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SUBJECT: Revised Version of HFIR Critical Experiment-2 (HFCE-2)

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ABSTRACT

A listing and description is given of the experiments associated with the HFIR Critical Experiment-2. The primary experiments concern the reactivity of the bare core, reactivity worth of "gray" control plates, core-power distribution, reactivity worth of "black" control plates, temperature coefficients of reactivity, and the island void coefficient of reactivity. The secondary experiments concern the reactivity of the fuel, and the reactivity worth of a "partial" gray plate.

Revised Version of HFIR Critical Experiment-2 (HFCE-2)

P. R. Kasten and R. D. Cheverton

Since the issuance of CF-60-8-145 (HFIR Critical Experiment-2),[1] there have been some revisions in the critical experiments and in the order in which they are to be performed. The experiments and their present order are listed in this memorandum. The designation of the experiment is in the order of their performance.

HFCE-2 Experiments and Their Order

Primary Experiments

Experiments which are of primary importance and to be done first are described below. All but experiment 4 are to be performed at room temperature.

Experiment 1 - Reactivity of Bare Core.

This involves the safety of the bare core in water. The reactivity of the initial clean core in a pool of water is required; if the bare core is subcritical, pulsed neutron techniques can be used to determine the multiplication constant. If the bare core in water is supercritical, additional experiments will be required to establish safe handling procedures.

Experiment 2 - Control Plate Position and Power Distribution

This experiment furnishes inter-related information concerning the core fission-power distribution, the reactivity of the initial loading, and the reactivity worth of the gray control plates.

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[1] P. R. Kasten, HFIR Critical Experiment-2 (HFCE-2), CF 60-8-145, Aug. 31, 1960.

The experiment is performed with the isotope target (mockup) in the island region. The initial loading of the reactor will have fuel and boron distributed so as to give a specified power distribution; the boron will be present in the inner fuel ring only. Criticality is to be achieved with no more than one-third of the black plates inserted into the core (control-plate movement will approximate that possible in the HFIR). If this cannot be achieved initially, the worth of the gray region will be supplemented by plating Cd on the gray surfaces. After reaching criticality with the desired control plate position, the power distribution is measured by counting the activity associated with small regions in removable-plate elements. Provision should also be made for measuring fission-chamber response in the region directly above the core as a function of position, and also in the radial direction outside the Be reflector.

The power distribution should be determined at the radial and axial positions indicated in Fig. 1, at 6 circumferential positions.

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*These readings only at one circumferential position (both fuel annuli), the single position being that which is least likely to be affected by the beam holes (midway between through-hole and radial hole).

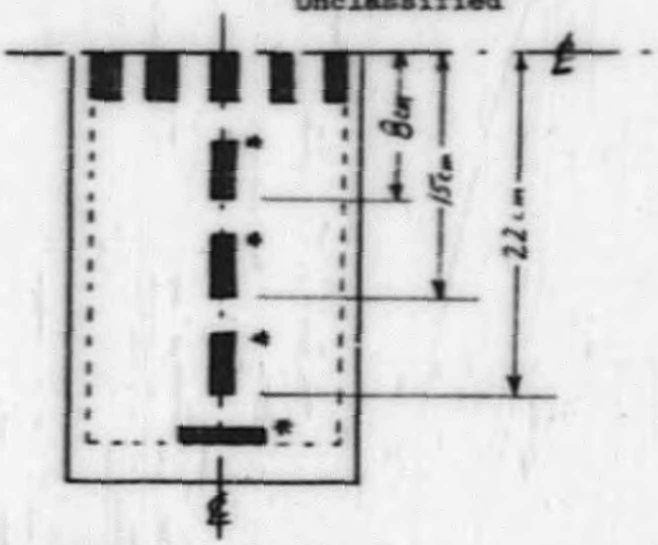

Fig. 1. Radial and axial positions at which power generation should be determined

If the results of the above experiment indicate the presence of more or less fuel than can be tolerated, it will be necessary at this time to determine the worth of the fuel by adding boric acid to the fuel region and attaining criticality with the core surrounded by the white control plate (see experiment 6).

Experiment 3 - Reactivity Worth of Black Plate

These associated experiments determine the reactivity-worth of the black control plates, and of a 3/4 "partial" black plate, and are performed with the target mockup placed in the island region.

First, the final critical conditions associated with experiment 2 are attained. Then the "upper" control plate is lowered gradually until the black region is completely inserted within the core. The associated reactivity change is determined by pulsed-neutron techniques (reactivity is obtained as a function of black-plate position).

The second part of the experiment is similar to the above, except that both the black and gray regions of the upper control plate have, at the same circumferential location, a one-quarter segment replaced with aluminum. The worth of the partial black plate should be determined by pulsed-neutron measurements.

Experiment 4 - Temperature Coefficient of Reactivity

This experiment measures the over-all temperature coefficient of reactivity of the reactor as a function of temperature, and the temperature coefficient of the fuel region. The final critical conditions associated with experiment 2 are first attained. The water within and surrounding the reactor is then heated, (or cooled), and reactivity as a function of reactor temperature is obtained. The Be trap, core, and outer-water regions are to have uniform temperatures of about 40, 70, 100, 130, and 160°F (or up to the temperature at which the over-all temperature coefficient becomes negative). The core temperature coefficient is to be obtained from the above information along with a measurement of the reactivity when the fuel region is about 160°F and the remainder of the system about 140°F. These experiments are to be performed both with and without the target in the island region, so as to provide information concerning reactor operation with and without the presence of the isotope target.

In running this experiment, it would be desirable to increase either the reflector or fuel temperature 20° above the other, and then after determining k_e, raise the lower temperature to approach the other temperature and at the same time obtain associated reactivity measurements.

Experiment 5 - Void Coefficient of Reactivity

This experiment measures the void coefficient of the island region, with and without an island target present. The final critical conditions of experiment 2 are first attained; the void coefficient of reactivity is measured by insertion of voids, plastic, or other appropriate material into the island region.

Secondary Experiments

If time is available, the following experiments should be performed, in the order presented below. These experiments should not be performed until the primary experiments are completed, except as noted above.

Experiment 6 - Reactivity Worth of Fuel

This experiment provides information concerning the reactivity available and the power distribution during the fuel cycle. Boron is added to the fuel region in the amount required to attain criticality with the white control plates surrounding the core. During this process, the control-plate position required (symmetrical) for criticality as a function of boron concentration is also obtained. The axial power distribution should be measured with a 30 cm white window surrounding the core. Also under these conditions, the fission-chamber response as a function of position is measured in the region directly above the core and in the radial direction outside the Be reflector.

Experiment 7 - Worth of "Partial" Gray Plate

The final conditions associated with experiment 6 are first attained. The upper control plate is modified so that the gray region and black region contain a white region covering one quarter of their surface area. This modified control plate (upper plate alone) is gradually inserted into the reactor and the reactivity of the core is obtained as a function of control-plate position by pulsed-neutron measurements.

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