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MASTER

# POWER DISTRIBUTION AND CONTROL ELEMENT REACTIVITY CHANGES IN ADVANCED TEST REACTOR DUE TO BERYLLIUM REFLECTOR REDESIGN

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A redesigned beryllium reflector has been installed in the Advanced Test Reactor (ATR) at the Idaho National Engineering Laboratory. The main feature of the redesigned reflector was the introduction of horizontal sawcuts at 13 different elevations immediately adjacent to the fuel region of the core (see Figure 1 for a one-eighth view of the ATR core components). These sawcuts reduce radiation-induced swelling stress parallel to the core axial direction and are expected to provide a longer reflector life. The new ATR reflector also has fewer axially directed coolant holes as compared to the previous reflector thus increasing the metal-to-water ratio. Two other significant core design changes were made at the same time: (1) the hafnium plates on the outer shim control cylinders were reduced in arc length from 134° to 122°, and (2) the inside diameter of the center flux trap baffle was reduced from 85.725 mm (3.375 in.) to 82.2325 mm (3.2375 in.) to increase the metal-to-water ratio in the center flux trap baffle region.

Following installation of the redesigned components, zero power physics tests were made with a core of new fuel elements prior to resuming full power operation. The result of these tests showed a redistribution of relative fuel element powers by as much as 5.3% and an increased integral reactivity worth for the outer shim cylinders when compared to identical tests in the Advanced Test Reactor Critical Facility (ATRC). The ATRC is a nuclear duplicate of ATR except for the beryllium reflector which matches the original reflector design for ATR. The same fuel elements were used in ATRC and ATR for these physics tests.

The power distribution measurements were obtained in both the ATR and ATRC by irradiating U-Al flux wires in each of the forty fuel elements. The irradiated wires are counted for beta activity which is then converted to specific fission rate. The specific fission rate data are used to calculate point power densities and fuel element powers. The ATR:ATRC fuel element power ratios, averaged over each similar fuel element location, are shown in the fuel element positions of Figure 1. For the power distribution measurements, the ATRC achieved criticality at 62.0° in outer shim cylinder rotation, whereas the ATR achieved criticality at only 56.9° in outer shim cylinder rotation.

The reactivity changes due to small increments of control cylinder movement were measured with a transient reactivity meter. The resulting reactivities from these differential measurements of control cylinder movement were then summed to form integral reactivity worth curves versus outer shim cylinder travel. In measuring the reactivity worth of the outer shim cylinders, one pair of cylinders in each quadrant (quarter core) was rotated out (withdrawn) while the other pair was rotated in (inserted) on alternate steps. This measurement technique minimizes cross-core power tilt during the measurement. Figure 2 shows the integral worth curves for one quadrant of outer shim cylinders for ATR (new reflector design) and for ATRC (original reflector design).

The results of the physics tests show that the new ATR beryllium reflector adds positive reactivity to the core as compared to the original reflector, the amount of added reactivity being a function of outer shim cylinder rotation. This may be concluded from the result that criticality was achieved with less rotation of outer shim cylinders and from the greater integral reactivity worth of the ATR outer shim cylinders as compared to the ATRC outer shim cylinders. However, the less withdrawn outer shim cylinders in ATR resulted in a net depression of local power in the fuel elements adjacent to the ATR beryllium reflector when compared to corresponding data in ATRC.

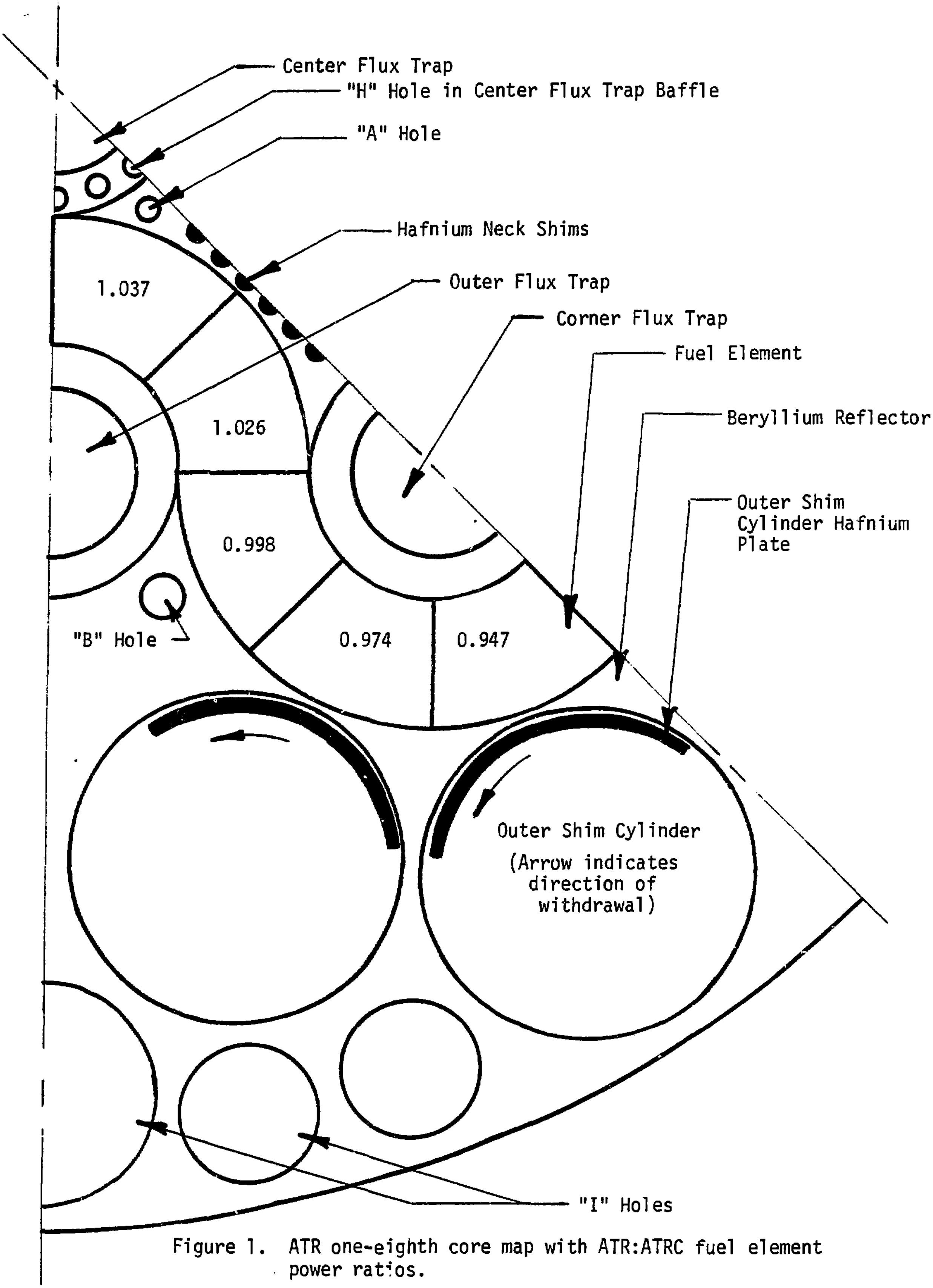


Figure 1. ATR one-eighth core map with ATR:ATRC fuel element power ratios.

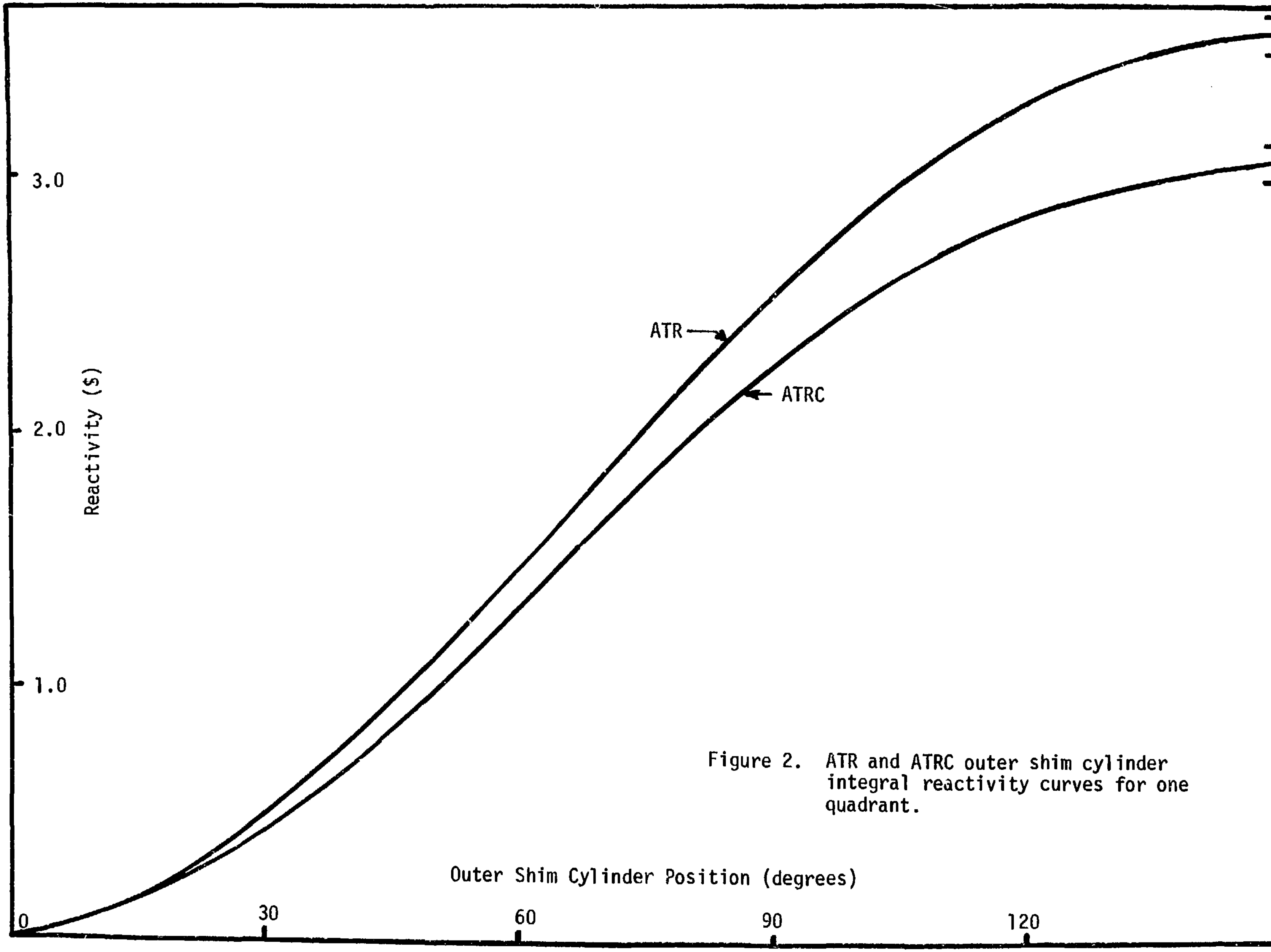


Figure 2. ATR and ATRC outer shim cylinder integral reactivity curves for one quadrant.