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POWER REACTOR PROCESSING: ESTIMATES OF THROUGHPUTS FROM MOBILE AND STATIONARY PLANTS, 1960–67

J. W. Ullmann

OAK RIDGE NATIONAL LABORATORY • U.S. ATOMIC ENERGY COMMISSION

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
UNION CARBIDE NUCLEAR COMPANY
A Division of Union Carbide and Carbon Corporation
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CHEMICAL TECHNOLOGY DIVISION

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0.0 ABSTRACT

Reactor fuel reprocessing requirements are estimated for the years 1960-67 based on published nuclear power growth curves. The large dollar value of propulsion plant fuels compared to stationary plant fuels indicates that both types should be considered in the design of a reprocessing facility.

1.0 INTRODUCTION

In order to size a plant it is necessary to estimate the load it will have to handle. For nuclear fuel reprocessing, this is especially difficult because, if the industry is successful, it is expected to grow very rapidly, and a plant will either be grossly oversized initially or will have to be expanded to handle the demand a few years after startup.

Since unit reprocessing costs fall very rapidly with increased plant size and capital investment requirements are of the order of tens of millions of dollars, a judicious plant sizing may be vital to the success or failure of a privately financed facility.

2.0 SUMMARY

Nuclear fuel reprocessing requirements will roughly triple in the period from 1962 to 1967, based on the power surveys of Lane, Knowlton, and the American Industrial Forum. Assuming that all stationary power reactors will be slightly enriched converters irradiating to 4000 Mwd/t, 1.5 tons per day of uranium will have to be processed by 1962.

Assuming that all propulsion reactors run at full power with 25% burnup of highly enriched fuel, 35 kg of U^{235} per day will have to be processed by 1962.

With these assumptions, the dollar value of highly enriched propulsion fuel to be processed from 1960 to 1967 is two to three times as great as slightly enriched stationary power fuel, and is therefore a market to be considered by a processing facility. Since propulsion

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reactors will primarily be used for mobile military plants which pay a premium for high performance at the expense of economy, it may be desirable for a processing plant to optimize its location for stationary reactors which are trying to achieve competitive power.

3.0 ESTIMATE OF STATIONARY POWER PROCESSING

The prediction used in this study is that of Lane.[1] An efficiency of 25% is assumed to convert Lane's curve from megawatts of electricity to megawatts of heat. Figure 1 shows data obtained from Lane's paper, the prediction of Knowlton,[2] and the minimum and maximum curves presented by the Atomic Industrial Forum.[3]

If it is assumed that all stationary power reactors are fueled with slightly enriched uranium irradiated to 4000 Mwd/t, the curve of Fig. 2 showing tons per day processing capacity required from 1960 to 1980 is obtained. This curve may be corrected by applying linear factors for different assumptions of megawatt-days per ton and for percentage of the total power from fast and thermal breeders. The curve does, however, point up the fact that, over the five-year period from 1962 to 1967, the processing required is more than tripled if the irradiation level and proportion of breeders are not changed. The size of the combination Thorex-Purex plant is not grossly affected by the use of blankets if slightly enriched cores are used because the blankets represent only a fraction of the reactor power and processing load.

4.0 ESTIMATE OF MOBILE POWER PROCESSING

Figure 3 presents the curve used for the heat generation of nuclear propulsion plants. The data were obtained by averaging the minimum and maximum predictions of the Atomic Industrial Forum.[3] This is felt to be a legitimate approximation since the maximum values were less than twice the minimum. The data are extrapolated for the period 1964 to 1967. The power approximately doubles from 1962 to 1967.

[1] J. A. Lane, "Determining Nuclear Fuel Requirements for Large-Scale Industrial Power," Nucleonics, 12(10), 65 (1954).

[2] A. E. Knowlton, "Nuclear Generation to Reach 200,000,000 kw by 2000 AD," Elec. World, 141(16), 108 (1954).

[3] Atomic Industrial Forum, "A Growth Survey of the Atomic Industry, 1955-65," Atomic Industrial Forum, Ins., New York, 1955.

It is assumed that all the propulsion reactors will be of the type used to drive military craft and will burn U^{235}. In order to obtain a factor for converting megawatts of heat to kilograms of U^{235} to be processed per day, an average value of 216 Mwd/kg U^{235}, equivalent to 24.4% U^{235} burnup, was used.

Figure 4 is a plot of the kilograms per day of U^{235} fed to a reprocessing plant based on the power levels of Fig. 3 and the irradiation level and burnup of Table 1. The estimate assumes full power operation, and is therefore open to question; a portion of the propulsion power (large vessels) may be supplied by slightly enriched or breeder reactors.

If the order-of-magnitude correctness of the assumptions is granted, the significant feature of the estimate is the large dollar volume of the propulsion reprocessing business, based on the value of the material to be handled. Table 1 gives a rough comparison of the annual value of slightly enriched and highly enriched material to be processed.

Table 1

Annual Dollar Value of Material Reprocessed

Basis: \$117,000/ton slightly enriched U (irradiated to 4000 Mwd/t)
\$15,000/kg U^{235} after burnup (irradiated to 216 Mwd/kg)

	Millions of Dollars	
Year	Stationary	Propulsion
1960	21	104
1962	64	192
1964	119	295
1967	222	416

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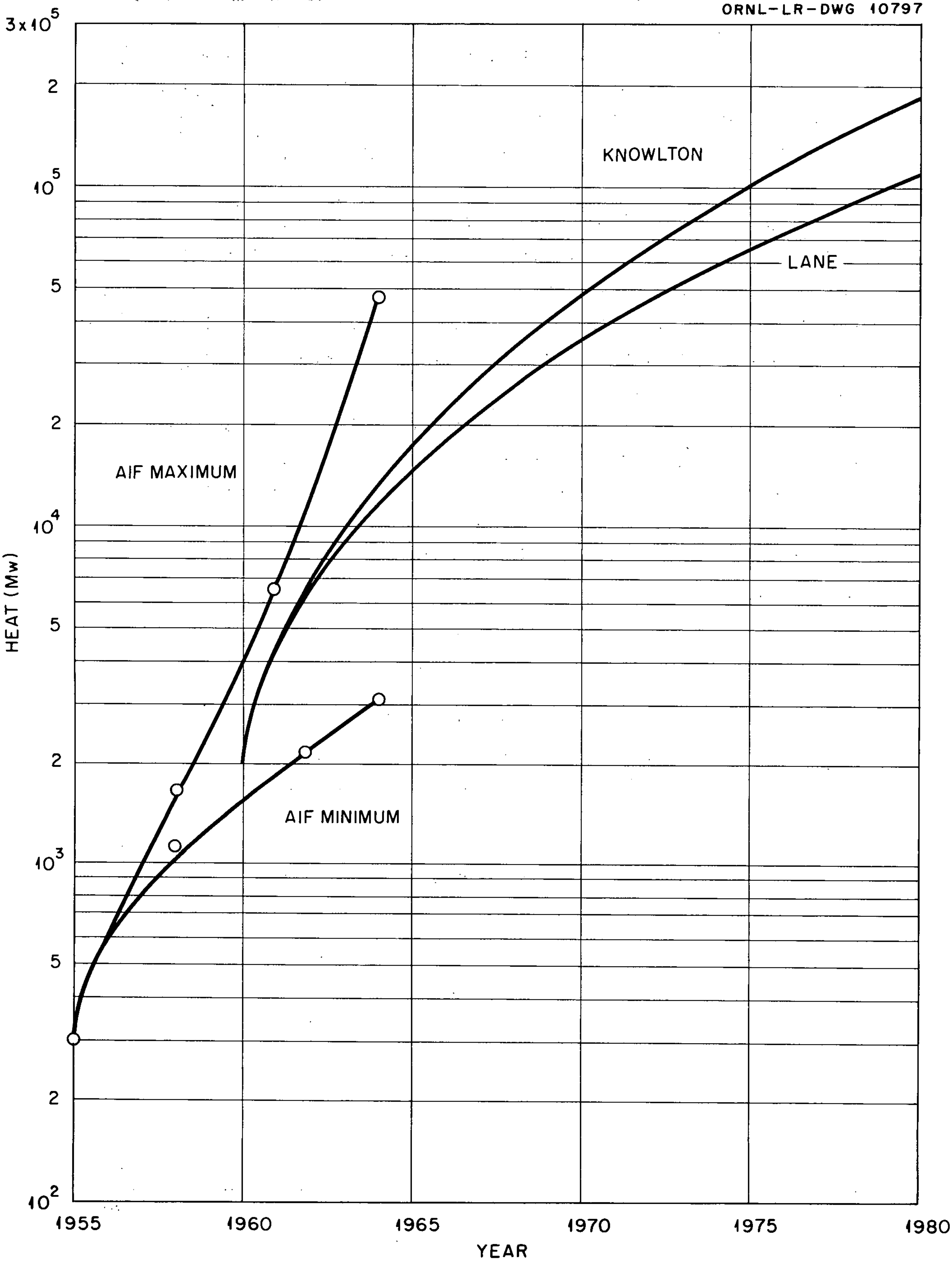

Fig. 1. Predicted Stationary Nuclear Power Growth. Basis: 25% efficiency in conversion of heat to electricity.

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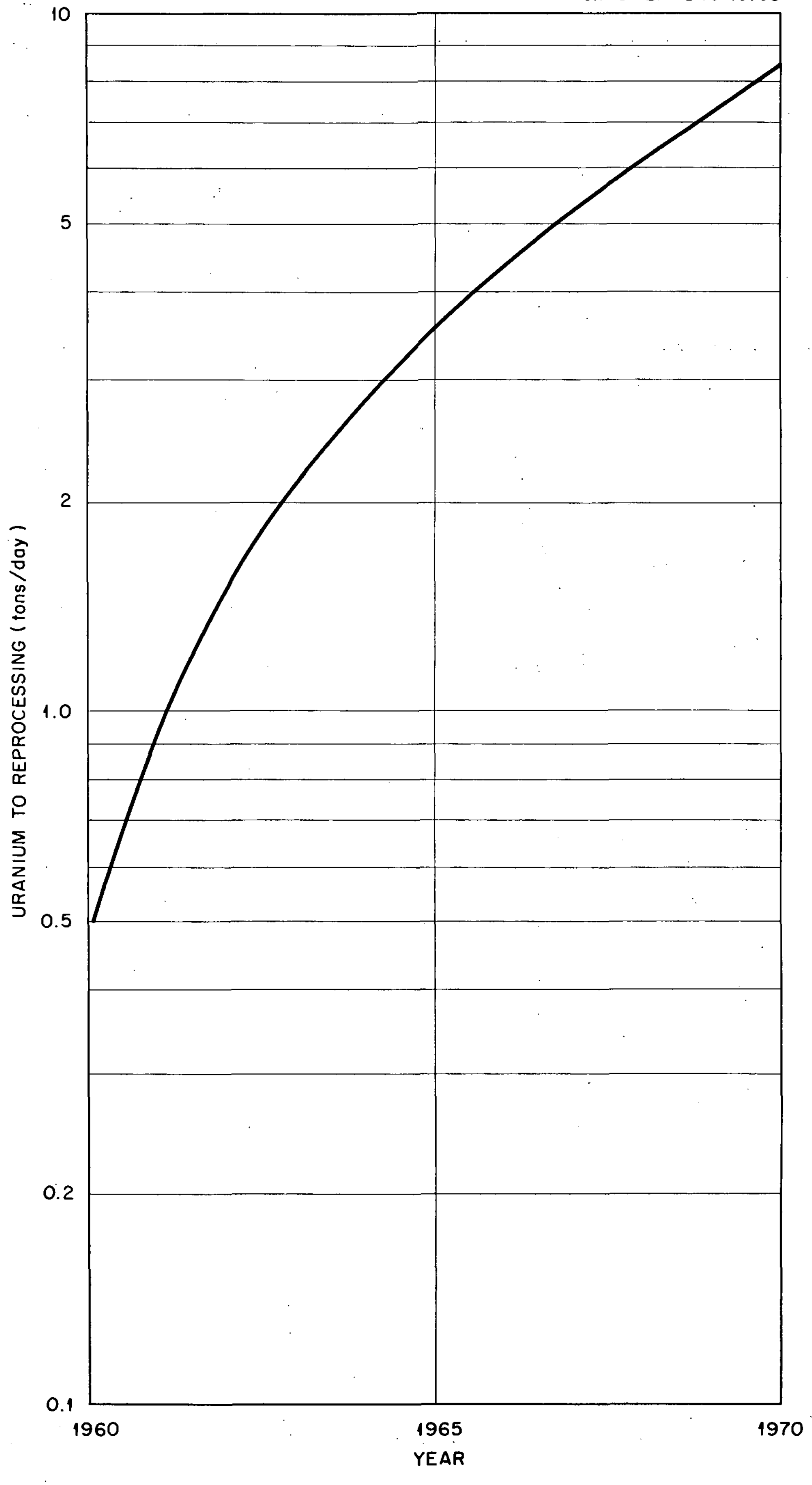

Fig. 2. Processing Required for Stationary Power Reactors. Basis: Lane data, 4000 Mwd/ton.

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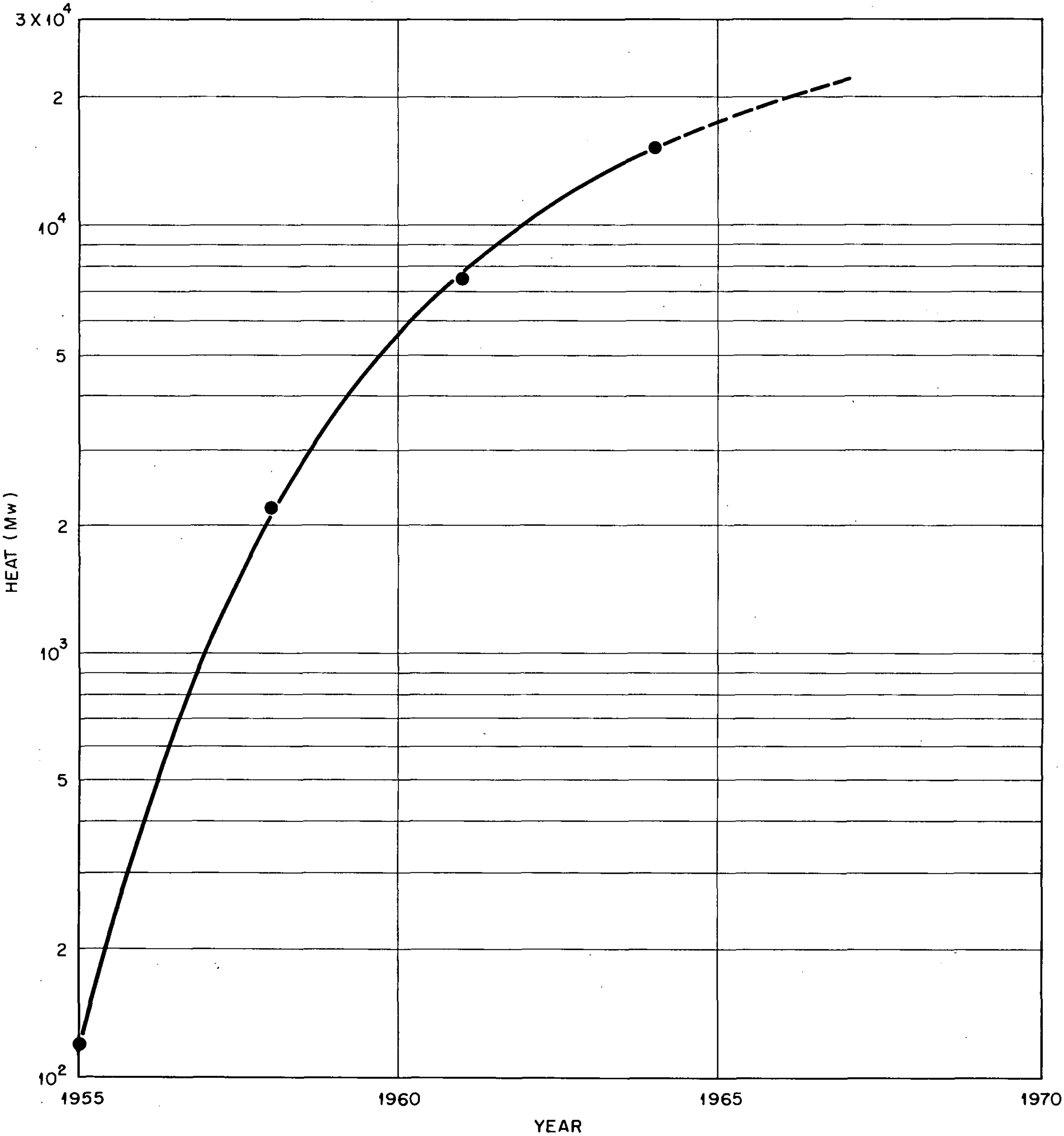

Fig. 3. Predicted Propulsion Nuclear Power Growth. Source : AIF survey, 1955

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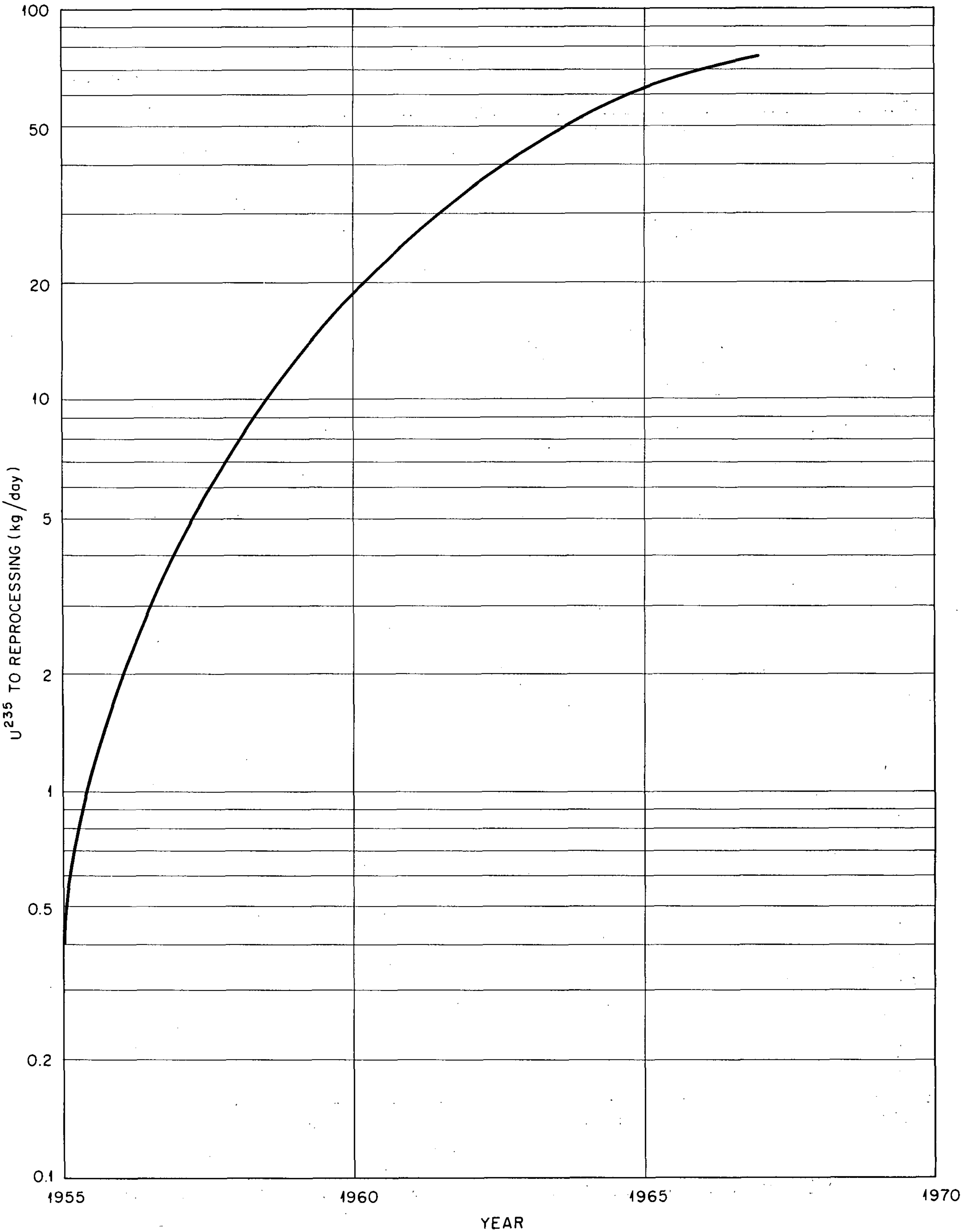

Fig. 4. Processing Required for Mobile Power Reactors. Basis: AIF data, 216 Mwd/kg U^{235}.