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RESULTS OF CRITICAL MASS STUDIES FOR
HANFORD AT K-25

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Hanford Works, Richland, Wash.

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For The Atomic Energy Commission

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RESULTS OF CRITICAL MASSSTUDIES FOR HANFORD AT K-25Introduction

In March 1949 a committee of consultants reviewed the nuclear safety problem in the bismuth phosphate separations process. In their report, "A Review of the Critical Mass Problem in the Chemical Separations Process at Hanford," March 3, 1949 (Doc. No. GEH-14,192) the committee expressed concern with the present batch size in view of a number of uncertainties which then existed. These uncertainties were specifically: (1) the uncertainty in the nuclear properties of plutonium solutions, (2) the possibility that a thick layer of iron might be more effective as a tamper than water, (3) the possible increased effectiveness of a tamper containing bismuth phosphate as compared to a tamper of water only, (4) the possible decrease in critical mass caused by inelastic scattering in bismuth and phosphorus in the core, (5) the possibility that a natural uranium solution is a more effective tamper than water.

The experimental program at P-11 was undertaken to establish the critical masses and pertinent nuclear properties of plutonium. An experimental program to eliminate the other four sources of uncertainty was undertaken by the critical mass group at K-25 using uranium solutions, since the effects involved are, to a high degree, independent of the fissionable material used.

Summary and Results

We have just received a report, "Critical Mass Studies, Part V," June 30, 1950, (Doc. No. K-643) giving the results of the K-25 program. The significance of these results to Hanford is as follows:

1. Iron, in the thickness existing in process equipment, is a less effective tamper than water.

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2. The moderating effect of bismuth and phosphate ion is inferior to that of the water which they displace, and their presence in the core or the reflector will not decrease the critical mass.
3. Solutions of uranyl nitrate in concentrations occurring in the separations process are no more effective as tampers than water.

These results eliminate the possibility that any of the tamper and impurity effects considered by the reviewing committee can result in a decrease in the critical mass.

Experiments performed with enriched uranyl nitrate as fuel will be valuable in establishing quantitatively the effect of hydrogen displacement in the core.

In addition to the above results, the K-25 group performed experiments checking certain features of the P-11 design.

The entire program has been of considerable value in assessing the nuclear safety situation at Hanford.

Details

Experiments with various thickness of stainless steel tamper indicated that in thicknesses less than 2-1/2 inches, steel is no better than water as a tamper and in some situations is decidedly inferior. The thickest steel in the Hanford process occurs on the bottom of the 40-inch centrifuge which is 2-1/4" thick near the hub. Thicknesses of the order of 1" are most common. In this situation the action of steel as a tamper cannot lead to reduced critical masses.

Phosphoric acid was found to act as a weak poison when added to the core solution and to be equivalent to water when added to the reflector.

A bismuth subcarbonate slurry was equal to water as a reflector. Bismuth added to the core in the form of rods was found to be a more effective moderator than air but much less effective than the water which it displaced. Independent data from Chalk River, which has recently come to our attention, Doc. No. MP-121 also indicates that bismuth-water mixtures have a considerably increased moderation length (square root of the age) as compared to pure water, and would therefore be expected to lead to higher critical masses.

The effectiveness of uranyl nitrate solutions as tampers was tested. Two solution concentrations, one equal to that occurring in the first product precipitation step, and one twice as great were used. Neither of these solutions could be distinguished from water by its effectiveness as a reflector.

A series of experiments with enriched uranyl nitrate solutions used as fuel will be of considerable value in conjunction with P-11 results in establishing the effect of displacement of hydrogen in critical assemblies and thus to a quantitative determination of the effect of bismuth phosphate.

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Finally the K-25 group tested the effectiveness of the control rod arrangement used in the initial design of the P-11 apparatus and also measured the effect of the source tube assembly used in the P-11 equipment.

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