for ammonia synthesis. Initial operation of this plant was planned for late 1968, but there has been no announcement concerning its operation and it may have been delayed.

10. In April 1966, Premier Kosygin stated that unit investment costs could be reduced by 25 percent by building production lines with annual capacities of 200,000 tons of ammonia, rather than lines with capacities of 100,000 tons. Later in the same year, it was reported that ammonia units with capacities of 400,000-500,000 tons per year would be built in the USSR during the current five-year plan, 1966-70. As of 1967, however, the largest Soviet-designed ammonia production lines still had annual capacities of only about 100,000 tons, although work on larger units clearly was under way.

11. By late 1968 the Soviet press indicated that Soviet technicians had developed the basis for producing large, single-train ammonia plants having capacities of 300,000-400,000 tons per year. Capital investment per ton of capacity in these plants was expected to be 50 percent less than in plants built previously. The USSR is not known to have had any ammonia plants in operation by the

end of 1968 that incorporated all major features associated with the new technology. However, three Soviet ammonia plants under construction in 1968 -- at Novgorod, Cherepovets, and Rovno -- are to employ new technology that presumably will include at least certain of the features found in modern Western plants. Early in 1969, equipment was being manufactured in the USSR for a large Soviet-designed single-train synthetic ammonia plant then under construction. This plant, possibly one of the three already mentioned as being built with new technology, is to include a centrifugal compressor that will develop about 4,300 psi, a somewhat higher pressure than the 2,000-3,000 psi used for ammonia synthesis in the most modern Free World plants.

Comparability of New Soviet Technology Uncertain

12. As yet, not enough is known about the new Soviet plants to be able to determine whether they will be fully comparable to those erected recently in Free World countries. Soviet publications indicate that the capacity of the plant at Rovno, which was commissioned in April 1969, may be somewhat smaller than that usually associated with the newer Free World plants. The plant at Cherepovets may use coke-oven gas from a large metallurgical combine as feedstock. An article published in 1964 concerning the intention to build an ammonia plant at Cherepovets mentioned this possibility. Some Soviet and Free World sources suggest that ammonia plants using coke gas can be competitive with plants using natural gas if situated at a source of plentiful supply. Natural gas could, however, now be available at Cherepovets through pipelines from Saratov and Vuktyl. In any case, the USSR can be expected to encounter problems in building and bringing up to design levels of operation, large new ammonia plants based on domestic technology and equipment that is as yet untested on a commercial scale.

Partial Dependence on Imported Equipment

13. The new Soviet plants apparently will not be built entirely with domestic equipment. Early in 1969, equipment produced in Czechoslovakia was being installed in the plant at Cherepovets, which is scheduled to produce 280,000 tons of ammonia per year. The nature of the Czechoslovak equipment has not been disclosed, but it may include a new spherical ammonia reactor developed in Czechoslovakia and tested there in a pilot plant in 1967.

The reactor is claimed to be very economical and adaptable to units capable of producing 200,000-500,000 tons of ammonia per year. By the end of 1968, no units of such size were known to have been produced in Czechoslovakia, but in December an agreement was concluded whereby Czechoslovakia and the USSR are to cooperate in manufacturing ammonia installations with unit capacities of 500,000 tons per year.

14. Interest in acquiring Free World equipment has also continued. Soviet officials are seeking to purchase one or more complete ammonia plants of the new type from Japanese or European firms and have been negotiating for the purchase of compressors and turbines from various US firms. Whether the USSR chooses to base its new ammonia plants primarily on Communist or on Free World technology, the level of benefits will depend on the speed with which new plants can be erected and brought up to capacity operation. Undue delays could be very costly.

The Stakes Are High

15. The efficiency of the Soviet nitrogen industry over the next decade will be heavily influenced by the type of ammonia plants built in the USSR during the next four to five years. The three large Soviet-designed plants already mentioned, together with the modern plant purchased from France, probably will add about one million tons of new capacity. A number of additional large-capacity plants would be required to achieve an increase of about 6 million tons in ammonia production capacity during 1969-72. Data concerning plants in the United Kingdom suggest that such an increase could involve capital costs of $420 million if based on single-train ammonia plants with annual capacities of 300,000 tons each, or $600 million if based on plants one-third that size.* Moreover,

* *Capital costs for ammonia plants commissioned in the United Kingdom in 1967 were reported to be $70 per ton of annual capacity in three single-train plants, each with an annual production capacity of 300,000 tons. Capital costs for plants with annual capacities of 100,000 tons reportedly would have been almost $100 per ton of annual capacity. According to some US sources, the new type of ammonia plant can reduce capital costs by as much as 40 to 50 percent, depending on the capacities of the plants.*

data on US experience indicate that the difference in annual operating costs of the two types of plants could amount to $120 million, assuming an increase in production of 6 million tons.* Although these data are approximate, and costs under Soviet conditions probably would vary somewhat, the analogies serve to illustrate the large potential benefit that the new ammonia technology offers the USSR.

16. The potential savings for the USSR could be even larger if some of the obsolescent plants now in operation were replaced by plants using the new technology. In the United States, 17 older plants that accounted for about 13 percent of total US ammonia production capacity at the beginning of 1967 were permanently closed during 1967-68. The USSR, however, is unlikely to retire many obsolescent plants in the near future. Shutting down of old plants will depend on the speed with which new ones can be built and on the willingness of planners to schedule retirements. Prospects are not bright on either count. Soviet planners and plant managers generally are slower than their US counterparts in replacing obsolescent processes and machines that are still productive. Soviet plants frequently are retained in service in spite of operational costs that considerably exceed those of more modern plants or the average costs in the industry. Moreover, demand for ammonia in the USSR is still far from satisfied, and many Soviet plants were built so recently that they have not been depreciated to a point that suggests early retirement. Approximately three-fourths of the ammonia produced in 1968 came from units that have been put into operation within the past nine years, and the normal depreciation period for equipment in the Soviet chemical industry is about 17 years.

17. Some savings undoubtedly can also be realized through use of the new technology in expanding and modernizing existing ammonia plants. One Soviet source indicates that some expansion to be undertaken will involve units with capacities of 180,000-200,000 tons, and it is probable that

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* *US data suggest that production costs of $20 per ton are possible in an integrated ammonia plant producing about 300,000 tons per year, whereas costs at a plant producing only 100,000 tons per year are about $40 per ton.*

such expansion will incorporate many elements of the new technology. At the same time, some expansion probably will also involve smaller capacities because it is doubtful that Soviet equipment producers are yet ready to supply large units in quantity. There will be increased use of natural gas, the raw material favored in many of the newer ammonia plants built in the United States. Natural gas is scheduled to provide 75 percent of the ammonia produced in the USSR in 1970. US experience suggests that the USSR probably can reduce production costs at small, old plants by incorporating some elements of the new technology but that the capital outlays required to make such plants as efficient as large new plants would be prohibitive.

Present Position and Prospects

18. The present position of the USSR probably is not as advanced as that of the United States in 1965, either in perfection of the new technology or in capability to introduce it quickly on a wide scale. It is doubtful that as many ammonia plants of the new type will go up in the next four years in the USSR as were put into operation in the United States during 1965-68. During 1969-72 the USSR will increasingly emphasize construction of large new plants, but expansion and modernization of existing units will continue. Significant improvement in the efficiency of production and substantial reduction in capital and operating costs of Soviet ammonia plants almost certainly will result, but delays and difficulties in introducing the new technology probably will prevent full realization of the cost reductions that are possible. Free World countries, enjoying a lead of several years in application of the new technology, are moving ahead rapidly in modernizing their ammonia production capacity, and the average technological level of ammonia plants in the USSR probably will lag behind that of major Free World producers of ammonia for some time to come.