Approved for Release: 2020/09/11 C06859456

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Supplement
to
Scientific Intelligence Digest

~~Secret~~

SI SID 77-007 Supp. 1
29 July 1977

Copy Nº 282

Approved for Release: 2020/09/11 C06859456

Approved for Release: 2020/09/11 C06859456

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CONTENTS

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Approved for Release: 2020/09/11 C06859456

Approved for Release: 2020/09/11 C06859456

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POTENTIAL FOR PRODUCTION OF WEAPON-GRADE URANIUM AT THE PLANNED BRAZILIAN URANIUM ENRICHMENT PLANT

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PREFACE

Under a 1975 agreement which provides for the construction of up to eight nuclear power plants and other facilities, West Germany is proceeding toward construction of a small uranium enrichment plant in Brazil. Estimates have been made of the time that would be required for production of highly enriched uranium at this plant. [redacted] (b)(1) (b)(3)

SUMMARY AND CONCLUSIONS

The uranium enrichment plant which West Germany plans to build for Brazil could be used to produce weapon-grade uranium rather than the reactor-grade uranium for which it is designed. Such use will be within the technical capabilities of Brazil. It would constitute a violation of safeguard agreements, however, and would entail recycling of enriched uranium through the plant in batches, which could be detected fairly easily by inspection teams.

The minimum time required to make highly enriched uranium would depend on the approach chosen and the amount and assay of enriched uranium that is desired. If Brazil were to start with natural uranium, more than a year would be needed to produce even a very small amount of weapon-grade uranium (90-percent U-235). To produce 25 kilograms of 90-percent U-235, which would be enough uranium for one nuclear device, about 1.5 years would be required. To produce 100 kilograms, which is a more practical quantity in light of the cost and effort involved, about 3 years would be required.

If Brazil could start with reactor-grade uranium, the time requirements could be reduced sharply. The plant could produce 25 kilograms of 90-percent-enriched U-235 in about 4 months, or 100 kilograms in 6 months.

An inefficient nuclear explosive could be made in less time by producing uranium enriched to less than 90-percent U-235. Using 65-percent-enriched uranium as an example, the minimum time required to produce 25 kilograms, starting with either natural or reactor-grade uranium, would be 20 weeks or 4 weeks, respectively. To produce 100 kilograms would require 38 weeks or 6 weeks, respectively.

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DISCUSSION

The uranium enrichment plant to be built by West Germany and Brazil will be a small plant intended to demonstrate the feasibility of using the West German (Becker nozzle) uranium enrichment process in a commercial plant. It is designed to provide only low enrichment of uranium; the plant will not contain the number of enrichment stages needed to produce weapon-grade uranium (about 90 percent uranium-235) in one pass. Brazil could produce highly enriched uranium, however, by recycling uranium through the plant several times in batches. This is a time-consuming process.

The number of cycles that would be needed to reach an enrichment level suitable for use in a nuclear device and the time and material needed to produce the desired quantity of highly enriched uranium depend on the technical characteristics of the Brazilian enrichment plant. Brazil could reduce the number of cycles required, and hence the time needed to make highly enriched uranium, by making major physical alterations in the plant. These alterations certainly would be difficult, would take many months, and would be detectable. The more likely route to production of highly enriched uranium is thus believed to be straightforward recycling of enriched uranium through the plant.

Several important technical characteristics of the Brazilian plant have been calculated in the past [redacted] suggest that the plant will have a capacity between 180 and 250 metric tons of separative work per year,* a depleted material assay of perhaps 0.35 percent U-235, and a cut* of 1/4. The Becker nozzle separation process that is to be used in the plant probably would exhibit an enrichment factor* of 0.0148 at this cut. From these technical data one would determine that the plant probably is made up of about 600 stages and that the plant normally would consume an estimated 458 metric tons (mt) of natural uranium per year while producing about 58 mt per year of uranium enriched to 3.2 percent U-235. A rough estimate of the inventory of such a plant (the quantity of uranium required initially to fill plant equipment) shows that about 0.5 mt of uranium would be needed just to fill 600 stages and their associated piping before any enriched product material could be produced.

[redacted] some of these plant characteristics probably are in error. In particular, the plant will contain fewer stages than [redacted] indicate. Although this reduces the estimated plant inventory of uranium to about 0.25 mt, it also means that an additional cycle is necessary to reach an assay of 90-percent U-235. (b)(1) (b)(3) (b)(1) (b)(3)

A possible scheme for recycling uranium [redacted] is presented in the figure. In the figure, "x" represents a number equal to the number of metric tons of weapon-grade uranium to be produced in the final cycle. One can calculate, from the figure, the minimum time required to produce any amount of 90-percent U-235. To produce 25 kilograms (kg) for example, which is enough to make one explosive device, about 13 months would be required to complete the initial (or normal) cycle. (b)(3) (b)(1)

It might be awkward for Brazil to run the plant for such an extended period without demonstrating a use for the accumulating product, although one could argue that a stockpile of reactor-grade uranium is a desirable buffer against unexpected shortages. Alternatively, the first cycle could be cut back or eliminated through purchases of outside enrichment services. In that regard, each of the four to eight West German power reactors to be built in Brazil will require annually 35 mt of 3.2-percent-enriched uranium which, for the most part, will have to be imported. A large amount of reactor-grade uranium, therefore, should be available to Brazil under safeguards. (b)(1) (b)(3)

Once the first cycle had been completed, the remaining four cycles would take much less time. Only about 4 months would be required to make 25 kg of weapon-grade uranium from the reactor-grade uranium.

For a number of reasons, it is unlikely that recycling would be done for production of only 25 kg of highly enriched uranium. An amount such as 100 kg, which would permit construction of a test device and several additional devices, would be more likely. Production of 100 kg would require about 3 years, including 2.5 years for the first cycle and 6 months for the remaining four cycles.

*Separative capacity figures can be used to determine uranium production rates for a variety of product enrichment levels. The cut determines the relative sizes of the enriched and depleted streams issuing from each stage in the plant. The enrichment factor determines the degree to which the assays of these two streams differ.

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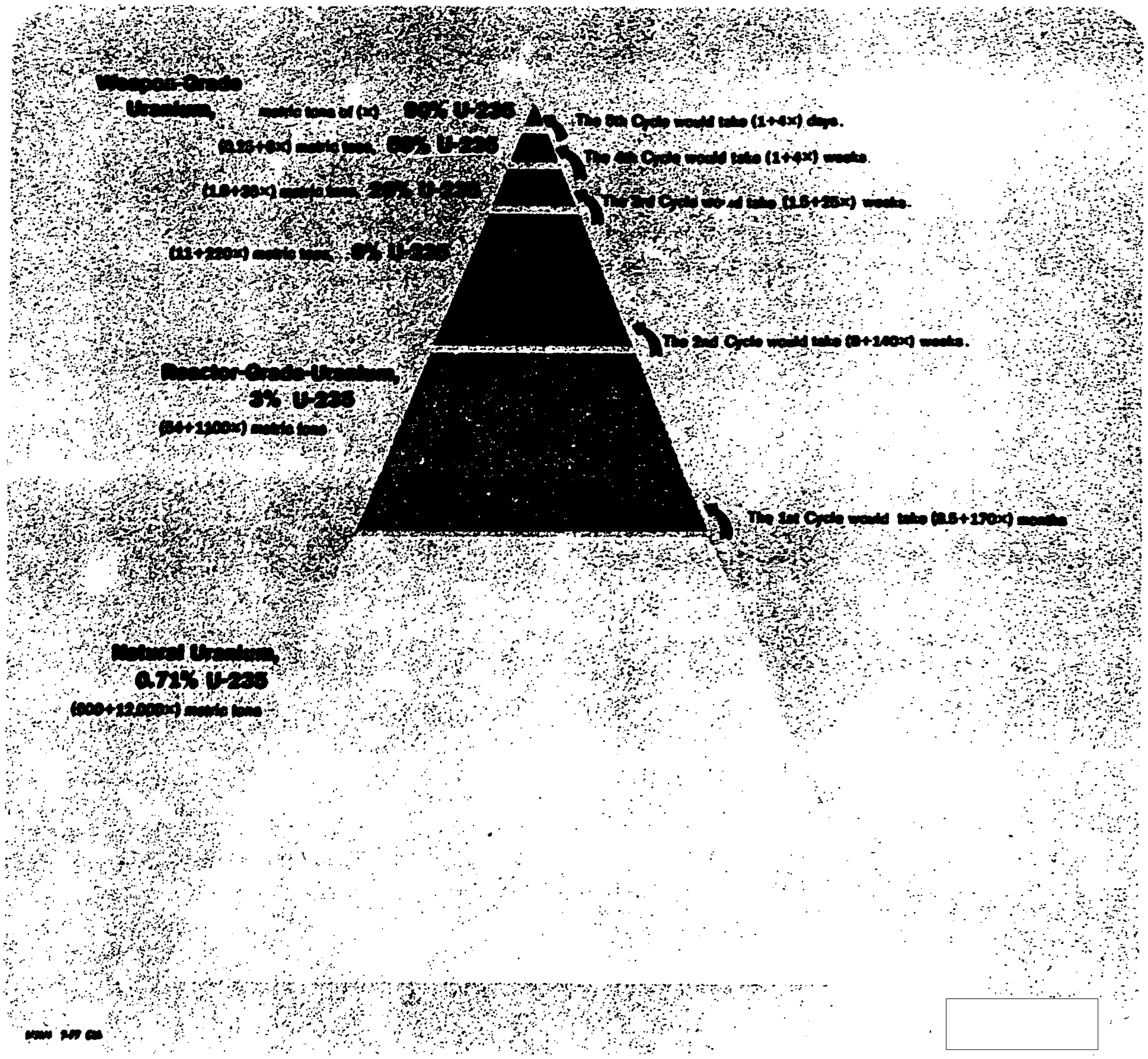

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A Scheme for Enriching Uranium in Cycles (x is a number that depends on the amount of weapon-grade uranium to be produced).

If Brazil were willing to settle for uranium enriched to less than 90-percent U-235, which would yield a less efficient nuclear device, the time involved could be reduced sharply. Starting with natural uranium, the minimum time required for production of 25 kg of uranium enriched to 65-percent U-235, for example, would be about 20 weeks. Production of 100 kg would take about 38 weeks. Starting with reactor-grade uranium, production of 25 kg or 100 kg would require 4 weeks or 6 weeks, respectively. The resultant uranium would be less appropriate than 90-percent U-235 for use in a weapon, however, and thus might not be considered worth the costs involved.

The technical difficulty of recycling uranium in batches through the plant would not be prohibitive for Brazil. Careful planning would be necessary, however, to determine the optimum conditions for each cycle and to prevent the possibility of creating a critical mass of uranium in the plant as enrichment levels

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increase. Some fairly minor alterations to the material feed and withdrawal systems also would be desirable, but the risk of early detection might preclude such modifications. Although within the technical capabilities of Brazil, recycle operations could well require more time than the minimum amounts estimated above. In particular, the time required to purge the process equipment after each cycle and to account for all the uranium involved would depend on the exactitude desired.

Although Brazil and West Germany have agreed that the enrichment plant will be under International Atomic Energy Agency safeguards, no means of implementing safeguards inspections has been openly discussed. For consideration of possible safeguard measures the data in the figure provide a good indicator of the time and material necessary for a recycling program, but these quantities are somewhat a matter of choice; they depend on the precise manner in which the plant is operated. Also, the exact technical specifications for the plant, which would permit a refinement of this estimate, are not yet available to us. Nonetheless, some statements can be made concerning the safeguard mechanisms which could be employed to assure detection of uranium recycling at the Brazilian plant.

Because the cycles of a recycle scheme are separate operations, there is no need to perform them together as a set. The second cycle for example, using 3 percent U-235 as feed material, could be followed by a period of normal operations. The remaining cycles could be performed at a later time. In fact, any one cycle could be performed in a series of short operations interrupted by periods of normal operations. It is apparent, therefore, that a safeguard inspection system for this plant must provide a fairly continuous record of plant operations if it is to assure detection of recycling. An ideal safeguard arrangement would include constant supervision of plant operations by the IAEA inspectors.

A technical means of assuring detection would be possible by measuring and recording the assay of uranium in each stage of the cascade. Several hundred tamper-proof instruments would be required, which probably would entail an unacceptable expense. On the other hand, the number of instruments required could be reduced with a small loss of safeguard effectiveness, because enrichment stages in the plant probably will be installed in groups and operated in groups. The consequence of this grouping, which reduces costly interstage valve connections, is that no stage can be operated as independent from the rest of the group. If there are 12 stages per group in the demonstration plant, recordings from only 40-50 points in the cascade would suffice to determine the performance of the entire cascade.

A simplification of this detection system could be achieved by connecting each group of stages to one central instrument with 40-50 tamper-proof tubes. The central instrument would monitor the operation of each group of stages and provide a composite record to be examined periodically by inspectors. [redacted] (b)(3)

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