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By JE Savely 8-5-93

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SPECIAL STUDY: SEPARATIONS CONSIDERATIONS

INTRODUCTION

One of the potential operating plans currently being considered at HAPO involves the irradiation of an E-N loading for simultaneous plutonium and tritium manufacture (Case II). The conditions of the study require that the "25" content of the E slugs be the maximum compatible with their recovery in existing or slightly modified separations facilities. This memorandum reviews the current status of knowledge and best guesses concerning this operating scheme.

SUMMARY

The upper limit of U-235 content permissible in the manufacture of E slugs for this purpose has been tentatively set as 0.94%, at which enrichment level uranium solutions may be processed without criticality limitations. The 0.94% enrichment is considered to be the most probable value of this limit, although experimental verification is required to firm it up. At this enrichment level, a power level of 15,000 MW combined with predicted operating efficiency factors would require that 585 tons uranium per month or 24 tons uranium per day be processed through the separations facilities.

While adequate separations facilities for processing uranium solutions at this rate are being provided by current projects, mixtures of solution and solids are not nuclearly safe without limitations which would limit the operating capacity at these points. The calcination facilities being provided have adequate capacity

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and are safe by geometry. If the twelve dissolvers in B, T, S, and A Plants were all operated with simultaneous dissolution of jacket and uranium to no heel, using a batch size of 3.3 tons currently estimated to be the minimum critical batch size for this enrichment level, about 30 tons of uranium could be dissolved per day. Decreasing the batch size to 1.7 tons would decrease the dissolution capacity to 12 tons per day. Dissolving the jackets and uranium separately as at present, would reduce these capacities about one-third. The dissolvers could be modified to retain the slugs in a safe geometry -- Redox in the form of a 20 to 24-inch cylinder, and Purex in a 12-inch-thick annulus surrounding a neutron-black core. With these loadings, a semi-continuous dissolution could be employed which might give Purex sufficient capacity and almost certainly would give Purex plus Redox adequate capacity.

DISCUSSION

Separations Limitations

The extrapolation of data obtained in criticality experiments performed at other sites indicates that the maximum concentration of U-235 permissible in solutions of uranyl nitrate lies between 0.90% and 0.95% (uranium basis), with the most probable value being 0.94%. At this concentration, criticality is predicted only if a hydrogen-to-uranium atomic ratio of six is obtained (bulk precipitation or partial calcination is required). Even under these conditions, a minimum of about three tons of uranium is required to reach criticality. Thus, the small calcination pots and the continuous calciners are safe by capacity limitations (the Luckey pots must yet be evaluated). The dissolvers would not be safe as currently designed and operated but could be operated safely by adopting a safe batch size limitation or by modifying the units to operate with safe geometry. These factors are discussed in more detail below.

DECLASSIFIEDThroughput Requirements

Assuming an 0.94% enrichment level for the E slugs, N slugs may be charged in sufficient quantity to produce the target quantities of tritium. The E slugs would be irradiated to a level of 660 MWD/ton as heat, producing plutonium equivalent to a 500 MWD/T irradiation.

The tonnage of the uranium to be processed through the separations facilities is determined by the power levels, operating efficiencies, and slug integrity. If, by January 1957, the forecasted operating conditions are realized such that a total of 15,000 MW are produced with an E-N loading, operating efficiencies of 0.38 (power) and 0.30 (time) are realized, and a target irradiation level is taken as 660 MWD/T (heat), then separations would have to process 485 tons uranium per month. Assuming this throughput is increased 20% by premature slug ruptures, the processing rate would be set at 585 tons per month. If a separations operating efficiency of 30% is realized, an instantaneous operating rate of 24 tons uranium per day would be required.

Separations Capacity

So long as the "25" content of the uranium used in the E slugs is held to a safe concentration for infinite solutions (assumed here as 0.94%), then adequate separations capacity is provided by current projects to process the 24 tons per day except at the slug dissolution and UTH calcination steps. Adequate calcination capacity with safe geometry is now being provided, leaving only the uranium dissolution step requiring modification.

The minimum critical mass for tamped uranium metal containing 0.94% U-235 is thought to be about 3.3 tons. Experimentation is in progress to firm up this number. The four separations plants (B, T, S, and A) contain a total of twelve dissolvers. If the maximum charge permitted in each dissolver at any time were set at 3.3 tons and total simultaneous dissolution of jackets and uranium were employed, these units could dissolve about 30 tons per day. If the maximum

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charge were set at 1.7 tons, about twelve tons per day could be dissolved. The dissolution of jackets and uranium separately as at present would reduce these capacities by about one-third.

Adequate dissolver capacity could be obtained in S and A Plants only, however, by adapting a safe geometry modification of the existing dissolvers and employing a semi-continuous dissolution technique. The safe geometry modification would take the form in Purex of extending the height of the slug crib (to prevent slugs from spilling out onto the coils) and inserting a "neutron-black" plug in the middle of the slug crib, forcing the slugs to occupy an annulus about one-foot-thick. About 10 to 15 tons of uranium could be so retained. In Redox, the modification would employ a slug-retention cylinder, about 20 to 24 inches in diameter, inserted through the slug loading port and extending to the bottom of the dissolver. The cylinder would be perforated to permit free access of solution. In either case, the uranium and aluminum would be dissolved simultaneously in nitric acid (mercury-catalyzed), and the slugs would extend above the solution at least part of the time to maintain nearly constant dissolving rates. High uranium-concentration solutions would be obtained by jetting only part (say, half) of the uranium solution from the dissolver periodically and replacing it with fresh nitric acid-mercury as required. Using these techniques, it is believed possible that the Purex Plant could handle the entire separations load and highly probable that Redox plus Purex could do the job.

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